BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

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Contents

i Executive summary

The main ToR of WGBFAS is to assess the status and produce a draft advice on fishing opportunities for 2022 for the following stocks:

- Sole in Division 3.a, SDs 20–24 (Skagerrak and Kattegat, western Baltic Sea; catch advice)
- Cod in Kattegat SD 21 (catch advice)
- Cod in SDs 22–24 (western Baltic; catch advice)
- Cod in SDs 24–32 (eastern Baltic; catch advice)
- Herring in SDs 25–27, 28.2, 29 and 32 (central Baltic Sea; 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 (Baltic Sea; catch advice)
- Plaice in SDs 21–23 (Kattegat, Belt Seas, and the Sound; catch advice)
- Plaice in SDs 24–32 (Baltic Sea, excluding the Sound and Belt Seas; catch advice)
- Flounder in SDs 24–25 (west of Bornholm and southwestern central Baltic; stock status advice)
- Flounder in SDs 26+28 (east of Gotland and Gulf of Gdansk; stock status advice)
- Flounder in SDs 27+29–32 (northern central and northern Baltic Sea; stock status advice)
- Brill in SDs 22–32 (Baltic Sea; stock status advice)
- Turbot SDs 22–32 (Baltic Sea; stock status advice)

The working group managed to assess the status and produce a draft advice for all of the stocks with one exception. The assessment for the Cod in SDs 22–24 (western Baltic) was not accepted by the group, due to very high retrospective patterns in the assessment (Mohns Rho at 0.53 for SSB and -0.45 for F). It was therefore decided to ask for an interbenchmark to try to solve the issue. Consequently, only the input data will be presented in the report and the full assessment will be available in September 2021.

The WG was not requested to produce an advice for Flounder in SDs 22–23, Dab and Brill in SDs 22–32 (Baltic Sea). For these stocks, however, data were compile and updated, and update assessments were conducted. In the introductory chapter of this report the Working Group (WG), in agreement with the other 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 reviews the recently published work on ecosystem effects on fish populations in the Baltic Sea. WGBFAS also completed the ToR concerning the productivity audit, which aims to list the ways in which ecosystem trends and variability are accounted for in each stock assessment, forecast, and reference point or management plan evaluation. The group thus completed all the ToRs addressed to us. 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).

ii Expert group information

Expert group name	Baltic Fisheries Assessment Working Group (WGBFAS)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair	Mikaela Bergenius Nord, Sweden
Meeting venue and dates	19 and 29 March 2021, By correspondence (Data preparation)
	13-20 April 2021, By correspondence (37 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' (EcosystemOverview_BalticSea_2020.docx). Comments and suggestions are presented below.

- "Many species and habitats of the Baltic Sea are not in good condition" This could be at species level when there is something to write (about the species).
- Instead of only stating whether overfishing has taken place or not (page 3), a view on the general situation of each fish stock that is important to fisheries, could be presented - e.g. with eastern Baltic cod nothing essential comes up from the statement that there is overfishing, when the major problems are in hypoxic conditions and depletion of suitable food for the cod, and additionally problems with parasites (especially *Contracaecum osculatum*).
- Although the fishery on sprat has been above F_{MSY}, the relationship with herring (competition) could be discussed, and the spatiality of the abundance of sprat, which is still very abundant in the northern areas.
- 'Structural shifts in the open-sea foodweb (including phytoplankton and zooplankton communities) of the central Baltic Sea occurred in the late 1980s and early 1990s. These were attributed to changes in abiotic conditions, such as increasing water temperature and hypoxia, and decreasing salinity, in combination with overfishing of eastern Baltic cod, in particular, during years characterized by low reproductive success of cod. Since then, the open-sea system has been dominated by small pelagic fish, such as sprat.'
  - a suggestion for formulation: '…, such as increasing water temperature and hypoxia, and decreasing salinity. These changes caused a decrease in the reproductive success of eastern Baltic cod, which has remained low since then. Overfishing may have had negative effects on the size structure of the cod population. Since then, the open sea…'
- 'In general, those seabird species eating sprat and herring have increased in number, while several that feed on the benthos are decreasing, possibly partly caused by bycatch in static net fisheries.'
- There is evidence on the effects of competitors feeding on benthos: increasing cyprinid fishes and round goby, a spreading exotic species.
- 'Grey seal populations have had a high growth rate over the past few decades following the cessation of hunting in the 1980s, but this has levelled off in recent years.'
- Evidence of levelling off? About 5 % increase per year.
- Pressures: The effects of climate change are larger than the human activities mentioned: e.g. decreasing salinity has had a major effect on the fish communities and the whole ecosystem.

Among the human activities could be mentioned the construction of rivers, i.e. the reproduction cycle of migratory fishes is still largely not functioning properly (brown trout, grayling, whitefish, vimba, and eel as well).

- "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?
- "There are two main commercially exploited demersal fish stocks in the Baltic Sea, namely the western Baltic cod and the eastern Baltic cod. The fishing mortality (F) of both cod stocks is above F_{MSY}. It is hypothesized that the reduced mean size and growth of the eastern Baltic cod stock since the 1990s is due to size-selective fishing, reduced size at maturation, poor condition of cod, hypoxia, and parasite infestation."
    - An important factor in reduced growth is a consequence of hypoxia: reduced food resources. The small numbers of eastern Baltic cod that are found in the northern Baltic Sea grow well and to large sizes despite the parasites.
- "Fishing has changed both foodwebs and the community structure in the Baltic Sea. Sudden changes occurred in the foodweb of the central Baltic ecosystem in the late 1980s and early 1990s which, in addition to abiotic changes, can be partly explained by unsustainable fishing pressure."
    - The collapse of eastern Baltic cod stock and as a consequence, following clupeid dominance would have most probably happened because of the abiotic changes even without fishery, though somewhat more slowly - thus abiotic changes (decreased salinity, warming and especially hypoxia) are the main reasons to the changes in the foodweb, in addition to which fishery had some effects especially to the rate at which the changes took place. In other words, changes in fish populations very probably did not cause the hypoxia, rather vice versa.
    - Despite fisheries remove large amounts of nutrients from the Baltic ecosystem, it has not been enough to prevent the eutrophication process and development of hypoxia.
    - Fishery is probably the most efficient way of removal of nutrients from the Baltic ecosystem, this could be mentioned, although it is not clear whether this nutrient removal has had any positive effects in the ecosystem.
- Figure 9, "The BIAS survey does not cover the Gulf of Bothnia or the Bothnian Sea." This is not true, BIAS has covered the Bothnian Sea since 2007, these data are only missing from the map. In update they should be included.
- "Hunting was the main reason for a drastic decline in grey seal and ringed seal populations in the early 1900s. In the 1970s and 1980s, seals were protected by all countries in the Baltic Sea region. After recovery of the populations, controlled hunting is allowed."
    - There were two major reasons at later stage: the seals had severe reproduction problems because of pollutants, especially PCBs - only few seals were able to reproduce, which made the populations very vulnerable to hunting. In the recent decades, the proportion of pregnant grey seal females has increased from 9% to 60%. This due to especially decreased PCB load in the seals.
- "The declining eastern Baltic cod condition (Figure 18) has been linked to limited food availability as well as hypoxia and selective fishing pressure."
    - Limited food availability is largely due to hypoxia.
    - it would be good to mention also increased parasites, especially the liver worm *Contracaecum osculatum*, which worsen the consequences of starvation.
- "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.

- 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.
- "Grey seals occur throughout the Baltic Sea and the population grew rapidly from 2000 to 2014, before levelling off at above 30 000 individuals."
    - In 2020, 40 000 specimens were counted in the Baltic Sea. In addition, there is a number of specimens that have not been seen in the countings.
- *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.
- "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?
- 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 in the overview). Total fishing effort has declined since 2003 (Figure 3 in the overview). The following country paragraphs highlight features of the fleets and fisheries of each country and are not exhaustive descriptions.

Denmark

The Danish fleet comprises close to 350 vessels divided into offshore fisheries (approximately 100 vessels 8–12 m and 80 vessels >12 m) and coastal fisheries (approximately 150 vessels). The large-vessel offshore fisheries target (a) sprat and herring in the northern Baltic Sea using small-meshed pelagic trawls and (b) cod and plaice in the southwestern Baltic fisheries using demersal trawls, however the last 2 years the cod fishery has been decreased substantially. 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 25-30 fishing vessels of 18–42 m, while the coastal fishery consists of several hundred of small boats of <12 m. The pelagic fleet consists mostly of stern trawlers, 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. Main areas of coastal herring fishery are the Gulf of Riga (Subdivision 28.1) and the Gulf of Finland (Subdivision 32), where trapnets and poundnets are used. 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 3352 vessels, of which about 1300 vessels are actively used in the fishery. The vast majority of the vessels are <10 m and operate in coastal fisheries. The offshore fleet is composed of 47 vessels >10 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, European whitefish, pikeperch, perch, pike, vendace, burbot, smelt and occasionally flounder. Recreational fisheries target mainly perch, pike, pikeperch, European 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 >18 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 165 000 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 2020 comprised 21 offshore vessels (>18 m) and 58 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, round goby, 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 151 active offshore vessels (12–35 m) and approximately 649 coastal vessels (<12 m). The larger offshore vessels (>18.5 m) target sprat and herring using pelagic trawls for fishing sprat and herring, while smaller offshore vessels (12–18.5 m) target cod, flounder, and sandeel using bottom trawls. Fishing occurs mainly in subdivisions 24, 25, and 26 and these species form about 98% of the total annual landings. The coastal fisheries harvest salmon, trout, turbot, plaice, eel, roach, perch, bream, pikeperch, whiting, european whitefish, crucian carp, and garfish. Recreational fisheries mostly target cod and salmon primarily along the central Polish coast and off the Hel Peninsula.

Russia

The fishing fleet is composed of about 45 vessels divided into offshore fisheries (41 vessels by 25–31 m size class) and coastal fisheries (four 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 450 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 2022.

For 2023 or later more candidates are for benchmarks.

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.

Common issues for Plaice in SD 21-23 and plaice in SD 24-32: Stock ID have to be evaluated by means of genetic studies and tagging (both are in progress), as both stocks have such similar development in survey indices, SSB and recruitment development. Age validation is needed, as differences in age reading are known and occur between national labs (studies in progress), age reading must be reviewed and corrected, if needed. Historical discards should be reviewed and improved.

Plaice in SD 21-23: There is a need to consider estimation of biological parameters for the assessment model instead of median values from the time series (which are resistant to changes). Further, investigate the impact of fluctuating and increasingly extreme environmental conditions on the survey tuning fleets and how to mediate this to reduce variability in advice (project underway).

Plaice in 24-32: If it keeps being its own stock, consider upgrading to category 1, as data basis has improved since the last benchmark and an exploratory SAM and SPiCT showed satisfactory.

If the two plaice stocks are merged into a single plaice stock in 21-32: input data need to be merged, parameter to be calculated, new assessment to be conducted, different options to be explored.

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 2023.

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 8.11). 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 Subdivision 22-32 with Brill in Subdivision 21.

Dab and brill are likely part of the much bigger stocks that cover the Kattegat and Skagerrak (according to BITS and IBTS density maps), ranging into the Baltic Sea areas 22-23(24), stock ID needs to be validated and both stocks might become part of the larger fraction.

Turbot sampling improved since the last benchmark, with over 2.500 length measured fish from the commercial fishery in 2020 (900 in 2015) and increasing discard estimates from the fishing countries. Data to be reviewed and to consider an upgrade to catch advice and inclusion of DLS proxy reference methods to assess the stock status (e.g. LBI as in Baltic flounder stocks). Review the stock size indicator (CPUE, number per hour from BITS) and consider if this could be improved as well.

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	2023 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
Sole2024	2023 or later	Stock structure; connectivity to North Sea stock establish Stock weight-at-age and maturity	1/1

Stock	Year for benchmark	Issues	Present/aimed category
Plaice 2123	2023 or later	Biological parameter estimation Inclusion of environmental variability Stock ID evaluation – both plaice stocks 2123 and 2432	1/1
Plaice2432	2023 or later	Change assessment approach to age based assessment	3/1
Brill2232	2023 or later	Stock ID evaluation with brill in SD 21 Biomass indices available – survey indices inadequate	?/?
Dab	2023 or later	Stock ID evaluation	?/?
Turbot	2023 or later	Stock size indicators – evaluation of survey Use of port sampling measures – DLS approach	?/3

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

A data call subgroup discussed the ICES data call for 2022. It was decided that surveys requested by WGBFAS should not be listed in the text part of the data call, but only in the Annex 1 of the Data Call. No other changes were made.

1.5 Identify research needs of relevance for the work of the Expert group

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

Below is list of the most important parameters needed for a reliable stock assessment. All parameters are dependent on the understanding of current ecosystem processes:

- *Reliable recruitment estimates*
  Important for the development of the stock and for the forecast,
- *Reliable growth estimates*

Important for stock development and health of the stock,

- *Accurate age determination*
  Vital for age base stock assessment models,
  Needed to accurately determine growth,
- *Catchability in the fishery*
  Shift in catchability will affect our perception of the stock development ,
- *Quality assured survey indices*
  Will affect our perception of the stock,
- *Ecosystem dependent estimates of natural mortality*
  Will affect our perception of the stock,
- *Accurate discard information*
  Accurate catch numbers and weight are central for stock assessment and are also important for the evaluation of the landing obligation,
- *Spatial distribution and migration between management areas*
  Integrated ecosystem knowledge is important to determine ecosystem advice,
- *Nutritional condition development*
  Important indicator of the ecosystem health and also possibly for information of infections,
- *Development of alternative stock assessment models that can include new information*
  The present variable ecological situation in the Baltic Sea and the need to integrate ecosystem factors in traditional assessment models demands alternative models.

Responsible persons for updating stock research needs/issue list during WGBFAS 2021:

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	Francesca Vitale	Alessandro Orio
cod-2224	Uwe Krumme	Marie Storr-Paulsen
cod-2432	Sofia Carlshamre	Margit Eero
sol-kask	Jesper Boje	Jesper Boje
ple-2123	Elliot Brown	Elliot Brown
ple-2432	Sven Stötera	Sven Stötera
fle-2223	Sven Stötera	Sven Stötera
fle-2425	Zuzanna Mirny	Zuzanna Mirny
fle-2628	Didzis Ustups	Didzis Ustups
fle-2732	Kristiina Hommik	Kristiina Hommik
her-2532	Julita Gutkowska	Tomas Gröhsler
her-riga	Maris Plikshs	Tiit Raid
her-30+31	Jukka Pönni	David Gilljam
spr-2232	Olavi Kaljuste	Jan Horbowy

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

STOCK	**DAB SD 22-32**					
Stock coordinator	Sven Stötera		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller dab in the survey	Biological data (age. Length, sex, maturity) from smaller/younger dab	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium
Stock identity	At the edge of its distributional area, with the center of gravity being positioned in Kattegat (ICES Subdivision 21). Survey CPUE low in SD25 and 0 further east	Production of a working document for SIMWG to review	Data to produce a combined survey index for dab; update on dab distribution for demersal surveys in Kattegat and Western/Southern Baltic Sea		Before 2023	High
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult dab		ongoing	medium
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop		medium
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				medium

Age reading	Assess quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	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; alternative abundance index (e.g. of juveniles)	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
Commercial data	Discard estimates	Improved sampling	Better coverage of catches			Medium
Age	Standardize otolith preparation method	Tests and agree on joined method between labs	Results from otoliths exchanges		Before 2023	medium
Age	Improve precision and accuracy of age reading	Conduct otolith exchange workshops and agree on a common approach; carry out age validation studies	Results from otolith exchanges; recaptures of chemically marked wild fish		Age validation of adults ongoing	medium
Age	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	Low
Assessment approach	Change from landing to catch advice	Improve discard data				

STOCK	COD SD 21 (COD IN KATTEGAT)					
Stock coordinator	Francesca Vitale		Last benchmark	2017 (ICES 2017)		
Stock assessor	Alessandro Orio		Stock category	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock id	Data on the proportion of North Sea cod in the Kattegat.	Analyses of data sampled in future surveys and analyses of otoliths from historical records.	National institutes, Danish /Swedish	WGBFAS	In progress	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	In progress	Medium
Assessment model	Formulation of a Stock Synthesis model (SS3).	Modelling	National institutes, Danish/ Swedish	WGBFAS	In progress	Medium

STOCK	COD SD 22-24 (WESTERN BALTIC COD)					
Stock coordinator	Uwe Krumme		**Last benchmark**	2019 (ICES 2019b)		
Stock assessor	Marie Storr-Paulsen		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Natural mortality	Has not been updated since many years	The multi-species WG to update natural mortality estimate	Stomach data from western Baltic cod from SD22 and SD24 are available	Data available	Before next benchmark	High
Sampling	Port Catch 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	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 from BITS Q1 and Q4 to DNK and SWE Regular exchange of Q1 age reading results from commercial samples each summer between DNK, SWE and GER Regular exchange of otolith images			ongoing	
Age reading	Different methods used for otolith preparation	DNK and GER use slicing while SWE is still reading broke otoliths	SWE to consider applying also slicing and transmitted light)		ongoing	
Model settings	Large retro in the present model settings	Need to test different settings in the model	No new data is needed		At IB	high
Effort data / commercial CPUE	Present model F is very large, to ensure an alternative data source effort should be investigated	Look into Effort data; assess changes in effort and catches of the Danish and German rockhopper fishery during peak summer in SD22 (e.g. using size sorting categories); and commercial CPUE	No need data is needed		At IB	High
Management measures	Since 2016 spawning closures changed in space and time every year; in addition, measures on Eastern Baltic cod affect the fishing in SD24 since 2019. Overall, this has changed the fishing pattern	Look into fishing reallocation due to management changes.	No need data is needed		At IB	High

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)	TABACOD project and follow-up scientific developments.	Establish a method for future growth monitoring (e.g., otolith microchemistry)	Some years	high
Ageing error	Age error matrix	Developing an age-error matrix to account for past uncertainties in age information in Stock Synthesis model	Past otolith exchanges plus tagging information	Develop age error matirx	Some years	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.			unknown	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	ongoing	high
		Otolith trace elements	Otoliths from annual sampling	DTU Aqua	Not yet initialized	low
		Tagging	Conventional tagging program	DTU Aqua	Not yet initialized	medium
		Egg/Larvae drift modelling	Biological and hydrographic data	DTU Aqua	2021-23	medium
		Identification of nursery grounds	Sampling from potential grounds		ongoing	medium
WEST	Establishment of stock weight at age	Data compilation	Sole survey	Compilation work	Benchmark 23	high
MAT	Establishment of maturity at age	Data compilation	Fishery sampling	Compilation work	Benchmark 23	high
Survey	Include expanded areas 2017-2020 in biomass index from survey	Deep thoughts	Data available	Compilation work	Benchmark 23	high

STOCK	PLAICE SD 21-23					
Stock coordinator	Elliot Brown		**Last benchmark**	2015 (ICES 2015b) (reviewed in 2019)		
Stock assessor	Elliot Brown		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identification	How many stocks are there in the Baltic Sea?	Provide results from genetic analyses to SIMWG for review	Genetic samples		Analyses done, paper in review	High
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
Use of long-term averages in biological parameters for assessment model	The stock annex specifies the use of mean values from the entire time series of observations in short-term forecasts for stock weight at age and maturity ogives. This reduces the assessment's ability to adapt to changes in stock attributes, whether they are intrinsic, fisheries driven or environmentally driven.	Investigate better methods for estimating biological parameters for short-term forecasts	Model development and or method comparisons	Investigate new SAM model features. Investigate sliding window means. Investigate mechanisms for any changes	Ongoing, implementation of findings for a benchmark	high

Environmental Variation in Survey Indices	Physical conditions such as oxygen, temperature and salinity conditions influence fish distributions. The variability of these parameters in areas where survey hauls are undertaken may lead to survey indices being more or less representative of the stock composition	Investigate the effect of environmental conditions during surveys on variation in survey indices and resultant assessments	Reliable CTD data from surveys, combined with other raw environmental data and hydrographic model output. Independent observations of changes in fish distribution corresponding to survey times.	Feedback and collaboration with ongoing project in Denmark (HypCatch)	2021-2022	high
Age reading	Collect age-validated otoliths to improve acccuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult plaice		ongoing	
	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

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?	Provide results from genetic analyses to SIMWG for review	Genetic samples		Analyses done, paper in review	High
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	
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult plaice		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Age reading	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

STOCK	Flounder SD 22-23					
Stock coordinator	Sven Stötera		Last benchmark	2014 (ICES 2014)		
Stock assessor	Sven Stötera		Stock category	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller flounder in the survey	Biological data (age. Length, sex, maturity) from smaller/younger flounder	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult flounder		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Age reading	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

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

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

STOCK	Flounder SD 27, 29-32					
Stock coordinator	Kristiina Hommik		Last benchmark	2014 (ICES 2014)		
Stock assessor	Kristiina Hommik		Stock category	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock ID	Two species in this management area	Genetic analysis	Data from commercial samples			Low
Fishing effort	Fishing effort for Estonia passive gears is missing	Quantifying the effort, as exact data 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 four years (2017-2020). Data collecting is ongoing work		Ongoing	High/medium

STOCK	**Herring SD 25-27, 28.2, 29, 32 (CENTRAL BALTIC HERR.)**					
Stock coordinator	Julita Gutkowska		**Last benchmark**	IBPBASH 2020 (ICES 2020), 2013 (ICES 2013)		
Stock assessor	Tomas Gröhsler		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Mixing of Western Baltic spring spawners and CBH components in SD 24–26.	Test the of different of methods	Genetic samples, morphometrics, otolith shapes etc.	Project		high
Tuning series	BIAS data. Do we have new bias data from SD 32 that could be used in the assessment?	Compare new indeces with spaly.	Index produced by WGBIFS members	WGBIFS		high
Biological Parameters	Mean weight in the stock. Equals currently mean weight in the catch!	Sensitivity analyses:	Mean weights at age and landings per SD and quarter.			medium
Assessment method	A possible change to the SAM model instead of the currently used XSA.	Configuration and subsequent testing of the SAM model.	CANUM, WECA, maturity, mortality, etc	DTU aqua		medium
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)
Age reading	Quality	Comparison of age readings	Reference otolith collection	Age reading WK		medium

STOCK	HERRING SD 28.1 (HERRING IN GULF OF RIGA)					
Stock coordinator	MarisPlikshs		Last benchmark	2008 (ICES 2008)		
Stock assessor	Tiit Raid		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**
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 macrostructure	Data available from Latvia and Estonia	No	Ongoing	High
Tuning series	Trapnet fleet	Estimation of trapnet fleet effort	Data available in national laboratories	No	Ongoing	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	Ongoing	Medium
Recruitment	Estimation of recruitment in the forecast basing it on environmental factors	Recruitment modelling	Data available in national laboratories	No	Ongoing	Medium

STOCK	HERRING SD 30-31 (HERRING IN GULF OF BOTHNIA)					
Stock coordinator	Jukka Pönni		**Last benchmark**	2021 WKCluB		
Stock assessor	David Gilljam		**Stock category**	1 for 2021		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
30 and 31 stock merging/separation	No strong biological evidence for merging or separating the stocks	Tagging and genetic studies suggested in Benchmark	No available data. Provision by Sweden and/or Finland.	Tagging and genetic studies	**Next benchmark**	Low
Possible extension of acoustic survey to SD 31	Aiming for better coverage for the whole stock	Most probably **not possible** due to limited funds and vessel time.			**Next benchmark**	Low
Analysing maturity ogive (suggestion by 2019 WGBFAS; last examined for 2012 WKPELA benchmark)	Reduction of annual variation	**1**) Examining the correlation of maturity@age to temperature and other environmental aspects. **2**) Testing ogive with e.g. 3-year running averages **3**) smoothening the time series	Mat data is available from Finnish catch sampling. Finnish environmental institute and Swedish meteorological institute have earlier provided env. data and could be expected to provide update data.		**Next benchmark**	Medium
Analysing maturity ogive (checking maturity at age of 2 year-olds)	Reduction of annual variation	Sampling the spawning schools (trapnets) to see if 2-year-olds are there	Age determinations from samples of spawning schools (trapnets) to see if 2-year-olds are there		**Next Benchmark**	Medium

STOCK	**SPRAT SD 22-32 (BALTIC SPRAT)**					
Stock coordinator	Olavi Kaljuste		**Last bench-mark**	2013 (ICES 2013)		
Stock assessor	Jan Horbowy		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Natural mortality	Predation mortality is estimated from SMS which is run every several years	Update SMS model and M values every 3-4 years	Data and model available	WGSAM; consider results from recent depth-stratified cod stomach content analyses	Every 3-4 years	
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)

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 work plan. As the WGIAB meeting in 2021 takes place in the autumn, there are no new results to review since last year's meeting in March-April 2020. The main activity and aim of the 2020 meeting was to do an indicator analysis using a common framework across Baltic Sea sub basins.

Members of the WGFAS and WGIAB has for several years discussed potential synergies between the groups and wishes to strengthen the collaborations in the strive towards an ecosystem based fisheries management. 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.

Some funds has been granted to the SLU Aqua and chair of the WGBFAS from the Swedish Agency for Marine and Water Management to hold a workshop in autumn 2021 (dates to be decided) to develop a common strategy for the two groups. The main aim of the workshop is to revise and develop working methods towards an ecosystem-based stock assessment and advice on fishing opportunities for commercial fish species in the Baltic Sea. The more specific objects are to

- Increased interaction between the working groups, mainly WGBFAS and WGIAB
- Synthesize and evaluate existing ecosystem-based advice frameworks, including MSEs
- Evaluate existing proposals on ecosystem aspects, including MSFD descriptors that can be included in the stock assessments and advice
- Synthesize existing and develop new ecosystem - based indicators for the Baltic Sea, which can be used to adjust advice on future fishing opportunities

The aim is to hold a series of workshops. In this first workshop we describe and evaluate the state of the art, propose new methods and indicators. In a second and third workshop we implement and continue the developments of new methods and indicators and evaluate proposed ecosystem based advice using management strategy evaluation tools.

1.6.2 Working group on Multispecies Assessment Methods (WGSAM)

The ICES Working Group on Multispecies Assessment Methods (WGSAM) met in a smaller constellation in October 2021. The focus was the North Sea SMS key run, and applications of the new key run criteria. So there are no news from this group concerning the Baltic Sea.

1.6.3 Working group on Mixed Fisheries (WGMIXFISH)

The Working Group on Mixed Fisheries Advice (WGMIXFISH-Advice) in 2020 made a first attempt to extend the mixed fisheries analysis to Kattegat, with focus on Kattegat cod. No full mixed fisheries analysis was conducted and the work will continue in 2021.

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

The presentation of WGBIFS 2021 was composed from three parts focused on the:

- Baltic acoustic-trawl surveys (BIAS, BASS) in 2020;
- BITS surveys in 2020-Q4 and 2021-Q1;
- Addressing the recommendations from WGBFAS.

BIAS

BIAS database was updated with the survey results from 2020.

The Baltic International Acoustic Survey (BIAS) in September-October 2020 was completed according to the plan. However, it did not cover the Russian EEZ, which was not planned either. The geographical distribution of herring and sprat abundance at age 1+ and age 0, and cod in the Baltic Sea, calculated per the ICES rectangles in 2020 was demonstrated in consecutive graphs. In September-October 2020, the highest concentrations of herring (age 0 and 1+) were detected in the ICES SDs 29, 30 and 32. Sprat (age 1+) dense shoals were mostly distributed in the eastern and northeastern part of the Baltic Proper. Total abundance of age 0 sprat was relatively high. Highest abundances of age 0 sprat were recorded in the northern 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 28.

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 BIAS index series calculated by the StoX can be used in assessment of the Gulf of Bothnia herring stock size with the restriction that the age-groups 0 and 1 are excluded from the dataset.

BASS

BASS database was updated with the survey results from 2020.

The Baltic Acoustic Spring Survey (BASS) in May 2020 was also completed according to the plan. However, it did not cover the Russian EEZ, which was not planned either. In the May survey, sprat was distributed relatively equally all over the survey area. Somewhat higher concentrations of sprat were found in the western part of the SD 25.

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-Q4/2020 and the BITS-Q1/2021 was on the level of 106% and 98% (by numbers), respectively and was considered by the WGBIFS-2021 as appropriate tuning series data for the assessment of Baltic and Kattegat cod and flatfish stocks. There were no trawl hauls planned and performed in the Russian EEZ in the 4th quarter 2020 BITS due to problems with financing research vessel. However, Russia participated in the 1st quarter 2021 BITS.

WGBIFS recommends that the data obtained and uploaded to DATRAS for both the 4th quarter 2020 and the 1st quarter 2021 BITS are used for calculating survey indices for the relevant cod and flatfish stocks.

Addressing the recommendations from WGBFAS 2019

The Baltic Fish Assessment Working Group recommends that WGBIFS should investigate if the sprat and herring length distribution data from the BITS survey is representative for these stocks and can be used as input in the assessment.

Results of a study were presented, where the length distributions of sprat and herring in the BITS surveys were compared with the length distributions in the BIAS and BASS surveys. Kolmogorov Smirnov test reveals that none of the pairwise compared distributions can be regarded as two random samples from the same population. Based on the available data, it cannot be concluded whether the test fails because of:

- the local variation in the spatial and temporal distribution of the herring and sprat stocks;
- the seasonal disagreement of the two types of surveys; or
- the different selectivity of the gears used.

The overall impression is that the length distributions in most cases look more similar if the recruitment is excluded. This suggests that there might be some useful information buried in the BITS data.

WGBFAS 2019 recommends that WGBIFS should include in its remits:
1. Analyse the results of Gulf of Riga acoustic herring survey in order to provide fishery- independent stock estimates of Gulf of Riga herring and evaluate the usage of that information for stock assessment purposes.
2. Conduct analyses related to the uncertainties in the Gulf of Riga acoustic herring survey in order to improve the quality of the GRAHS and subsequent indices.
3. Consider the possibilities of organizing and maintaining a data from the Gulf of Riga acoustic herring survey and incorporate this information in the ICES Acoustic database.
4. Due to the high uncertainty of abundance estimates of younger ages from the GRAHS the usefulness of extending the BIAS survey into the Gulf of Riga (SD 28.1) should be considered.

WGBIFS has dedicated ToR l) for addressing this recommendation: Conduct analyses related to the uncertainties in the Gulf of Riga Acoustic Herring Survey (GRAHS) in order to improve the quality of the GRAHS and subsequent indices. WGBIFS plans are as following:

- Before the next WGBIFS meeting perform the StoX calculation testing for years 2011-2020.
- Before the next WGBIFS meeting upload the data from the rest of the years (1999-2010) into the ICES database for acoustic-trawl surveys.
- At the WGBIFS 2023 meeting present the results of the new Gulf of Riga herring index calculated in StoX.

The WGBFIS is asked to evaluate if there are methodological and/or environmental reasons for different survey catchabilities (understood as ratio of acoustic estimate of stock size and true stock size in given area/AUs) in former assessment units (subdivisions) and what may be magnitude of these differences.

WGBIFS has dedicated ToR m) for addressing this recommendation: Evaluate if there are methodological and/or environmental reasons for different survey catchabilities in different ICES Sub-divisions and what may be magnitude of these differences.

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 SDs 22—24 – although the analytical assessment was not accepted by the WG this year
b) Cod in the SDs 24—32
c) Sole in Division 3.a + SDs 22—24
d) Plaice in SDs 21—23
e) Herring in SDs 25—29 and 32, excluding SD 28.1
f) Herring in SD 28.1)
g) Herring in SDs 30-31
h) Sprat in the SDs 22—32.

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

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

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 assessments of cod in SDs 24-32 and herring in SDs 30-331 were 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 assessmwent and short-term prediction

1.8 Stock annex

A table containing links to the stock annexes covered by WGBFAS is found in Annex 5 of this report.

1.9 Ecosystem impacts on commercial fish vital parameters

WGBFAS recognizes the importance of considering ecosystem effects on fish population dynamics. To this end, the sections below reviews recently published knowledge and research highlights on commercial fish vital parameters reproduction, natural mortality and growth, as well as changes in spatial distributions and trends in the fish community e.g. due to alien species or temperature increase.

1.9.1 Reproduction and recruitment

Rau *et al.* (2019) explore the fine scale spatial and temporal distribution of the entire demersal fish and flatfish assemblages in the Western Baltic with a special focus on the abiotic and biotic drivers influencing the abundance of the three commercially and ecologically important flatfish species, namely flounder (*Platichthys flesus*), plaice (*Pleuronectes platessa*) and dab (*Limanda limanda*). Interannual fluctuations explained a large percentage of the variance in flatfish CPUE whereby salinity, water temperature and sediment type were identified as the most important abiotic drivers. Dab was mainly influenced by sediment type and high salinity, while for flounder the main driver was water temperature. Plaice was also impacted by salinity, but was primarily influenced by biotic variables. The availability of benthic prey organisms in the area was verified as biotic driver for flatfish, especially for plaice.

The newly described Baltic flounder *Platichthys solemdali* has adapted to reproduction at low salinity conditions since it colonized the Baltic Sea 7000 years BP; in the area studied (ICES SD 3d 28.2) spawning occurs at 3–20 m depth at ca 7 psu. Nissling & Wallin (2020). The authors monitored variability in year-class strength as newly settled 0-gr fish in three coastal nursery areas, and compared obtained recruitment indices with prevailing temperature and salinity conditions. 0-gr abundance indices varied considerably between years, from 1 to 90, 10–296 and 17–86 at the respective sampling site, and showed strong accordance with the age structure of the adult stock. Variability in temperature showed no effect, but stronger and weaker year-classes respectively were related to variability in salinity in the range 6.6–7.1 psu with stronger year classes at >6.8 psu. This coincides with variability in spermatozoa motility, fertilization rates and early egg development at different salinities and suggests that the year-class strength may be set already at the egg stage. Thus, only small changes in salinity at spawning may affect reproductive success and ultimately stock development.

Ojaveer *et al.* (in press) combine a suite of methods designed to detect the non-linear, non-stationary and interactive relationships. They re-evaluate the potential drivers and their interactions responsible for the multiannual dynamics of the recruitment dynamics of the Gulf of Riga (Baltic Sea) spring spawning herring population at the longest time-span to date (1958-2015) allowing coverage of variable ecosystem conditions. R was affected significantly by prey density and the severity of the first winter. Although SSB was not a good predictor of R, adding interaction with SSB significantly improved the overall performance of the model, hence the effect of the two environmental variables on R was modulated by SSB. While temporal changes in the environment-R relationship were generally gradual, several abrupt changes were evident in the strength of these relationships.

1.9.2 Natural mortality rates

Natural mortality of Eastern Baltic cod has substantially increased and is estimated more than three times higher than fishing mortality in recent years by this Working Group. Eero et al. (2020) report that there are different views within scientific community on the relative importance of drivers for cod natural mortality, which is subject to ongoing research.

1.9.3 Growth and condition

McQueen *et al.* (2020) combined data from cod tagged in different regions of the Baltic Sea during 2007–2019. An average-sized cod (364 mm) caught in the western Baltic Sea and assigned to the western Baltic cod stock grew at more than double the rate (145 mm $year^{-1}$) on average than a cod of the same size caught in the eastern Baltic Sea and assigned to the eastern Baltic cod stock (58 mm $year^{-1}$), highlighting the current poor conditions for the growth of cod in the eastern Baltic Sea. The regional differences in growth rate were more than twice as large (63 mm $year^{-1}$) as the stock differences (24 mm $year^{-1}$). The authors conclude that although the relative importance of environmental and genetic factors cannot be fully resolved through their study, these results suggest that environmental experience may contribute to growth differences between Baltic cod stocks.

Five decades of stomach content data allowed insight into the development of consumption, diet composition, and resulting somatic growth of *Gadus morhua* (Atlantic cod) in the eastern Baltic Sea. Neuenfeldt et al. (2020) show a recent reversal in feeding level over body length. Present feeding levels of small cod indicate severe growth limitation and increased starvation-related mortality. For young cod, the low growth rate and the high mortality rate are manifested through a reduction in size-at-age. The food reduction is amplified by stunted growth leading to high densities of cod of smaller size competing for the scarce resources. The average growth rate is negative, and only individuals with feeding levels well above average will survive, though growing slowly.

For Western Baltic cod, Funk *et al.* (2020) show that diet composition in shallow areas (<20 m depth) was dominated by benthic invertebrate species, mainly the common shore crab *Carcinus maneas*. Compared to historic diet data from the 1960s and 1980s (limited to depth >20 m), the contribution of herring *Clupea harengus* decreased and round goby *Neogobius melanostomus* occurred as a new prey species. Generalized additive modelling identified a negative relationship between catch depth and stomach content weight, suggesting reduced food intake in winter when cod use deeper areas for spawning and during peak summer when cod tend to avoid high water temperatures. The results of their study highlight the importance of shallow coastal areas as major feeding habitats of adult cod in the western Baltic Sea, which were previously unknown because samples were restricted to deeper trawlable areas. The results strongly suggest that historic stomach analyses overestimated the role of forage fish and underestimated the role of invertebrate prey.

Haase *et al.* (2020) investigated the diets of cod and flounder for the first time using stomach content data collected simultaneously in 2015-2017 over a large offshore area of the southern Baltic Sea. The diet of flounder was relatively constant between sizes and seasons and was dominated by benthos, with a high proportion in weight of the benthic isopod *Saduria entomon*. The diet of cod differed between seasons and showed an ontogenetic shift with a relative decrease of benthic prey and an increase of fish prey with size. Historic diet data of cod were used to explore cod diet changes over time, revealing a shift from a specialized to generalist feeding mode paralleled by a large relative decline in benthic prey, especially *S. entomon*. Flounder populations have increased in the past 2 decades in the study area, and therefore the authors hypothesized that flounder have deprived cod of important benthic resources through competition. This competition could be exacerbated by the low benthic prey productivity due to increased hypoxia, which could contribute to explaining the current poor status of the Eastern Baltic cod.

1.9.4 Migrations and spatial distributions

Orio *et al.* (2020) used four decades of data on cod and flounder distributions covering the southern and central Baltic Sea to: (1) model and map the changes in the distributions of the two species using generalized additive models; (2) quantify the temporal changes in the potential competitive and predator–prey interactions between them using spatial overlap indices; (3) relate these changes in overlap to the known dynamics of the different cod and flounder populations in the Baltic Sea. Competition overlap has continuously increased for cod, from the beginning of the time-series. This is a possible cause of the observed decline in feeding levels and body condition of small and intermediate sized cod. Flounder overlap with large cod instead has decreased substantially, suggesting a predation release of flounder, potentially triggering its increase in abundance and distribution range observed in the last decades.

Casini *et al.* (2021) show that the depth distribution of Eastern Baltic cod has increased during the past four decades at the same time of the expansion, and shallowing, of waters with oxygen concentrations detrimental to cod performance. This has resulted in a progressively increasing spatial overlap between the cod population and low-oxygenated waters after the mid-1990s. This spatial overlap and the actual oxygen concentration experienced by cod therein statistically explained a large proportion of the changes in cod condition over the years. These results complement previous analyses on fish otolith microchemistry that also revealed that since the mid-1990s, cod individuals with low condition were exposed to low-oxygen waters during their life. They conclude that further studies should focus on understanding why the cod population has moved to deeper waters in autumn and on analyzing the overlap with low-oxygen waters in other seasons to quantify the potential effects of the variations in physical properties on cod biology throughout the year.

Krumme *et al.* (2020) report that the coincidence of a validated translucent otolith zone (TZ) formation and observed adverse environmental conditions for cod during peak summer suggests deteriorating conditions for Western Baltic cod given ongoing warming, heat waves and spreading of hypoxic areas in the future. They argue, that during this century, temperatures in the Baltic Sea are predicted to continue to rise (Doscher & Meier, 2004, Meier *et al.*, 2006), salinity is predicted to decline (Schrum, 2001), and, if external nutrient loads stay the same, eutrophication and oxygen depletion are predicted to increase (Meier *et al.*, 2012). If the volume, depth and duration of hyperthermic shallow water areas in the western Baltic Sea increase, cod could move deeper, but stratification during summer restricts down-shore movements due to widespread restricts down-shore movements due to widespread hypoxic areas in the deep regions of the western Baltic (Karlson *et al.*, 2002, HELCOM 2003). Consequently, the period during which cod are restricted to intermediate depths, sandwiched between unfavorably warm water in the shallows and hypoxic deeper water below, will last longer, and cod will potentially have to aggregate in smaller cells of appropriate water conditions (Funk *et al.*, 2020). This may result in negative consequences for cod in these aggregations, such as greater catchability and parasite load, decreased food availability, lower condition or reduced growth, and ultimately in reduced productivity of the stock. Krumme *et al.* (2020) conclude, that a validated TZ formation during summer highlights that this period is an eco-physiological bottleneck for WBC that will probably narrow in the future.

1.9.5 Changes in the fish community

Olsson et al. (2019) state that declines in predatory fish in combination with the impact of climate change and eutrophication have caused planktivores, including three-spined stickleback (*Gasterosteus aculeatus*), to increase dramatically in parts of the Baltic Sea. Resulting impacts of stickleback on coastal and offshore foodwebs have been observed, highlighting the need for increased knowledge on its population characteristics. They quantify abundance, biomass, size structure, and spatial distribution of stickleback using data from the Swedish and Finnish parts of the Baltic International Acoustic Survey (BIAS) during 2001–2014. The highest abundance was found in the central parts of the Baltic Proper and Bothnian Sea. The proportion of stickleback biomass in the total planktivore biomass increased from 4 to 10% in the Baltic Proper and averaged 6% of the total planktivore biomass in the Bothnian Sea. In some years, however, stickleback biomass has ranged from half to almost twice that of sprat (*Sprattus sprattus*) in both basins. Given the recent population expansion of stickleback and its potential role in the ecosystem, Olsson et al. (2019) recommend that stickleback should be considered in future monitoring programmes and in fisheries and environmental management of the Baltic Sea.

Isotalo (2020) shows that during reproduction, three-spined sticklebacks respond to higher temperatures with increased courtship activity, increased parental activity, quicker breeding cycles, and more weight lost. Parental care activity in constant high temperature decreases from the first to the second breeding cycle, while parental activity in c onstant low temperature increases. During temperature fluctuations, males experiencing a rise in temperature increase their parental care activity, while males experiencing a drop in temperature demonstrate the opposite. However, no significant consequences of temperature and temperature changes for reproductive success and the viability of offspring were detected during the two breeding cycles. Overall, Isotalo (2020) concludes that the results of this study would indicate that the three-spined stickleback will prove to be a resilient species, and maintain population growth in the face of increased temperatures and temperature fluctuations in the Baltic Sea

Christensen *et al.* (2021) examined the effects of acclimation to temperatures ranging from 5 to 28°C on aerobic metabolic rates, upper temperature tolerance, as well as temperature preference and avoidance of the invasive round goby (*Neogobius melanostomus*).They show that round goby maintained a high aerobic scope from 15 to 28°C; that is, the capacity to increase its aerobic metabolic rate above that of its maintenance metabolism remained high across a broad thermal range. Round goby maintained a large thermal safety margin across acclimation temperatures, indicating a high level of thermal resilience in this species. The unperturbed physiological performance and high thermal resilience were probably facilitated by high levels of phenotypic buffering, which can make species readily adaptable and ecologically competitive in novel and changing environments. The authors suggest that these physiological and behavioural traits could be common for invasive species, which would only increase their success under continued climate change.

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 2021 analytical assessments were carried out for cod in Kattegat, cod in SDs 24-32 (eastern stock), herring in SDs 25–29, 32 (excl. GoR), herring in GoR, sole in SDs 20-24, sprat in SD 22–32 and plaice in SDs 21–23. Spawning stock trends are given for plaice in SDs 24–32 and herring in SDs 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. The assessment of cod in SD 22–24 (western stock) was not accepted by the WG and the group has called for an interbenchmark to attempt to provide a draft advice based on an analytical assessment in September 2021. Results of the assessments are presented in the subsequent sections of the WG report, but below we first provide a brief overview of each of the fishery on each stock. Secondly we present a brief overview of the combined fishery in the Baltic Sea in the format of maps and figures from the regional data base (RDB).

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 been estimated very high. Due to very large retrospective pattern the analytic assessment was not accepted by the working group this year and has been put forward for an interbenchmark.

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

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

1.10.4 Sole in Subdivisions 20-24

The landings of sole in SD20–24 reached a maximum of 1400 t in 1993 and have since then decreased to around 400 t in recent years. Sole is mainly been caught in a mixed fishery as a valuable bycatch; in the trawl fishery for *Nephrops* and in a gillnet fishery for cod and plaice. The effort regulations on kw-days that was put in force in 2009 might potentially have restricted the effort on sole although the precise vessel behaviour in relation to the many regulations over time is poorly known. The closed area in Kattegat to protect spawning cod also restrict trawl fisheries for sole. Spawning stock biomass was between $B_{pa}/B_{trigger}$ (2600 t) and B_{lim} (1850 t) in the past decade but is in recent years increasing to above $B_{trigger}$. Fishing mortality has decreased continuously since the mid-1990s and is recently below F_{MSY} (0.23). The low fishing mortality might have caused the SSB to increase and produce some relatively good year classes in 2017-2018 even within the present regime with lower productivity (since 2004).

1.10.5 Plaice in 21–23

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

1.10.6 Plaice in 24–32

Plaice is mainly caught in the area of Arkona and Bornholm basin (subdivisions 24 and 25). ICES Subdivision 24 is the main fishing area with Poland, Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in the rest of the Eastern Baltic. The stock size indicator from surveys has increased steadily since the early 2000s about five fold since the start of the survey time-series in 2001. Especially the years 2017 and 2018 (Q1) display a strong increase in plaice abundance. The average stock size indicator in the last two years (2020–202019) is 17% higher than the abundance indices in the three previous years (2016–2018). In 2014 discard data was for the first time included in the advice of the stock. Discard was estimated to be relatively high for this stock – close to 45% in 2014 and about 26% in 2019. Discards in 2016 were exceptional high (~67%). Since 2017, plaice is under a landing obligation, resulting in an additional landings of 17 tons of "unwanted catch" (BMS landings) in the most recent year.

1.10.7 Flounder in the Baltic

In January 2014 the flounder stocks in the Baltic were benchmarked. As a result four different stocks of flounder were identified (WKBALFLAT, ICES 2014). Based on new genetic analysis, the currently described two sympatric populations (pelagic spawning *Platichthys flesus* and demersal spawning *Platichthys solemdali* flounder) are considered to be two different species. Flounder (*Platichthys flesus*) is the most widely distributed among all flatfish species in the Baltic Sea.

1.10.8 Flounder in 22–23

The stock size indicator from surveys has increased steadily since 2005 about four fold, but is decreasing since 2016. The average stock size indicator (biomass-index) in the last two years (2019–2018) is 44% lower than the biomass-indices in the three previous years (2015–2017), due to a weak abundance in the BITS Q4 surveys. ICES Subdivision 22 is the main fishing area for this stock with Denmark and Germany being the main fishing countries. Subdivision 23 is only of minor importance (around 10% of the total landings of the stock). Discards of flounder are known to be high with ratios around 30–50% of the total catch of vessels using active gears. Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market-prices and quota of target-species (e.g. cod), discards vary between quarter and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

1.10.9 Flounder in 24–25

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

1.10.10 Flounder in 26 and 28

Flounder is taken as bycatch in demersal fisheries and, to a minor extent, in a directed fishery. The main countries landing flounder from subdivisions 26 and 28 are Latvia, Russia, Poland, and Lithuania. Flounder landings in both subdivisions are dominated by active gears, taking in average 80% of total landings. Discards are considered to be substantial and determined by cod fishery and market capacity. The stock showed a decreasing trend from the beginning of the century although the estimated indices in last the years showing increasing trend. The results of LBI show that stock status is above possible reference points.

1.10.11 Flounder in 27, 29–32

Flounder is mainly taken in a directed fishery, and some extent as bycatch in demersal fisheries. Major part of the landings are taken in subdivisions 29 and 32, the role of subdivision 29 has been increasing year by year. The main landing country is Estonia (>80%), followed by Sweden and Finland. Landings mainly originate from passive gears such as gillnets (80-90% of landings). Discard patterns are unknown. In Estonia, discards are not allowed. Flounder in the northern Baltic Sea is also caught to a great extent in recreational fishery; estimates from surveys collated by ICES (2014d) suggest recreational landings of around 30% of the total landings.

The ICES BITS survey do not cover the Northern Baltic area and the survey conducted are local surveys close to the coast. The indices are very variable between years and no uniform trend is evident between the surveys. The total stock size indicator value seems to show a slight increasing trend from 2012 onwards. However, this trend is largely thrived by one survey in SD29 (Küdema survey, Estonia).

1.10.12 Dab in 22–32

Dab (*Limanda limanda*) is distributed mainly in the western part of the Baltic Sea. The eastern border of its occurrence is not clearly identified. Survey data suggest that the Baltic dab is part of the larger dab stock in Kattegat, whose distribution is ranging into the western Baltic Sea. The main dab landings are taken by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22). The landings of dab are mostly bycatches of the directed cod fishery but also from flatfish directed fisheries. Discards are substantial for this stock and estimated to be close to 50%. The stock size indicator from surveys has increased steadily since 2001 nearly threefold. The survey index varied around 106 kg hour-1 between 2010 and 2019 in SD 22– 24 and remains stable.

1.10.13 Brill in 22–32

Brill is distributed mainly in the western part of the Baltic Sea and Brill fishery is dominated by Denmark in SD 22 (95% of the catches in 1985–2016). Yearly landings within the Baltic Sea have varied between 27 and 105 tonnes during the last ten years. The eastern border of its occurrence is not clearly described. Additional information have been available based on the international coordinated Baltic International Trawl Survey (BITS) since 2001 where standard gear were applied and common survey design were used. The stock size indicator from surveys was the highest in 2011 and varied around 1.1 individuals hour-1 larger or equal to 20 cm between 2012 and 2019 in SD 22– 24.

1.10.14 Turbot in 22–32

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

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

This stock, which is one of the largest herring stocks assessed by the WG, comprises a number of spawning components. This stock complex experienced a high biomass level in the early 1970s but has declined since then. The proportion of the various spawning components has varied in both landings and in stock. The southern components, in which individuals are growing to a relatively larger size, has declined and during the last years the more northerly components, in which individuals reach a maximum size of only about 18–20 cm, are dominating in the landings. The recent interbenchmark assessment in March 2020, which introduced updated natural mortalities for 1974-2018, lead to a downward revision of SSB and upward revision of fishing mortality. The latest stronger year-classes were the 2002, 2007, 2011 and 2014 year class, respectively. Recruitment in 2020 is well above average. Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ since 2002. SBB shows a decreasing trend since 2014 and is just below MSY $B_{trigger}$ in 2020. The amount of reported landings taken within the small meshed industrial fisheries may be uncertain as it is mostly caught in mixed fisheries together with sprat. Fishing mortality has shown an increasing trend since 2014 and has been above F_{MSY} since 2015.

1.10.16 Gulf of Riga herring

The stock is classified to have a full reproduction capacity. The spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40 000–60 000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, reaching the record high level of 120 000 t in 1994. Since then the SSB has been the range of 71 000–138 000 t. The year class abundance of this stock is significantly influenced by hydro- meteorological conditions (by the severity of winter, in particular). Mild winters in the second half of 1990s have supported the formation of series of rich year-classes and increase of SSB. Due to low and only occasional presence of sprat in the Gulf, there is no mixed pelagic fishery in the Gulf of Riga.

1.10.17 Herring in subdivisions 30 and 31

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

1.10.18 Sprat in subdivisions 22–32

The spawning stock biomass of sprat has been low in the first half of 1980s, when cod biomass was high. At the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed SSB of 1.8 million t. The stock size increased due to the combination of strong recruitments and declining natural mortality (effect of quickly decreasing cod biomass). The increase in stock size was followed by large increase in catches (which reached record high level of over half million t. in 1997) and decline in weight at age by about 40%. High catches in following years and five in row below average year-classes (2009-2013) led to stock decline to below 1 million t. in 2007-2015. Stock biomass fluctuates; strong or above average year-classes (1994, 2003, 2008, 2014, 2019) are followed by 4-5 weaker ones. The y-c 2019-2020 are above average and stock is predicted to increase to about 1.2 million t. in 2023.

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.

Overview of the combined fishery in the Baltic Sea.

From the RDB it is possible to get an overview of the combined fishery in the Baltic (Russian data is not included). In the Baltic Sea the main part of the small pelagic fishery is sprat and herring and Finland, Poland and Sweden are the countries with the main part of the fishery Figure 1.1). The main area were these fisheries are conducted is in SDs 25 and 26 (Figure 1.2). The demersal fishery mainly consist of cod but also smaller amount of whiting and Poland and Denmark are the main fishing nations (Figure 1.3). The main part of this fishery is conducted in the southern and western part of the Baltic Sea (Figure 1.4). Several species of flatfish are landed in the Baltic Sea but flounder, plaice and dab are the most important in quantities. Poland is the main fishing nation in this fishery and target primary flounders (Figure 1.5). The main area the fishing is conducted is the same area as the cod fishery the southern and western Baltic Sea (Figure 1.6).

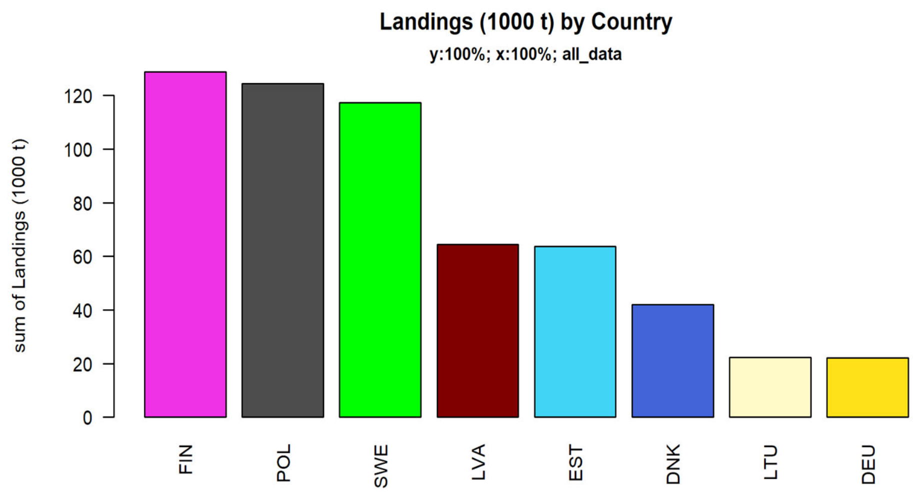


Figure 1.1. Landings (1000 t) of small pelagic (mainly sprat and herring) by Country in 2020.

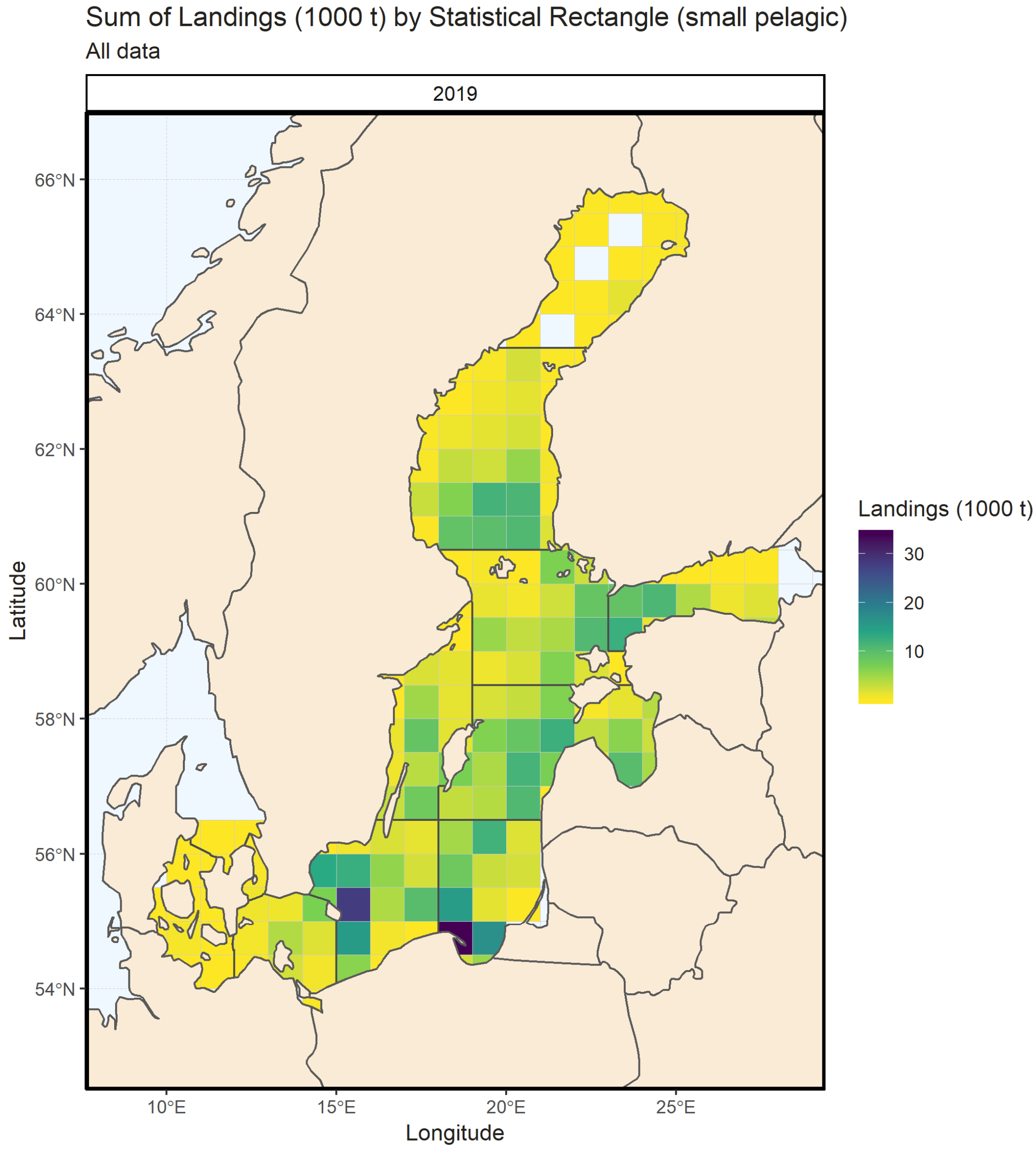


Figure 1.2. Sum of Landings (1000 t) in 2020 by Statistical Rectangle (small pelagic- mainly sprat and herring).

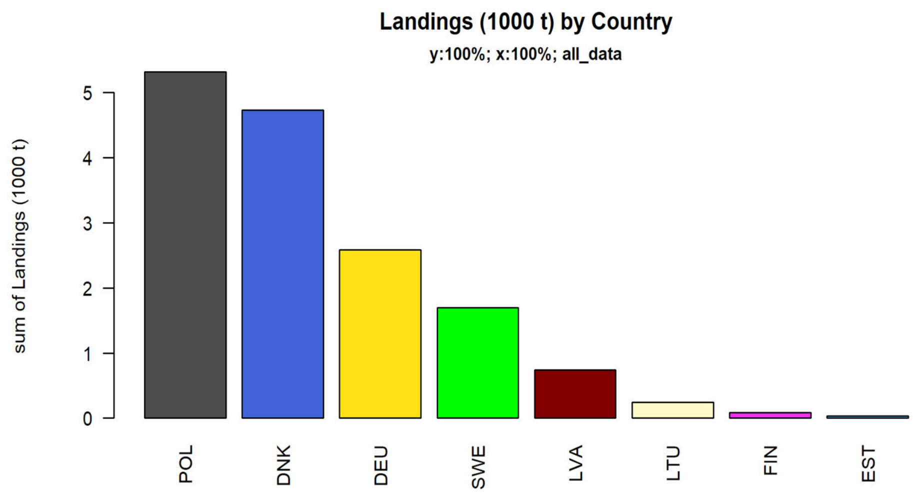


Figure 1.3. Landings (1000 t) of demersal (mainly cod) by Country in 2020.

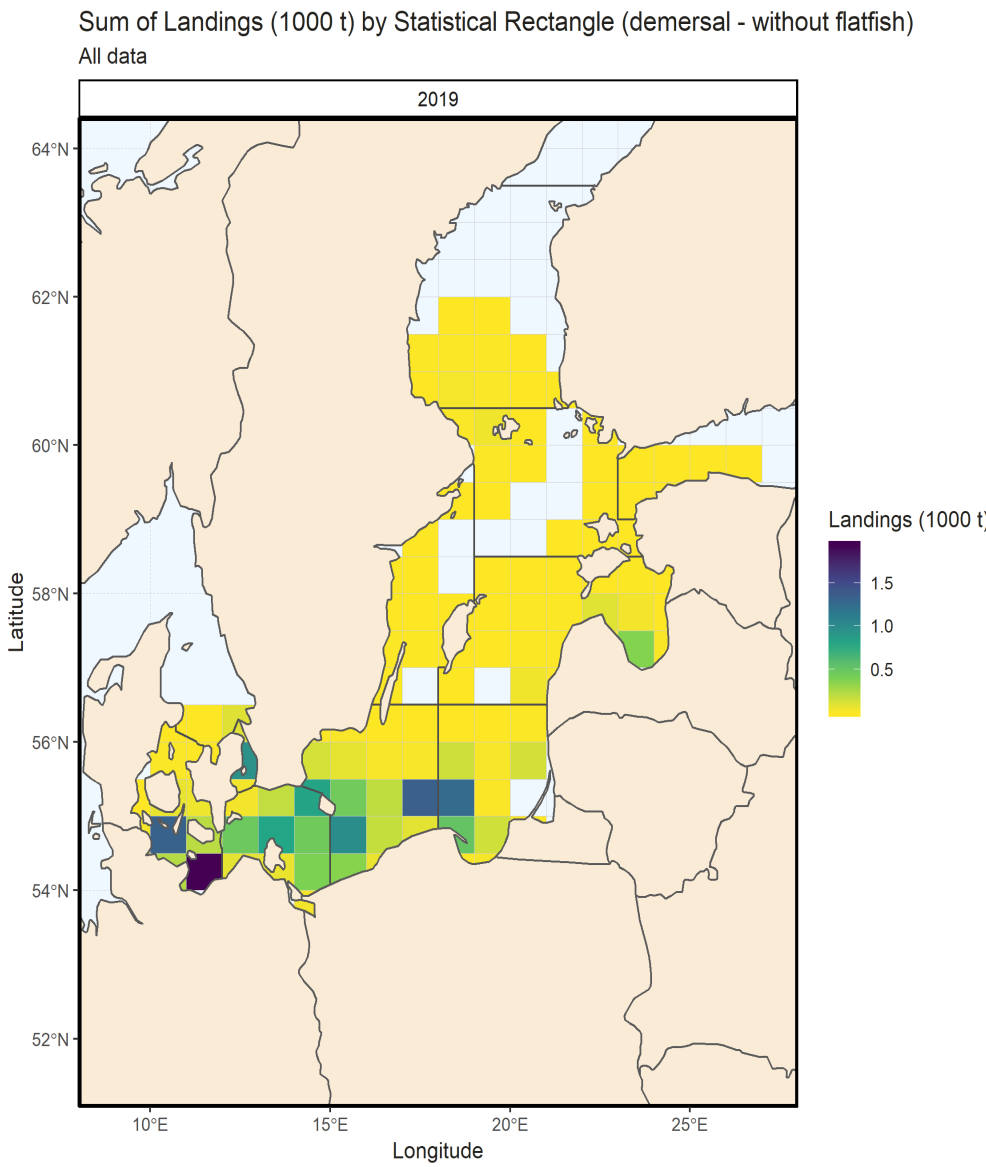


Figure 1.4. Sum of Landings (1000 t) in 2020 by Statistical Rectangle (demersal - without flatfish).

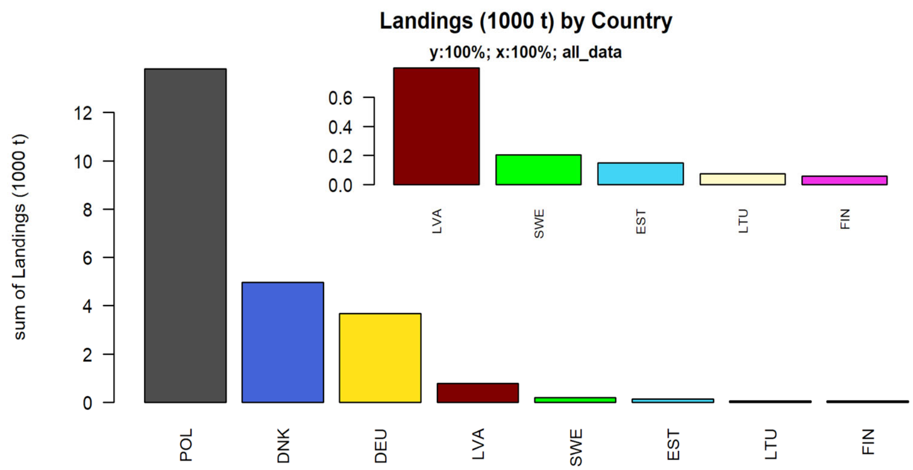


Figure 1.5. Landings (1000 t) in 2020 of flatfish by Country.

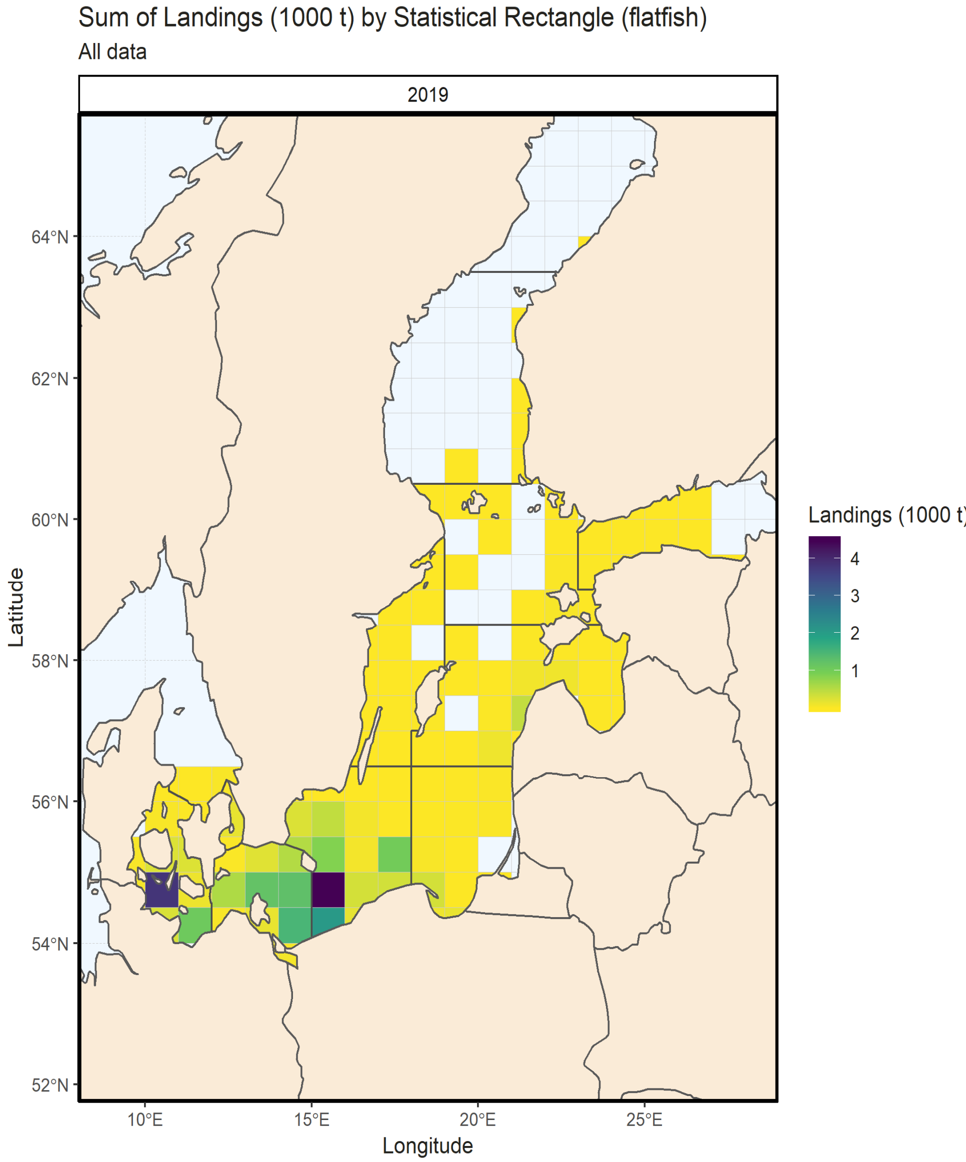


Figure 1.6. Sum of Landings (1000 t) of flatfish in 2020 by Statistical Rectangle.

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

Due to the poor state of the stock, all fishing targeting cod has been prohibited from the third quarter of 2019 onwards. Bycatch of cod has still been allowed in pelagic fisheries and demersal fisheries targeting other species than cod.

From 2015, there is a landing obligation in place 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 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 bycatch 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 later years.

National landings of cod from the eastern Baltic management area (subdivisions 25–32) by year are given in Table 2.1 as provided by the Working Group members. Landings by country, fleet and subdivision in 2020 are shown in Table 2. 2a. The total provided landings in SD 25-32 in 2020 summed up to 2319 t (Figure 2.1), whereof more than 99% were above MCRS and only 8 t were BMS landings (tables 2.2b, 2.3). The vast majority of the cod landings in 2020 were taken by Russia, that was not affected by the closure of the cod fishery (Table 2.1).

Part of the landings of Eastern Baltic cod stock are taken in SD 24, i.e. the management area of Western Baltic cod (Figure 2.2). 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 2020 (Figure.2.2; Table 2.3).

2.1.1.2 Unallocated landings

For 2020, similar to 2010–2019, 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 later years was related to a decreasing fishing fleet due to EU vessel scrapping program and improvement of fishing control. The TAC has not been taken since 2009, and misreporting has been considered a minor problem in recent years. However, in 2020, the substantially reduced quota may have resulted in misreporting of landings.

2.1.1.3 Discards

Due to a combination of a very low fishing effort in the demersal fleet, and disruptions to sampling programmes caused by the covid-19 pandemic, very few discard samples were achieved in 2020. The discard amounts in 2020 are therefore very uncertain, even though believed to be rather limited considering the low fishing effort in the demersal fishery. Only 10% of the EU landings were covered by a discard estimate, all from active gears. No discard estimates were submitted for passive gears and consequently no discards could be estimated for those. The landings from passive gears constituted only 9% of the total landings and the discards are believed to be small. However, even though the demersal fishery has declined drastically, it would be important to investigate the extent of discarding of cod in the demersal fishery for flatfishes that is still carried out by a few countries.

The EU discards in 2020, in subdivisions 25-32, were estimated to 101 t (not including any BMS landings), which constituted 16% of the total catch by EU countries in weight. All discard estimates shown in this report refer to EU countries.

The poor sampling levels affect both the length distribution of discards, as well as the discard amount. The length distribution of cod discards was estimated from very few samples in 2020. Table 2.4 shows the number of length samples bycatch category and fleet in later years.

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 2020 was length class 30-34 cm (59% in numbers) followed by length classes 35-37 cm and 25-29 cm (17% and 16%, respectively) (Table 2. 5).

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 50 tonnes of estimated discards of eastern Baltic stock in SD 24 in 2020 (Table 2.3).

2.1.1.4 Effort and CPUE data

No data on commercial CPUEs was presented at WGBFAS. The effort data from EU STECF (2019) shows a decline in kw-days for demersal trawls in 2012-2019 in the central Baltic Sea, while the effort in gill-net fishery is more stable in these years. No EU STECF effort data from 2020 was available at the time of the WGBFAS 2021 meeting, but the effort submitted to WGBFAS (days at sea by active/passive gears) showed a very large decline in 2020, especially for active gears.

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 2020 was 38-44 cm (43% in numbers), followed by 35-37 cm (31%) and 30-34 cm (14%) (Table 2.5). Table 2.6 gives the estimated mean weight per length class and gear in the landings and discards 2020.

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 2020. All countries biological data was estimated nationally before being uploaded and further processed in InterCatch. However, the difficulties to collect samples from commercial fisheries, caused by covid-19 and the very low fishing effort in the demersal fishery, led to very low sampling levels in 2020. Numbers and mean weight-at-length were provided for 80% of the total landings (>MCRS) in weight and for 12% of the estimated discards. No samples were reported for BMS landings. This was a drastic decrease from previous years, particularly for discards, but all catch categories were affected by the disrupted sampling programmes in 2020. Table 2.4 shows the decrease in the number of samples bycatch category and fleet from 2017-2020. Length distributions should therefore be considered more uncertain than earlier years, especially for discards. However, the resulting overall length distribution of catch in 2020 is similar to that in earlier years.

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 2013–2020 and the data compiled in previous years.

2.1.3 Fishery independent information on stock status

Stock distribution

Data from BITS surveys indicate that within the management area of ICES SDs 25-32, cod is mainly distributed in SDs 25 and 26 (Figure 2.3). 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. The coverage of SD 26 improved in 2021 Q1 survey compared to recent years, as Russia participated again in the survey (Figure 2.3).

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, in all length groups(Figure 2.4). The proportion of cod at 40-60cm in length with very low condition (Fulton K <0.8) in samples from Q1 surveys has been increasing from below 5% in the 1990s and early

2000s to close to 20% in 2013-2014, and is around 10-15% in latest years. In Q4, condition is generally more poor than in Q1, and the condition values in latest years are among the lowest observed in the time-series since the 1990s (Figure 2.5).

Growth and natural mortality

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

Maturity

Size at maturation has substantially declined in the period from the 1990s to 2000s. The 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 (Figure 2.6).

Recruitment

Larval abundances from ichthyoplankton surveys in 2018 were among the lowest observed since the late 1980s. The values for 2019 and 2020 are somewhat higher, but still much lower compared to 2011-2012 or 2016-2017, which were the years with highest larval abundances in last decade (Figure 2.7).

Relative biomass trends and size distribution from surveys

Time-series of cod CPUE show a decline in biomass in both Q1 and Q4 in later years. The estimates for 2018-2020 indicate stable low biomass in both Q1 and Q4, while the biomass in Q1 in 2021 shows a further decline (Figure 2.8). 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 2019-2020 (Figure 2.9).

2.1.4 Input data for stock assessment

Overview of the times series included in stock assessment with Stock Synthesis model is provided in Table 2.7.

2.1.4.1 Catch data

The time-series of catch data used in stock assessment starts in 1946 (Figure 2.10). 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 2020 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 2020. However, to be able to use the survey information from 2021 Q1, the last data year in the Stock Synthesis model is set to 2021. This implies that catches for 2021 need be assumed. The catch in 2021was set to 3595 tonnes (sum of EU TAC at 595 t plus Russian quota at 3000 t).

2.1.4.2 Age and length composition of catch

Age compositions of catches are 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). 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 (Figure 2.11). 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. Both ALKs from Q1 (1991-2020) and Q4 (1998-2020) were included. The average length-at-age in the individual fish data from BITS, used as basis for ALK, are presented in Figure 2.12.

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	1991-2021	Baltic International Bottom Trawl Survey, Q1 (G2916), data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#BITSQ4	1993-2020	Baltic International Bottom Trawl Survey, Q4 (G8863), data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#TrawlSurvey1	1975-1992	CPUE (kg*h–1) by German RV Solea in SD 25 (Thurow and Weber, 1992)
#TrawlSurvey2	1978-1990	CPUE (g/hour) from bottom trawl surveys by the Swedish Board of Fisheries and Baltic Fisheries Research institute (BaltNIIRH), SDs 25–28, yearly average. The index refers to total CPUE in biomass of all length groups caught in the survey (Orio et al., 2017).
#CommCPUE1	1948-1956	Commercial CPUE (kg/h) of former USSR , February–June (Dementjeva, 1959)
#CommCPUE2	1957-1964	Commercial CPUE (kg/h) of former USSR in Gdansk area, February-June (Birjukov, 1970)
#CommCPUE3	1954-1989	Commercial CPUE (kg/day) of USSR (Latvian republic), SDs 26-28, annual average (Lablaika et al. 1991)
#SSBEggProd	1986-2020	SSB indices based on annual egg production method (Köster et al. 2020). Used in SS model to represent spawning stock biomass trends (survey type 30 in SS). Data from ichthyoplankton surveys.
#Larvae	1987-2020	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 & 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 2019, representing the period for which age and length compositions are available. Recruitment deviates were assumed to have a standard deviation (σR which corresponds to the stochastic recruitment process error) of 0.6. The model assumes a level of steepness (*h*) of 0.99 for the SRR, assuming that recruitment is mainly environmentally driven in EBC. Settlement time for recruitment is set to month 8 as an average for the entire 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 2020 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 2.8).

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 2.8).

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 2020 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 2.8).

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 2.8). 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 2.9.

The settings and estimated parameters by the model are presented in Table 2.8. Natural mortality is estimated to have substantially increased and is estimated considerably higher than fishing mortality in later years (Figure 2.13). At the same time, growth has declined since around the year 2000 (Figure 2.14), which is in line with the available biological knowledge on the stock (WKBALTCOD2 2019). The estimated time invariant selectivity is shown in Figure 2.15.

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 2.16, 2.17), 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 2.18), besides the BITS surveys indices for 2008-2011, which were always underestimated in the model.

The retrospectives of the model were reasonable (Figure 2.19). The estimated Hurtado-Ferro (2014) variant of the Mohn´s index was 0.23 for SSB and -0.23 for F (estimated from retrospective analyses for 5 years). 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 2.19).

The spawning stock biomass is estimated to have declined since 2015 (Figure 2.20, Table 2.10). The development of the stock size is not entirely represented by the spawning stock biomass in recent years, due to a large decline in size at maturation. The SSB is 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, but stable since 2019 (Figure 2.21). Fishing mortality has declined over the last years and dropped further in 2020 to a historic low level (0.03) (Figure 2.20). The 2018 and 2019 year –classes are estimated to be the weakest in the entire time-series (Figure 2.20, Table 2.10).

The stock numbers and fishing mortalities at age are given in Tables 2.11 and 2.12.

2.1.6 Exploratory stock assessment analyses with Stock Synthesis

Exploratory stock assessment runs were conducted to explore the potential effect of uncertainties in commercial catch amounts in 2020 on perception of the stock. The catches in 2020 are considered relatively more uncertain than in earlier years due to increased incentives for misreporting related to a very low quota, as well as low sampling levels for estimating discard amounts. The effect of catch uncertainties in 2020 on assessment results was explored in two ways:

i. Increasing the variance applied on catch amounts in 2020
ii. Increasing the catch value for 2020

The CV of catch is normally set to 0.05 for all years in the assessment model. In the exploratory runs associated with (i), three alternative CV values for catch in 2020 were applied, i.e. 0.1, 0.5, and 0.9. This had no effect on outcomes of the assessment in terms of SSB, F and R (results not shown). Also, the fits to survey data did not change, as the model was fitting survey data relatively closely already in the assessment with standard settings. i.e. CV for catch at 0.05 (Figure 2.18). Furthermore, the model statistics in terms of likelihoods and gradient indicating convergence level did not improve in any of the runs with a higher CV on catch in 2020. Therefore, the CV on catch in 2020 was kept at 0.05 in the final assessment.

Secondly, an exploratory run was conducted with increased catch amounts in 2020. The purpose of this run was to investigate whether the perception of the stock and associated advice would be affected by possibly higher catches in 2020. As targeted cod fishing was not allowed in 2020, cod is expected to have been caught as bycatch in flatfish fisheries. Landings of flounder and plaice in the distribution area of eastern Baltic cod declined in 2020 compared to 2018-2019. Furthermore, survey data suggest a stable biomass of eastern Baltic cod in 2018-2020. Therefore, a higher cod catches in 2020 compared to those taken in 2019 were considered highly unrealistic. It was also considered unrealistic that similar catch levels as in 2019 could have been taken in 2020, especially in the light of declining flatfish landings. However, as an extreme scenario, in this exploratory run the catch amounts in 2020 were set equal to those in 2019. This scenario increased the F in 2020 (from 0.03 to 0.13), and accordingly resulted in slightly lower SSB in 2020 and 2021. However, the perception of the stock status remained unchanged.

At lack of any quantitative evidence for adjusting the catch levels for potential misreporting, the final assessment (presented in section 2.1.5) is based on catches as reported to the Working Group by different countries, presented in this report. The exploratory analyses conducted showed that the perception of the stock status and associated catch advice are robust to possible uncertainties in catches in 2020.

2.1.7 Exploratory stock assessment with SPICT

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

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 2.22).

SPICT estimates the fishing mortality of the stock to be above F_{MSY} Proxy in 2020. This is despite the very low F, as the estimated F_{MSY} in the model is declining as well, along with reduced productivity of the stock. The biomass is estimated below B_{MSY} trigger proxy since 2018 (Figure 2.23). These results are in line with the stock status estimates based on Stock Synthesis model.

2.1.8 Short term forecast and management options

The short-term projections were done with Stock Synthesis, using stochastic forecast with multivariate log-normal approximation (MVLN) (Walter and Winker, 2019; Winker *et al.,* 2019), that 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 2020. For maturity and weight-at-length, the values for the latest time-block were used.

Variable	Value	Notes
Fages 4–6 (2021)	0.04	F based on catch constraint.
SSB (2021)	60366	Stock Synthesis assessment estimate
R_{age0} (2020-2023)	1813170	Average of 2015-2019
Total catch (2021)	3595	EU TAC 595 tonnes + Russian quota 3000 tonnes

In all explored catch scenarios, SSB in 2023 is estimated to increase compared to 2022 (Table 2.13). 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 2023, with very high probability.

2.1.9 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 (2021) estimated the B_{lim} to be at 104 402 t (SSB in 2012 in the present assessment).

B_{lim} at 104 402 t corresponds to B_{pa} at 116 061 t ($B_{lim} \times \exp(1.645 \times \sigma)$, where σ=0.07).

2.1.10 Quality of the assessment

Sampling of landings and discards was considerably reduced in 2020 due to a combination of COVID-19 disruption and low catches. Low quotas may also have caused misreporting of landings. However, the perception of the stock status and present advice were found robust to possible uncertainties in catch data in 2020.

Survey coverage in SD 26 has been relatively poor in later years, which could affect the CPUE estimates for these years; the coverage was improved in 2021 Q1 survey.

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.

2.1.10.1 Comparison with previous assessment

The assessment is consistent with the last years' assessment.

2.1.10.2 Management considerations

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. 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

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
1969	44061		58	25979	17432			60749		22301	41580				212160
1970	42392		70	18099	19444			68440		17756	32250				198451
1971	46831		53	10977	16248			54151		15670	20910				164840
1972	34072		76	4055	3203			57093		15194	30140				143833
1973	35455		95	6034	14973			49790		16734	20083				143164
1974	32028		160	2517	11831			48650		14498	38131				147815
1975	39043		298	8700	11968			69318		16033	49289				194649
1976	47412		287	3970	13733			70466		18388	49047				203303
1977	44400		310	7519	19120			47702		16061	29680				164792
1978	30266		1437	2260	4270			64113		14463	37200				154009
1979	34350		2938	1403	9777			79754		20593	75034	3850			227699
1980	49704		5962	1826	11750			123486		29291	124350	1250			347619
1981	68521		5681	1277	7021			120901		37730	87746	2765			331642
1982	71151		8126	753	13800			92541		38475	86906	4300			316052
1983	84406		8927	1424	15894			76474		46710	92248	6065			332148
1984	90089		9358	1793	30483			93429		59685	100761	6354			391952
1985	83527		7224	1215	26275			63260		49565	78127	5890			315083
1986	81521		5633	181	19520			43236		45723	52148	4596			252558
1987	68881		3007	218	14560			32667		42978	39203	5567			207081
1988	60436		2904	2	14078			33351		48964	28137	6915			194787
1989	57240		2254	3	12844			36855		50740	14722	4520			179178
1990	47394		1731		4691			32028		50683	13461	3558			153546
1991	39792	1810	1711		6564	2627	1865	25748	3299	36490		2611			122517
1992	18025	1368	485		2793	1250	1266	13314	1793	13995		593			54882
1993	8000	70	225		1042	1333	605	8909	892	10099		558		18978	50711
1994	9901	952	594		3056	2831	1887	14335	1257	21264		779		44000	100856
1995	16895	1049	1729		5496	6638	4513	25000	1612	24723		777	293	18993	107718
1996	17549	1338	3089		7340	8709	5524	34855	3306	30669		706	289	10815	124189

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
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
2020	20	2	24		12	76	11	376	1778	11					2310

*** 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 2.2a. Cod in SD 25-32. Landings (tonnes) by fleet, country and subdivision in 2020. (Wanted catch, i.e. BMS excluded).

Subdivision		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	18	0	0		0				18
	Estonia	0	0		0	0			0	0
	Finland	2				0	0	0		2
	Germany	12								12
	Latvia	28	24		2					54
	Lithuania	0	6		0					6
	Poland	296	33	0	0	0				329
	Russia		1681							1681
	Sweden	7		0	0			0		7
Total Active gears		364	1743	0	2	0	0	0	0	2109
Passive	Denmark	1	0	0		0				1
	Estonia	0	0		0	1			1	2
	Finland					23	0	0	0	23
	Latvia		8		15					23
	Lithuania		4							4
	Poland	47	0	0	0	0				47
	Russia		97							97
	Sweden	2		1	0	0				3
Total Passive gears		50	110	1	15	24	0	0	1	201
Total All gears		414	1853	1	18	24	0	0	1	2310

Table 2.2b. Cod in SD 25-32. Total landings (tonnes) by country in 2020, in SDs 25-32, separated between landings for human consumption (above MCRS) and the reported BMS landings.

Country	Landings for human consumption (t)	BMS landings (t)
Denmark	20	1
Estonia	2	0
Finland	24	0
Germany	12	1
Latvia	76	3
Lithuania	11	1
Poland	376	1
Russia	1778	0
Sweden	11	2
Total	2310	8

Table 2.3. 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		
	Unallocated*	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

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		
	Unallocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
1981				331642	6185	337827	13759		13759	345401	6185	351586
1982				316052	11548	327600	12239		12239	328291	11548	339839
1983				332148	10998	343146	9853		9853	342001	10998	352999
1984				391952	8521	400473	8709		8709	400661	8521	409182
1985				315083	8199	323282	6971		6971	322054	8199	330253
1986				252558	3848	256406	6604		6604	259162	3848	263010
1987				207081	9340	216421	6874		6874	213955	9340	223295
1988				194787	7253	202040	8487		8487	203274	7253	210527
1989				179178	3462	182640	5721		5721	184899	3462	188361
1990				153546	4187	157733	5543		5543	159089	4187	163276
1991				122517	2741	125258	3762		3762	126279	2741	129020
1992				54882	1904	56786	2324		2324	57206	1904	59110
1993	18978			50711	1558	52269	3885		3885	54596	1558	56154
1994	44000			100856	1956	102812	6551	621	7172	107407	2577	109984
1995	18993			107718	1872	109590	5585	668	6253	113303	2540	115843
1996	10815			124189	1443	125632	10040	1116	11156	134229	2559	136788
1997**				88600	3462	92062	6547	641	7189	95147	4103	99251

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		
	Unallocated*	**Landings AMS**	**Landings BMS**	**Total landings**	**Discards**	**Catch**	**Total landings**	**Discards**	**Catch**	**Total landings**	**Discards**	**Total catch**
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

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		
	Unallocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
2015				38079	5970	44049	5029	930	5959	43108	6900	50008
2016				29313	3279	32591	4541	306	4847	33854	3585	37438
2017		25317	179	25496	3238	28734	2004	227	2231	27500	3465	30965
2018		15800	108	15907	3103	19010	2295	300	2595	18202	3403	21605
2019		8326	57	8383	1337	9720	1598	621	2219	9980	1958	11938
2020		2310	8	2319	101	2420	429	50	479	2748	152	2899

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

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

Table 2.4. Cod SDs 25-32. Number of length samples reported to InterCatch by year, fleet, and catch category, 2017-2020.

		Year			
Catch category	Fleet	2017	2018	2019	2020
Landings	Active	239	263	147	76
	Passive	71	72	35	21
Discards	Active	127	114	51	6
	Passive	16	37	16	0
BMS landings	Active	83	91	38	0
	Passive	19	36	15	0

Table 2.5. 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 2020.

Length class	Wanted catch	Unwanted catch	Total
<20	2	0	2
20-24	7	12	19
25-29	12	56	69
30-34	367	204	571
35-37	1237	60	1296
38-44	1808	11	1819
45-49	320	0	321
≥50	89	0	89
Total	3843	344	4187

Table 2.6. 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 2020.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20	85	57
	20-24	101	108
	25-29	204	207
	30-34	378	326
	35-37	473	412
	38-44	637	488

Fleet	Length class (cm)	Wanted catch	Unwanted catch
	45-49	950	879
	≥50	1363	1048
Passive	<20		57
	20-24		108
	25-29	196	207
	30-34	355	327
	35-37	401	413
	38-44	683	488
	45-49	1056	880
	≥50	1439	1048

Table 2.7. 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	1946-2020	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	2000-2020	5-120 cm	
Maturity ogives	Size at 50% maturity(L_{50}) and slope	1946-2020		Yes (1998-2020, L_{mat})
Growth	Von Bertalanffy growth parameters	1946-1990		No
Age length keys	Age length keys from BITS Q1 and Q4	1991-2020	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	1975-2021		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2021		
Commercial CPUE indices	Commercial CPUE 1-3	1948-1989		
SSB index	SSB index from egg production method	1986-2020		
Larval index	Larval abundance	1987-2020		

Table 2.8. Eastern Baltic cod in SDs 24-32. Settings and estimated parameters. The columns show: number of estimated parameters, the initial values (from which the numerical optimization is started), the intervals allowed for the parameters, the priors used, and the value estimated by maximum likelihood. Parameters in bold are set and not estimated by the model.

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
Natural mortality (age classes 0.5, 1.5, 5.5, 15.5)		1.243, 0.857, 0.361, 0.215			
M (2000-2020) of age class 5.5	21	Estimated using random walk annual deviations	(0.1,2.0)	no prior	0.35-0.72
Stock and recruitment					
Ln(R_0)	1	14.8	(13,16)	no prior	15.2
Steepness (h)		0.99			
Recruitment variability (σ_R)		0.60			
Ln (recruitment deviations): 1946-2019	74				
Recruitment autocorrelation		0			
Growth					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2020)	30	Estimated using random walk annual deviations	(40-150)	no prior	122-49
k (1946-1990)		0.10			
k (1991-2020)	30	Estimated using random walk annual deviations	(0.07-0.45)	no prior	0.10-0.25
L at minimum age (0.5 years) t_0		12			
CV of young individuals	1	0.290	(0.05-0.8)	no prior	0.26
CV of old individuals		0.05			
Weight (kg) at length (cm)					
a (1946-1990)		6.58e-06			
b (1946-1990)		3.1353			
a (1991-1993, 1994-1996, 1997-1999, 2000-2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017, 2018-2020)		6.58E-06, 8.05E-06, 6.81E-06, 6.78E-06 6.76E-06, 7.47E-06 6.70E-06, 7.73E-06, 8.78E-06,			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
		7.56E-06			
b (1991-1993, 1994-1996, 1997-1999, 2000-2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017,2018-2020)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0086,3.0588			
Maturity					
Length (cm) at 50% mature (1946-1990)		38			
Slope of the length at maturity ogive		-0.23			
Length (cm) at 50% mature (1991-1997, 1998-2000, 2001-2007, 2008-2014, 2015-2020)		38, 36, 31, 26, 21			
Initial fishing mortality					
Active gears		0.60			
Selectivity (logistic)					
Active gears					
Time-invariant length based logistic selectivity	2	35; 12.68	(20,45; 0.01,50)	no prior	(39; 8.7)
Passive gears					
Time-invariant length based logistic selectivity	2	35; 10	(20,65; -12,15)	no prior	(41.9; 9.0)
BITS Q1 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27.2;9.5)
BITS Q4 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27.9; 10.1)
Commercial CPUE 1-3		Mirror active fleet			
Trawl surveys 1-2		Mirror BITS Q1			
Catchability					
BITSQ1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
BITSQ4					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			
Trawl survey 1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.30
Trawl survey 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.02
Commercial CPUE 1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.09
Commercial CPUE 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.06
Commercial CPUE 3					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.32
SSBEggProd					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,1.2)	no prior	0.45
Larvae index					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.3			

Table 2.9. Eastern Baltic cod in SDs 24-32. Catch at age, estimated from Stock Synthesis.

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1946	855	8172	14230	5859	3084	1590	659	782
1947	610	17291	27928	14783	3823	1779	886	790
1948	1062	11153	50989	23929	7674	1721	767	709
1949	1246	15890	27436	36854	10406	2876	616	517
1950	1320	19574	41590	21359	17365	4236	1119	431
1951	1039	20195	49527	30961	9545	6675	1554	554
1952	960	17862	55933	39682	14764	3901	2598	799
1953	806	10518	32929	30767	13066	4166	1047	887
1954	1284	13156	28661	27399	15877	5907	1810	822
1955	1114	17447	30665	20589	12177	6163	2200	958
1956	853	21112	54573	28701	11826	6097	2961	1482
1957	911	16038	62686	46270	14349	5043	2471	1751
1958	1211	11582	33216	37456	16051	4193	1392	1131
1959	1063	18948	29729	24989	16689	6097	1513	886
1960	1549	20428	57215	25028	12054	6748	2326	888
1961	1100	18111	38809	29918	7229	2849	1488	684
1962	1142	16594	43825	26308	11615	2351	873	645
1963	1340	18478	42567	31208	10672	3936	750	469
1964	1577	15084	34586	22751	9560	2732	949	285
1965	1955	23192	37051	24872	9760	3515	957	421
1966	2578	45361	84429	37241	14496	4814	1644	626
1967	2393	37892	104006	50875	12163	3844	1189	539
1968	2309	37966	92702	67045	17902	3492	1030	446
1969	1818	34524	88274	57296	22605	4917	894	364
1970	1902	26769	79102	54161	19258	6202	1258	310
1971	2135	25370	56926	46083	17502	5110	1538	375
1972	2508	28516	55350	34916	16058	5076	1394	504
1973	2585	32357	61187	33986	12430	4815	1439	521
1974	1303	31756	66152	36688	12180	3820	1410	558

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1975	1176	20785	84113	52485	17885	5184	1562	786
1976	1397	16094	51715	64917	25075	7466	2078	919
1977	2536	19193	36531	34689	26860	9083	2601	1020
1978	2227	39041	44676	25314	15204	10486	3432	1341
1979	1310	34075	106664	41128	15399	8362	5605	2508
1980	3027	26711	107559	105944	26319	8824	4637	4415
1981	2481	40427	63577	84892	53735	11832	3821	3842
1982	1777	40533	102165	48111	39988	22239	4711	2990
1983	1038	26893	104198	81239	23965	17570	9414	3198
1984	1081	20267	86877	103613	50503	13067	9207	6465
1985	1265	18943	56526	67634	47281	19636	4834	5638
1986	1912	20980	52952	44879	31300	18518	7296	3782
1987	1277	33963	59202	39649	18861	10933	6096	3533
1988	856	21625	89474	40358	14872	5819	3163	2691
1989	834	13633	53600	58363	14546	4414	1618	1572
1990	774	15652	35985	36948	22253	4556	1292	902
1991	1131	10372	36836	22684	12463	6015	1138	526
1992	948	9194	12529	11351	3688	1607	712	188
1993	419	8874	15193	5915	3145	867	357	194
1994	452	8979	30797	19740	4875	2267	598	370
1995	683	8410	20648	21364	8939	1904	839	348
1996	528	10275	23453	19451	13067	4888	987	598
1997	1035	6566	21828	14886	6989	3914	1373	427
1998	1194	11724	13353	12353	4493	1656	845	371
1999	1072	12730	29249	11328	5486	1513	493	342
2000	740	14223	32438	21881	4259	1465	346	175
2001	990	10168	33361	21190	7324	1032	298	96
2002	506	9666	17183	15404	5244	1385	169	58
2003	653	6282	23195	13495	6754	1831	433	66

Year	a1	a2	a3	a4	a5	a6	a7	a8+
2004	1146	7115	14544	17359	5696	2191	526	133
2005	1044	13422	15575	9805	6374	1610	538	150
2006	782	8970	32047	15340	5865	3036	687	274
2007	617	6620	18674	21923	6145	1814	821	239
2008	611	6627	16599	13389	8575	1867	482	260
2009	663	7237	19061	17079	7773	3869	751	278
2010	606	7322	18539	18240	10100	3581	1581	396
2011	716	6533	20801	19289	11818	5257	1645	853
2012	1368	8383	21525	25206	13727	6559	2563	1118
2013	1042	7642	15405	15154	9980	3951	1599	808
2014	772	9258	21423	16088	8729	4110	1349	736
2015	687	6697	24087	22138	9501	3692	1426	634
2016	340	4033	11986	17953	10129	3253	1061	526
2017	653	2749	9779	11718	10984	4824	1341	594
2018	393	3512	5068	7490	5551	4052	1558	572
2019	59	1559	5222	3292	3002	1721	1106	541
2020	27	162	1109	1410	543	385	198	182

Table 2.10. Eastern Baltic cod in SDs 24-32. Spawning stock biomass (SSB, at the spawning time, tonnes), recruitment at age 0 (thousands) and fishing mortality (F_{bar} for ages 4-6). "High" and "low" values correspond to 90% confidence intervals.

Year	Recruitment	High	Low	SSB	High	Low	Fishing Mortality	High	Low
1946	2142740	2405970	1908309	61984	68701	55267	0.40	0.44	0.36
1947	3114960	3432851	2826507	81627	89279	73976	0.52	0.56	0.47
1948	3686940	4037390	3366909	104998	113879	96117	0.59	0.63	0.54
1949	3776440	4130779	3452496	113596	123706	103486	0.57	0.61	0.52
1950	2951930	3266353	2667773	119470	129883	109057	0.59	0.64	0.55
1951	2361070	2647608	2105543	131329	141885	120773	0.60	0.64	0.56
1952	2714750	3028060	2433858	134695	145526	123864	0.67	0.72	0.62
1953	3945770	4316949	3606505	140502	152224	128780	0.49	0.53	0.46
1954	3830840	4185415	3506303	134802	146990	122614	0.53	0.57	0.49
1955	2335780	2607492	2092381	136155	148050	124260	0.49	0.53	0.45
1956	1940320	2181055	1726156	140869	151338	130400	0.61	0.65	0.57
1957	2964810	3249152	2705352	132390	141375	123405	0.75	0.79	0.71

Year	Recruitment	High	Low	SSB	High	Low	Fishing Mortality	High	Low
1958	2452410	2712315	2217410	117482	125866	109098	0.65	0.69	0.61
1959	2721340	2992929	2474396	99213	106572	91854	0.70	0.74	0.66
1960	2479850	2757166	2230426	83701	90433	76969	0.92	0.99	0.85
1961	2554460	2874251	2270249	82822	89509	76134	0.74	0.80	0.69
1962	2751350	3133368	2415907	85098	92059	78138	0.75	0.80	0.69
1963	4381690	4858606	3951588	82853	90776	74929	0.80	0.87	0.74
1964	5721170	6232786	5251549	89934	100236	79631	0.62	0.68	0.55
1965	4969040	5469211	4514611	104105	117689	90521	0.60	0.67	0.53
1966	4766340	5238290	4336911	114800	126963	102637	0.91	0.96	0.85
1967	4323740	4759707	3927705	134710	146711	122709	0.87	0.95	0.79
1968	3370100	3753752	3025659	141043	151698	130388	0.89	0.96	0.82
1969	3512050	3914197	3151220	137477	146974	127980	0.89	0.95	0.83
1970	4369200	4848584	3937213	128661	138203	119119	0.88	0.94	0.82
1971	5805080	6381505	5280722	119461	129773	109149	0.80	0.86	0.74
1972	7180620	7833200	6582406	120000	131400	108600	0.73	0.79	0.67
1973	4495680	5039509	4010537	141158	154199	128117	0.64	0.69	0.58
1974	3787900	4306746	3331561	192945	208365	177525	0.50	0.54	0.46
1975	5453080	6118091	4860353	242072	260086	224058	0.51	0.55	0.48
1976	11818100	12831440	10884786	242068	263089	221047	0.50	0.54	0.46
1977	9605150	10563589	8733671	248476	272528	224424	0.41	0.45	0.38
1978	5691000	6452223	5019585	306579	333003	280155	0.34	0.37	0.32
1979	9499160	10407559	8670048	402719	430727	374711	0.38	0.40	0.36
1980	9607160	10462952	8821365	452632	482746	422518	0.48	0.51	0.45
1981	6330050	6990261	5732194	417425	448272	386578	0.49	0.52	0.45
1982	3928820	4390146	3515971	442611	471639	413583	0.46	0.49	0.44
1983	3367980	3725052	3045136	440964	465090	416838	0.47	0.49	0.44
1984	3526670	3821191	3254850	375841	394332	357350	0.61	0.63	0.58
1985	5296790	5595350	5014160	282223	296170	268276	0.65	0.67	0.62
1986	3212140	3437519	3001538	195202	207124	183280	0.72	0.76	0.68
1987	2005520	2169269	1854132	150258	157065	143451	0.78	0.80	0.77
1988	2027740	2178082	1887776	142675	148608	136742	0.80	0.84	0.77
1989	1490820	1620413	1371591	119519	124722	114316	0.81	0.84	0.78
1990	2983480	3196290	2784839	89969	94852	85086	0.93	0.97	0.89
1991	3544030	3774439	3327686	57626	61235	54018	1.05	1.08	1.01
1992	2393320	2576812	2222895	61172	67556	54788	0.56	0.61	0.51
1993	2014170	2174510	1865653	103168	113575	92761	0.35	0.38	0.32
1994	1972720	2126677	1829908	120262	130826	109698	0.54	0.58	0.50
1995	1471660	1610305	1344952	131902	141542	122262	0.55	0.58	0.52
1996	2761540	2994108	2547037	93588	100751	86424	0.85	0.90	0.80

Year	Recruitment	High	Low	SSB	High	Low	Fishing Mortality	High	Low
1997	2805580	3059835	2572452	63105	68653	57558	0.91	0.98	0.85
1998	2858060	3119646	2618409	56016	61034	50998	0.88	0.96	0.81
1999	2194300	2443136	1970808	52113	56918	47309	0.95	1.03	0.87
2000	2849860	3104299	2616275	61873	66734	57011	1.03	1.11	0.96
2001	1881450	2074158	1706646	75458	80907	70008	1.01	1.08	0.94
2002	2298460	2508930	2105646	84381	90134	78628	0.73	0.78	0.67
2003	3936930	4240980	3654678	85567	91269	79864	0.74	0.80	0.69
2004	3072120	3358822	2809890	74389	80029	68748	0.76	0.82	0.71
2005	3802200	4164120	3471736	92596	98955	86237	0.60	0.64	0.56
2006	3996900	4392776	3636701	92517	99241	85792	0.67	0.72	0.62
2007	3755980	4155489	3394880	90869	98123	83615	0.54	0.58	0.50
2008	3942900	4375832	3552801	129494	139163	119825	0.41	0.44	0.37
2009	3403170	3827096	3026202	142129	152713	131545	0.39	0.42	0.36
2010	3643590	4113044	3227718	145781	156596	134966	0.37	0.39	0.34
2011	4927200	5524156	4394753	129709	139640	119778	0.41	0.44	0.38
2012	5022750	5638419	4474307	104402	113030	95774	0.55	0.60	0.51
2013	3147370	3604285	2748378	98482	106762	90202	0.41	0.45	0.37
2014	2618680	3011434	2277149	107774	116702	98846	0.40	0.44	0.36
2015	1876890	2204192	1598190	128084	138443	117725	0.39	0.43	0.36
2016	3182910	3629329	2791402	111625	120659	102591	0.30	0.33	0.28
2017	2410190	2813858	2064431	86329	93455	79203	0.30	0.33	0.28
2018	725300	969510	542604	79386	86161	72612	0.25	0.27	0.23
2019	870580	1269680	596930	78382	85230	71534	0.139	0.153	0.126
2020	1813170			72532	78997	66066	0.032	0.035	0.029
2021	1813170			60366	66771	53960			

Table 2.11. Eastern Baltic cod in SDs 24-32. Stock numbers at age (in the beginning of the year).

Year	a1	a2	a3	a4	a5	a6	a7	a8
1946	2275780	449045	123509	25788	10457	4806	1921	2230
1947	1269730	740169	190970	52234	10528	4395	2116	1849
1948	1845830	412870	312224	76986	19384	3909	1687	1528
1949	2184780	600062	173032	122123	27032	6713	1390	1144
1950	2237810	710251	251640	68121	43524	9552	2442	923
1951	1749230	727464	297362	98030	23762	14954	3369	1182
1952	1399100	568631	304473	115612	34055	8120	5243	1587
1953	1608680	454714	236468	114776	37931	10825	2630	2191

Year	a1	a2	a3	a4	a5	a6	a7	a8
1954	2338150	523046	191713	96016	43480	14505	4297	1916
1955	2270040	760142	219762	76508	35210	15954	5503	2354
1956	1384110	738104	320649	89273	28967	13447	6323	3113
1957	1149770	449917	308454	123822	30640	9750	4637	3235
1958	1756850	373588	185705	112154	37993	8947	2878	2298
1959	1453230	570975	155397	70441	37365	12335	2968	1708
1960	1612580	472255	236688	57736	22518	11498	3856	1450
1961	1469480	523770	192464	80231	15455	5515	2795	1265
1962	1513700	477524	216724	70399	24783	4542	1638	1191
1963	1630370	491886	197520	79172	21701	7266	1345	829
1964	2596450	529716	202470	70400	23298	5997	2017	595
1965	3390200	844019	221462	78181	24121	7819	2061	892
1966	2944510	1102130	353555	86141	27110	8214	2729	1024
1967	2824390	956601	451350	121283	23369	6727	2022	905
1968	2562110	917628	392700	157163	33901	6028	1729	738
1969	1997020	832304	375388	134959	43002	8523	1507	605
1970	2081130	648714	340341	129068	37029	10859	2142	521
1971	2589050	676026	265287	117445	35743	9472	2769	666
1972	3439910	841190	278247	94653	34664	9919	2642	943
1973	4255020	1117890	348510	102330	29519	10310	2985	1065
1974	2664010	1383180	467172	133725	34540	9707	3463	1349
1975	2244600	866207	583533	189440	50314	13066	3805	1882
1976	3231340	729769	364650	235105	70660	18854	5072	2205
1977	7003100	1050850	308687	148343	88550	26715	7380	2844
1978	5691750	2277770	447080	130152	60034	36757	11595	4449
1979	3372330	1851030	969057	192387	55522	26819	17338	7620
1980	5628940	1096770	786489	411316	79703	23864	12119	11339
1981	5692920	1830040	461116	318461	156803	30897	9640	9513
1982	3751010	1851360	773790	188218	121362	60334	12343	7682

Year	a1	a2	a3	a4	a5	a6	a7	a8
1983	2328110	1219680	782087	317815	72909	47755	24717	8239
1984	1995770	757084	515498	320585	122788	28627	19528	13497
1985	2089800	648874	317722	200883	110842	41530	9905	11362
1986	3138720	679343	271104	121531	67299	36074	13786	7025
1987	1903420	1020350	283397	101310	38496	20281	10980	6267
1988	1188410	618672	423843	103322	30506	10852	5731	4802
1989	1201570	386223	255980	152541	30543	8420	2999	2868
1990	883414	390536	159723	91676	44869	8398	2319	1594
1991	1767910	286970	159511	54302	24422	10840	2003	914
1992	2100090	574658	118208	53334	13389	5223	2238	582
1993	1418210	682770	243603	48148	19535	4775	1894	1010
1994	1193540	461249	290289	106123	20650	8651	2211	1347
1995	1168980	388080	193608	115398	39147	7492	3200	1303
1996	872060	379813	161181	75107	41304	14149	2785	1662
1997	1636400	283350	156160	56908	21321	10860	3715	1137
1998	1662500	531660	117500	55683	15796	5223	2591	1122
1999	1693590	539880	219655	43191	16099	3998	1266	865
2000	1300270	550265	224210	81060	12334	3794	867	432
2001	1688740	422430	225530	77612	21356	2707	755	239
2002	1114890	548661	174494	78400	20509	4796	560	190
2003	1362000	362347	229348	67604	25569	6136	1393	207
2004	2332900	442652	151670	88437	21947	7419	1707	423
2005	1820450	758097	185352	58589	28194	6189	1963	530
2006	2253070	591436	315689	73661	20693	9279	1985	767
2007	2368450	732635	248966	123946	24780	6218	2627	736
2008	2225700	770401	312357	103787	45516	8341	1990	1023
2009	2336450	723945	327911	134258	41337	17063	3045	1064
2010	2016620	759937	306412	138267	53255	15445	6178	1452
2011	2159090	655890	321190	127817	54092	19889	5586	2699

Year	a1	a2	a3	a4	a5	a6	a7	a8
2012	2919710	702200	276647	132224	47758	18774	6611	2657
2013	2976320	949247	294454	110367	45112	13958	4964	2273
2014	1865040	967929	400283	122202	41452	15112	4287	2097
2015	1551750	606434	406307	164421	45613	13818	4592	1807
2016	1112190	504550	253638	164535	60598	15118	4190	1809
2017	1886100	361752	211955	104402	63101	21627	5096	1944
2018	1428200	613424	151936	87145	39693	22181	7187	2255
2019	429791	464569	258241	63545	34352	14622	7799	3252
2020	515883	139861	196592	110904	26840	14143	5939	4564
2021	1074440	167902	59381	86311	49791	12317	6677	5316

Table 2.12. Eastern Baltic cod in SDs 24-32. Fishing mortality at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1946	0.001	0.029	0.164	0.323	0.418	0.461	0.479	0.485	0.487	0.488	0.488	0.488	0.488	0.493
1947	0.001	0.037	0.212	0.418	0.542	0.598	0.621	0.629	0.632	0.632	0.633	0.633	0.633	0.638
1948	0.001	0.043	0.242	0.474	0.612	0.675	0.700	0.709	0.712	0.713	0.713	0.713	0.713	0.718
1949	0.001	0.043	0.235	0.459	0.591	0.652	0.676	0.685	0.688	0.688	0.689	0.689	0.689	0.694
1950	0.001	0.044	0.246	0.480	0.620	0.683	0.709	0.718	0.721	0.721	0.721	0.721	0.721	0.726
1951	0.001	0.045	0.248	0.484	0.625	0.689	0.715	0.724	0.727	0.728	0.728	0.728	0.728	0.733
1952	0.002	0.051	0.279	0.542	0.697	0.768	0.797	0.807	0.810	0.811	0.811	0.811	0.811	0.816
1953	0.001	0.037	0.204	0.398	0.512	0.565	0.586	0.593	0.596	0.596	0.596	0.596	0.596	0.601
1954	0.001	0.041	0.222	0.430	0.554	0.610	0.633	0.641	0.643	0.644	0.644	0.644	0.644	0.650
1955	0.001	0.037	0.204	0.398	0.514	0.566	0.588	0.595	0.598	0.598	0.598	0.598	0.598	0.604
1956	0.001	0.046	0.255	0.497	0.640	0.706	0.732	0.741	0.744	0.745	0.745	0.745	0.745	0.751
1957	0.002	0.059	0.315	0.609	0.782	0.861	0.893	0.904	0.908	0.909	0.909	0.909	0.909	0.916
1958	0.002	0.051	0.273	0.526	0.676	0.744	0.772	0.782	0.785	0.785	0.786	0.786	0.786	0.792
1959	0.002	0.054	0.293	0.568	0.730	0.804	0.833	0.844	0.847	0.848	0.848	0.848	0.848	0.854
1960	0.002	0.071	0.385	0.745	0.958	1.055	1.094	1.108	1.112	1.113	1.114	1.114	1.114	1.118
1961	0.002	0.056	0.309	0.602	0.776	0.855	0.887	0.898	0.902	0.903	0.903	0.903	0.903	0.908
1962	0.002	0.056	0.310	0.604	0.778	0.858	0.890	0.901	0.905	0.905	0.906	0.906	0.906	0.911
1963	0.002	0.061	0.335	0.650	0.837	0.923	0.957	0.969	0.973	0.974	0.974	0.974	0.974	0.979
1964	0.001	0.046	0.255	0.498	0.643	0.709	0.736	0.745	0.748	0.749	0.749	0.749	0.749	0.754
1965	0.001	0.044	0.247	0.486	0.628	0.693	0.720	0.729	0.732	0.733	0.733	0.733	0.733	0.738
1966	0.002	0.066	0.373	0.732	0.945	1.043	1.082	1.096	1.100	1.101	1.101	1.101	1.101	1.107
1967	0.002	0.064	0.358	0.702	0.906	1.000	1.037	1.051	1.055	1.056	1.056	1.056	1.056	1.062
1968	0.002	0.068	0.371	0.723	0.932	1.027	1.065	1.079	1.083	1.084	1.085	1.085	1.085	1.091
1969	0.002	0.068	0.371	0.720	0.927	1.022	1.060	1.073	1.078	1.079	1.079	1.079	1.079	1.085
1970	0.002	0.068	0.367	0.711	0.915	1.007	1.045	1.058	1.062	1.063	1.063	1.063	1.063	1.070
1971	0.002	0.061	0.334	0.647	0.833	0.918	0.952	0.964	0.968	0.969	0.969	0.969	0.969	0.977
1972	0.002	0.055	0.303	0.592	0.764	0.842	0.873	0.885	0.888	0.889	0.889	0.889	0.889	0.896
1973	0.001	0.046	0.261	0.513	0.663	0.732	0.760	0.770	0.773	0.773	0.774	0.774	0.774	0.781
1974	0.001	0.037	0.206	0.405	0.523	0.578	0.599	0.607	0.610	0.610	0.610	0.610	0.610	0.617
1975	0.001	0.039	0.212	0.413	0.533	0.587	0.609	0.617	0.619	0.620	0.620	0.620	0.620	0.627
1976	0.001	0.034	0.203	0.404	0.524	0.579	0.601	0.609	0.612	0.612	0.612	0.612	0.612	0.619
1977	0.001	0.028	0.167	0.332	0.430	0.476	0.494	0.500	0.502	0.503	0.503	0.503	0.503	0.510
1978	0.001	0.028	0.146	0.279	0.357	0.392	0.407	0.412	0.413	0.414	0.414	0.414	0.414	0.420
1979	0.001	0.030	0.160	0.308	0.396	0.435	0.451	0.457	0.459	0.459	0.459	0.459	0.459	0.466
1980	0.001	0.040	0.207	0.392	0.499	0.547	0.567	0.574	0.576	0.576	0.577	0.577	0.577	0.583
1981	0.001	0.035	0.199	0.392	0.506	0.559	0.580	0.587	0.589	0.590	0.590	0.590	0.590	0.597
1982	0.001	0.035	0.193	0.376	0.484	0.533	0.553	0.560	0.563	0.563	0.563	0.563	0.563	0.570
1983	0.001	0.035	0.195	0.378	0.486	0.535	0.555	0.562	0.564	0.565	0.565	0.565	0.565	0.572
1984	0.001	0.042	0.246	0.489	0.635	0.702	0.729	0.739	0.742	0.743	0.743	0.743	0.743	0.750
1985	0.001	0.046	0.264	0.521	0.674	0.744	0.772	0.782	0.785	0.786	0.786	0.786	0.786	0.792
1986	0.001	0.048	0.287	0.577	0.751	0.830	0.863	0.874	0.878	0.879	0.879	0.879	0.879	0.884
1987	0.001	0.052	0.312	0.627	0.817	0.905	0.940	0.953	0.957	0.958	0.958	0.958	0.958	0.962
1988	0.002	0.056	0.325	0.646	0.838	0.927	0.963	0.976	0.980	0.981	0.981	0.981	0.981	0.985
1989	0.001	0.057	0.330	0.651	0.842	0.930	0.966	0.979	0.983	0.984	0.984	0.984	0.984	0.989
1990	0.002	0.069	0.382	0.750	0.972	1.074	1.116	1.132	1.136	1.137	1.138	1.138	1.138	1.143
1991	0.001	0.061	0.399	0.827	1.093	1.219	1.270	1.289	1.295	1.297	1.297	1.297	1.297	1.301
1992	0.001	0.032	0.201	0.432	0.582	0.655	0.686	0.698	0.702	0.703	0.703	0.703	0.703	0.707
1993	0.001	0.029	0.134	0.274	0.366	0.411	0.430	0.438	0.440	0.441	0.441	0.441	0.441	0.446
1994	0.001	0.042	0.226	0.424	0.565	0.635	0.666	0.677	0.681	0.682	0.683	0.683	0.683	0.688
1995	0.002	0.052	0.250	0.455	0.569	0.631	0.658	0.668	0.671	0.672	0.673	0.673	0.673	0.677
1996	0.002	0.063	0.344	0.686	0.887	0.978	1.022	1.039	1.045	1.047	1.047	1.047	1.047	1.052
1997	0.002	0.054	0.334	0.709	0.958	1.074	1.122	1.142	1.150	1.152	1.152	1.152	1.152	1.159
1998	0.002	0.058	0.304	0.668	0.925	1.058	1.113	1.134	1.142	1.145	1.145	1.145	1.145	1.153
1999	0.002	0.052	0.300	0.680	0.996	1.169	1.248	1.279	1.290	1.293	1.294	1.294	1.294	1.302
2000	0.002	0.066	0.366	0.764	1.072	1.261	1.350	1.387	1.400	1.403	1.404	1.405	1.405	1.412
2001	0.002	0.058	0.361	0.761	1.049	1.221	1.313	1.353	1.368	1.373	1.374	1.374	1.374	1.381
2002	0.002	0.046	0.251	0.547	0.757	0.876	0.941	0.972	0.984	0.988	0.989	0.990	0.990	0.998
2003	0.002	0.044	0.252	0.545	0.778	0.909	0.976	1.009	1.024	1.029	1.031	1.031	1.031	1.039
2004	0.002	0.042	0.246	0.555	0.795	0.945	1.020	1.057	1.074	1.080	1.082	1.083	1.083	1.093
2005	0.002	0.046	0.211	0.442	0.625	0.734	0.795	0.823	0.836	0.841	0.843	0.844	0.844	0.852
2006	0.001	0.034	0.216	0.477	0.697	0.836	0.912	0.952	0.970	0.977	0.979	0.980	0.980	0.989
2007	0.001	0.019	0.147	0.373	0.560	0.686	0.761	0.799	0.818	0.826	0.829	0.830	0.830	0.842
2008	0.001	0.018	0.106	0.273	0.425	0.523	0.584	0.618	0.635	0.642	0.645	0.646	0.647	0.663
2009	0.001	0.021	0.114	0.258	0.401	0.499	0.557	0.590	0.608	0.616	0.620	0.621	0.622	0.641
2010	0.001	0.020	0.114	0.254	0.375	0.469	0.528	0.561	0.580	0.589	0.593	0.595	0.595	0.618
2011	0.001	0.019	0.118	0.283	0.424	0.525	0.598	0.643	0.667	0.680	0.687	0.689	0.690	0.712
2012	0.001	0.023	0.141	0.359	0.575	0.730	0.835	0.910	0.955	0.979	0.993	0.999	1.001	1.025
2013	0.001	0.016	0.094	0.250	0.420	0.558	0.653	0.716	0.762	0.789	0.804	0.813	0.816	0.841
2014	0.001	0.019	0.098	0.244	0.408	0.549	0.655	0.727	0.776	0.810	0.831	0.843	0.850	0.878
2015	0.001	0.021	0.106	0.245	0.397	0.532	0.639	0.717	0.771	0.807	0.833	0.848	0.857	0.886
2016	0.001	0.015	0.083	0.195	0.308	0.408	0.491	0.555	0.603	0.637	0.660	0.676	0.686	0.720
2017	0.001	0.014	0.080	0.195	0.311	0.408	0.489	0.555	0.608	0.648	0.677	0.698	0.711	0.749
2018	0.001	0.011	0.060	0.153	0.256	0.342	0.411	0.469	0.517	0.556	0.588	0.614	0.631	0.670
2019	0.000	0.005	0.032	0.082	0.142	0.194	0.236	0.269	0.297	0.320	0.339	0.355	0.369	0.407
2020	0.000	0.002	0.010	0.021	0.033	0.043	0.052	0.058	0.064	0.068	0.072	0.075	0.077	0.105

Table 2.13. Eastern Baltic cod in SDs 24-32. Catch scenarios.

Basis	Total catch (2022)	F (2022)	SSB* (2022)	SSB* (2023)	Probability of SSB (2023) >B_{lim} (%)	% SSB change	% Catch change**
ICES advice basis							
F = 0	0	0	59450	63775	< 0.01	7	-100
Other scenarios							
F = 0.05	3689	0.050	58081	61062	< 0.01	5	27
F = F (2020)	2399	0.033	58524	62078	< 0.01	6	-17
Catch = TAC (2021)	3595	0.050	58032	60938	< 0.01	5	24
Catch = 0.75 × TAC (2021)	2696	0.037	58334	61676	< 0.01	6	-7

**SSB at the spawning time

**Catch in 2022 compared to catch in 2020 (2899 tonnes).

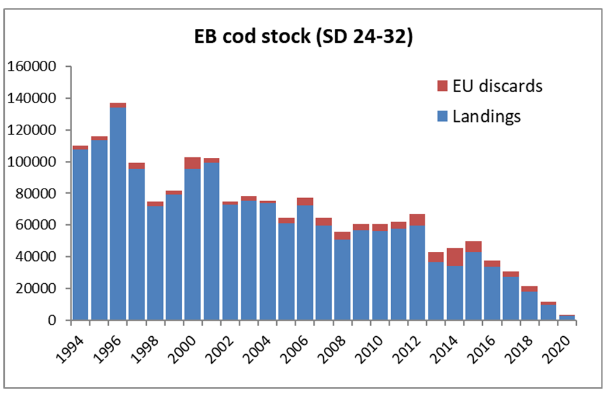


Figure 2.1 Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010) and estimated EU discards in management area of SD 25-32.

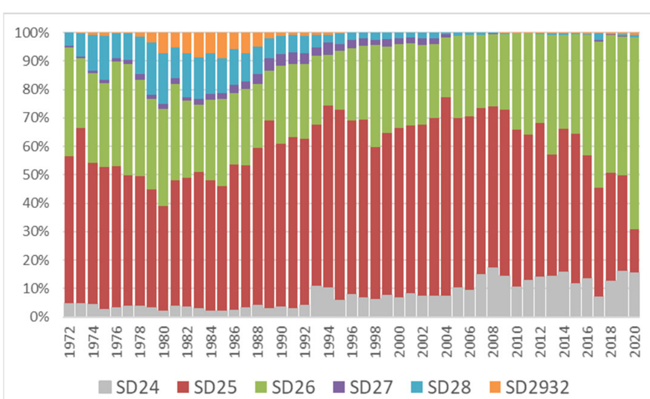


Figure 2.2. Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

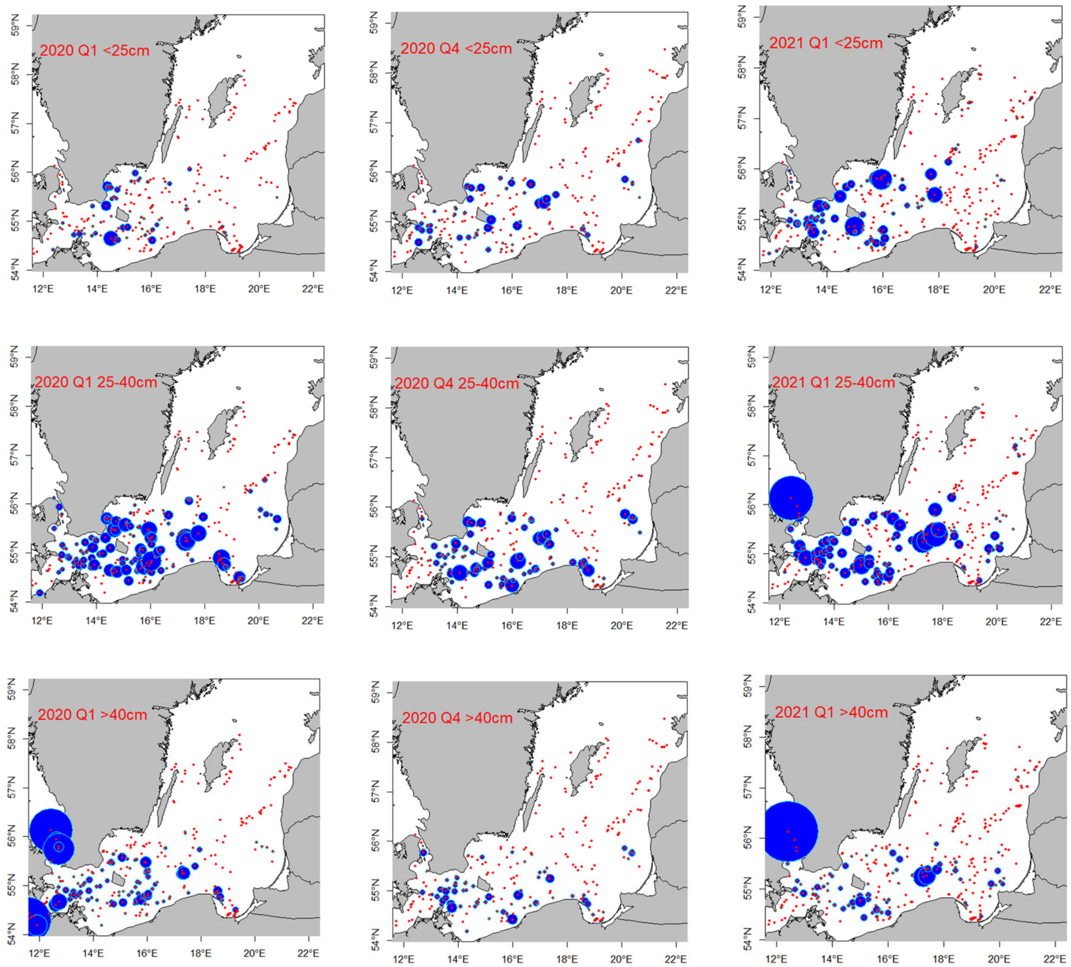


Figure 2.3. Eastern Baltic cod in SDs 24-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2020 and Q1 in 2021, by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

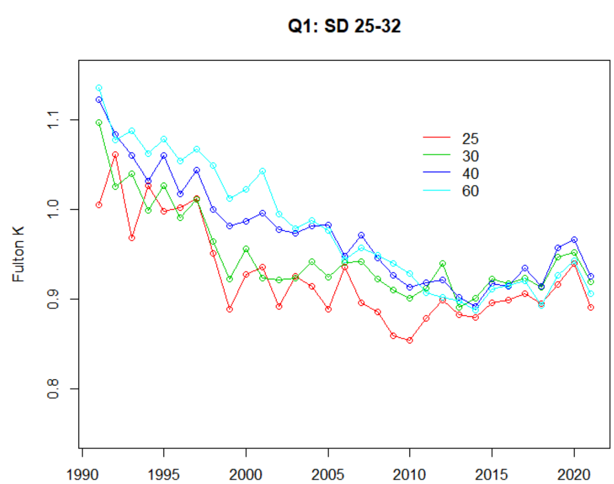


Figure 2.4. Eastern Baltic cod in SDs 24-32. Condition (Fulton K) of cod by length groups (<25 cm, 25-30 cm, 30-40 cm, 40-60 cm) in Q1 BITS survey.

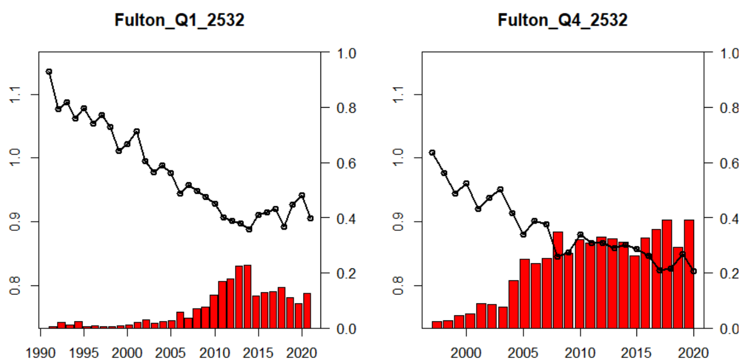


Figure 2.5. Eastern Baltic cod in SDs 24-32. Average condition (Fulton K) of cod at 40-60 cm in length in Q1 and Q4 BITS survey in SD 25-32. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.

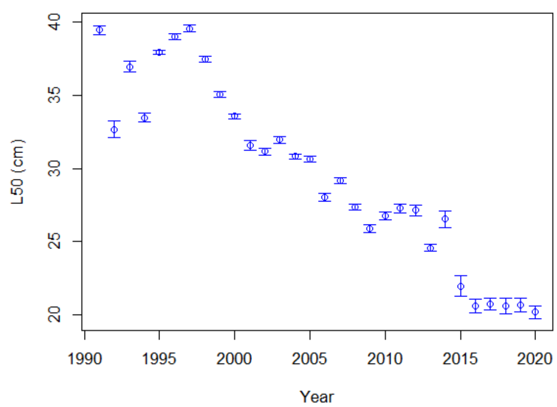


Figure 2.6. Eastern Baltic cod in SDs 24-32. Size (cm) at which 50% of the stock is mature (L_{50}). Data from BITS Q1 survey.

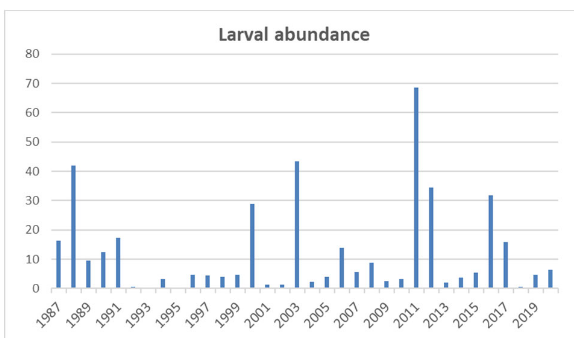


Figure 2.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

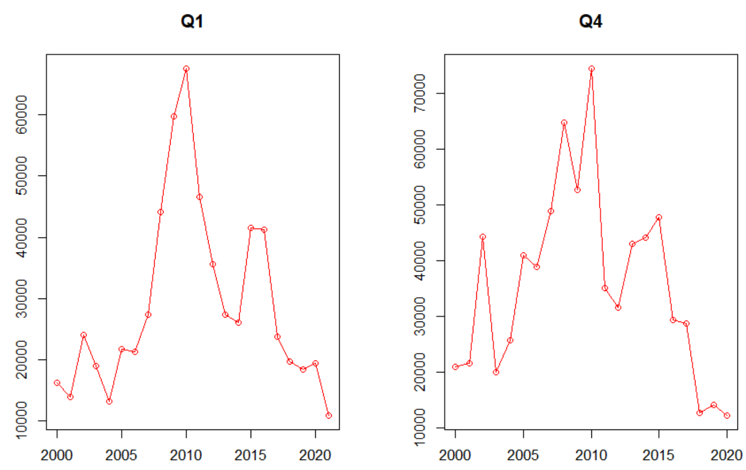


Figure 2.8. Eastern Baltic cod in SDs 24-32. Relative total biomass index (CPUE), estimated from Q1 and Q4 BITS surveys.

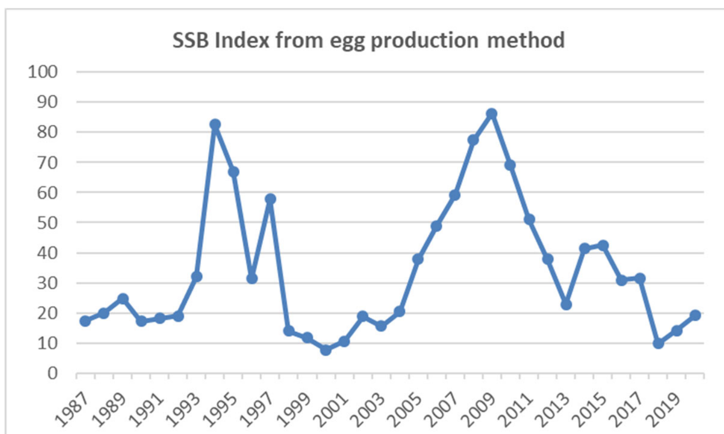


Figure 2.9. Eastern Baltic cod in SDs 24-32. Index of spawning-stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

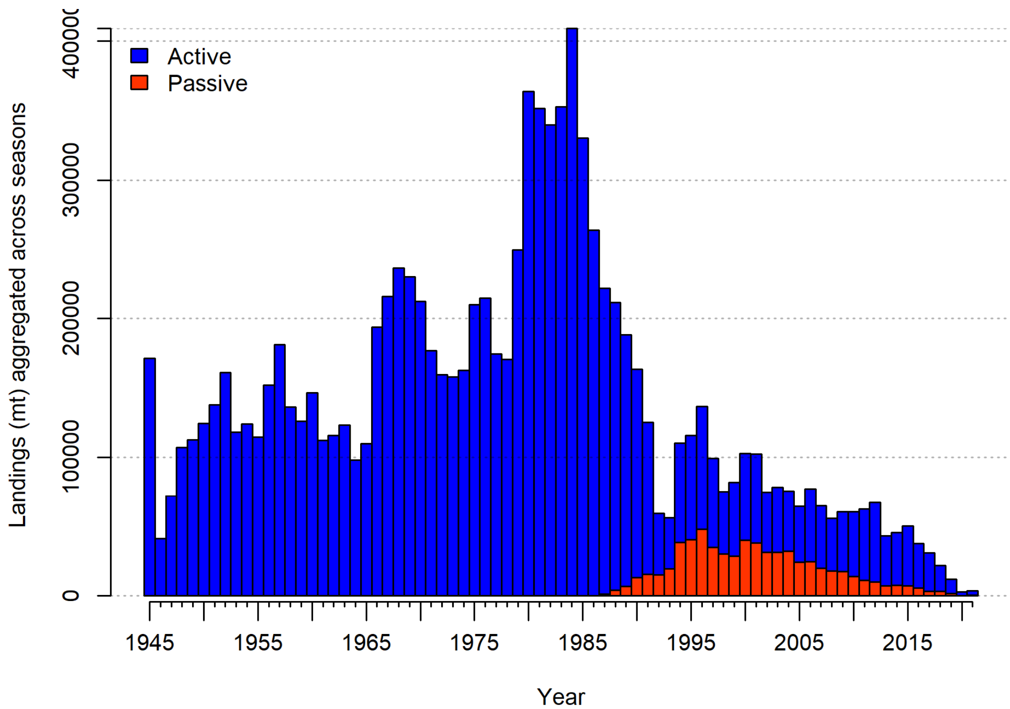


Figure 2.10. Eastern Baltic cod in SDs 24-32. Time-series of total catch used in the assessment, by fleets).

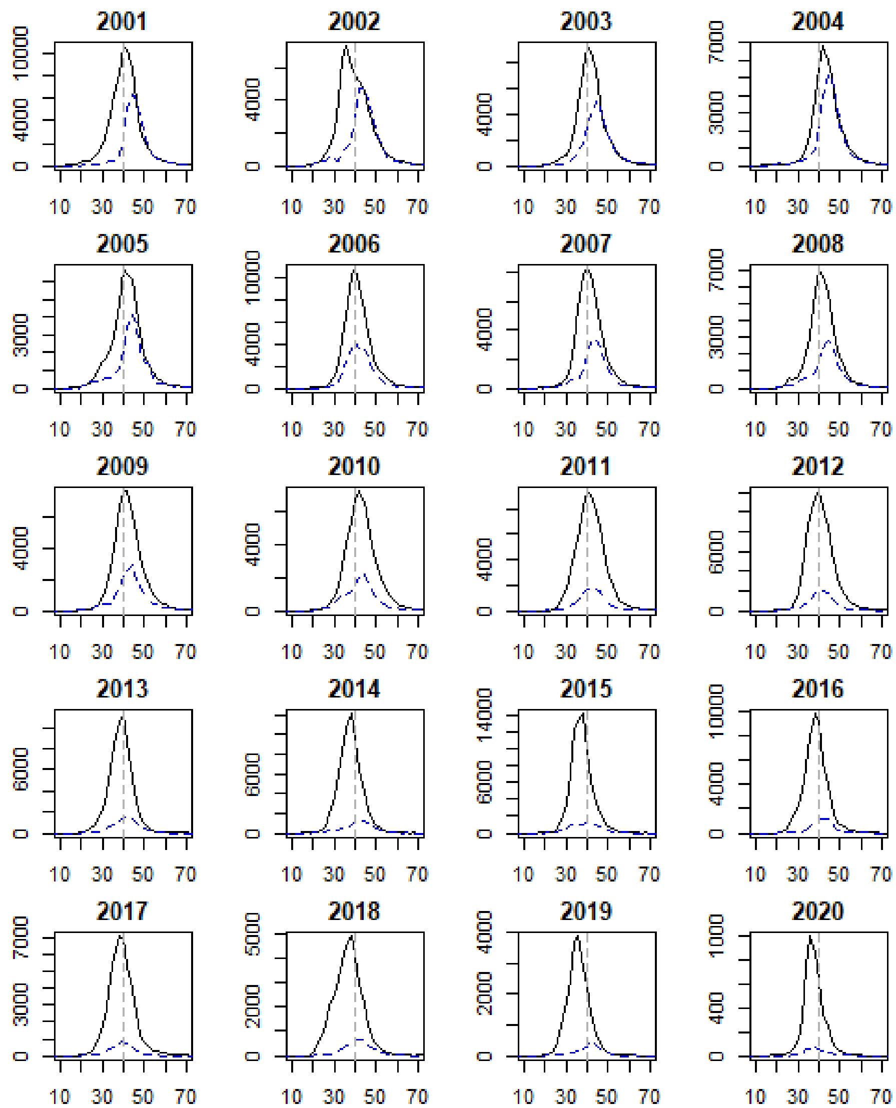


Figure 2.11. Eastern Baltic cod in SDs 24-32. Annual length distributions of total commercial catch by Active (in black) and Passive (in blue) gears.

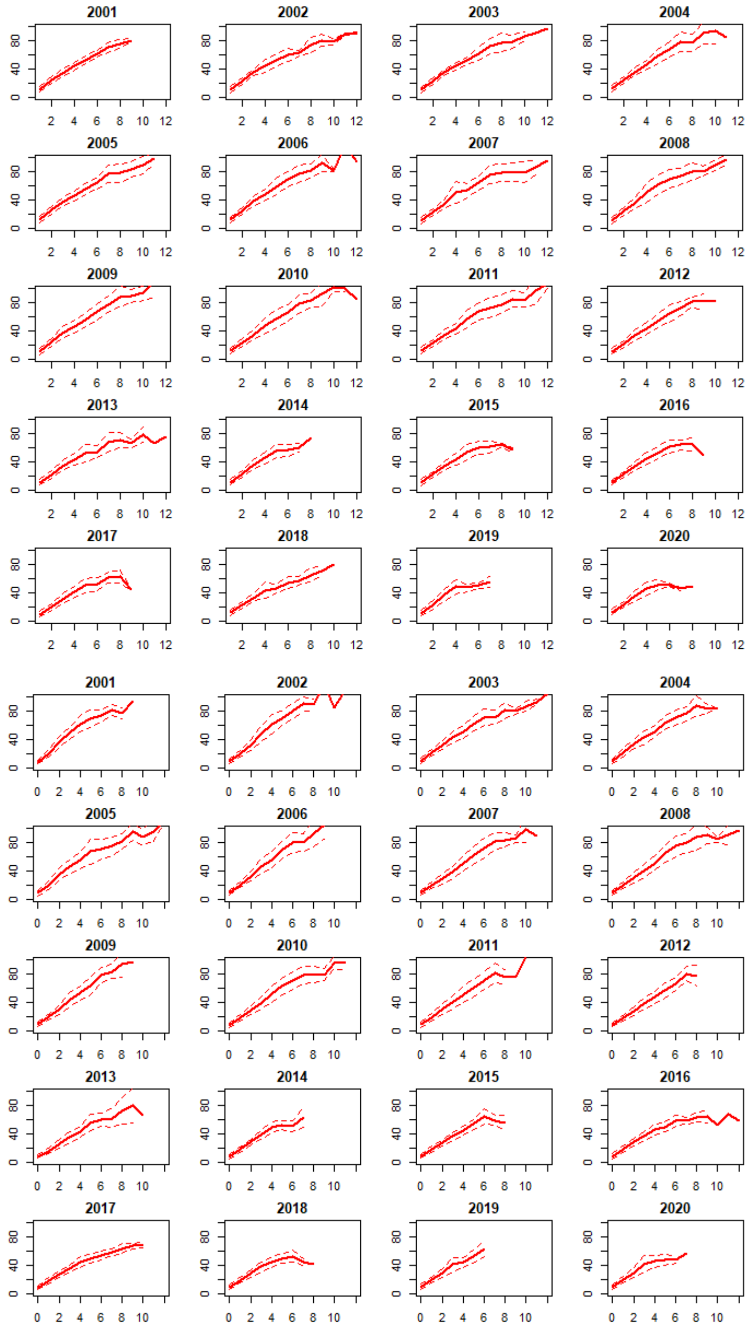


Figure 2.12. Eastern Baltic cod in SDs 24-32. Mean length-at-age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

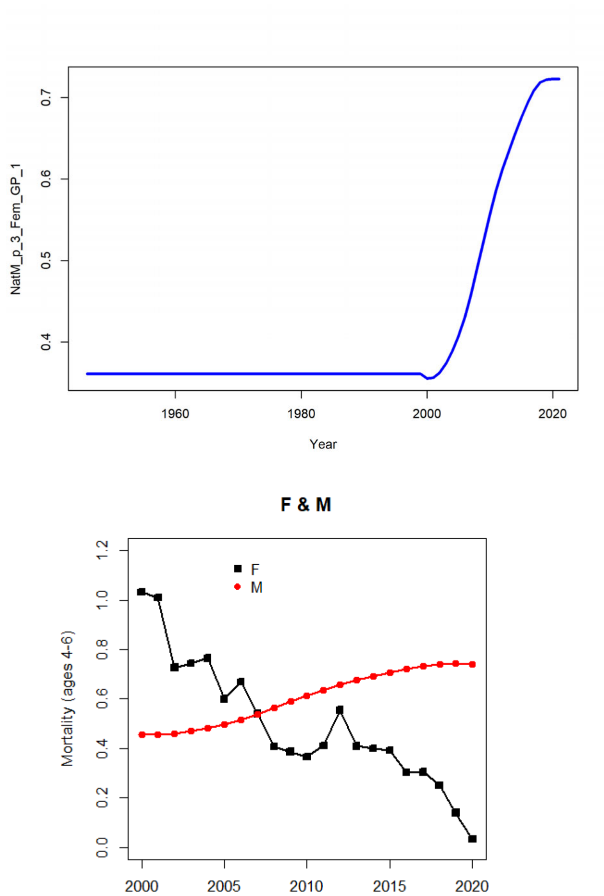
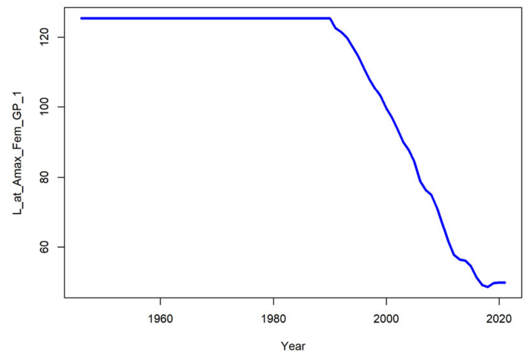


Figure 2.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).



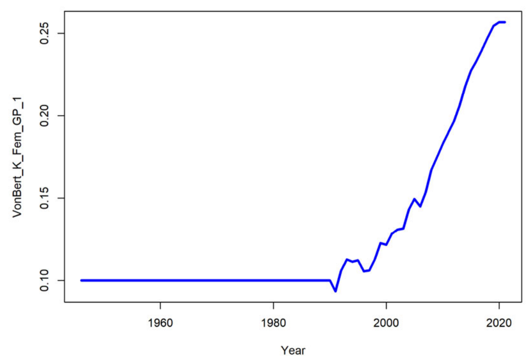


Figure 2.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters L_{inf} (left panel) and K (right panel) from Stock Synthesis model.

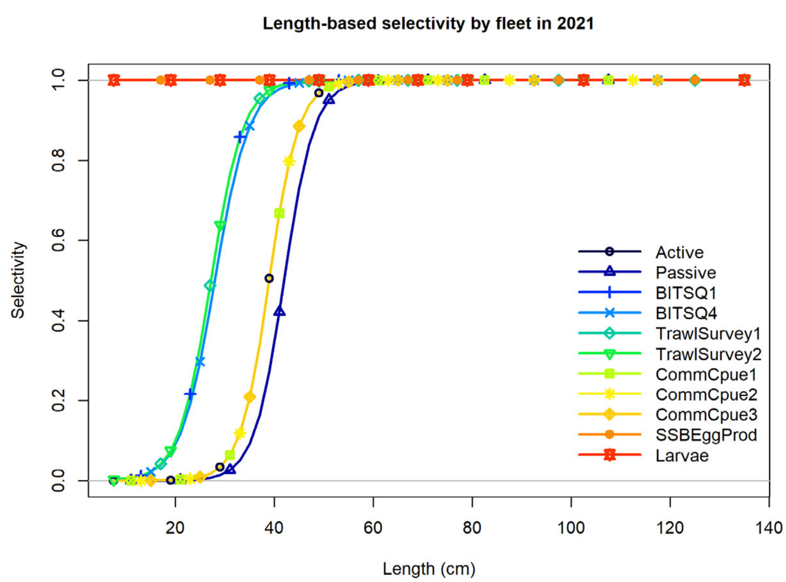


Figure 2.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.

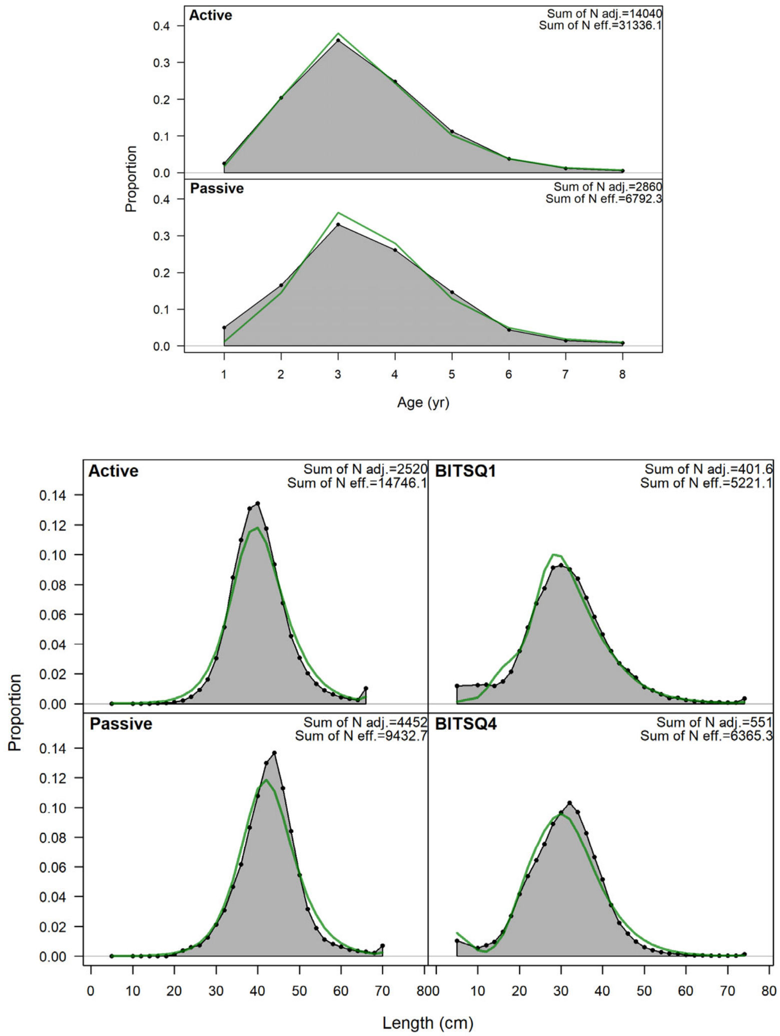


Figure 2.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.

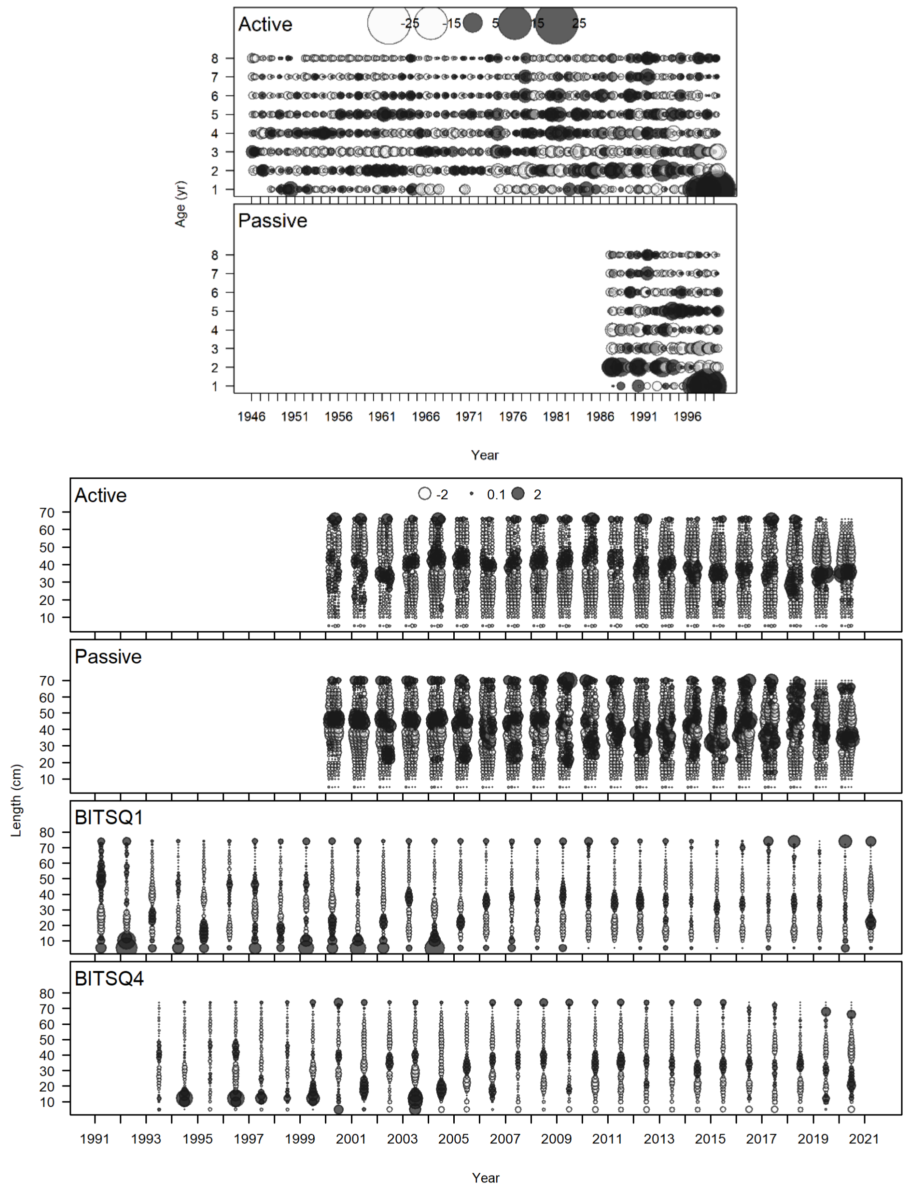


Figure 2.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to age (upper panels) and length (lower panels) composition data for different fleets.

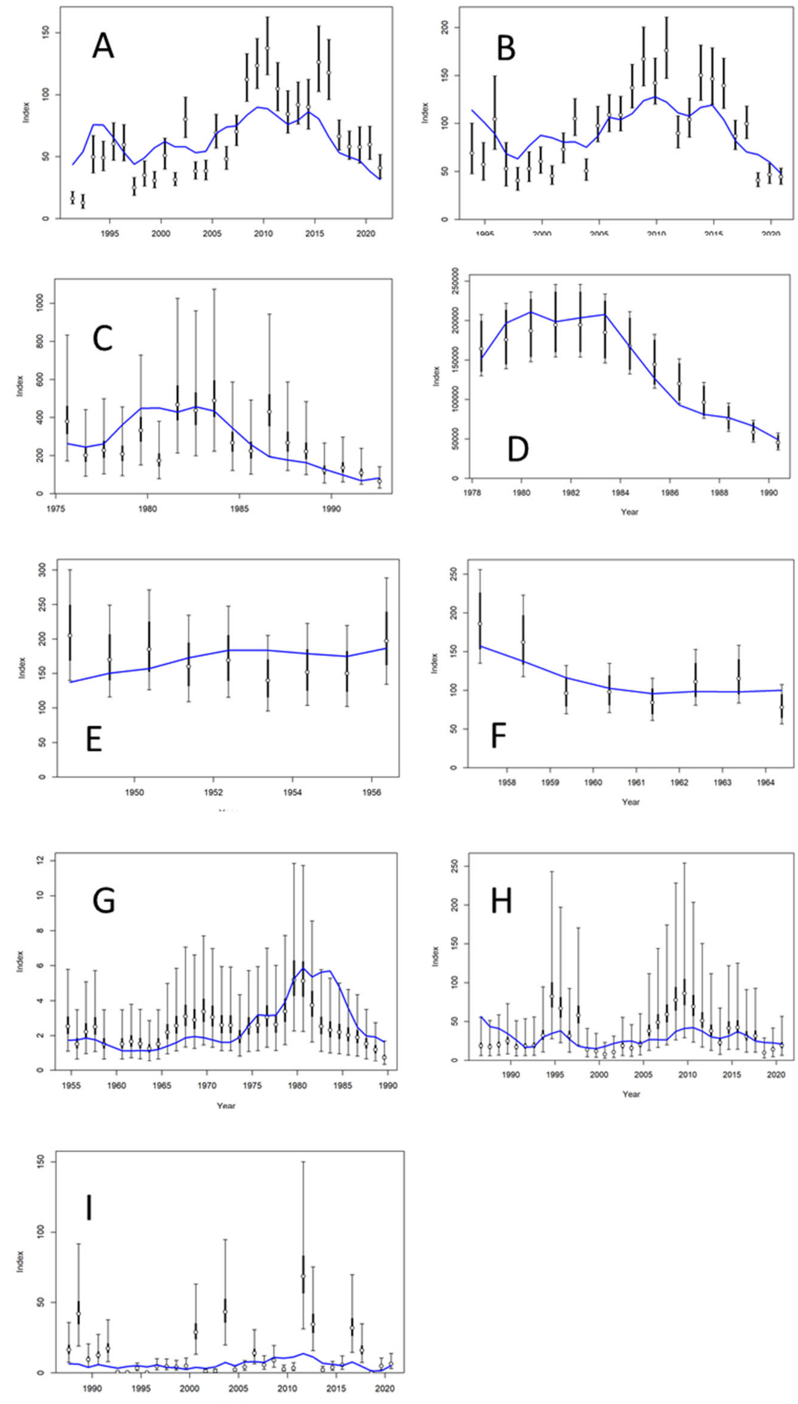


Figure 2.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- TrawlSurvey1; D- TrawlSurvey2; E- CommCPUE1; F- CommCPUE2; G- CommCPUE3; H- SSBEggProd; I- Larvae.

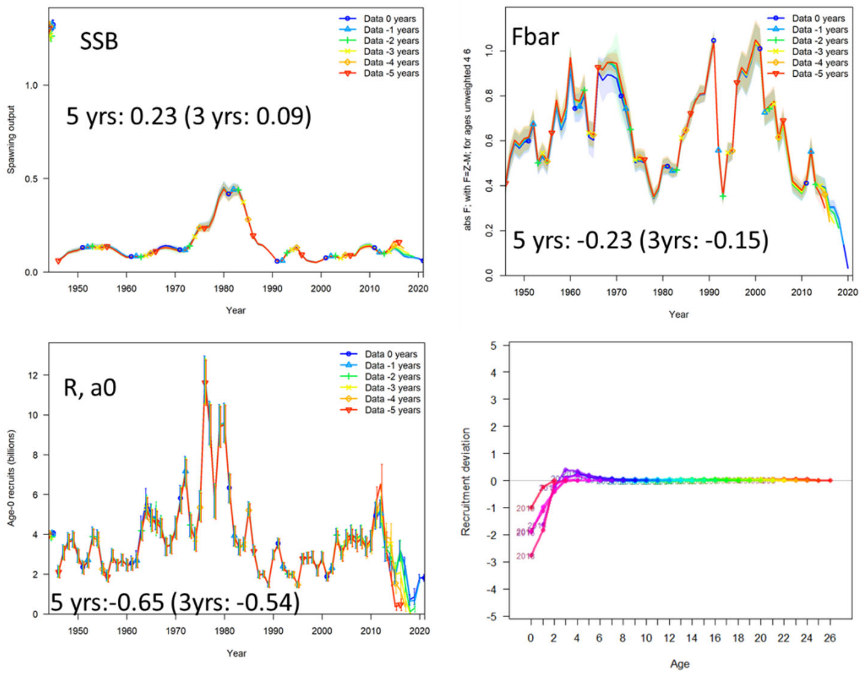


Figure 2.19. Eastern Baltic cod in SDs 24-32. Retrospective analyses, including Mohn's Rho values estimated for 5 years and 3 years (in brackets).

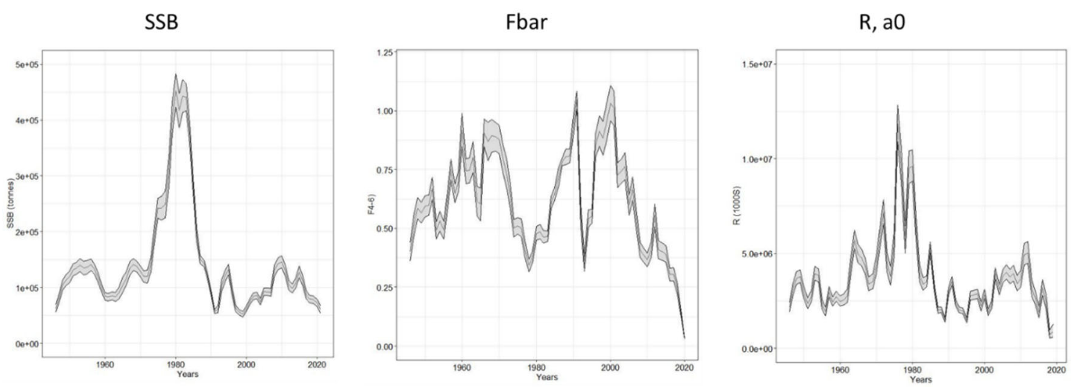


Figure 2.20. Eastern Baltic cod in SDs 24-32. Spawning-stock biomass, fishing mortality (average of ages 4-6) and recruit-ment (age 0).

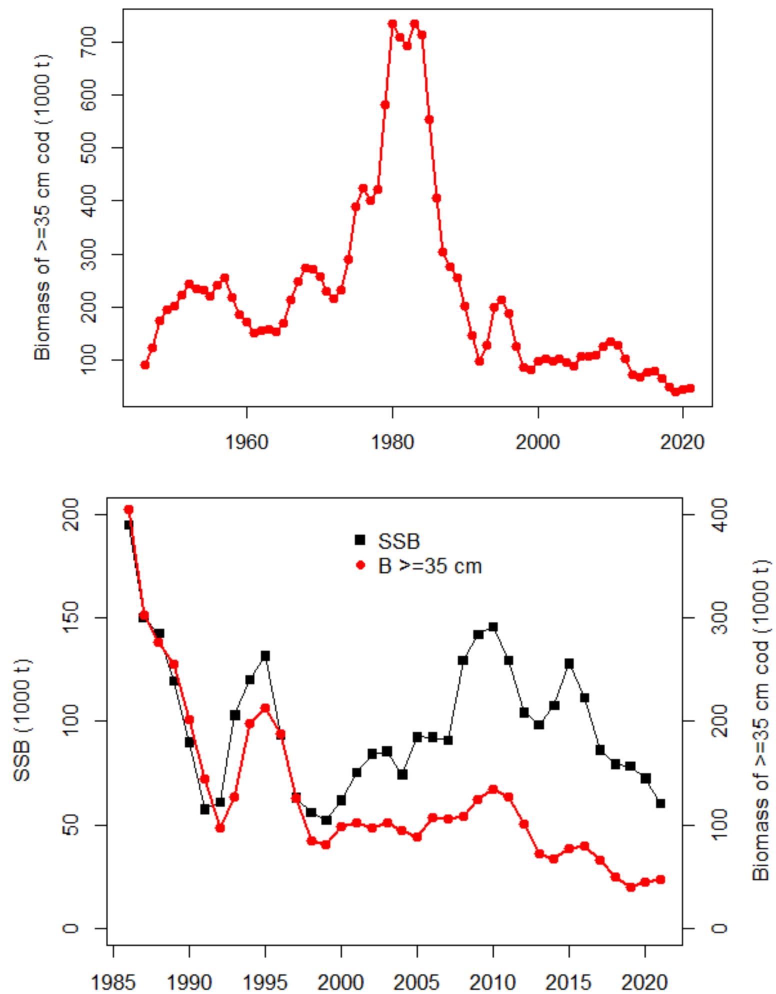


Figure 2.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (≥35 cm in length) (upper panel), compared to SSB in later years (lower panel).

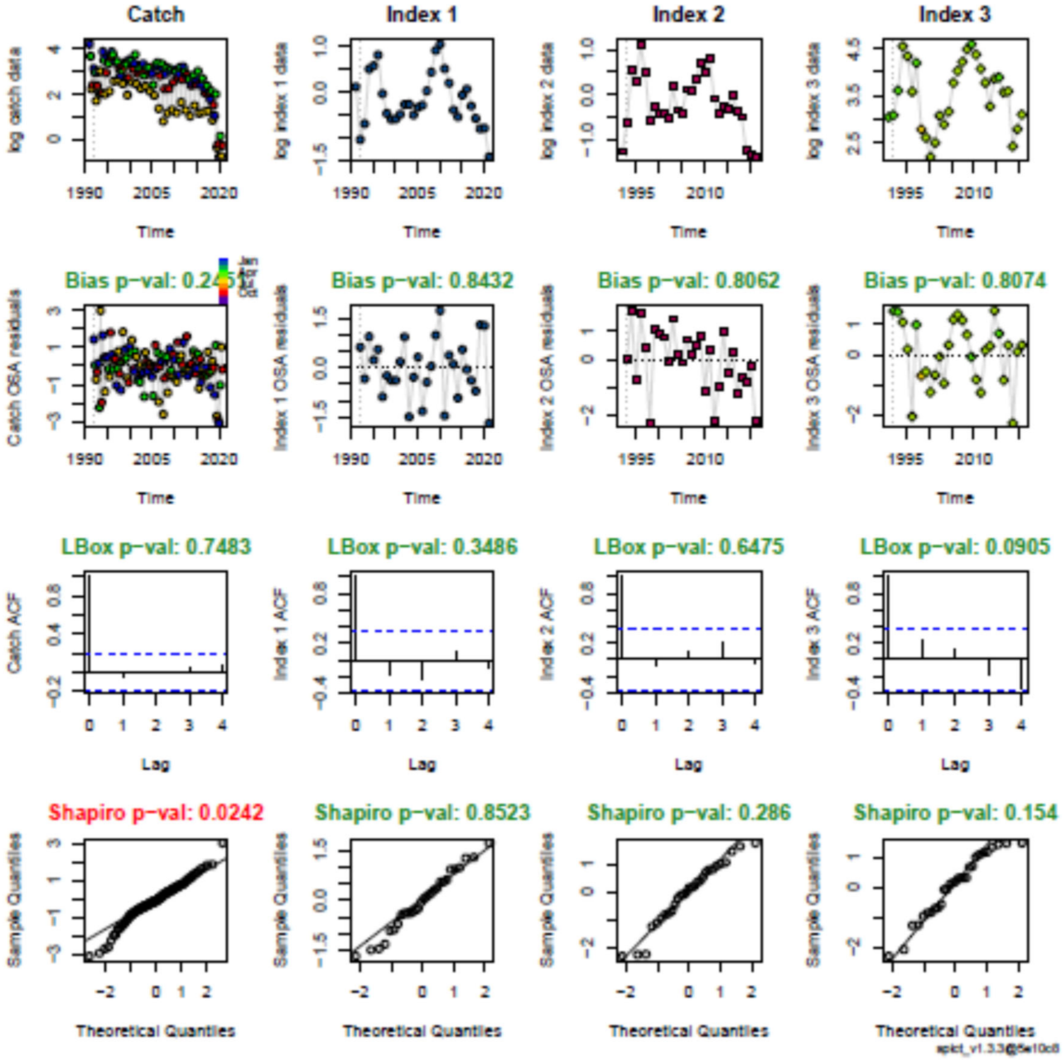


Figure 2.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

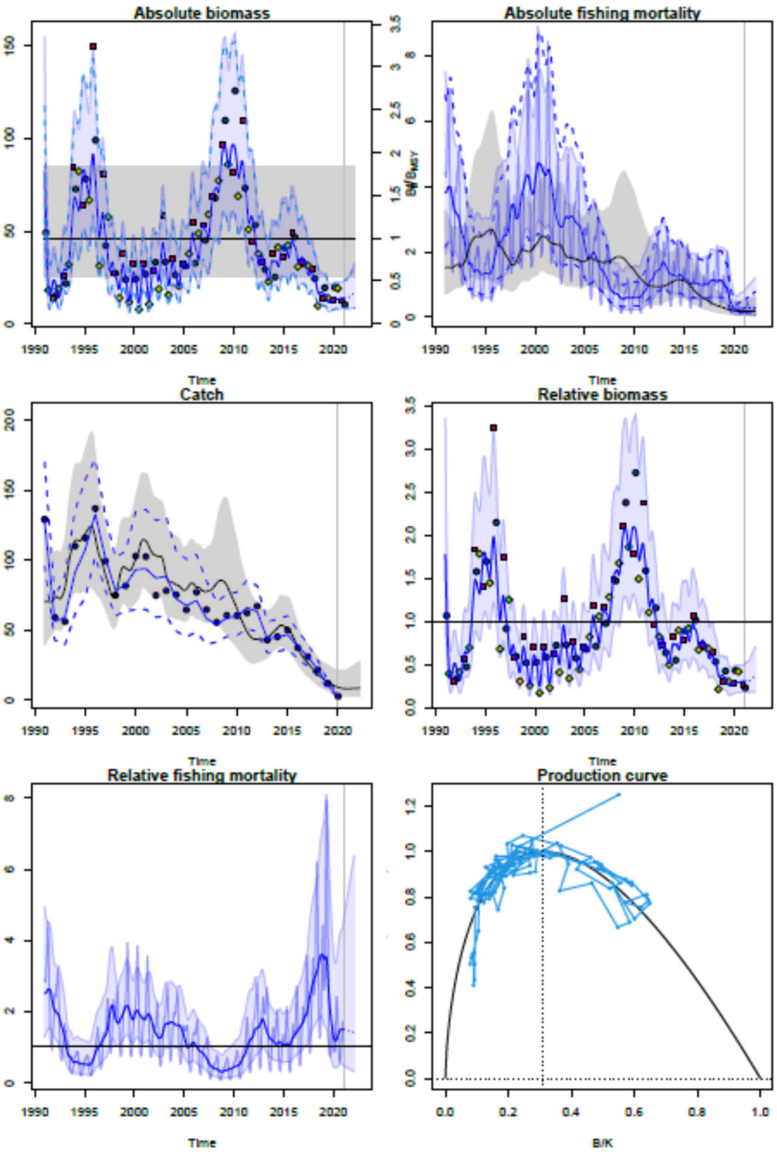


Figure 2.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

2.2 Cod in Subdivision 21 (Kattegat)

2.2.1 The fishery

A general description of Kattegat cod fishery is presented in the Stock Annex.

2.2.1.1 Recent changes in fisheries regulations

The TAC is mainly regulating the fishing of Kattegat cod 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 by-catch-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 Landings

National landings of cod from Kattegat management area (Subdivision 21) by year and country are given in Table 2.14 and Figure 2.24, as provided by the Working Group members.

Due to the Covid-19 disruption in 2020 the sampling coverage for Swedish landings was lowered and some quarters (Q1 and Q3) were not sampled. Hence some data manipulation was performed by the Swedish data submitters. Averages were computed and data in Q2 + Q4 were borrowed to compute averages for Q1 and Q3. Also size 3 was used for size 1 and size 2.

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 2020 were 36 tonnes, the lowest of the time-series (Table 2.14 and Figure 2.24)

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—2020 and from Denmark for 2000—2020. The estimated discard numbers by age and total discards in tonnes are presented in Figure 2.25 and in Table 2.15. The sampling levels are shown in Tables 2.16 and 2.17a,b.

In 2020, the estimated discards formed about 63% of the catch weight and this proportion of discards in the catches has largely increased in the last year compared to the previous years (Figure 2.24). In numbers, the available data indicates that close to 96% of the cod caught in the Kattegat is discarded. Similarly to previous years, discarding in 2020 has mostly affected ages 1-2, with a larger proportion of age 1 caught compared to previous years

Due to the Covid-19 disruption in 2020 the sampling coverage for Swedish discards was lowered and some quarters, namely Q2-Q4 for active gears and Q2 and Q4 for passive gears, were not sampled. Hence some data manipulation was performed by the Swedish data submitters.

For active gears Q2-Q4 discards were calculated by using average discard per hour fished 2017-2019 * hours fished 2020. Numbers at age and length were calculated as an average of proportion in 2017-2019 per age/length*discard weight calculated as above and then divided by the sampled weight. For passive gears, Q1 was borrowed for Q2 and Q3 was borrowed for Q4.

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 catches

2.2.2.1 Age composition

Historical total catches in numbers by age and year are given in Table 2.19.

2.2.2.2 Quality of the biological data

Both Danish and Swedish sampling data were available from the commercial fishery in 2020. Danish and Swedish commercial sample sizes are shown in Table 2.16. and Table 2.17. Landings were allocated to age groups using the Danish and Swedish age information as shown in Table 2.18. The catch numbers followed the same procedure as the landings, and catch in numbers-by-age is presented in Table 2.19)

2.2.2.3 Mean weight-at-age

Historical mean weight-at-age in the catches, provided by Sweden and Denmark, is given in Table 2.20 for all years included in the assessment (1997-2020).

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

During 2021, a minor error was discovered in the calculation of the mean weight-at-age in the stock used as the input data in the 2020 assessment. The values of the mean weight-at-age in the stock from 2019 for age classes 1-3 were revised. The new corrected values were included in a sensitivity SAM run (see paragraph "Assessment using state-space model (SAM)").

The historical time-series of mean weight-at-age in the stock is given in Table 2.21.

2.2.2.4 Maturity-at-age

The historical time-series of maturity based on visual inspections used in the assessment is presented in Table 2.22. 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 3 years.

During 2021, a minor error was discovered in the calculation of the maturity ogives used as the input data in the 2020 assessment. The values of the maturity ogives from 2019 for age classes 1-3 were revised. The new corrected values were included in a sensitivity SAM run (see paragraph "Assessment using state-space model (SAM)").

2.2.2.5 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 2.26a–d. The survey indices available for the Working Group are presented in Table 2.23.

The tuning series available for assessment:

Fleet	Details
BITS-1Q	Danish survey, 1st quarter, RV Havfisken (age 1-3) (1997-2021)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2020)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2021)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2020)

Due to corrections of the survey data from previous years during 2020, some indices from past times differ this year compared to previous year's assessment.

The whole time-series of IBTS 1st Q, IBTS 3rd Q and BITS 4th Q (CPUE per age per area) were re-downloaded from the DATRAS database and corrected accordingly, as in some years the indices were recalculated and presented different values. The new calculated indices were included in a sensitivity SAM run (see paragraph "Assessment using state-space model (SAM)").

A mistake in the input data for CODS-4Q in the 2020 assessment was detected. In 2017, the estimation was changed to an inverse weight estimation procedure based on inclusion probabilities. Unfortunately, the implemented procedure did not correctly account for the independent replicate groups, putting too much weight on the higher density strata. In addition, changes to the code used for estimation introduced an error in the age-length key. These errors have now been corrected and a new time-series of indices for this survey was produced in 2021. The new calculated indices were included in a sensitivity SAM run for the assessment 2020 (see paragraph "Assessment using state-space model (SAM)").

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.

The assessment run and the software internal code are available at https:/www.stockassessment.org,

Three sensitivity runs were performed.

A sensitivity run using the assessment run performed in 2020 as a base run and a new one including the corrected Cod Survey 4th quarter information was performed (Figure 2.29; codkat2020updateCODS on https:/www.stockassessment.org). The main difference is an upscaling of the SSB in the mid-2010s and an increase in mortality (Z-0.2) in the last years. However, this does not affect the perception of the stock status or the advice given in 2020.

Two other sensitivity runs were performed. One including the changes in the mean weight-at-age in the stock and in the maturity ogive (codkat2020updateinputs2 on https:/www.stockassessment.org), and one including the updated time-series of BITS Q1, IBTS Q1 and IBTS Q3 (codkat2020_updateALLinputs2 on https:/www.stockassessment.org). Both runs had negligible effects on the assessment presented in 2020.

The two updated assessment runs were performed as follows.

Catch (landings and discards) from 1997—2020 with estimating total removals from 2003—2020 within the model based on survey information. (SPALY _Scaling; codkat2021_new on https:/www.stockassessment.org)

Catch (landings and discards) from 1997—2020 without estimating total removals (SPALY_No Scaling; codkat2021_new on stockassessment.org)

Unallocated removals were estimated separately for the years 2003—2020, but common for all age-groups within a year. The scaling factors estimated for 2005—2020 were significant for all the years in the SAM run with landings and total removals estimated.

Estimates of recruitment, SSB and mortality (Z-0.2) with confidence intervals from the two runs with and without total removals estimated are presented in Figures 2.30—2.32 and Tables 2.24—2.25. The total removals were estimated several fold higher than reported landings, and are not explainable by the estimated discard data only (Figure 2.33).

All information about the residuals and results from the two SAM runs are shown in Figure 2.34.

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 2013, the year classes of 2018 and 2021 are the lowest in the times-series (Figure 2.28,). 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 (Figure 2.28, Figure 2.32).

2.2.3.4 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 0.4 to 1.75. In contrast, the run without estimating total removals in the interval of 0.3 to 1.63. (Tables 2.24—2.25, Figure 2.31).

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 four 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—2020, 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 0.3-1.75 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 2020, around 307 tonnes, and it is still low in 2021 (454 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 2.24 and 2.25.

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; Stepputtis *et al.*, 2020). 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 analyse 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.

A longer-term step would be to gather genetic samples from the whole size range of cod, and also analyse the samples back in time that would be needed 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 were explored.

The reference points were 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 points during the assessment 2018, no further elaboration has been performed yet.

2.2.11 Evaluation of surveys duplication in Kattegat

The Expert Working Group EWG 19-05 met in 2019 to evaluate research surveys of marine fish resources and propose surveys to be included on the list of mandatory surveys, as a revision of the EU Multiannual Programme for data collection (EU MAP).

The EWG 19-05 proposed a series of actions to be carried out by ICES and one of them relates to potential survey duplications in the Kattegat-Skagerrak area; Scientific, Technical and Economic Committee for Fisheries (STECF) noted that the following surveys did not fully satisfy the criterion for 'no survey duplication': BITS_Q1, CODS_Q4, IBTS_Q1, IBTS_Q3.

The stocks associated with these possibly duplicate surveys are all in the Skagerrak and Kattegat region, which has complex geography that may require a number of smaller surveys to achieve adequate coverage of the stock. STECF suggested that the results of this evaluation be discussed by ICES and evaluated in future benchmarks for that region.

Those surveys, flagged as needing further expert evaluation, are associated with Cod in the Kattegat, being the main source of tuning indices on which the assessment of this stock is based on.

Due to the issues of mixing of different cod stocks in Kattegat the current assessment is only used as indicative of trends. Therefore, it is not possible at this stage to evaluate the issue of duplication of surveys in the Kattegat until the stock identification issue will be solved in the next benchmark.

2.2.12 Reporting deviations from stock annex caused by missing information from Covid-19 disruption

1. Stock: **Cod.27.21**

2. Missing or deteriorated survey data: **None**

3. Missing or deteriorated catch data: **Swedish sampling Q1 and Q3 of landings were missing and averages were computed by the data submitters (see Section 2.2.1.2). Same applies for Swedish discards for Q2-Q4 (See Section 2.2.1.3).**

4. Missing or deteriorated commercial LPUE/CPUE data: **None**

5. Missing or deteriorated biological data: **None**

6. Brief description of methods explored to remedy the challenge: **None**

7. Suggested solution to the challenge, including reason for this selecting this solution: **-**

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? **No changes have been done to the assessment since the impact of the decreased quality of the catches has been deemed to be minor for the assessment and the advice of cod27.21**

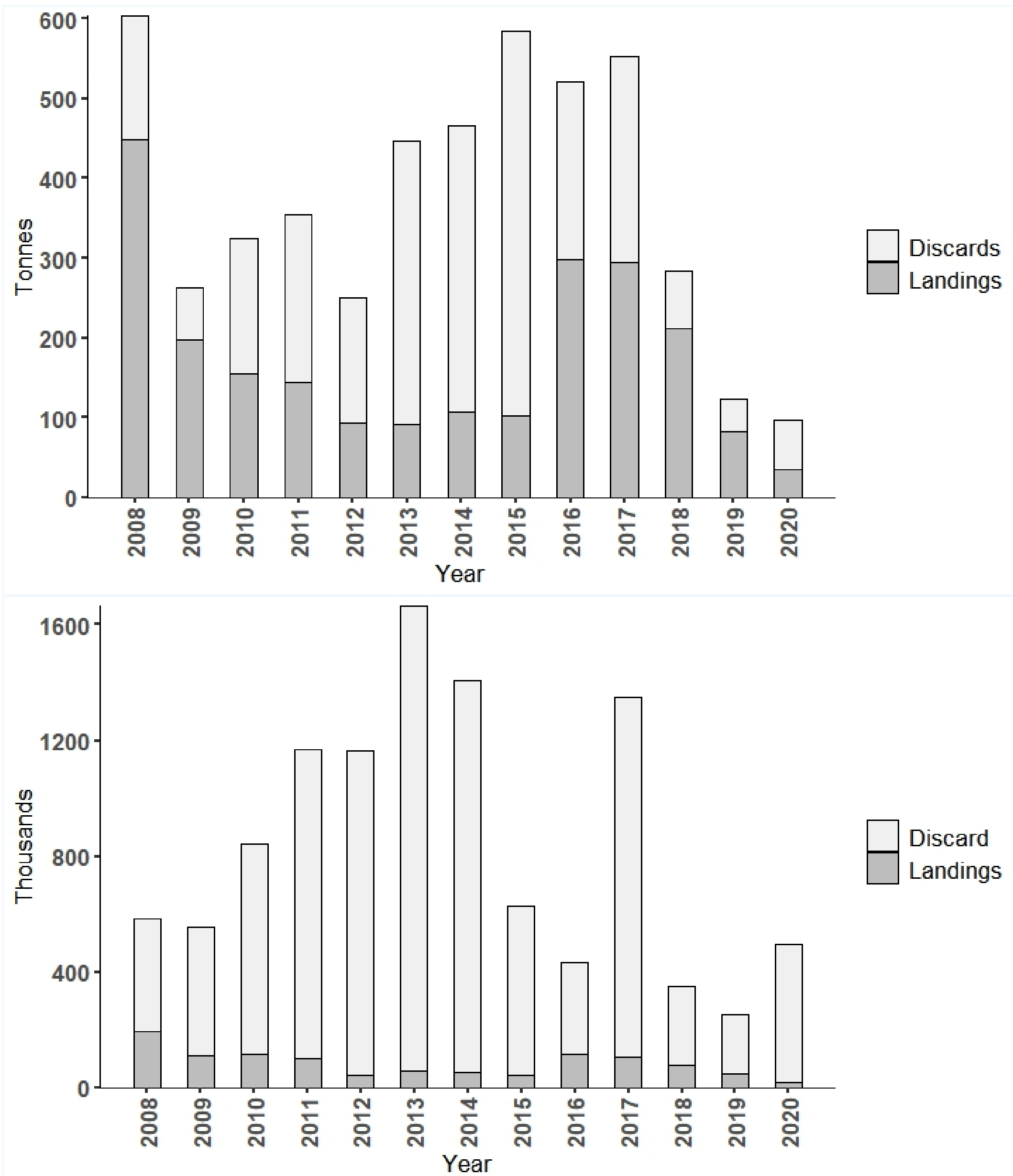


Figure 2.24. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in weight (upper panel) and in numbers (lower panel).

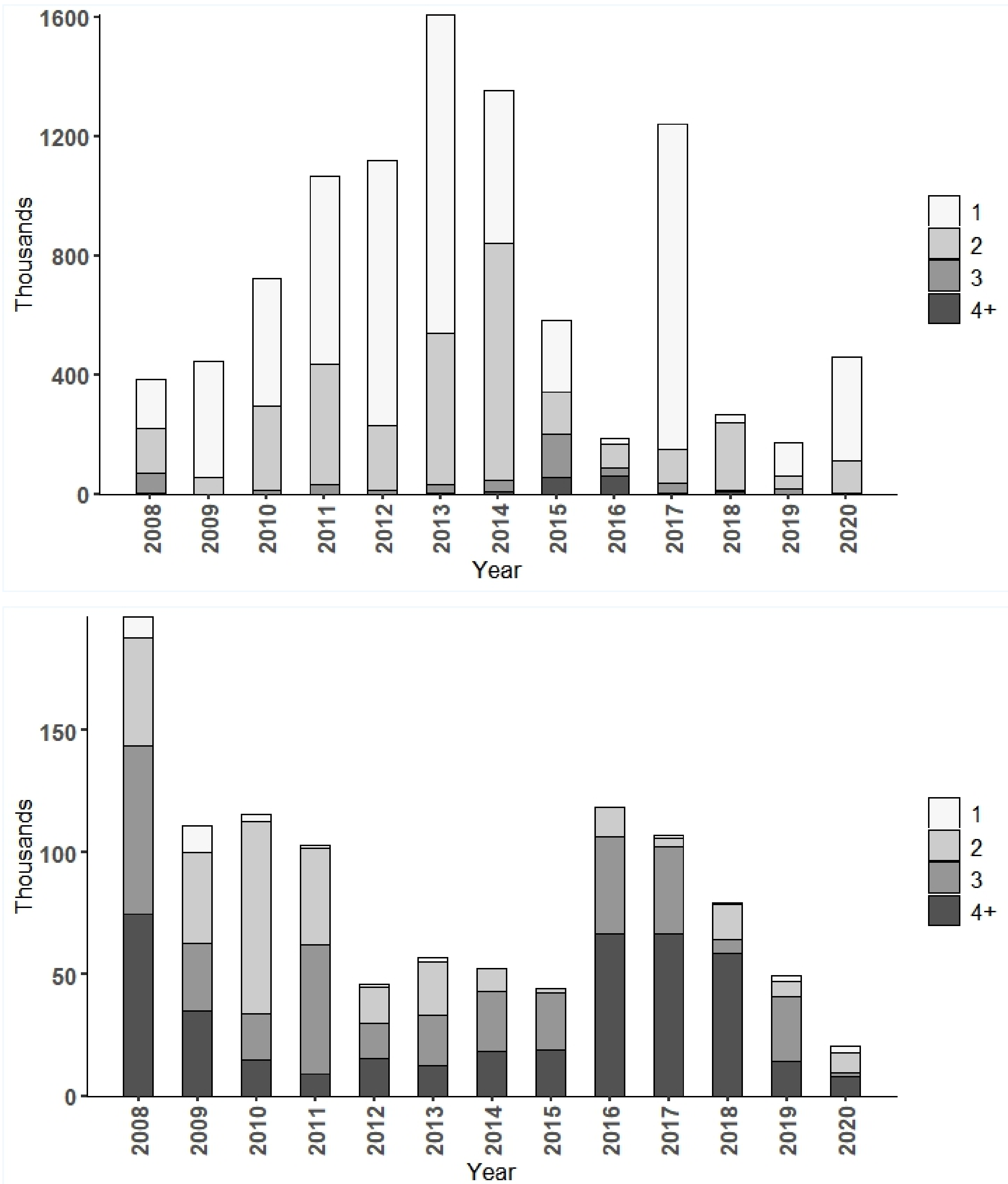
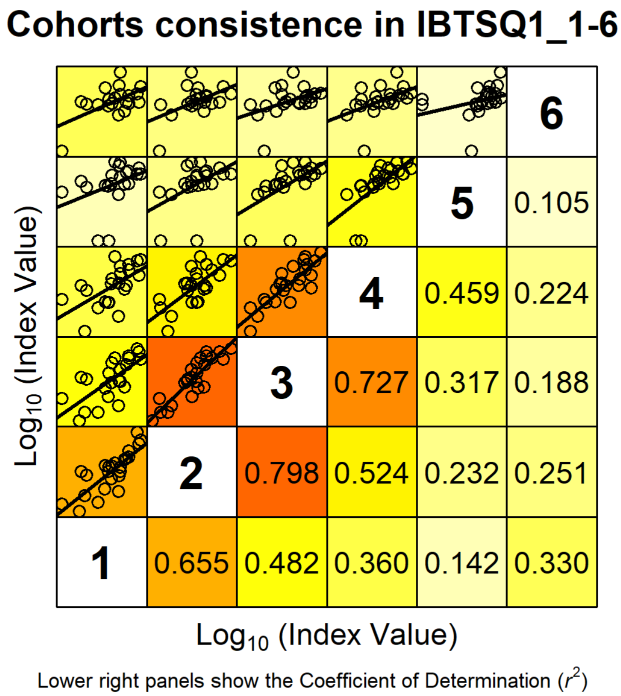
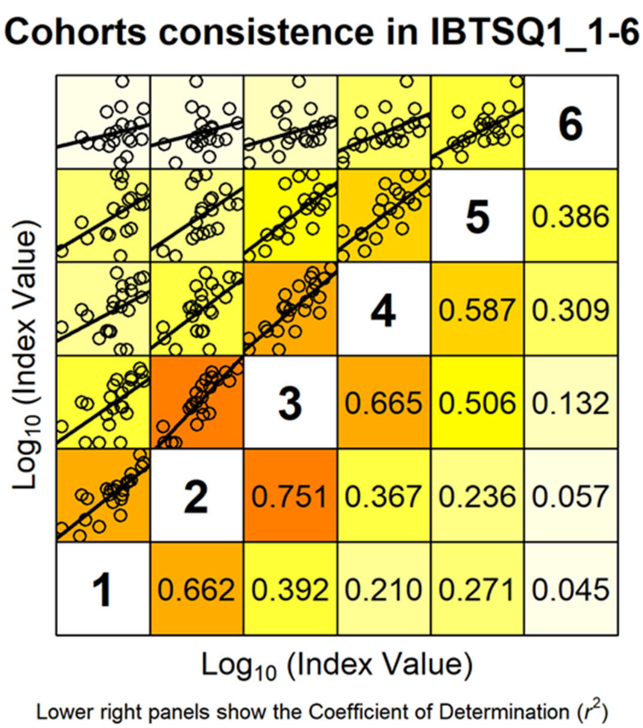


Figure 2.25. Cod in the Kattegat. Estimates of discards in numbers by age in the upper panel and landings in numbers by age in the lower panel (Sweden and Denmark combined).

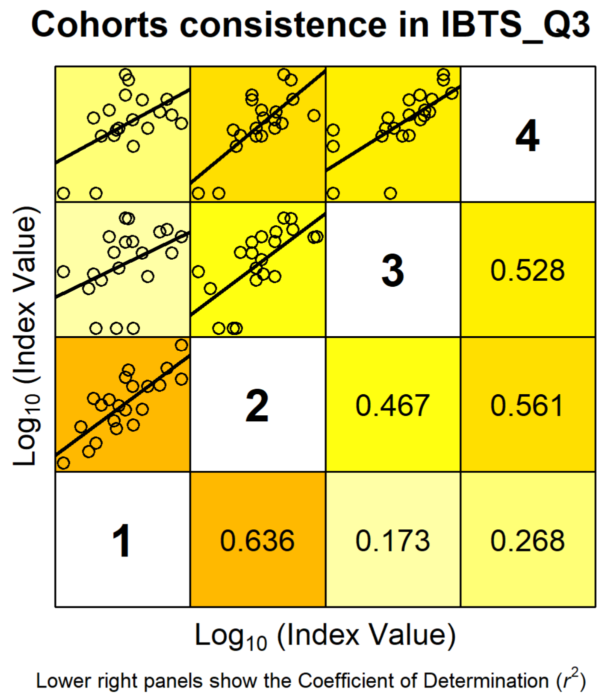


2021

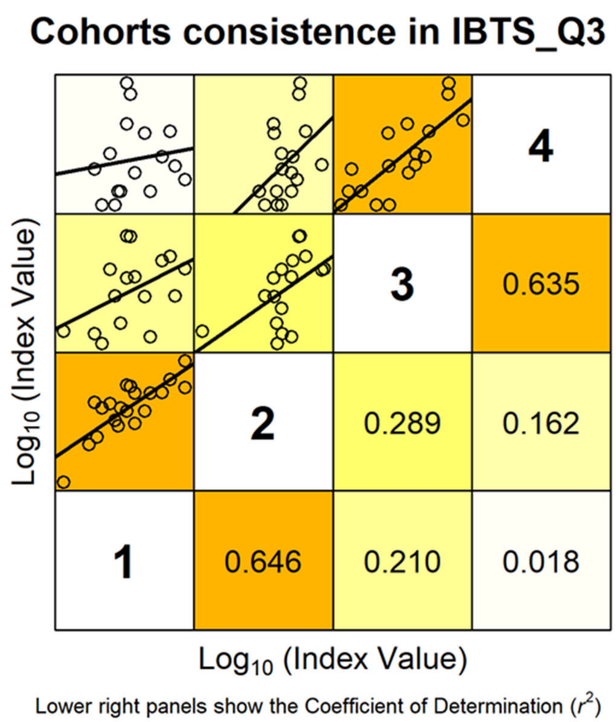


2020

Figure 2.26a. 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 1997-2021. Upper plot 2021 and lower plot 2020

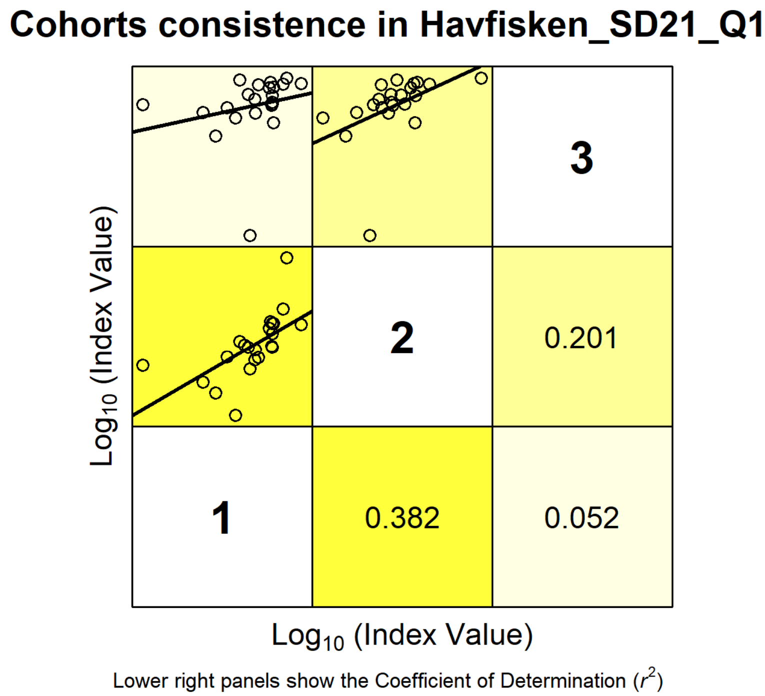


2020

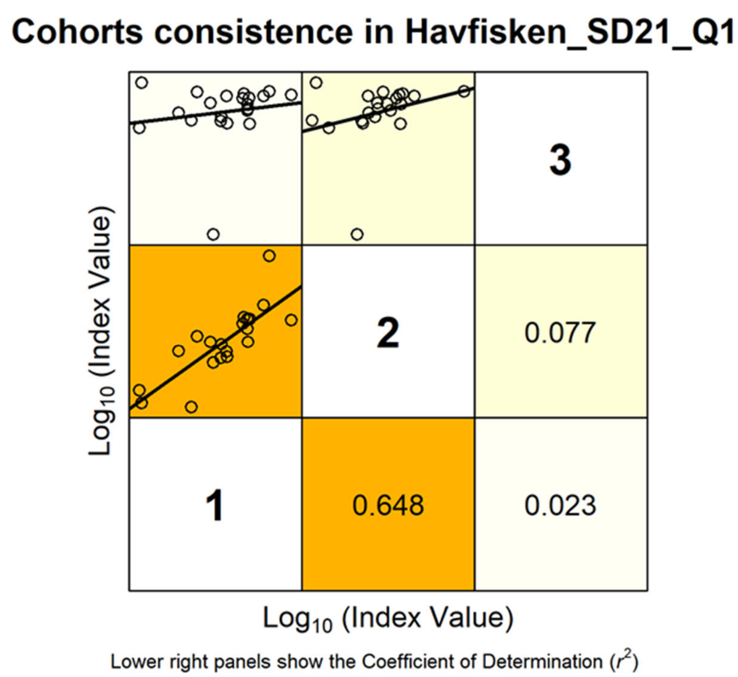


2019

Figure 2.26b. 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 1997-2020. Individual points are given by year-class. Upper plot 2020 and lower plot 2019.

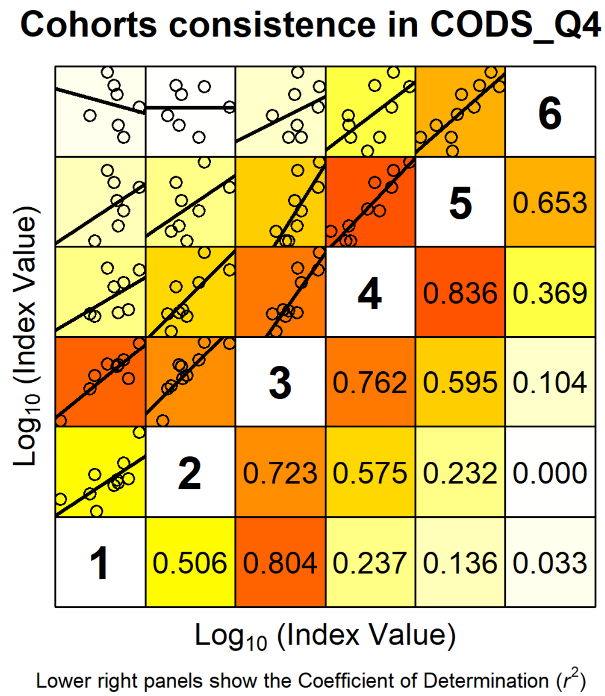


2021

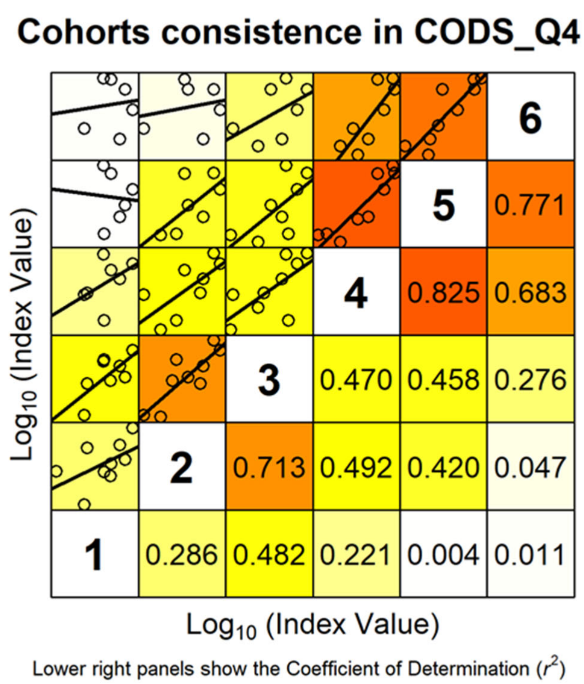


2020

Figure 2.26c. 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 1997-2021. Upper plot 2021, lower plot 2020.



2020



2019

Figure 2.26 d . Cod in Kattegat. Cod Survey 4th quarter numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2020. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2020, lower plot 2019

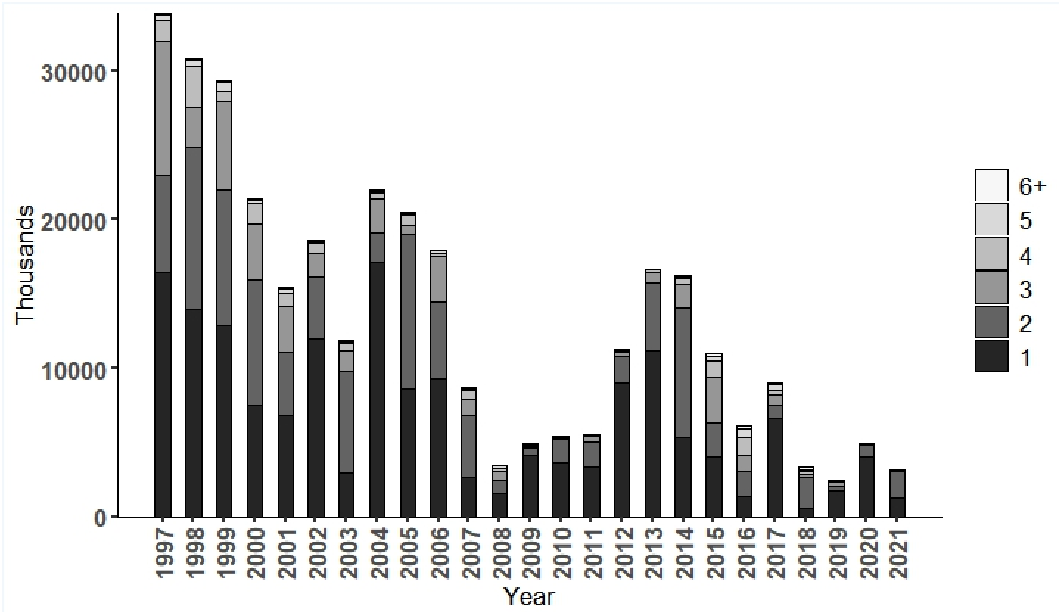


Figure 2.27. Cod in Kattegat. Stock numbers at age for the period 1997-2021 from SAM output

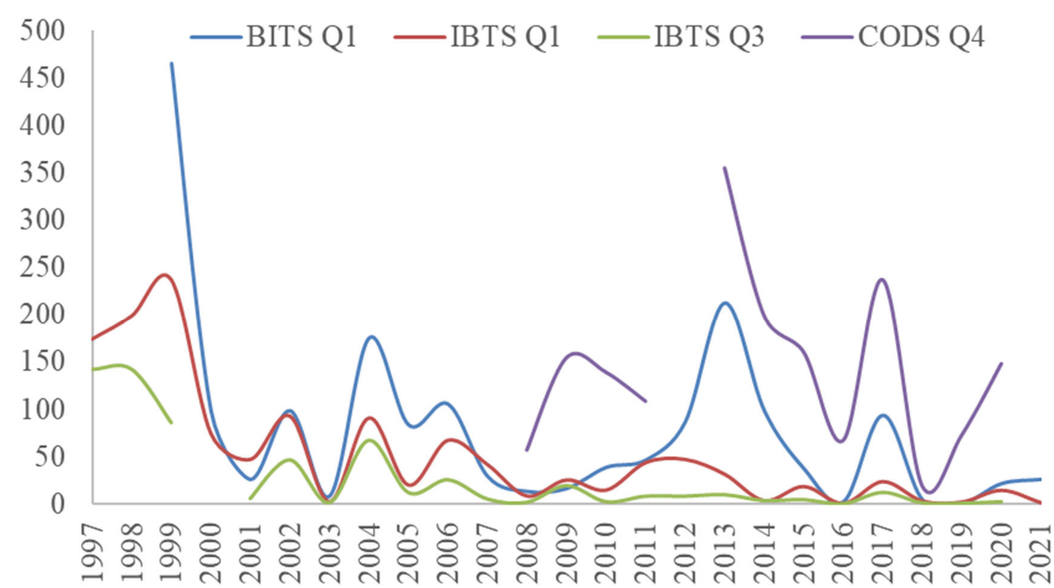


Figure 2.28. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

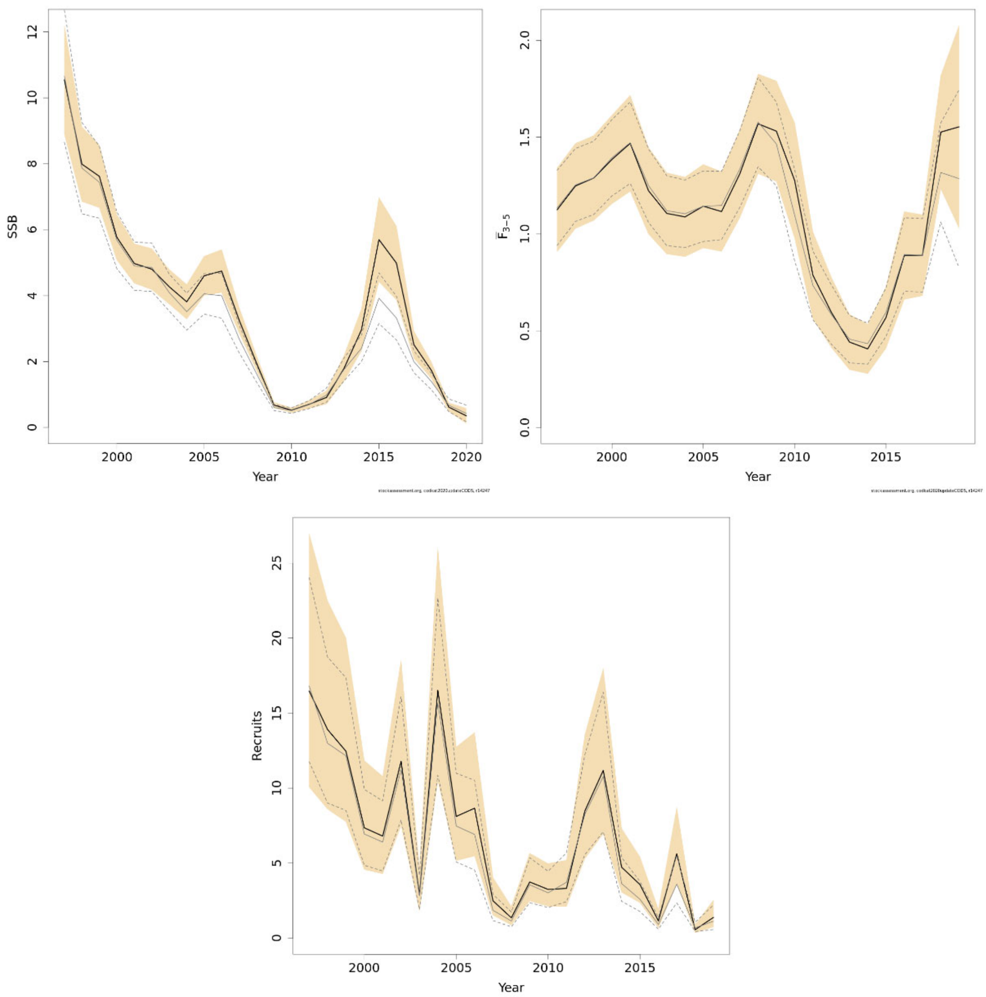


Figure 2.29. Cod in Kattegat. Comparison SAM run assessment 2020. SSB (upper left plot; in thousand tonnes), Unallocated mortality (Z-0.2, Upper right plot) and Recruitment (lower plot; in millions) for final SAM run presented in 2020 (grey lines) and SAM run including the corrected Cod Survey 4th Quarter time-series (black line with brown 95% confidence interval).

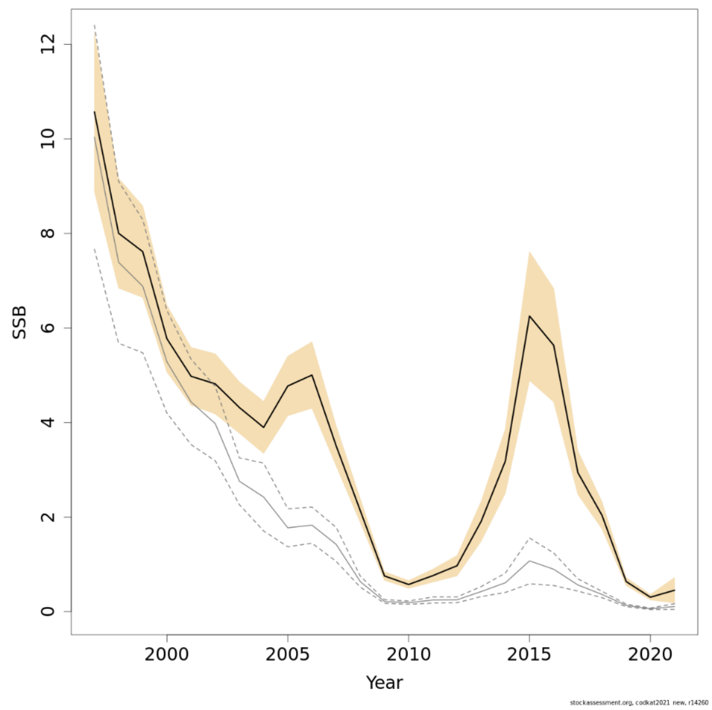


Figure 2.30. Cod in Kattegat. SSB in tonnes. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval)

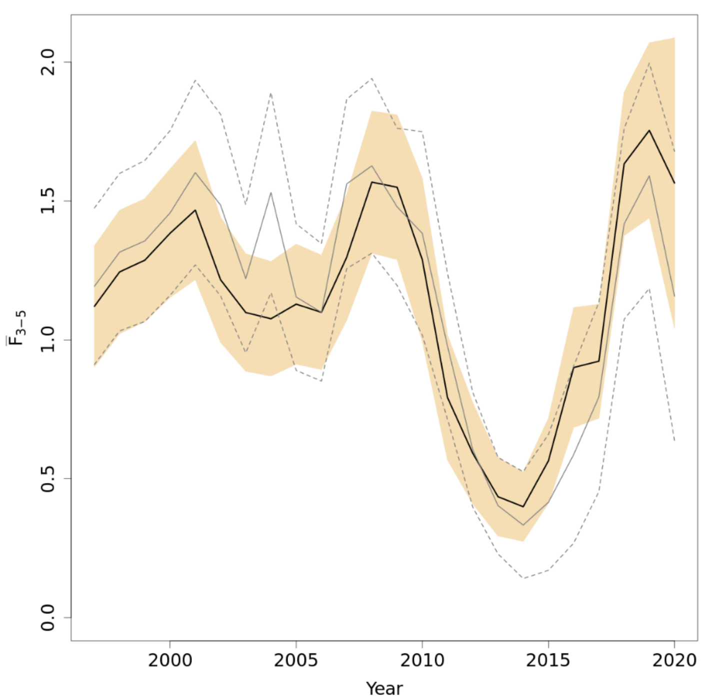


Figure 2.31. Cod in Kattegat. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval)

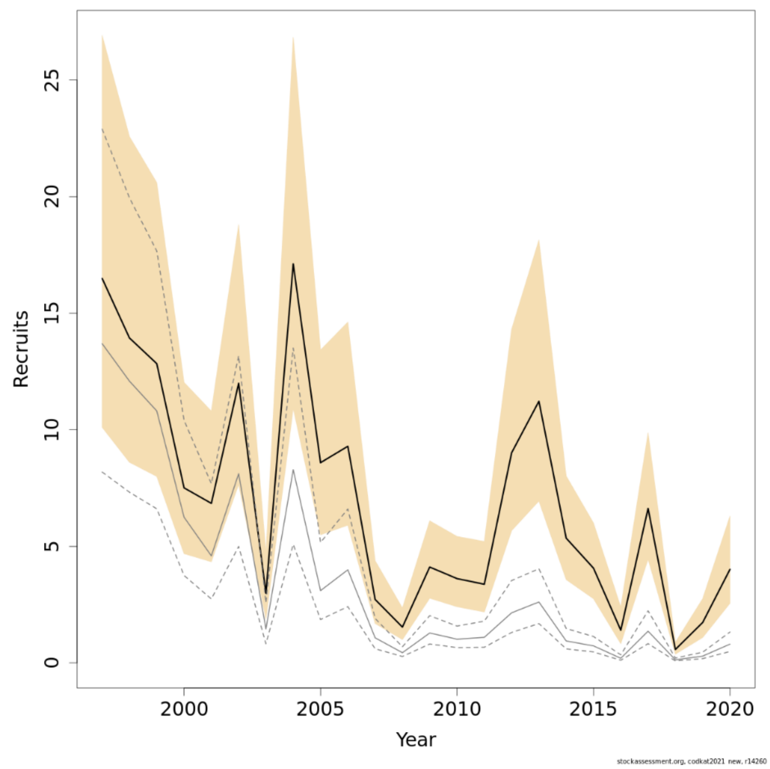


Figure 2.32. Cod in Kattegat. Recruitment in millions. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95 % confidence interval)

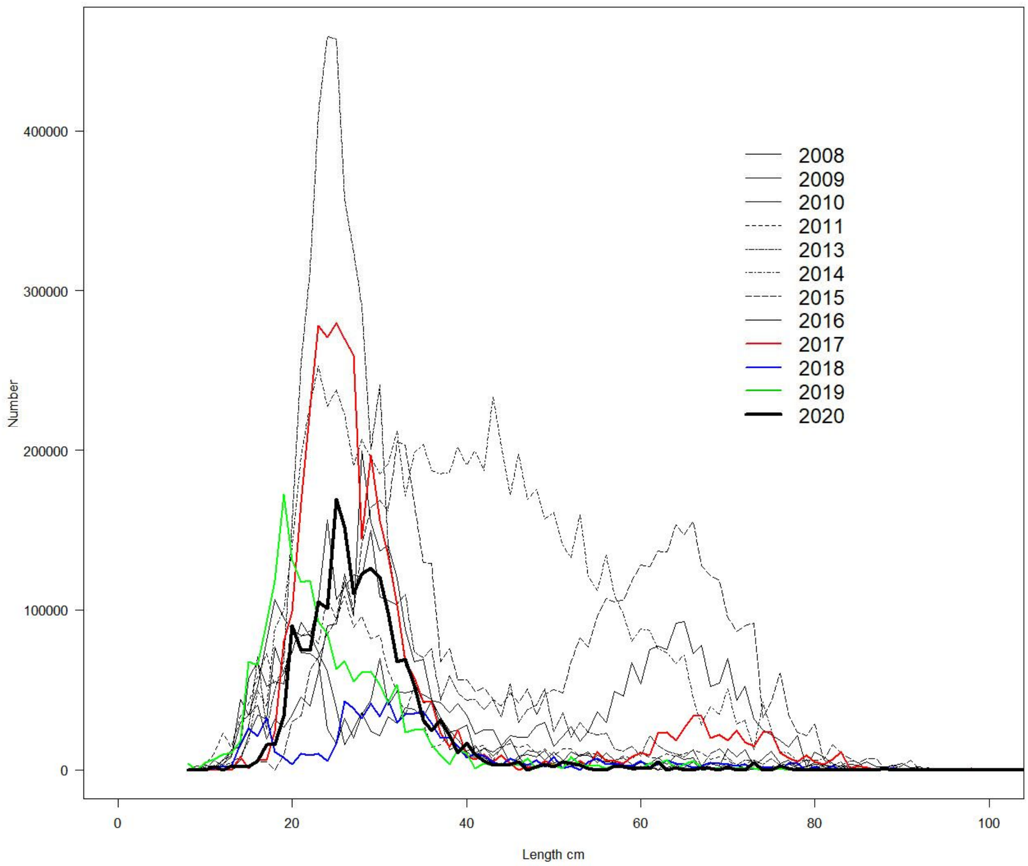
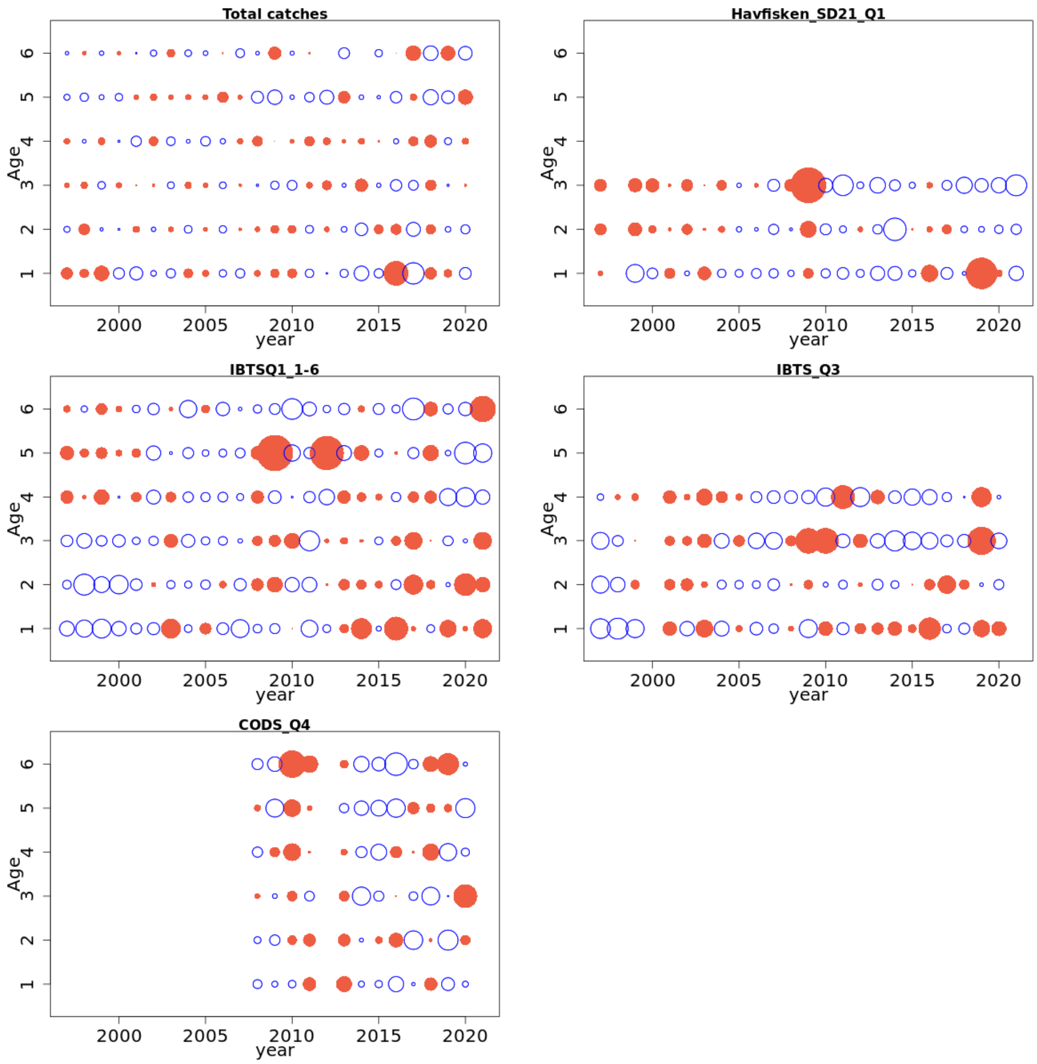


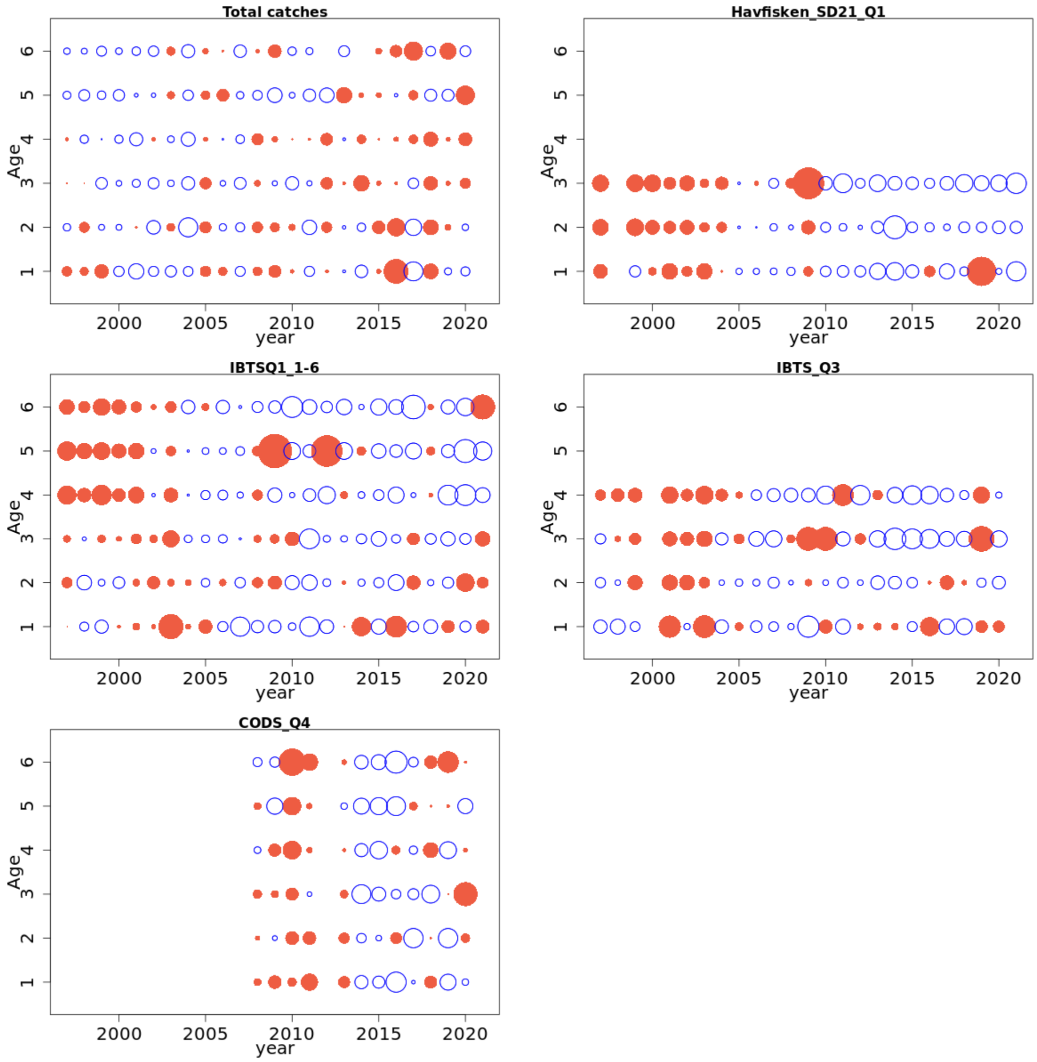
Figure 2.33. Cod in Kattegat. Length distributions from the Cod survey 2008-2020.

Year	Catch multiplier
2003	1.48
2004	1.12
2005	2.9
2006	2.75
2007	2.05
2008	3.44
2009	3.59
2010	2.79
2011	2.54
2012	4.12
2013	4.79
2014	6.45
2015	7.64
2016	9.16
2017	6.04
2018	6.3
2019	5.17
2020	6.14

Figure 2.33. Cod in Kattegat. Catch multiplier. The scaling factor by year from the SAM run with scaling.


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

a)



b)

Figure 2.34. Cod in Kattegat. Residuals. a) SAM run with scaling b) SAM run 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 2.14. Cod in the Kattegat. Landings (in tonnes) 1971-2020.

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	83
2020	26	11	0.1	36

[1] Landings statistics incompletely split on the Kattegat and Skagerrak.

[2] Including 900 t reported in Skagerrak.

[3] Including 1.600 t misreported by area.

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

[5] Including 1.700t reported in Sub-division 23.

[6] Including 116 t reported as pollack

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

Table 2.15. Cod in the Kattegat. Estimates of discards in numbers (in thousands) by ages and total weight in tonnes. The estimation of total discards in 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
2020	282	69	1	1	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
2020	67	40	2	0	0	0

DK and SWE discard numbers combined Year	a1	a2	a3	a4	a5	a6	Total discard in 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	40
2020	349	109	4	1	0	0	61

Table 2.16. Cod in the Kattegat. Numbers of hauls (Sweden) and observer trips (Denmark, usually 1 hauls per trip) 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
2020	27	45	72

Table 2.17a. Cod in the Kattegat. Sampling level of Danish landings, 2020

Quarter	n. of harbour days	n. of cod aged	n. of cod weighed	n. of cod measured
1	4	242	242	242
2	4	64	64	64
3	5	146	146	146
4	3	162	198	198
Total	16	614	650	650

Table 2.17b. Cod in the Kattegat. Sampling level of Swedish landings, 2020

Quarter	n. of hauls	n. of cod aged	n. of cod weighed	n. of cod measured
1	16	103	115	115
2	0	0	0	0
3	11	61	96	96
4	0	0	0	0
Total	27	164	211	211

Table 2.18. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2020.

Sub-div	**21**					
Year	**2020**	**Quarter**	**1**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1			0.166	1296.36	0.17	1296.36
2	0.560814	777.2927	0.338	1897.7721	0.90	1198.65
3	0.578941	1408.567	0.049	3090.3863	0.63	1539.80
4	3.009428	1976.718	0.312	3080.9566	3.32	2080.45
5	0.127799	3136.713	0.008	4375.8	0.14	3209.71
6	0.554893	2798.845	0.008	4352.4	0.56	2820.92
7	0.08	3200.21			0.08	3200.21
8	0.07	4486.34			0.07	4486.34
9						
10						
SOP (t)	9.72			2.04	11.76	
Landings (t)	9.51			2.04	11.55	

Sub-div	**21**					
Year	**2020**	**Quarter**	**2**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1			0.132	1296.36	0.13	1296.36
2	0.423148	803.6567	0.567	2122.791	0.99	1559.05
3	0.174446	1568.415	0.093	2817.9014	0.27	2002.90
4	0.705365	2310.602	0.584	2948.2016	1.29	2599.39
5	0.048047	1542.645	0.011	4375.8	0.06	2070.44
6	0.300756	2681.199	0.011	4352.4	0.31	2740.17
7	0.10	1807.94			0.10	1807.94
8	0.03	3220.97			0.03	3220.97
9						
10						
SOP (t)	3.39			3.45	6.84	
Landings (t)	3.31			3.42	6.73	

Sub-div	**21**					
Year	**2020**	**Quarter**	**3**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	0.33	586.22	0.153	1296.36	0.49	809.57
2	1.051536	1188.968	0.464	2071.4944	1.52	1459.16
3	0.205953	2119.559	0.086	3113.5607	0.29	2412.36
4	0.465383	3279.901	0.543	3092.0924	1.01	3178.77
5	0.039239	4344.243	0.014	4375.8	0.05	4352.54
6			0.014	4352.4	0.01	4352.40
7						
8						
9						
10						
SOP (t)	3.58			3.23	6.81	
Landings (t)	3.52			3.19	6.71	

Sub-div	**21**					
Year	**2020**	**Quarter**	**4**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	2.30	598.38	0.125	1296.360	2.43	634.29
2	4.150126	1141.71	0.505	2494.321	4.66	1288.45
3	0.418278	3229.555	0.078	3458.650	0.50	3265.56
4	0.661736	3254.665	0.127	3534.570	0.79	3299.73
5						
6			0.013	4352.400	0.01	4352.40
7						
8						
9						
10						
SOP (t)	9.62			2.20	11.82	
Landings (t)	9.33			1.93	11.26	

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	2.638081	598.3761	0.576	1296.36	3.21	723.46
2	6.185625	1188.968	1.874	2494.3207	8.06	1492.49
3	1.377619	3229.555	0.306	3458.6501	1.68	3271.19
4	4.841913	3279.901	1.566	3534.57	6.41	3342.14
5	0.215085	4344.243	0.033	4375.8	0.25	4348.44
6	0.86	2798.84	0.046	4352.4	0.90	2878.10
7	0.18	3200.21			0.18	3200.21
8	0.094762	4486.342			0.09	4486.34
9						
10	0.03	2458.17			0.03	2458.17
SOP (t)	33.66			12.36	46.02	
Landings (t)	25.70			10.57	36.27	

Table 2.19. Cod in the Kattegat. Catches (Landings + Discards) in numbers (in thousands) by year and age. In the assessment the plus-group is defined as 6+

	Age					
Year	1	2	3	4	5	6
1997	1456	2540	5137	891	222	88
1998	1499	3587	1595	1908	283	76
1999	1201	3859	3972	455	409	77
2000	1819	3942	2346	1027	125	103
2001	2166	2012	2034	703	187	45
2002	3190	2161	1062	391	85	40
2003	628	2441	650	184	65	16
2004	3547	1077	1195	206	65	39
2005	854	2169	121	167	21	12
2006	1406	1305	796	36	33	9
2007	668	1446	383	190	16	26
2008	175	191	136	40	33	7
2009	400	92	30	22	9	4
2010	433	361	33	8	4	2
2011	631	445	84	6	2	1
2012	889	231	30	13	2	0
2013	1068	533	49	12	3	1
2014	510	804	66	20	6	0
2015	239	144	167	56	15	6
2016	16	95	68	75	38	13
2017	1090	119	68	28	30	14
2018	28	240	12	23	19	25
2019	114	46	46	5	7	3
2020	352	117	5	7	0	1

Table 2.20. Cod in the Kattegat. Weight at age (kg) in the catches by year and age. In the assessment the plus-group in defined as 6+

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1972	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1973	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1974	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1975	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1976	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1977	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1978	0.699	0.880	1.170	1.690	2.860	4.120	5.180	6.900
1979	0.708	0.868	1.086	1.890	2.215	3.382	7.314	6.101
1980	0.691	0.893	0.951	1.440	2.478	3.157	3.526	6.903
1981	0.604	0.799	1.123	1.432	2.076	3.532	4.420	4.644
1982	0.600	0.784	1.233	1.391	2.078	2.911	3.698	6.480
1983	0.595	0.752	1.129	1.943	3.348	3.141	5.301	6.325
1984	0.711	0.745	1.133	1.687	2.798	3.022	5.273	7.442
1985	0.606	0.839	0.986	1.614	2.575	4.090	6.847	7.133
1986	0.671	0.705	1.253	1.955	2.956	4.038	7.100	7.290
1987	0.483	0.716	1.118	1.972	2.868	4.200	5.185	8.288
1988	0.541	0.784	1.099	1.792	2.880	4.283	5.852	7.073
1989	0.621	0.921	1.269	2.296	3.856	5.733	5.166	6.527
1990	0.618	0.973	1.584	2.323	3.288	5.383	6.412	10.337
1991	0.578	0.861	1.533	2.986	4.548	4.179	9.127	12.055
1992	0.610	0.707	1.291	2.662	4.048	5.888	7.067	7.895
1993	0.567	0.862	1.583	2.321	4.970	7.566	9.391	8.705
1994	0.549	0.783	1.276	2.652	3.526	7.279	9.793	10.130
1995	0.598	0.799	1.121	1.947	2.404	3.537	9.973	10.708
1996	0.469	0.669	1.088	1.771	2.638	3.773	4.677	7.871
1997	0.450	0.621	0.959	1.950	2.806	3.877	5.756	7.213
1998	0.623	0.697	0.853	1.680	2.497	4.317	6.669	8.948
1999	0.496	0.624	0.911	1.616	2.588	4.665	5.376	8.040
2000	0.487	0.611	0.868	1.332	2.779	3.944	5.069	9.020
2001	0.466	0.646	0.901	1.585	2.597	4.693	7.117	7.691
2002	0.546	0.711	1.120	2.052	3.539	4.814	6.915	7.833
2003	0.550	0.700	1.370	2.460	3.750	5.920	7.840	10.890
2004	0.570	0.700	1.010	1.630	2.700	3.920	6.180	9.420
2005	0.428	0.854	1.623	2.343	3.584	5.442	6.439	8.307
2006	0.480	0.880	1.519	3.130	3.995	4.222	5.264	6.713
2007	0.48	0.802	1.482	2.275	3.344	3.829	1.802	7.897
2008	0.574	1.075	1.837	3.210	4.097	4.437	5.552	5.827
2009	0.717	0.976	1.493	2.651	4.069	4.693	4.870	5.792
2010	0.412	0.879	1.910	3.081	4.038	3.592	4.252	6.404
2011	0.444	0.915	1.498	2.695	3.372	4.997	4.059	7.569
2012	0.545	1.191	1.769	3.174	4.004	5.224	4.305	6.921
2013	0.488	0.888	1.702	2.545	3.726	3.310	5.100	NA
2014	0.434	1.007	1.907	2.523	3.938	5.431	NA	NA
2015	0.434	1.343	1.879	2.597	3.726	3.777	NA	NA
2016	0.434	1.267	2.472	2.534	2.793	3.665	NA	NA
2017	0.434	0.915	1.996	2.942	3.453	3.921	NA	NA
2018	0.434	0.249	0.783	2.511	3.265	3.766	NA	NA
2019	0.434	0.348	1.047	2.019	2.537	3.078	NA	NA
2020	0.113	0.255	1.034	2.39	3.18	2.888	NA	NA

Table 2.21. Cod in the Kattegat. Weight at age (kg) in the stock by year and age. In the assessment the plus-group in defined as 6+

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1972	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1973	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1974	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1975	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1976	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1977	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1978	0.059	0.355	1.006	1.69	2.86	4.12	5.18	6.9
1979	0.059	0.35	0.934	1.89	2.215	3.382	7.314	6.101
1980	0.058	0.361	0.817	1.44	2.478	3.157	3.526	6.903
1981	0.051	0.323	0.965	1.432	2.076	3.532	4.42	4.644
1982	0.05	0.317	1.06	1.391	2.078	2.911	3.698	6.48
1983	0.05	0.304	0.971	1.943	3.348	3.141	5.301	6.325
1984	0.06	0.301	0.974	1.687	2.798	3.022	5.273	7.442
1985	0.051	0.339	0.848	1.614	2.575	4.09	6.847	7.133
1986	0.056	0.285	1.077	1.955	2.956	4.038	7.1	7.29
1987	0.041	0.289	0.961	1.972	2.868	4.2	5.185	8.288
1988	0.045	0.317	0.945	1.792	2.88	4.283	5.852	7.073
1989	0.052	0.372	1.091	2.296	3.856	5.733	5.166	6.527
1990	0.052	0.393	1.362	2.323	3.288	5.383	6.412	10.337
1991	0.06	0.415	1.799	2.986	4.548	4.179	9.127	12.055
1992	0.052	0.34	1.191	2.662	4.048	5.888	7.067	7.895
1993	0.056	0.353	1.086	2.321	4.97	7.566	9.391	8.705
1994	0.035	0.269	1.225	2.652	3.526	7.279	9.793	10.13
1995	0.032	0.148	1.31	1.947	2.404	3.537	9.973	10.708
1996	0.027	0.22	0.496	1.771	2.638	3.773	4.677	7.871
1997	0.034	0.179	0.743	1.95	2.806	3.877	5.756	7.213
1998	0.049	0.213	0.442	1.68	2.497	4.317	6.669	8.948
1999	0.046	0.207	0.625	1.616	2.588	4.665	5.376	8.04
2000	0.046	0.176	0.624	1.332	2.779	3.944	5.069	9.02
2001	0.065	0.269	0.72	1.585	2.597	4.693	7.117	7.691
2002	0.045	0.29	1.334	2.052	3.539	4.814	6.915	7.833
2003	0.066	0.224	1.054	2.46	3.75	5.923	7.835	10.891
2004	0.052	0.407	1.007	1.63	2.7	3.916	6.181	9.423
2005	0.058	0.349	1.187	2.343	3.584	5.442	6.439	8.307
2006	0.064	0.280	1.083	3.130	3.995	4.222	5.264	6.713
2007	0.058	0.289	1.060	2.275	3.344	3.829	1.802	7.897
2008	0.045	0.335	1.010	3.210	4.097	4.437	5.552	5.827
2009	0.053	0.300	1.069	2.651	4.069	4.693	4.870	5.792
2010	0.052	0.285	1.171	3.081	4.038	3.592	4.252	6.404
2011	0.051	0.269	0.905	2.695	3.372	4.997	4.059	7.569
2012	0.044	0.251	0.923	3.174	4.004	5.224	4.305	6.921
2013	0.041	0.247	0.911	3.173	4.004	5.224	5.1	NA
2014	0.041	0.255	1.043	2.545	3.726	3.31	NA	NA
2015	0.049	0.285	1.05	2.541	3.869	5.431	NA	NA
2016	0.055	0.311	1.036	2.023	3.385	2.873	NA	NA
2017	0.045	0.338	1.041	2.448	2.72	3.665	NA	NA
2018	0.037	0.275	0.993	2.91	3.353	3.858	NA	NA
2019	0.038	0.232	1.103	2.511	3.265	3.766	NA	NA
2020	0.039	0.23	1.101	2.02	2.537	3.078	NA	NA
2021	0.039	0.277	1.157	2.39	3.18	2.888	NA	NA

Table 2.22. Cod in the Kattegat. Proportion mature at age (combined sex). In the assessment the plus-group in defined as 6+

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1972	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1973	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1974	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1975	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1976	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1977	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1978	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1979	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1980	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1981	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1982	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1983	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1984	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1985	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1986	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1987	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1988	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1989	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1990	0.02	0.61	0.62	0.99	0.93	1.00	1.00	1.00
1991	0.02	0.62	0.64	0.88	1.00	1.00	1.00	1.00
1992	0.07	0.51	0.99	1.00	1.00	1.00	1.00	1.00
1993	0.03	0.49	0.73	0.95	0.87	1.00	1.00	1.00
1994	0.01	0.60	0.96	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.12	0.97	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.29	0.57	0.95	1.00	1.00	1.00	1.00
1997	0.00	0.19	0.90	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.38	0.65	1.00	1.00	1.00	1.00	1.00
1999	0.02	0.58	0.87	1.00	1.00	1.00	1.00	1.00
2000	0.02	0.42	0.92	1.00	1.00	1.00	1.00	1.00
2001	0.02	0.44	0.91	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.57	0.92	0.99	1.00	1.00	1.00	1.00
2003	0.00	0.54	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.74	0.86	1.00	1.00	1.00	1.00	1.00
2005	0.01	0.53	0.83	0.92	1.00	1.00	1.00	1.00
2006	0.00	0.59	0.81	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.60	0.89	0.93	1.00	1.00	1.00	1.00
2008	0.00	0.35	1.00	1.00	1.00	1.00	1.00	1.00
2009	0.00	0.54	0.90	0.95	1.00	1.00	1.00	1.00
2010	0.00	0.48	0.94	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.60	0.90	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.63	0.86	0.95	1.00	1.00	1.00	1.00
2013	0.00	0.49	0.87	0.92	1.00	1.00	1.00	1.00
2014	0.00	0.37	0.46	0.91	1.00	1.00	1.00	1.00
2015	0.01	0.364	0.591	0.83	1.00	1.00	1.00	1.00
2016	0.01	0.51	0.57	0.84	1.00	1.00	1.00	1.00
2017	0.01	0.59	0.72	0.82	1.00	1.00	1.00	1.00
2018	0.00	0.516	0.774	0.851	1.00	1.00	1.00	1.00
2019	0.00	0.49	0.85	0.94	1.00	1.00	1.00	1.00
2020	0.02	0.5	0.84	1.00	1.00	1.00	1.00	1.00
2021	0.02	0.59	0.98	1.00	1.00	1.00	1.00	1.00

Table 2.23. Tuning data for the Kattegat cod Assessment 2019.

```
Tuning Data; Cod in the Kattegat (part of Division IIIa)_07/04/21
     104
Havfisken_SD21_Q1
1997  2021
1   1   0   0.25
1   3
        1 104.5521 24.10579 16.37002
        1     -9        -9       -9
        1 464.8633 25.74058 8.849066
        1 97.61678 44.32915 5.524313
        1 25.78995 30.09901 11.12194
        1   98.273 16.65293 3.154042
        1 8.341221 47.24216 5.778205
        1 175.0556 11.18347 5.333216
        1 83.14981 86.67933 2.545501
        1 105.1494  38.4633 10.83763
        1 28.87485 46.52737  8.60812
        1 13.09734 6.648042 1.012895
        1 16.21239 0.908864    0.001
        1 38.50059 21.42233 1.388749
        1 46.24852 15.00446 14.26268
        1 86.61548  10.8254 1.844459
        1 212.3437 51.34188 10.25782
        1 98.15682 781.2383 12.33839
        1 37.23411 16.90285 15.66501
        1 2.231747 9.862954 3.595991
        1 93.50864 3.781223 4.307714
        1 4.370284 17.71467  1.90121
        1 0.083652 2.379284 2.978978
        1 21.37097 7.788465 0.443476
        1 25.77316  18.4757 3.091073
IBTSQ1_1-6
1997  2021
1   1   0   0.25
1   6
        1 174.4673 54.17918  108.874   6.3358 1.379162 1.052075
        1 199.3658 470.6493 47.07079 24.61658 2.672512 1.320837
        1 237.6786 167.7995 62.98428 2.257075 3.113862 0.583337
        1 74.84901 233.6876 47.39008 14.02511   1.3133 1.159887
        1 47.05208 46.05903 24.37296 5.275775 1.692212 0.747912
        1 93.04713 21.15468 15.40363 14.68903   3.2729 1.065962
        1 2.342425 52.46283 3.545637  2.61305  1.69975    0.375
        1 91.01563 14.12248 32.84681 6.007112 2.050562  2.64905
        1 19.99001  86.9476 5.060875 10.69735      1.2   0.3875
        1 67.31363 21.88264 27.46999 2.661387 2.247375   0.9875
        1 41.60551 41.93674 7.399237 7.522862 0.766212 0.827775
        1 8.391675   2.4089 2.224437 0.858337 0.583337 0.416662
        1 25.38333    0.925 0.441675 2.041675    0.001 0.333337
        1 14.63573 22.46011 0.241662 0.333337 0.529162 0.541662
        1 43.72658 24.42604 17.48698      0.6 0.177087    0.125
        1 47.11146 9.586875 2.019437 4.055562    0.001 0.083337
        1 31.39375 14.16423   3.6191 0.877075   1.4125    0.275
        1 3.451525 30.88956 9.951462 3.132475   0.4625 0.333337
        1 18.44983 10.18948 27.39344  9.53065 4.195962 2.151037
        1 0.522925 14.55145 4.311475 18.67959 5.759175 3.000337
        1 23.69166      0.8   0.9375 1.923612 6.200687  15.4382
        1 2.993487 7.596475 0.809862 0.846037 0.379162    0.625
        1   2.0238 1.708825 3.111112 1.065975 0.444437   0.3125
        1 14.40613  0.41975   0.2425   2.9664  0.22985   0.2425
        1 1.191487   2.9848 0.116212    0.125 0.583337    0.001
IBTS_Q3
1997  2020
1   1   0.75  0.83
1   4
        1   141.86    32.69    14.63     0.78
        1   141.92    38.42     1.57     0.92
        1    85.73     6.18     1.64      0.2
        1       -9       -9       -9       -9
        1    6.025    2.109    0.458    0.117
        1    46.53    1.566    0.268     0.21
        1    1.701    4.499    0.133     0.05
        1   67.119    2.282    2.432    0.083
        1   12.166   10.937    0.083    0.256
        1   25.694    4.263    2.977    0.167
        1    5.326    4.222    1.153    0.617
        1    1.942    0.467    0.067     0.15
        1   19.492    0.217    0.001    0.083
        1    2.504    1.279    0.001    0.075
        1    8.348    1.594     0.45    0.001
        1    8.335    1.248     0.05    0.583
        1    9.925    6.823    1.086     0.05
        1    3.717    9.976    7.543    0.816
        1    4.755    2.104    7.362     3.23
        1    0.376    0.692    1.666    2.225
        1   12.383    0.075    0.467    0.294
        1    1.326    0.555    0.099    0.051
        1    0.902     0.14    0.001    0.001
        1    2.558    0.509    0.025    0.025
CODS_Q4
    2008  2020
        1      1     0.83     0.92
        1      6
        1   57.1     24.2      9.1      5.8      2.8        1
        1  154.4     20.7      2.7      1.7        2      0.8
        1  139.1       39        2      0.4      0.2     0.03
        1  108.5     30.7     16.2      1.4      0.4      0.1
        1     -9       -9       -9       -9       -9       -9
        1    355    109.7       21      9.7      3.7      0.7
        1  199.2    346.5      164     37.6     13.6      4.5
        1  160.4       85    143.8    119.2     31.6     10.4
        1   67.2     34.3     29.6     32.9     58.2     33.9
        1  237.1     49.9     19.9     13.4      9.5      9.3
        1     19     41.3        7      1.5      1.8      1.5
        1   72.8     16.4      5.3      1.2      0.6      0.1
        1  148.2      9.5      0.1      1.9      0.2      0.3
```

Table 2.24. Summary run SPALY with scaling.

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

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1997	16491	10106	26913	12744	10982	14788	10572	9018	12395	1.121	0.923	1.362
1998	13937	8605	22573	10541	9222	12048	8006	6926	9254	1.245	1.041	1.488
1999	12836	7998	20600	9475	8334	10772	7615	6705	8648	1.287	1.084	1.529
2000	7508	4685	12030	7161	6357	8067	5774	5110	6523	1.384	1.171	1.636
2001	6844	4338	10798	6259	5560	7046	4980	4404	5630	1.467	1.237	1.74
2002	11994	7655	18793	6061	5345	6874	4818	4223	5498	1.217	1.011	1.464
2003	2986	1886	4727	5212	4607	5897	4317	3807	4896	1.099	0.906	1.332
2004	17115	10918	26828	5327	4619	6143	3898	3385	4489	1.076	0.889	1.303
2005	8588	5496	13419	7233	6298	8306	4775	4185	5448	1.129	0.932	1.367
2006	9291	5905	14618	6835	5960	7838	5006	4350	5761	1.099	0.912	1.325
2007	2721	1689	4383	4369	3887	4910	3509	3110	3959	1.297	1.089	1.545
2008	1536	1003	2352	2407	2154	2691	2136	1898	2403	1.568	1.332	1.846
2009	4112	2775	6093	1076	939	1233	756	670	853	1.55	1.31	1.833
2010	3616	2410	5425	1017	862	1201	576	500	664	1.289	1.026	1.618
2011	3372	2184	5209	1153	966	1376	763	638	913	0.792	0.596	1.052
2012	9011	5675	14307	1590	1287	1964	972	780	1212	0.592	0.435	0.805
2013	11223	6944	18138	3067	2492	3774	1912	1534	2383	0.435	0.315	0.602
2014	5350	3571	8013	5789	4725	7093	3186	2573	3946	0.399	0.292	0.545
2015	4064	2752	5999	8675	7043	10686	6254	5029	7776	0.565	0.431	0.74
2016	1402	823	2387	6864	5626	8374	5635	4555	6971	0.901	0.709	1.144
2017	6628	4451	9868	3704	3192	4298	2942	2516	3440	0.923	0.739	1.153
2018	576	376	883	2455	2173	2774	2037	1771	2343	1.634	1.395	1.913
2019	1733	1091	2753	798	697	914	638	558	729	1.754	1.466	2.1
2020	4013	2559	6294	565	456	701	307	254	370	1.565	1.12	2.185
2021	1333	309	5757	703	387	1278	454	251	820	1.57	0.94	2.624

Table 2.25. Summary run SPALY without scaling.

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

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1997	13692	8187	22899	11973	9616	14908	10036	7925	12709	1.193	0.942	1.511
1998	12085	7322	19947	9694	7968	11795	7392	5863	9319	1.316	1.061	1.632
1999	10808	6610	17670	8505	7001	10332	6884	5612	8444	1.356	1.095	1.68
2000	6249	3751	10410	6498	5374	7858	5285	4306	6488	1.457	1.189	1.786
2001	4591	2742	7687	5465	4540	6579	4437	3620	5439	1.602	1.302	1.972
2002	8115	4999	13175	4877	4050	5872	3979	3265	4849	1.486	1.192	1.851
2003	1456	821	2583	3303	2766	3944	2759	2305	3303	1.221	0.981	1.519
2004	8287	5085	13507	3182	2437	4154	2426	1805	3259	1.531	1.209	1.937
2005	3099	1858	5168	2691	2120	3416	1775	1416	2224	1.154	0.918	1.451
2006	3993	2415	6603	2530	2075	3085	1832	1487	2257	1.099	0.878	1.377
2007	1076	607	1909	1778	1390	2275	1425	1108	1834	1.562	1.284	1.898
2008	437	275	692	719	606	853	636	529	765	1.627	1.341	1.974
2009	1283	812	2026	315	266	373	217	182	259	1.479	1.222	1.791
2010	1019	657	1580	333	275	402	193	161	230	1.383	1.062	1.803
2011	1097	672	1790	372	290	477	247	190	321	0.977	0.746	1.278
2012	2148	1306	3533	403	324	501	252	198	320	0.605	0.43	0.851
2013	2611	1688	4039	682	549	847	426	333	546	0.403	0.262	0.621
2014	942	601	1475	1085	793	1483	612	439	855	0.333	0.187	0.594
2015	730	471	1132	1477	971	2249	1075	685	1686	0.415	0.23	0.749
2016	199	114	347	1088	770	1535	898	613	1318	0.587	0.341	1.01
2017	1361	828	2237	708	571	878	566	451	711	0.795	0.518	1.22
2018	133	85	207	448	373	538	365	304	438	1.417	1.112	1.806
2019	290	184	459	165	135	200	134	108	165	1.591	1.233	2.053
2020	805	489	1325	111	88	140	62	48	80	1.158	0.738	1.816
2021	180	52	619	162	93	282	110	64	189	1.158	0.615	2.18

2.3 Western Baltic cod (update assessment)

The assessment for this stock was not accepted by the group (WGBFAS) this year, due to very high retrospective patterns in the SPALY assessment (Mohns Rho at 0.53 for SSB and -0.45 for F). It was decided to ask for an interbenchmark to try to solve the issue. Therefore, only the input data will be presented in the report in May 2021 and the full assessment will be available in September 2021.

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 the second half of 2019 and in 2020, a large area of SD 24 was closed for directed cod fishery, to protect the eastern Baltic cod. This has led to a change in the fishing pattern towards SD 22. 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 2.26. Since 2017 landing numbers include the BMS fraction, which was 1 t in 2020. Landings by SD, passive and active gear in 2020 are given in Table 2.27 (both include eastern Baltic cod landings in SD 24).

The total commercial human consumption landings in 2020 was 3326 t + 1 t BMS, which corresponds to 43% of last year’s level (7701 t) and a quota utilization of 87% (3806 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 (only 36%) and dropped further to 20% in 2020. This change is due to a management regulation installed since mid-2019 (see below), where a directed cod fishery in SD 24 was prohibited (Figure 2.35 and Table 2.36).

There were 11 t 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 (30%) Figure 2.36.

As the Western and Eastern Baltic cod stock mix 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 2.35). To do this, a weighted average of the proportions of WB cod in SD 24 in the two sub-areas was applied (Area 1 and Area 2 in Figure 2.37 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 1 January 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 (Figure 2.38).

In 2019, there was no spawning closure in place in the western Baltic (SD 22–24) unlike the last couple of year, but in 2020 the spawning closure was reintroduced. However, in June 2019, the European Commission issued an immediate measure to protect the cod stock of the eastern Baltic Sea (EU 2019/1248). It also prohibited to carry out a directed fishery for cod in SD 24, with special regulations for active and passive gear fisheries. The Danish fishing pattern in 2020 can be seen by VMS plots in Figure 2.39.

In the recreational fishery bag limits have been in place since a few years, and in 2020 the regulation was five cod per day and only two cod per day during the main spawning time (1 February to 31 March), (Table 2.36).

2.3.1.2 Discards

All relevant countries uploaded their discard data to InterCatch. Discard data from at-sea observer programs for 2020 were available from Germany, Sweden, Denmark and Poland for SD 22–24. Besides the sample level shown in Table 2.29, 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 in SD 22 was estimated to be 0.2% for active and 1.9% for passive gears, and 0% and 11.9% in SD 23, respectively. For cod in SD 24, the discard rate of the active and passive gear was estimated to be 13.2% and 3.7%, respectively. In Q3 and Q4 2020 there was evidence for high-grading in SD24, mainly occurring in active gear catches. Discards per gear segment and quarter can be seen in Table 2.30.

The discard weights-at-age for SD 22 and SD 23 for 2020 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 catches

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 has been lower since 2017 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 2020 is estimated to be 1311 t.

The amount of recreational catches included in the assessment compared to commercial landings and discards is shown in Figure 2.36 and Table 2.31. All recreational cod caught in SD 22–24 is assumed to be WB cod (WKBALTCOD2, 2019).

2.3.1.4 Unallocated removals

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 (e.g. 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. 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 or other fleet segments.

In 2015, Germany included for the first time cod discard estimates from the German pelagic trawl fishery targeting herring in SD24 (PTB_SPF); in 2020, the estimate was 0.16 t.

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 4363 t in 2020. Landings and discards of eastern Baltic cod in SD 24 is estimated to be 479 t and are shown in Table 2.31. By management area, the total catch is estimated to be 4842 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 2.27, Table 2.32). 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 2020 (i.e. the allocation overview) applied in InterCatch is given for landings and discards in Table 2.29.

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.

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 2020 are given in Table 2.28.

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 2.28). Possible effects of the differences between national sampling levels on data quality of the international dataset 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 following year classes from the 2017, 2018, and 2019 cohorts in their age readings.

Sampling data from recreational fisheries are shown in tables 2.33 and 2.34.

2.3.2 Biological data

2.3.2.1 Proportion of WB cod in SD 22–24

During the benchmark the time-series of estimated mixing proportions of eastern and western Baltic cod within SD 24 was updated (WKBALTCOD2 2019). The proportions of eastern and western cod in SD 24 are estimated separately for 2 subareas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.37.

In 2020, 36% of cod in SD 24 was found to be WB based on otolith shape analysis and genetics (Table 2.35). The split is conducted on the cod genetics and otoliths sampled from the commercial Danish and German trawl fisheries in SD 24. Samples for otolith shape analysis were collected during all four quarters. The spilt is weighted with landings from Germany, Denmark, Sweden, and Poland based on 2020 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 2.37, 2.38, 2.39, and 2.40, 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 2020 was age-group 4 from the large 2016-year class amounting to 71% of the total catch in numbers (Figure 2.40, Table 2.40). This year class was also relatively large in the recreational catches, accounting for 62% of the total share, however, the share in the discard for this year class has dropped to 13% (Table 2.37 and table 2.38).

2.3.2.3 Mean weight-at-age

Mean weight-at-age in commercial landings, discards and in total catch is shown in Tables 2.41, 2.42 and 2.43, 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 2020 the weight estimate for age 4 (the 2016-year class) in the commercial catch was unusually low (30% below average), probably due to the very wide length range of this age group (covering ~30-80 cm). This has a very large effect on the SSB estimate in 2020 as the 2016-year class is by far the most dominant age group in the stock presently. In last year's assessment the weight for the intermediate year (2020) was taken as 3 years mean as it is usually done. As the observed data being 30% lower than the 3 years average, this had an effect on the SSB estimated in 2020.

2.3.2.4 Maturity ogive

The maturity ogive estimations are based on data from BITS Q1 surveys in SD 22–23 (Table 2.45) 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 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 2.46).

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 (age 0) 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 2.47. Internal consistency of BITS Q1 and Q4 series is presented in Figure 2.41a-d and the time-series in Figure 2.42.

The CPUE by age from the BITS tuning series are shown in Figure 2.42. 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. The abundances of cod <25 cm TL caught in the survey can been seen in Figure 2.43.

After a detailed analysis during WGBFAS 2020, inconsistencies in the BITS age data were found. Questionable otoliths were selected and an age reading workshop between Denmark, Germany and Sweden was conducted in late 2020. This led to changes in the age data of the BITS from 2017, 2018, and 2019 (Davies, 2020). The revised age readings were uploaded to DATRAS. These revised age readings for the Q1 survey did not have a large effect for the assessment as the main part of the revisions involved age 1 and 2 (Figures 2.41a-d). However, in the Q4 survey, the revisions were mainly in the older age groups and changed a large proportion of the fish from age 4 to age 5. As age 5 is not included in the Q4 survey, these fish were removed from the data and had a large effect on the assessment.

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)	2001–2020	age 0–4
BITS, Q1, SD22–24W (12–13 degrees)	2001–2021	age 1–4
FEJUCS, SD22	2011-2020	age 0

Table 2.26. Cod in management area of SD 22–24. Total landings (tonnes) and discard of cod in the ICES subdivisions 22, 23, 24 (includes eastern Baltic cod landings in SD 24).

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

	Denmark			Finland	German Dem.Rep.[1]	Germany, FRG		Estonia		Lithuania	Latvia	Poland	Sweden			Total				
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	Unalloc.	Grand total
1965			19457		9705		13350								2182	27867		17007		44874
1966			20500		8393		11448								2110	27864		14587		42451
1967			19181		10007		12884								1996	28875		15193		44068
1968			22593		12360		14815								2113	32911		18970		51881
1969			20602		7519		12717								1413	29082		13169		42251
1970			20085		7996		14589								1289	31363		12596		43959
1971			23715		8007		13482								1419	32119		14504		46623
1972			25645		9665		12313								1277	32808		16092		48900
1973			30595		8374		13733								1655	38237		16120		54357
1974			25782		8459		10393								1937	31326		15245		46571
1975			23481		6042		12912								1932	31867		12500		44367
1976		712	29446		4582		12893								1800	33368	712	15353		49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079		46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603		40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290		45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366		41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933		53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775		47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750		48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506		49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757		40159
1986		748	16195		2998		2902							227	3622	11975	975	13742		26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821		28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203		29159
1989		636	8059		2144		2498							192	4987	5738	828	11950		18516
1990		722	8584		1629		3054							120	3671	5361	842	11577		17780
1991		1431	9383				2879							232	2768	7184	1663	7846		16693
1992		2449	9946				3656							290	1655	9887	2739	5370		17996
1993		1001	8666				4084							274	1675	7296	1275	7129	5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	7502	30695
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801		33895
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	2300	50845
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995		43624
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049		34216
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225		42155
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264		38347
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451		34244
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781		24158
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127		24624
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	13	20854
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	9	22045
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858		22751
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183		23736
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256		20082
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259		15549
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016		14120
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641		16332
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053		17072
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333		12968
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862		13538
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193		13418
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313		10629
2017	1167	506	2352			1029	1281					926		435	352	2196	941	2714		5852
2018	1010	475	2235	0.5		1005	1373					886		395	462	2014	870	2942		5826
2019	2074	608	3194			1653	1992					991	2	559	334	3728	1167	2783		7679
2020	1456	177	1791			691	936					74	1	331	17	2147	508	671		3326

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

Table 2.27. 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: 2020 **Gear: Active and passive gear combined**

Subdivision	22	23	24	22-24
Country:				
Denmark	1456	177	335	1968
Germany	691	0	245	936
Sweden	1	332	17	349
Poland	0	0	74	74
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	2147	509	671	3327

Year: 2020 **Gear: Active gear**

Subdivision.	22	23	24	22-24
Country:				
Denmark	1027	29	298	1354
Germany	490	0	202	692
Sweden	0	1	59	59
Poland	0	0	1	1
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	1517	29	560	2106

Year: 2020 **Gear: Passive gear**

Subdivision	22	23	24	22-24
Country:				
Denmark	429	148	38	615
Germany	201	0	43	244
Sweden	1	331	16	347
Poland	0	0	15	15
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	630	479	112	1221

Table 2.28a. Cod in Sub-divisions 22-23. Unsampled landings strata and allocated sampled strata in 2020.

DE_27.3.c.22_Gillnets set_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Gillnets set_2_L,DK_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_1_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_4_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_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_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_4_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_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_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_4_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
DK_27.3.b.23_Active_1_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_1_L,DE_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_3_L,DE_27.3.c.22_Active_3_L,X
DK_27.3.b.23_Active_3_L,DE_27.3.c.22_Active_4_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.b.23_Active_4_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_3_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_4_L,X
DK_27.3.b.23_Gillnets set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_1_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_4_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_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_4_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_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_2_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_2_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.c.22_Gillnets set_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_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_4_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_4_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_4_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_4_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_2_L,X

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

Table 2.28b. Unsampled discard strata and allocated sampled strata for Western Baltic cod in 2020 (SD22-23).

DE_27.3.c.22_1_Longline set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_1_Longline set_D,DE_27.3.c.22_4_Gillnets set_D,X
DE_27.3.c.22_1_Longline set_D,DK_27.3.b.23_3_Gillnets set_D,X
DE_27.3.c.22_1_Longline set_D,DK_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_2_Active_D,X
DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,DE_27.3.c.22_4_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,DK_27.3.b.23_3_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,DK_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_3_Active_D,DE_27.3.c.22_4_Active_D,X
DE_27.3.c.22_3_Active_D,DK_27.3.c.22_3_Active_D,X
DE_27.3.c.22_3_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DE_27.3.c.22_3_Gillnets set_D,DK_27.3.b.23_3_Gillnets set_D,X
DE_27.3.c.22_3_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_3_Longline set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_3_Longline set_D,DE_27.3.c.22_4_Gillnets set_D,X
DE_27.3.c.22_3_Longline set_D,DK_27.3.b.23_3_Gillnets set_D,X
DE_27.3.c.22_3_Longline set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_1_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_1_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_2_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_3_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_3_Active_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_4_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_4_Active_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DK_27.3.b.23_3_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.c.22_1_Gillnets set_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.c.22_1_Gillnets set_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.c.22_2_Gillnets set_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.c.22_2_Gillnets set_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.c.22_4_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_4_Active_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.c.22_4_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.c.22_4_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DK_27.3.b.23_3_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
SE_27.3.b.23_1_Active_D,DE_27.3.c.22_1_Active_D,X
SE_27.3.b.23_1_Active_D,DE_27.3.c.22_2_Active_D,X
SE_27.3.b.23_1_Active_D,DE_27.3.c.22_4_Active_D,X
SE_27.3.b.23_1_Active_D,DK_27.3.c.22_1_Active_D,X
SE_27.3.b.23_1_Active_D,DK_27.3.c.22_2_Active_D,X
SE_27.3.b.23_1_Active_D,DK_27.3.c.22_3_Active_D,X
SE_27.3.b.23_3_Active_D,DE_27.3.c.22_1_Active_D,X
SE_27.3.b.23_3_Active_D,DE_27.3.c.22_2_Active_D,X
SE_27.3.b.23_3_Active_D,DE_27.3.c.22_4_Active_D,X
SE_27.3.b.23_3_Active_D,DK_27.3.c.22_1_Active_D,X
SE_27.3.b.23_3_Active_D,DK_27.3.c.22_2_Active_D,X
SE_27.3.b.23_3_Active_D,DK_27.3.c.22_3_Active_D,X
SE_27.3.c.22_2_Passive_D,DE_27.3.c.22_1_Gillnets set_D,X
SE_27.3.c.22_2_Passive_D,DE_27.3.c.22_4_Gillnets set_D,X
SE_27.3.c.22_2_Passive_D,DK_27.3.b.23_3_Gillnets set_D,X
SE_27.3.c.22_2_Passive_D,DK_27.3.c.22_3_Gillnets set_D,X

Table 2.29. 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 2020 (upper, middle, and lower table, respectively). Colour codes indicate sampling coverage (see legend below). Also SD 24 has otolith and length samples.

Table.2.3.9. Cod 22-24. Number of samples by quarter for 2020 available to the Working Group (SD22-23 samples only).

SD2223		Area	27,3,c,22				27,3,b,23						
Number of samples			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	7	2	4						13		
TAC 44%		Gillnets set			1				2		3	78	37%
	Landings *2	Active	10	6	5	5				5	31		
		Gillnets set	10	6	5	5				5	31		
Germany	Discards *1	Active	3	1		5					9		
TAC 21%		Gillnets set	2			7					9	50	24%
		Longline set											
	Landings *1	Active	8	2	2	4					16		
		Gillnets set	6		3	7					16		
		Longline set											
Sweden	BMS *3	Gillnets set					9	7	7	2	25		
TAC 16%	Discards *2	Gillnets set					9	7	7	2	25	81	39%
	Landings *2	Gillnets set					17	5	8	1	31		
			46	17	20	33	35	19	24	15	209		

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

SD2223		Area	27,3,c,22				27,3,b,23						
Number of length measurements			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	34	4	6						44		
TAC 44%		Gillnets set			19				255		274	1019	18%
	Landings	Active	299	64	41	77					481		
		Gillnets set	299	64	41	77				220	220		
Germany	Discards	Active	6		5	36					47		
TAC 21%		Gillnets set	6			77					83	3243	56%
		Longline set											
	Landings	Active	828	332	434	958					2552		
		Gillnets set	184		71	306					561		
		Longline set											
Sweden	BMS	Gillnets set					265	170	256	45	736		
TAC 16%	Discards	Gillnets set					265	170	256	45		1529	26%
	Landings	Gillnets set					500	114	141	38	793		
Total			1357	400	576	1454	765	284	652	303	5791		

SD2223		Area	27,3,c,22				27,3,b,23						
Number of otoliths age-read			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	24	4	6						34		
TAC 44%		Gillnets set			12				75		87	817	19%
		Longline set											
	Landings	Active	296	64	41	76					477		
		Gillnets set	296	64	41	76				219	219		
Germany	Discards	Active	6		5	21					32		
TAC 21%		Gillnets set	6			56					62	1853	44%
	Landings	Active	434	237	318	450					1439		
		Gillnets set	149		25	146					320		
		Longline set											
Sweden	BMS	Gillnets set					265	170	256	45	736		
TAC 16%	Discards	Gillnets set					265	170	256	45		1529	36%
	Landings	Gillnets set					500	114	141	38	793		
Total			915	305	407	749	765	284	472	302	4199		

Table 2.30. Cod 22–23. 2020. Discard (Number * 1000) by quarter and gear type for management area.

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	4	1	1	7	15
Active gears	25	35	87	32	180
Grand Total	30	37	88	40	194

Table 2.31. Western Baltic cod. Catches in the WB management area (SD 22–24) for WB and EB stocks (in tonnes). Recreational catch (Germany, Denmark and Sweden). Landings in 2017-2020 includes BMS.

Year	WB cod stock					EB cod stock					EB+WB cod stock		
	Landings	Discards	Recreational catch	% discard	% of comm. catch in SD 24	Landings in SD 24	Discards in SD24	Landings in SD 25-32	Discards in SD 25-32	% of catch in SD 24	Catch in SD 22-24	% commercial catch of west cod	stock Comm. catch in SD 24
1985	33188		2075		0.29	6971		315083	8199	2	42234	0.83	0.71
1986	20088		2078		0.36	6604		252558	3848	3	28770	0.75	0.93
1987	21692		2081		0.37	6874		207081	9340	3	30647	0.76	0.86
1988	20672		2082		0.47	8487		194787	7253	4	31241	0.71	0.87
1989	12795		2083		0.49	5721		179178	3462	3	20599	0.69	0.92
1990	12237		2085		0.49	5543		153546	4187	3	19865	0.69	0.92
1991	12931		2087		0.32	3762		122517	2741	3	18780	0.77	0.92
1992	15672		2420		0.19	2324		54882	1904	4	20416	0.87	0.76
1993	11815		2752		0.27	3885		50711	1558	7	18452	0.75	1.20
1994	16642	1614	3088	0.09	0.41	6551	621	100856	1956	7	28516	0.72	0.97
1995	28310	3016	3417	0.10	0.29	5585	668	107718	1872	5	40996	0.83	0.68
1996	38505	6868	3419	0.15	0.32	10040	1116	124189	1443	8	59948	0.80	0.77
1997	37077	3981	3420	0.10	0.33	6547	641	88600	3462	7	51666	0.85	0.53
1998	29634	5575	3410	0.16	0.37	4582	631	67428	2299	7	43833	0.87	0.40
1999	35934	4378	3416	0.11	0.32	6221	599	72995	1838	8	50549	0.86	0.52
2000	31132	3738	3432	0.11	0.32	6316	1209	89289	6019	7	45827	0.82	0.68
2001	27781	2449	3427	0.08	0.36	7794	389	91328	2891	8	41840	0.79	0.75
2002	20410	1395	3437	0.06	0.31	5060	562	67740	1462	8	30864	0.80	0.84
2003	17205	3473	3448	0.17	0.34	5729	862	69477	2024	8	30718	0.76	0.95
2004	17686	2189	3445	0.11	0.27	5309	188	68578	1201	7	28817	0.78	1.04
2005	18493	3265	3771	0.15	0.42	6064	1729	55032	1670	12	33322	0.74	0.86
2006	18503	1686	2923	0.08	0.27	6767	144	65531	4644	9	30024	0.74	1.28
2007	17384	1325	2782	0.07	0.35	8792	875	50843	4146	15	31158	0.66	1.46
2008	11302	336	3039	0.03	0.31	8811	787	42234	3746	17	24274	0.55	2.66
2009	7313	351	2648	0.05	0.42	8284	464	48438	3328	14	19060	0.47	2.75
2010	8007	838	3367	0.09	0.36	6049	533	50276	3543	11	18793	0.57	2.08
2011	9107	299	2595	0.03	0.24	7545	482	50368	3850	13	20029	0.54	3.59
2012	8622	370	3661	0.04	0.31	8469	536	51225	6795	13	21657	0.50	3.28
2013	7697	1007	3106	0.12	0.29	5359	1243	31355	5020	15	18413	0.57	2.62
2014	8083	837	4044	0.09	0.33	5455	1298	28909	9627	15	19716	0.57	2.30
2015	8390	432	4568	0.05	0.29	5029	930	38079	5970	12	19348	0.60	2.35
2016	6122	143	3505	0.02	0.31	4541	306	29313	3279	13	14617	0.56	2.53
2017	3861	180	1315	0.04	0.20	2058	227	25496	3238	7	7642	0.64	2.86
2018	3555	157	1600	0.04	0.21	2295	300	15907	3103	12	7907	0.59	3.39
2019	6103	655	2573	0.10	0.26	1598	621	8383	1337	19	11550	0.75	1.27
2020	2900	152	1311	0.05	0.10	429	50	2319	101	17	4842	0.86	1.62
3 avr.					0.19								2.09

Table 2.32. Cod in SD 22–23. Numbers at age (LANUM) and mean weight-at-age (WELA) in commercial landings for sub-divisions 22 and 23, by quarter and gear in 2020.

Year:		Gear:	Trawl, gillnet and longlines combined			
Year:	**2020**	**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	660	0	641	0.002	650
2	11	1599	2	1322	13	1473
3	15	1643	3	1661	17	1651
4	686	2229	88	2047	774	2147
5	15	3639	4	3366	19	3502
6	6	5115	2	4889	8	5002
7	1	6569	0.2	6165	2	6367
8	0.1	6852	0	7394	0.1	7123
9	0	10209	0	10209	0.07	10209
SOP [t]	1248		153		1406	
Landings (t)	1235		150		1385	
Year:	**2020**	**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	0.002	657	0	660	0.002	658
2	1	1429	7	1392	8	1412
3	3	2229	3	1750	6	2055
4	73	2617	64	2202	137	2466
5	5	3928	1	3423	6	3744
6	2	5417	2	4673	4	5147
7	0.2	6394	0.1	5711	0.3	6146
8	1	7438	0.1	6491	1	7094
9	0	10209	0	10209	0.1	10209
SOP [t]	242		127		369	
Landings (t)	239		124		363	
Year:	**2020**	**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	660	1.4	636	1.4	643
2	5	1265	8	1259	12	1262
3	1.3	2566	2	1956	4	2261
4	35	3045	44	2173	80	2649
5	0.9	4789	1.2	3194	2	3992
6	0.2	4272	0.6	4330	0.7	4304
7	0.05	7069	0.05	5157	0.1	6007
8	0.2	7504	0.5	6991	0.7	7248
9	0	10209	0	10209	0.03	10209
SOP [t]	121		96		218	
Landings (t)	120		94		215	

continued

Table 2.32. 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 2020. 2/2

Year:	2020 Quarter:	4				
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weights [g]
1	22	616	12	687	34	656
2	40	1941	21	1286	62	1650
3	4	2691	1,4	2075	6	2427
4	212	2581	56	2089	268	2362
5	6	3874	2	2390	8	3214
6	0,4	3719	0,3	4056	0,7	3943
7	0,1	7549	0,1	3580	0,2	5281
8	0,1	6810	0	5759	0,1	6389
9	0	10209	0	10209	0,1	10209
SOP [t]	558		143		703	
Landings (t)	552		140		692	

Year:	2020 Quarter:	All				
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weights [g]
1	22	646	14	656	36	651
2	57	1575	38	1312	95	1451
3	23	2230	10	1842	33	2060
4	1007	2620	252	2126	1259	2408
5	27	4046	8	3114	35	3626
6	9	4890	4	4501	13	4695
7	2	6765	0,4	5210	2	6008
8	1	7233	0,6	6801	2	7042
9	0	10209	0,02	10209	0,2	10209
SOP [t]	2168		519		2695	
Landings (t)	2147		508		2655	

Table 2.33. Western Baltic Cod. Overview of the recreational total catch data (tons) used in stock assessment

CATON	SD 22	SD23	SD24
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

CATON	SD 22	SD23	SD24
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 2.34. 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		Same as in SD 22

	from self-sampling during fishing competitions (land-based)		
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 2.35. Western Baltic cod. Percentage of western cod in Area 1 (W: western part of SD 24, 12– 13 degrees longitude) and Area 2 (E: eastern part of SD 24, from 13 -15 degrees longitude); and weighted average of those percentages applied to extract the WB cod landings in SD 24.

year	Area 1 _ W	Area 2 E	Percent WBC in landings for SD 24
1985	65	56	58
1986	65	46	52
1987	65	50	54
1988	65	50	53
1989	65	50	52
1990	65	50	52
1991	65	50	52
1992	65	54	57
1993	65	41	46
1994	65	47	51

year	Area 1 _ W	Area 2 E	Percent WBC in landings for SD 24
1995	65	57	60
1996	66	49	57
1997	69	60	66
1998	72	71	71
1999	72	60	66
2000	71	49	60
2001	65	48	57
2002	63	45	54
2003	62	43	52
2004	61	40	49
2005	63	50	54
2006	54	35	44
2007	54	35	41
2008	46	20	27
2009	52	23	27
2010	57	26	33
2011	51	15	22
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
2020	93	35	36

Table 2.36. Western Baltic cod. Management regulations effecting the western Baltic cod stock in relations area closures and bag limits in the recreational fishery.

Year	Area (SD)	Time period	restricted distance from coast	Regulation	Baglimits (recreational fishery)	restricted depth
2016	22-24	15.02.-31.03. 1.5 months		2015/2072 17. Nov. 2015	No bag limit	
2017	22-24	01.02.-31.03. 2 months		2016/1903 28. Oct. 2016	5 cod/day 3 cod/day (1/2-31/3)	
2018	22-24	01.02.-31.03. 2 months		2017/1970 27. Oct. 2017	5 cod/day 3 cod/day (1/2-31/3)	
2019	22-24	No clouser		2018/1628 30. Oct. 2018	7 cod/day	
2020	22-23	01.02.-31.03. 2 months		2019/1838 30. Oct. 2019	5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
	24	entire year 12 months	not further than 6 nm		5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
2021	22-23	01.02.-31.03. 2 months		2020/1579 29. Oct. 2020	5 cod / day in time period 01.02-31.03 2 cod / day	
	24	entire year 12 months	not further than 6 nm			not deeper 20 m

Table 2.37. 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

age	a1	a2	a3	a4	a5	a6	a7+
1993	2	10171	3718	727	79	5	33
1994	669	3741	11158	1685	61	14	12
1995	676	10765	4638	5317	1141	123	3
1996	96	23597	17390	721	2068	108	2
1997	1831	2000	28844	2563	322	325	77
1998	2413	18597	2129	5721	654	105	76
1999	661	23558	12559	1602	1219	245	92
2000	813	6484	20538	3078	127	245	47
2001	1503	11121	7013	5111	841	49	95
2002	450	8615	8716	1659	923	269	18
2003	647	10092	4525	1303	230	190	65
2004	65	1519	8842	1923	340	123	84
2005	293	9153	1810	3256	374	99	53
2006	260	1575	11186	527	586	79	15
2007	58	3372	2657	3697	419	223	34
2008	20	597	2585	942	867	256	127
2009	179	453	1540	1007	521	189	83
2010	196	3503	1064	634	448	139	56
2011	70	848	3377	1268	285	81	40
2012	112	1300	1264	1919	523	60	14
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
2020	38	101	36	1373	38	14	4

Table 2.38. Western Baltic cod. Discard (in numbers (000)) by year and age for the for the western Baltic cod stock.

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

age	a1	a2	a3	a4	a5	a6	a7+
2013	903	666	500	469	52	0	0
2014	667	1592	48	7	0	0	0
2015	220	829	303	23	0	0	0
2016	40	282	50	1	0	0	0
2017	451	99	54	12	1	0	0
2018	10	563	7	3	3	0	0
2019	213	38	1345	10	1	0	0
2020	173	68	4	40	1	1	0

Table 2.39. 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	413	703	681	260	64	21	9
1986	400	830	669	244	46	14	3
1987	333	736	672	238	76	30	10
1988	335	752	673	269	52	11	2
1989	367	671	682	334	65	16	5
1990	337	708	665	251	114	14	7
1991	351	902	640	171	29	5	1
1992	486	600	968	166	32	10	1
1993	432	1011	599	321	87	5	1
1994	561	970	1197	126	45	6	1
1995	566	1463	900	415	39	8	1
1996	347	1637	928	359	78	7	2
1997	857	836	1291	290	50	9	1
1998	609	1522	685	500	55	7	2
1999	278	1583	928	308	101	9	2
2000	573	1250	1043	405	79	13	2
2001	445	1382	773	505	77	19	4
2002	780	1199	983	214	128	21	1

age	a1	a2	a3	a4	a5	a6	a7+
2003	243	1785	822	280	37	6	1
2004	758	1230	1106	236	39	6	1
2005	107	2671	549	517	20	3	1
2006	366	638	1520	78	55	3	0
2007	145	1427	492	465	21	10	1
2008	39	603	1040	361	112	8	1
2009	381	1744	619	312	52	31	7
2010	299	2076	472	236	121	26	9
2011	218	869	1247	81	21	7	4
2012	284	1160	799	793	56	13	0
2013	517	1465	985	196	103	7	2
2014	376	2079	1125	442	65	24	7
2015	184	1651	1882	223	74	16	7
2016	159	1223	1061	531	103	13	3
2017	425	324	591	145	49	6	2
2018	64	1498	110	148	28	7	1
2019	109	41	2325	25	48	6	2
2020	151	233	40	863	17	4	1

Table 2.40. 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	5703	9638	14816	3069	691	241	135
1986	11008	7489	4944	3095	486	184	80
1987	3092	29531	3893	1143	524	110	62
1988	2866	7320	11987	1184	258	152	64
1989	1311	2031	4305	2711	275	74	51
1990	1823	4178	2242	1633	803	94	50
1991	4569	7913	2636	614	296	227	65
1992	13556	9405	3577	640	126	83	72

age	a1	a2	a3	a4	a5	a6	a7+
1993	1724	15008	4488	1052	166	10	33
1994	3193	6584	13038	1821	105	20	13
1995	3381	18047	5845	5768	1180	132	4
1996	23060	27642	18328	1079	2146	114	4
1997	17895	2836	30135	2853	372	333	78
1998	20027	22827	2935	6221	710	112	78
1999	3601	34143	13789	1910	1319	254	94
2000	4065	12123	24066	3484	206	258	49
2001	3929	16966	8091	5664	918	67	98
2002	2741	12056	9916	1888	1051	291	18
2003	1955	19464	5761	1596	267	196	66
2004	3062	3613	12318	2158	379	129	85
2005	1368	19465	2403	3773	393	102	54
2006	1498	4846	13469	648	644	82	16
2007	480	7265	3653	4201	446	233	34
2008	131	1743	3818	1307	979	264	128
2009	758	2697	2344	1332	573	221	90
2010	720	6521	2025	1182	577	165	65
2011	476	1861	4801	1554	312	88	45
2012	761	2770	2238	2836	581	73	14
2013	1705	2729	3204	1467	890	318	70
2014	1085	6328	2250	1268	203	168	31
2015	577	3423	5202	622	301	50	68
2016	200	2380	2482	1559	243	68	37
2017	991	554	1498	606	327	59	32
2018	74	3326	262	492	174	87	24
2019	328	108	7896	183	191	41	19
2020	362	402	80	2276	57	19	5

Table 2.41. Western Baltic cod. Mean weight-at-age in commercial landings.

age	a1	a2	a3	a4	a5	a6	a7+
1985	0.456	0.744	1.159	2.113	3.605	5.768	8.812
1986	0.457	0.747	1.160	2.102	3.578	5.714	8.131
1987	0.462	0.756	1.162	2.075	3.512	5.581	8.128
1988	0.461	0.756	1.162	2.077	3.516	5.590	8.191
1989	0.462	0.757	1.162	2.071	3.502	5.561	7.982
1990	0.463	0.759	1.163	2.065	3.487	5.532	8.181
1991	0.468	0.770	1.165	2.033	3.409	5.374	7.508
1992	0.471	0.776	1.167	2.015	3.366	5.287	7.379
1993	0.464	0.762	1.163	2.057	3.468	5.492	7.627
1994	0.445	0.834	1.367	2.378	4.491	6.436	5.045
1995	0.398	0.792	1.215	2.112	3.643	6.064	10.446
1996	0.442	0.685	1.086	2.091	2.879	5.544	8.371
1997	0.503	0.753	0.993	1.685	2.195	4.043	6.407
1998	0.524	0.737	1.155	1.915	2.960	3.940	6.444
1999	0.528	0.666	1.133	1.405	3.141	3.920	4.978
2000	0.509	0.707	0.957	1.655	3.479	5.174	7.303
2001	0.519	0.688	1.082	1.756	3.181	5.090	7.026
2002	0.512	0.716	1.124	1.701	3.386	4.079	6.586
2003	0.593	0.810	1.092	2.002	3.679	5.162	7.224
2004	0.517	0.776	1.008	1.487	3.376	4.179	6.132
2005	0.599	0.738	1.270	2.207	3.362	4.875	6.874
2006	0.217	0.625	1.086	2.485	3.674	4.205	5.725
2007	0.412	0.862	1.186	2.093	3.185	4.747	6.423
2008	0.437	0.906	1.347	2.187	3.234	4.352	6.953
2009	0.768	0.702	1.158	1.794	3.120	4.979	4.986
2010	0.807	0.944	1.111	1.805	2.924	3.384	4.305
2011	0.955	1.212	1.292	1.382	1.905	2.551	2.117
2012	0.902	0.976	1.189	2.000	2.610	2.506	3.504

age	a1	a2	a3	a4	a5	a6	a7+
2013	0.832	1.035	1.288	1.843	2.517	3.301	3.534
2014	0.859	0.988	1.467	2.793	3.857	5.577	5.453
2015	0.625	0.807	1.585	2.601	4.759	4.507	6.926
2016	0.710	1.027	1.239	2.488	3.273	4.947	6.306
2017	0.796	1.059	1.423	2.265	3.650	4.274	5.478
2018	0.550	1.015	1.870	2.702	3.674	4.937	6.050
2019	0.588	0.816	1.202	2.598	3.271	4.033	6.386
2020	0.631	1.019	1.640	1.852	3.319	4.283	6.897

Table 2.42. 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
2020	0.282	0.488	1.279	1.576	2.505

Table 2.43. 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	0.648	1.127	2.078	3.500	5.562	8.491
1986	0.319	0.662	1.138	2.070	3.475	5.516	7.991
1987	0.321	0.666	1.124	1.989	3.308	4.852	7.423
1988	0.328	0.683	1.139	2.004	3.324	5.410	8.100
1989	0.303	0.703	1.125	2.012	3.237	5.067	7.661
1990	0.326	0.699	1.117	2.001	3.270	5.166	7.593
1991	0.326	0.687	1.170	2.013	3.369	5.343	7.491
1992	0.333	0.683	1.143	2.017	3.340	5.097	7.365

age	a1	a2	a3	a4	a5	a6	a7+
1993	0.340	0.678	1.154	1.947	2.749	4.659	7.589
1994	0.328	0.699	1.318	2.384	3.897	5.782	5.147
1995	0.291	0.665	1.174	2.091	3.634	5.928	9.171
1996	0.261	0.664	1.096	1.985	2.872	5.451	6.462
1997	0.294	0.761	1.005	1.702	2.302	4.036	6.400
1998	0.294	0.705	1.139	1.907	2.935	3.952	6.418
1999	0.308	0.601	1.128	1.472	3.085	3.901	4.975
2000	0.314	0.600	0.927	1.669	3.059	5.070	7.206
2001	0.371	0.620	1.083	1.741	3.131	4.260	6.900
2002	0.339	0.672	1.127	1.726	3.281	3.942	6.588
2003	0.373	0.647	1.101	1.977	3.654	5.135	7.218
2004	0.287	0.710	0.948	1.547	3.359	4.176	6.128
2005	0.325	0.607	1.268	2.133	3.348	4.877	6.868
2006	0.305	0.526	1.072	2.318	3.556	4.211	5.729
2007	0.357	0.693	1.108	2.038	3.146	4.687	6.439
2008	0.413	0.802	1.308	2.081	3.135	4.324	6.926
2009	0.422	0.471	1.165	1.847	3.119	4.683	4.798
2010	0.516	0.804	1.043	1.545	2.789	3.347	4.628
2011	0.429	0.965	1.247	1.306	1.949	2.594	2.361
2012	0.410	0.820	1.183	1.864	2.670	2.559	3.555
2013	0.385	0.744	1.152	1.395	2.333	3.288	3.513
2014	0.332	0.759	1.308	2.409	3.305	5.143	4.681
2015	0.338	0.666	1.424	2.370	4.285	3.838	6.535
2016	0.483	0.835	1.202	2.218	2.814	4.490	6.149
2017	0.280	0.713	1.257	2.097	3.429	4.118	5.434
2018	0.145	0.759	1.679	2.390	3.441	4.790	5.961
2019	0.262	0.567	1.010	2.383	3.158	3.927	6.034
2020	0.353	0.693	1.277	1.593	2.736	3.946	6.558

Table 2.44. 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	2.078	3.500	5.562	8.491
1986	0.005	0.063	0.301	0.874	2.070	3.475	5.516	7.991
1987	0.005	0.063	0.301	0.874	1.989	3.308	4.852	7.423
1988	0.005	0.063	0.301	0.874	2.004	3.324	5.410	8.100
1989	0.005	0.063	0.301	0.874	2.012	3.237	5.067	7.661
1990	0.005	0.063	0.301	0.874	2.001	3.270	5.166	7.593
1991	0.005	0.063	0.301	0.874	2.013	3.369	5.343	7.491
1992	0.005	0.063	0.301	0.874	2.017	3.340	5.097	7.365
1993	0.005	0.063	0.301	0.874	1.947	2.749	4.659	7.589
1994	0.005	0.063	0.301	0.874	2.384	3.897	5.782	5.147
1995	0.005	0.063	0.301	0.874	2.091	3.634	5.928	9.171
1996	0.005	0.057	0.259	0.990	1.985	2.872	5.451	6.462
1997	0.005	0.050	0.327	0.896	1.702	2.302	4.036	6.400
1998	0.005	0.081	0.316	0.735	1.907	2.935	3.952	6.418
1999	0.005	0.042	0.285	0.801	1.472	3.085	3.901	4.975
2000	0.005	0.059	0.234	0.801	1.669	3.059	5.070	7.206
2001	0.005	0.043	0.388	0.895	1.741	3.131	4.260	6.900
2002	0.005	0.043	0.433	1.117	1.726	3.281	3.942	6.588
2003	0.005	0.054	0.321	1.032	1.977	3.654	5.135	7.218
2004	0.005	0.067	0.536	0.870	1.547	3.359	4.176	6.128
2005	0.005	0.051	0.350	1.038	2.133	3.348	4.877	6.868
2006	0.005	0.043	0.310	0.795	2.318	3.556	4.211	5.729
2007	0.005	0.073	0.411	0.908	2.038	3.146	4.687	6.439
2008	0.005	0.043	0.465	1.019	2.081	3.135	4.324	6.926
2009	0.005	0.051	0.559	1.327	1.847	3.119	4.683	4.798
2010	0.005	0.066	0.369	1.082	1.545	2.789	3.347	4.628
2011	0.005	0.045	0.360	0.767	1.306	1.949	2.594	2.361
2012	0.005	0.050	0.301	0.882	1.864	2.670	2.559	3.555

age	a0	a1	a2	a3	a4	a5	a6	a7+
2013	0.005	0.049	0.391	0.866	1.395	2.333	3.288	3.513
2014	0.005	0.039	0.345	0.965	2.409	3.305	5.143	4.681
2015	0.005	0.057	0.415	0.891	2.370	4.285	3.838	6.535
2016	0.005	0.045	0.357	0.695	2.218	2.814	4.490	6.149
2017	0.005	0.043	0.241	1.033	2.097	3.429	4.118	5.434
2018	0.005	0.074	0.327	0.948	2.390	3.441	4.790	5.961
2019	0.005	0.050	0.487	0.892	2.383	3.158	3.927	6.034
2020	0.005	0.046	0.324	0.958	1.593	2.736	3.946	6.558

Table 2.45. 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	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1986	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1987	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1988	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1989	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1990	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1991	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1992	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1993	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1994	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1995	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1996	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1997	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1998	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1999	0.03	0.34	0.77	0.72	1.0	1.0	1.0
2000	0.03	0.34	0.77	0.72	1.0	1.0	1.0
2001	0.02	0.39	0.76	0.73	1.0	1.0	1.0
2002	0.02	0.41	0.76	0.72	1.0	1.0	1.0

age	a1	a2	a3	a4	a5	a6	a7+
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	0.67	0.89	0.89	1.0	1.0	1.0
2017	0.05	0.60	0.88	0.90	1.0	1.0	1.0
2018	0.15	0.65	0.89	0.87	1.0	1.0	1.0
2019	0.14	0.72	0.91	0.90	1.0	1.0	1.0
2020	0.15	0.74	0.91	0.88	1.0	1.0	1.0
2021*	0.14	0.70	0.90	0.89	1.0	1.0	1.0

*** 3 year mean**

Table 2.46. Western Baltic cod. Natural mortality at age.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1985	0.8	0.32	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.8	0.261	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.8	0.259	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.8	0.274	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.8	0.263	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.8	0.25	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.8	0.235	0.2	0.2	0.2	0.2	0.2	0.2

age	a0	a1	a2	a3	a4	a5	a6	a7+
1992	0.8	0.228	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.8	0.245	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.8	0.266	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1997-2020	0.8	0.242	0.2	0.2	0.2	0.2	0.2	0.2

Table 2.47. Western Baltic cod. Tuning fleets BITS Q4, Q1 and pound net survey FEJUCS.

BITS Q1	a1	a2	a3	a4
1996	12366	108263	12770	220
1997	12173	2440	11211	461
1998	26713	7327	548	487
1999	7191	13034	2371	57
2000	10572	5810	6234	1067
2001	4574	4499	835	455
2002	11387	2717	1259	89
2003	970	3919	375	124
2004	9876	1445	1576	49
2005	8967	28996	863	484
2006	13078	5368	4826	98
2007	2532	8178	1517	1009
2008	111	902	750	209
2009	8512	612	584	197
2010	3164	9222	255	104
2011	12032	6783	8838	35
2012	2087	2977	1085	767
2013	7869	2600	1544	174
2014	4796	4117	413	149
2015	3175	4423	1267	106

BITS Q1	a1	a2	a3	a4
2016	85	772	359	342
2017	17806	318	681	229
2018	426	20430	227	446
2019	396	1336	5999	119
2020	2523	942	311	1504
2021	7698	2356	387	17

BITS Q4	a0	a1	a2	a3	a4
1999	11191	4359	3307	556	26
2000	3724	2383	989	430	27
2001	13893	540	452	135	85
2002	1472	1343	337	261	15
2003	14815	863	860	109	44
2004	5174	7680	944	401	32
2005	4262	1681	1578	153	74
2006	2434	2572	344	963	81
2007	465	281	190	246	301
2008	20473	36	62	120	75
2009	2898	1652	69	160	23
2010	10161	617	588	42	12
2011	3590	1182	129	267	7
2012	16474	1121	427	145	53
2013	7276	2668	213	130	25
2014	5870	1176	833	209	62
2015	456	602	335	466	69
2016	41902	194	101	59	101
2017	407	9504	104	229	62
2018	1947	657	518	30	66
2019	4878	568	15	173	6

BITS Q4	a0	a1	a2	a3	a4
2020	6631	1024	50	34	128

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

FEJUCS	a0
2011	20.7
2012	NA
2013	16.8
2014	25.5
2015	14.3
2016	169.8
2017	0.3
2018	2.2
2019	4.1
2020	2.1

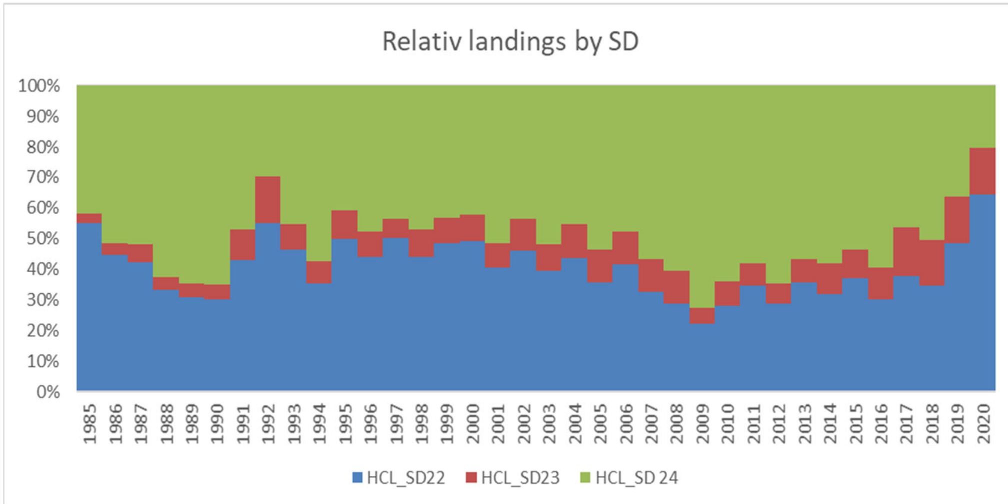


Figure 2.35. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

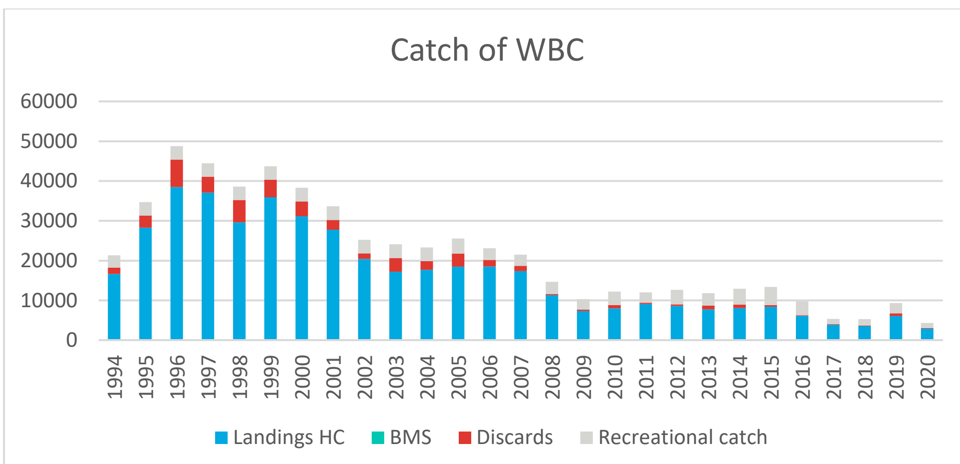


Figure 2.36. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

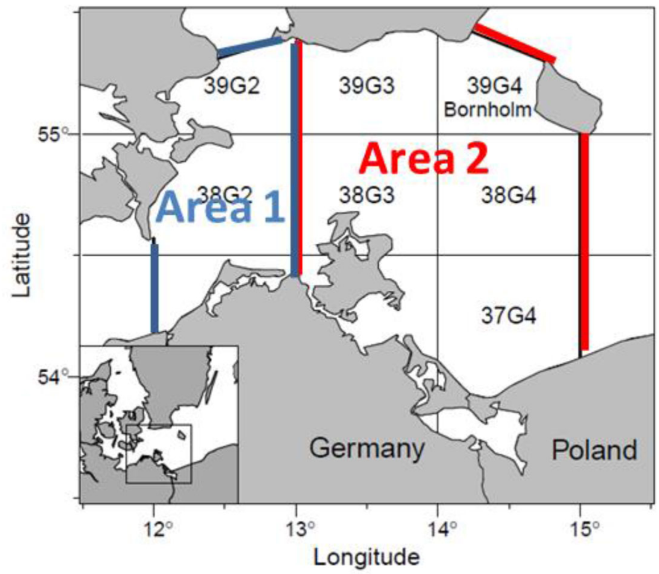


Figure 2.37. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

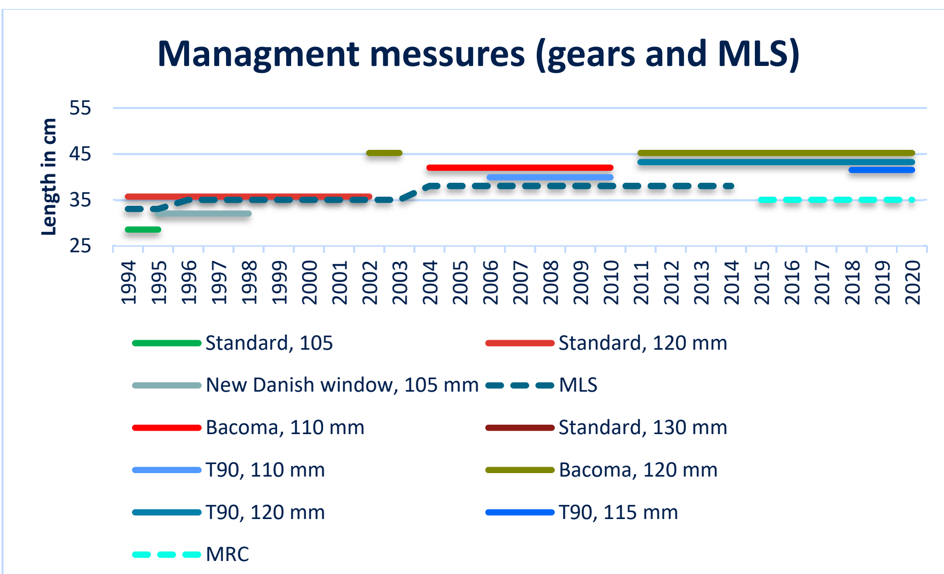


Figure 2.38. Western Baltic cod. Management measures for gear and minimum landing size, since 1994.

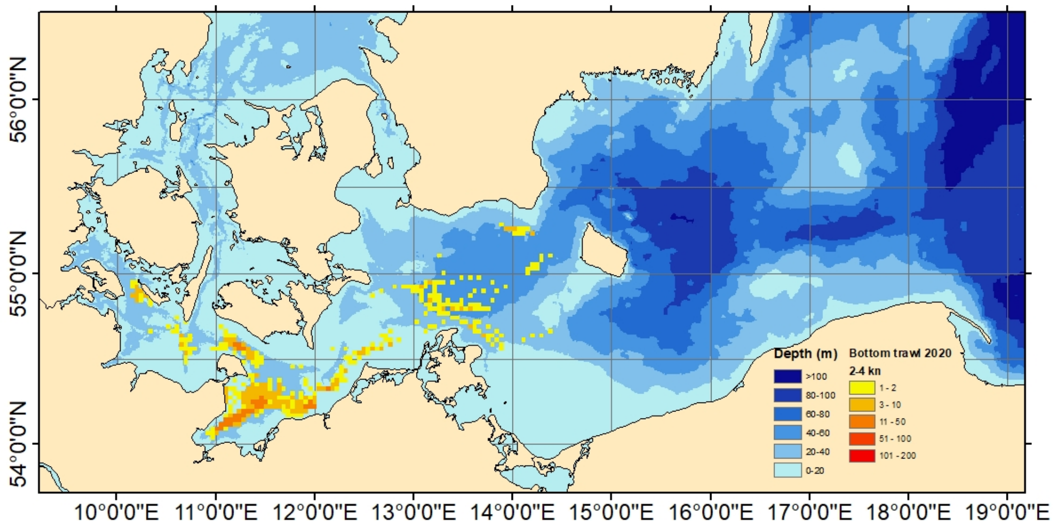


Figure 2.39. Danish VMS data from 2020 from OTB.

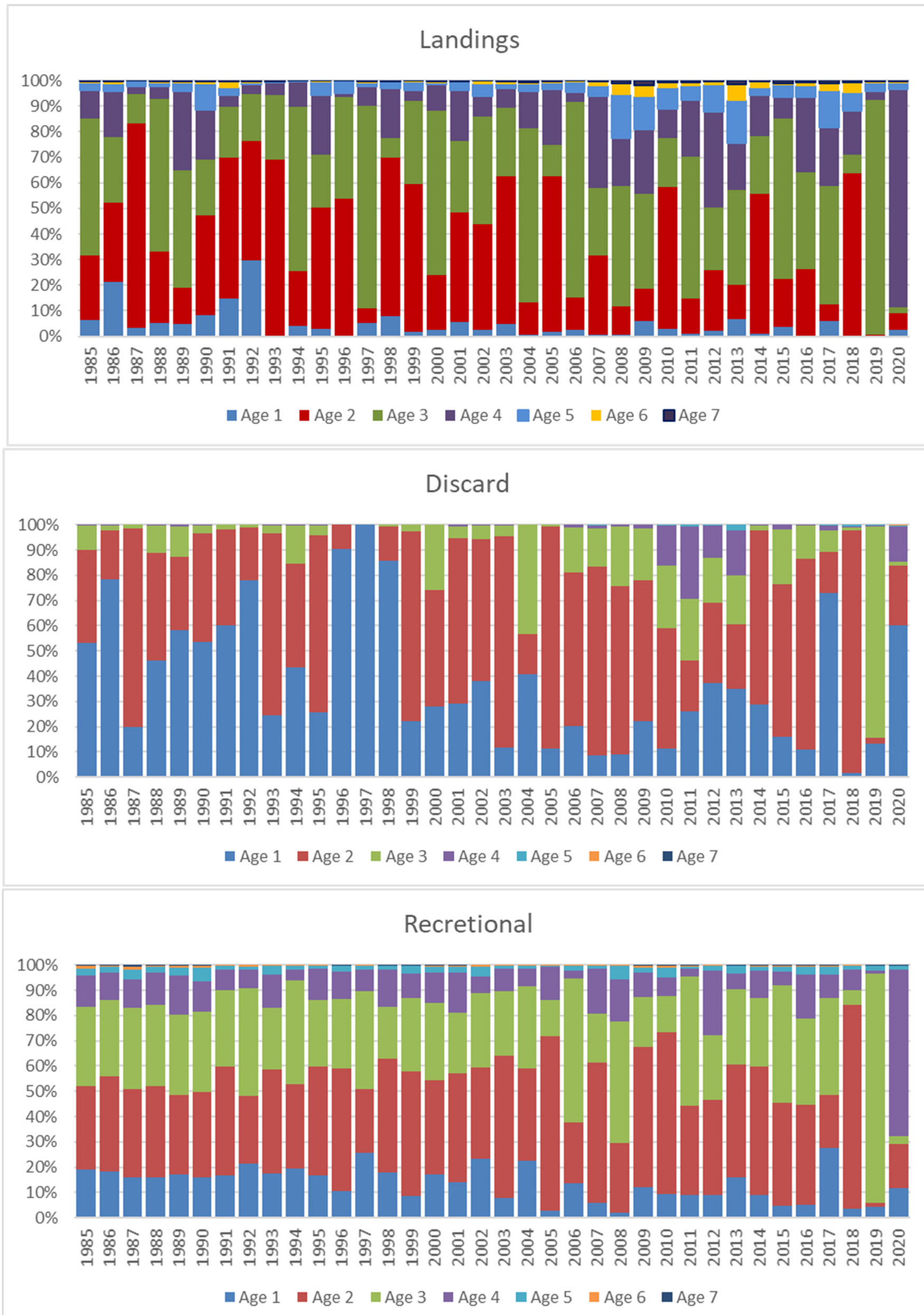


Figure 2.40. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

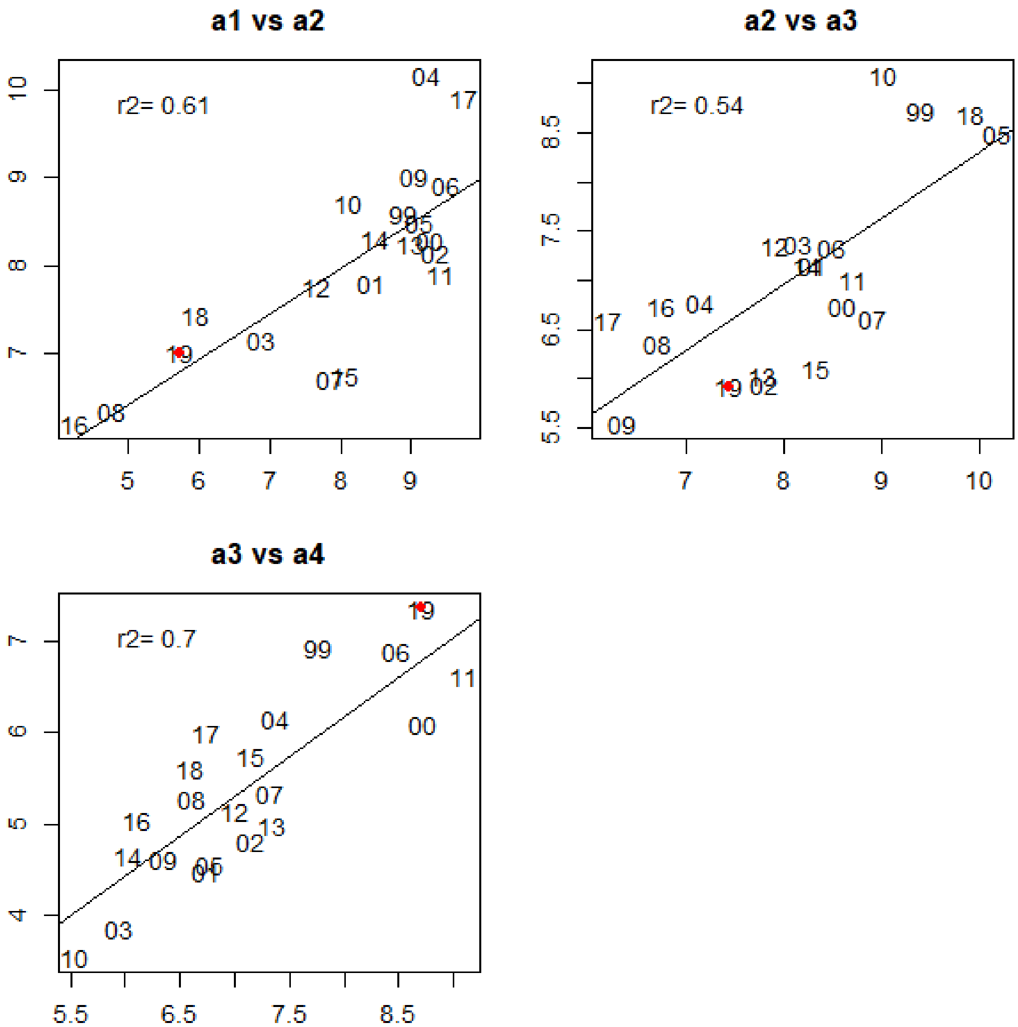


Figure 2.41a. Western Baltic cod. Last year's data before the survey data was updated. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

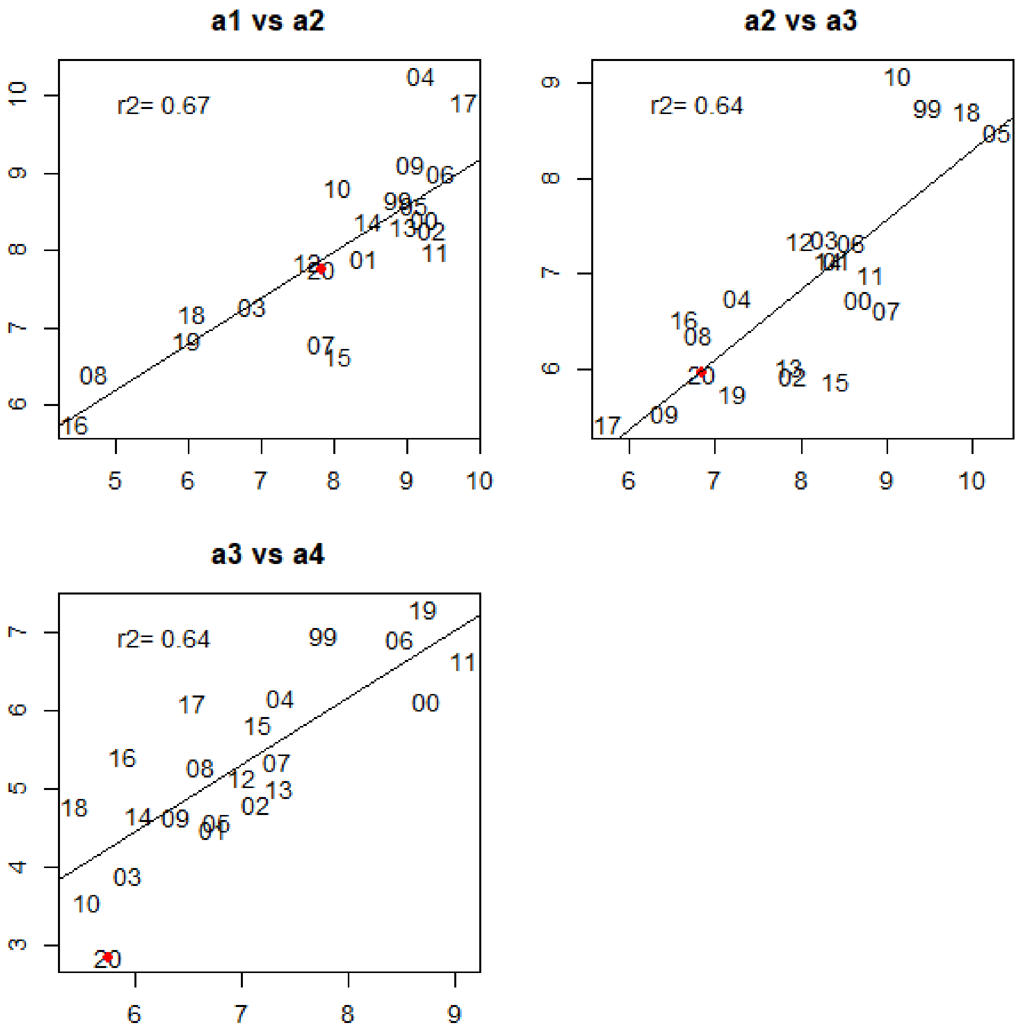


Figure 2.41b. Western Baltic cod. Updated CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

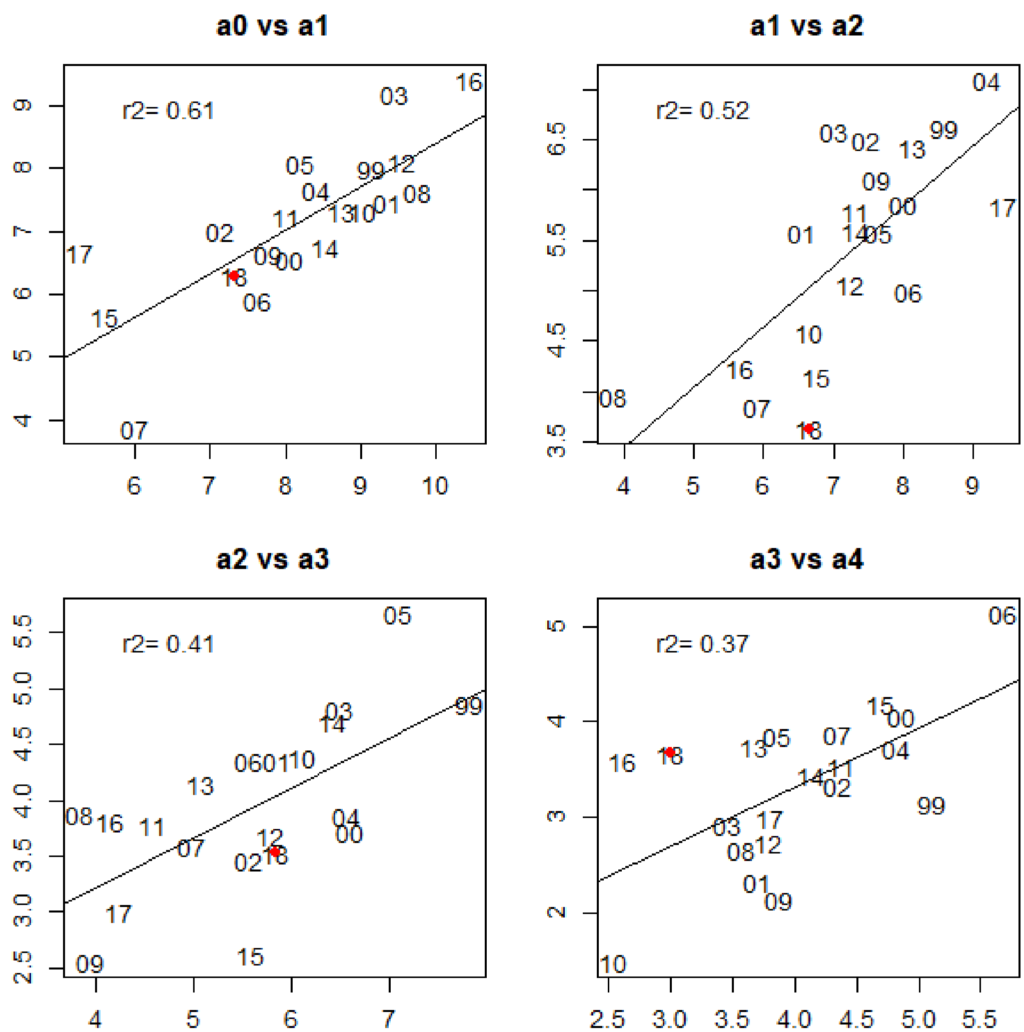


Figure 2.41c. Western Baltic cod. Last year's data before the survey data was updated. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

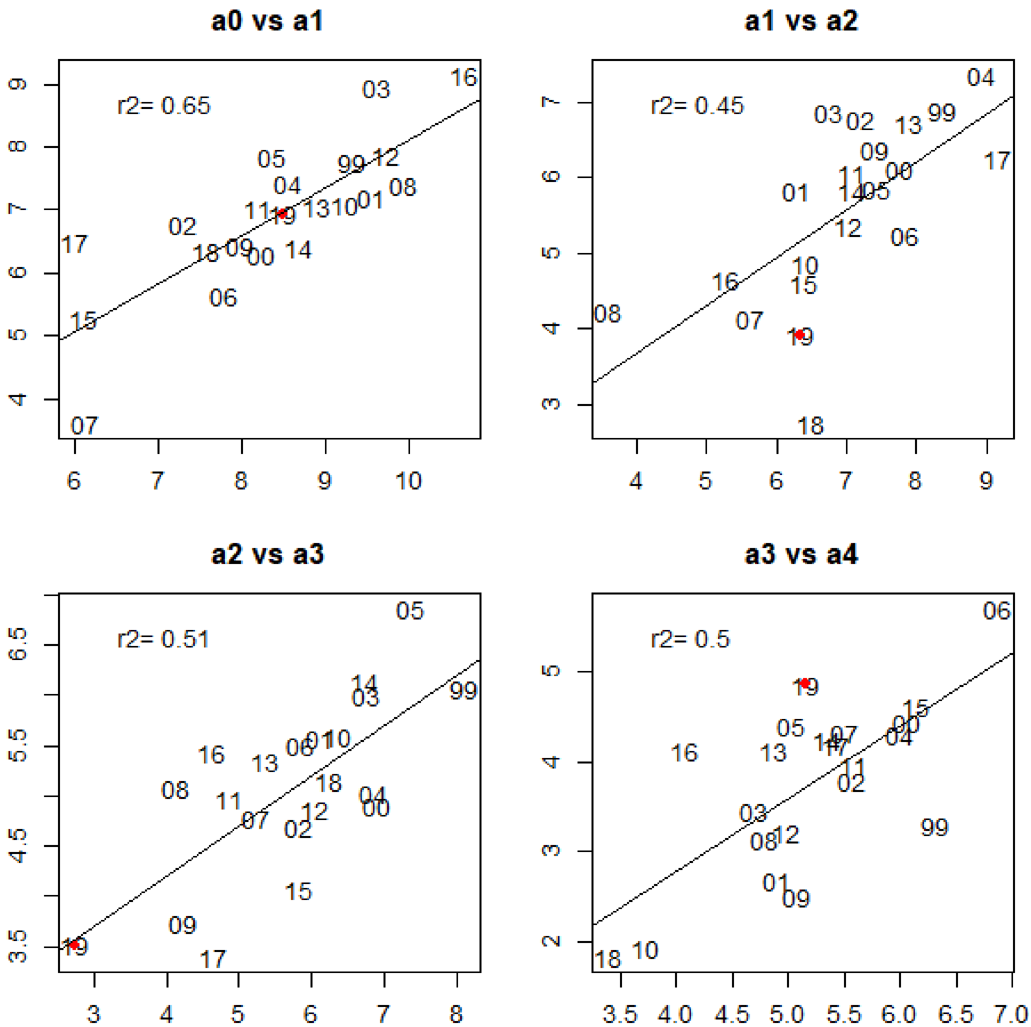


Figure 2.41d. Western Baltic cod. Western Baltic cod. Updated CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

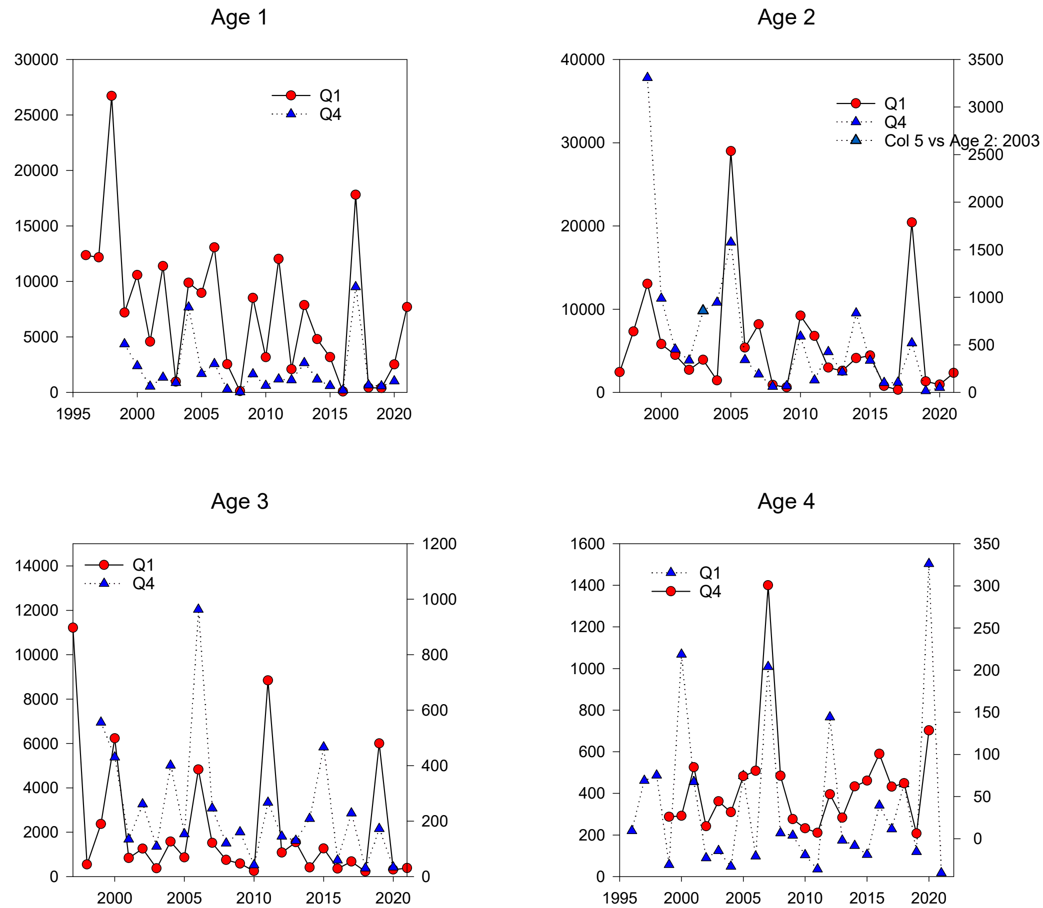


Figure 2.42. Western Baltic cod. Time-series of BITS Q1 and BITS Q4 in numbers by age groups.

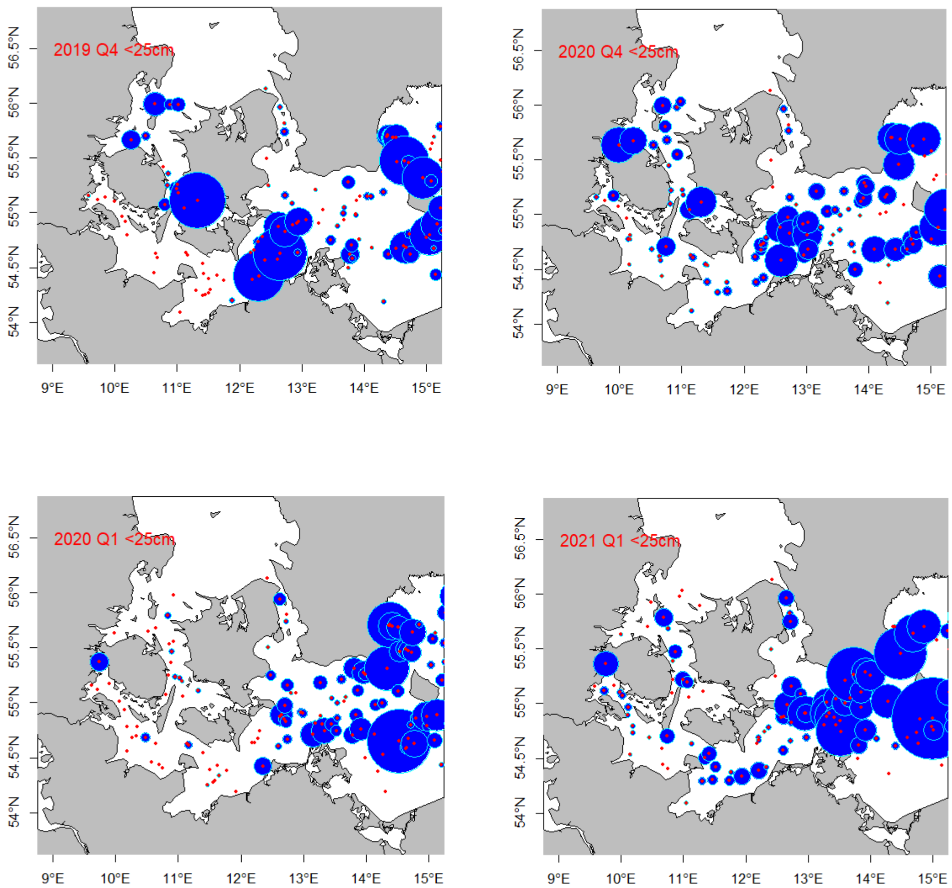


Figure 2.43. Western Baltic cod. Abundance of cod below 25 cm from BITS Q1 and Q4.

3 Flounder in the Baltic

3.1 Introduction

3.1.1 Stock identification

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

There are significant disparities between two sympatric flounder populations (since 2018 considered as two separate species) in the Baltic Sea, the pelagic, and the demersal spawners. They differ in their spawning habitat, egg characteristics (Nissling *et al.*, 2002; Nissling and Dahlman, 2010), and genetics (Florin and Höglund, 2008; Hemmer-Hansen *et al.*, 2007a), although they utilize the same feeding grounds in summer - autumn (Nissling and Dahlman, 2010).

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

Pelagic spawners are distributed in the southern and the deeper eastern part of the Baltic Sea and spawn at 70–130 m depth. The activation of their spermatozoa and 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 SD23, flounder in these areas are assumed to be connected through the western part of SD 24.

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

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

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

Table 3.1. Proportion of pelagic ecotypes per SD.

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

3.1.2 WKBALFLAT – Benchmark

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

3.1.3 Discard

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

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

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

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

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

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

3.1.4 Tuning fleet

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

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

3.1.5 Effort

Time-series from 2009–2020 was available from ICES WGBFAS data call where countries submitted flatfish effort data by fishing fleet and subdivision. Effort data were asked to report as days at sea. However, different calculation methods were used by countries. Some countries reported all of fishing days when flounder were landed, some countries reported number of fishing days were significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet. It was discussed than in the future more specific description about methodology should be given.

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

3.1.6 Biological data

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

3.1.7 Survival rate

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

3.1.8 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Where available, commercial landings were used to estimate length distribution and average weight by length groups The alternative was to use survey length distribution data. Biological parameters: L_{∞} and L_{mat} were calculated using survey data from DATRAS with the exception of the Northern flounder stock. For estimating L_{∞} data from Q1 and Q4 were taken unsorted by sex. In the case of L_{mat} data was derived from only from Q1 and females, as distinguishing between mature and immature fish were possible only for this time of the year.

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

3.2.1 The Fishery

The landing data of flounder in the Western Baltic (fle.27.2223) according to ICES subdivisions and countries are presented in Table 3.2. The trend and the amount of the landings from this flatfish stock are shown in Figure 3.1.

Flounder is mainly caught in the area of the Belt Sea (SD 22). The Sound (SD 23) is of minor importance for the contribution to the total landings (Table 3.3). Denmark and Sweden are the main fishing countries in the both areas.

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. 63%), whereas landings from passive gears are low. However, in SD 23, passive gears provide around 85% of total flounder landings (for the Swedish fleet 98–100%) in this area. Flounder is mostly caught as a bycatch-species in cod targeting fisheries (i.e. mostly trawlers) and in a mixed flatfish fishery (i.e. mostly gillnetters).

3.2.2 Landings

The highest total landings of flounder in subdivisions 22 and 23 were observed at the end of the seventies (3790 t in 1978). Landings decreased in the period between 1989 and 1993. Since 1993 the landings increased again and reached a moderate maximum in 2000 (2597 t). After 2000 the landings decreased to 866 t in 2006. Landings slightly increased since 2006 and vary between 1400 and 1000 tonnes since then. Landings in 2020 were at about 775 tonnes (Table 3.3).

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 from the respective countries. The recreational fishery on flounder takes place, but removals are considered to be minor and not taken into account in the catches.

3.2.2.2 Discards

Discards of flounder are known to vary greatly (Figure 3.2). It can be with around 20–50% of the total catch of vessels using active gears (e.g. trawling). Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market prices, quality and quota of target species (e.g. cod), discards vary between hauls, trips, vessels, areas, quarters and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

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

Subdivision 22 (the Belt) shows a relatively good sampling coverage that allows reasonable discard estimations at least for the last four years. Subdivision 23 (Sound) is sampled less; only a few biological samples are available. However, discard estimations provided by national data submitters are given in many strata. Sampling intensity has increased steadily in the last years; therefore less discard ratio were borrowed. Table 3.4 gives an overview of total landings and the estimated discard weights and empty strata. Before 2006, sampling intensity was too low to give a reasonable estimation, especially in the passive segment, where almost no data were available. The discards in 2020 are estimated to be around 121 tonnes, which would result in a discard ratio of 14% of the total catch, which is slightly lower than in the previous three years, where about 18% of the total catch was discarded (Figure 3.2).

3.2.3 Fishery independent information

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

Average number of flounder ≥20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. These are multiplied with the average weight of the length-class (Figures 3.4 and 3.5).

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

3.2.4 Assessment

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

The update on the stock status is based on the data-limited approach of ICES. The "advice based on landings" has been changed to "advice based on catch" in 2016 and was based on estimated discards of the respective last three years. The intermediate stock status update for 2020 was also a catch advice. The mean biomass index of 2019 and 2020 was 27% lower than the mean of the biomass index from 2016–2018 (Figure 3.5). The length-based indicators are suggesting a good status of the stock. A precautionary buffer was applied the last time in 2014. Length-based indicators are used to assess the stock status in terms of over-exploitation of immatures and/or large individuals following the guidelines provided by WKLIFE V (2015). The 3-year average (2018–2020) absolute value of $L_{F=M}$ was used as a F_{MSY} Proxy.

3.2.5 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (2015). CANUM and WECA of commercial catches from 2014–2020 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

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

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.5).

The results of LBI show that the stock status of fle.27.2223 is above possible reference points, for most of the variables (Table 3.6). However, $L_{max5\%}$ is at the lower limit of 0.80 in 2020, some truncation in the length distribution in the catches might take place. Compared to last year's data, higher amounts of mega spawners occur, P_{mega} accounts for 36% of the catch and is therefore above the optimum of >0.3. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield. Exploitation consistent with F_{MSY} proxy (LF=M) (Figure 3.3).

Table 3.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by country and sub-division.

Year/SD	Denmark		Germ. Dem. Rep.	Germany, FRG	Sweden	
	22	23	22	22	22	23
1970						
1971						
1972						
1973	1983		181	349		
1974	2097		165	304		
1975	1992		163	469		
1976	2038		174	392		
1977	1974		555	393		
1978	2965		348	477		
1979	2451		189	259		
1980	2185		138	212		
1981	1964		271	351		
1982	1563	104	263	248		
1983	1714	115	280	418		
1984	1733	85	349	371		
1985	1561	130	236	199		
1986	1525	65	127	125		
1987	1208	122	71	114		
1988	1162	125	92	133		
1989	1321	83	126	122		
1990	941		52	183		
1991	925			246		
1992	713	185		227		
1993	649	194		235		26
1994	882	181		44		84
1995	859	231		286		58
1996	1041	227		189	2	58

Year/SD	Denmark		Germ. Dem. Rep.	Germany, FRG	Sweden	
	22	23	22	22	22	23
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
2020	377	36		350	0	12

Table 3.3. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by subdivision.

Year	Total by SD		Total
	22	23	SD 22-23
1973	2513	0	2513
1974	2566	0	2566
1975	2624	0	2624
1976	2604	0	2604
1977	2922	0	2922
1978	3790	0	3790
1979	2899	0	2899
1980	2535	0	2535
1981	2586	0	2586
1982	2074	104	2178
1983	2412	115	2527
1984	2453	85	2538
1985	1996	130	2126
1986	1777	65	1842
1987	1393	122	1515
1988	1387	125	1512
1989	1569	83	1652
1990	1176	0	1176
1991	1171	0	1171
1992	940	185	1125
1993	884	220	1104
1994	926	265	1191
1995	1145	289	1434
1996	1232	285	1517
1997	2011	42	2053
1998	1783	61	1844
1999	1983	37	2020
2000	2556	41	2597

Year	Total by SD		Total
	22	23	SD 22-23
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
2020	727	48	775

Table 3.4. 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

Year	landings	estimates discard	ratio	total strata*	Unsampled strata
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
2020	775	121	0.14	30	7

Table 3.5. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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

Table 3.6. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Indicator status for the most recent three years.

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%} / L_{mat}$	L_{max5} / L_{inf}	P_{mega}	L_{mean} / L_{opt}	$L_{mean} / L_{F=M}$
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
2020	0.80	1.34	0.91	0.36	1.04	1.31

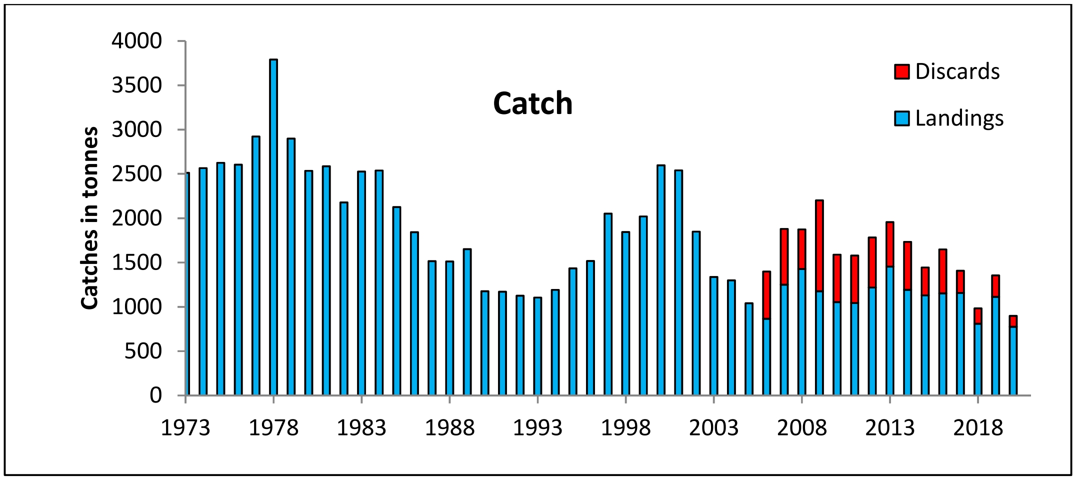


Figure 3.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

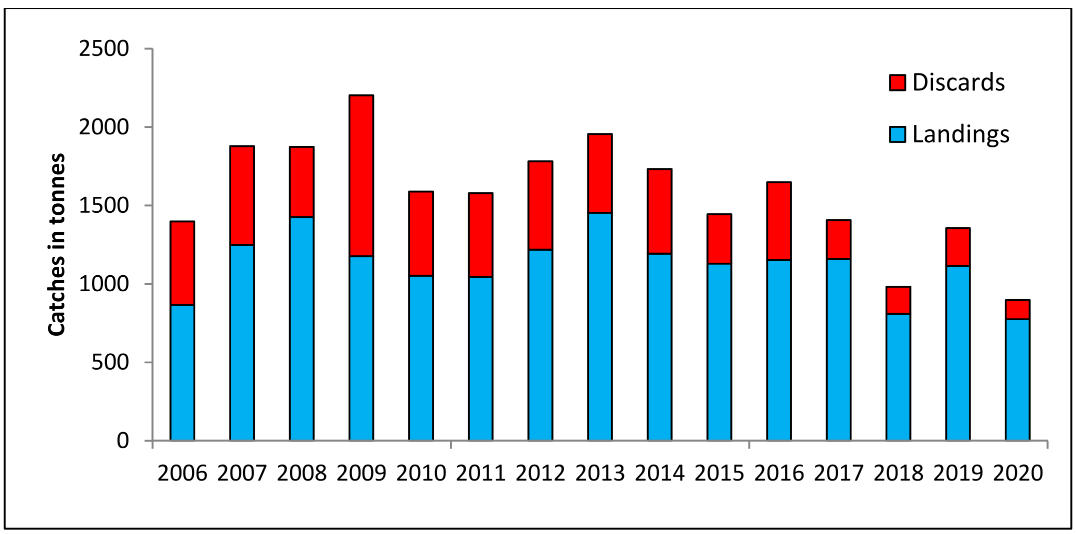


Figure 3.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

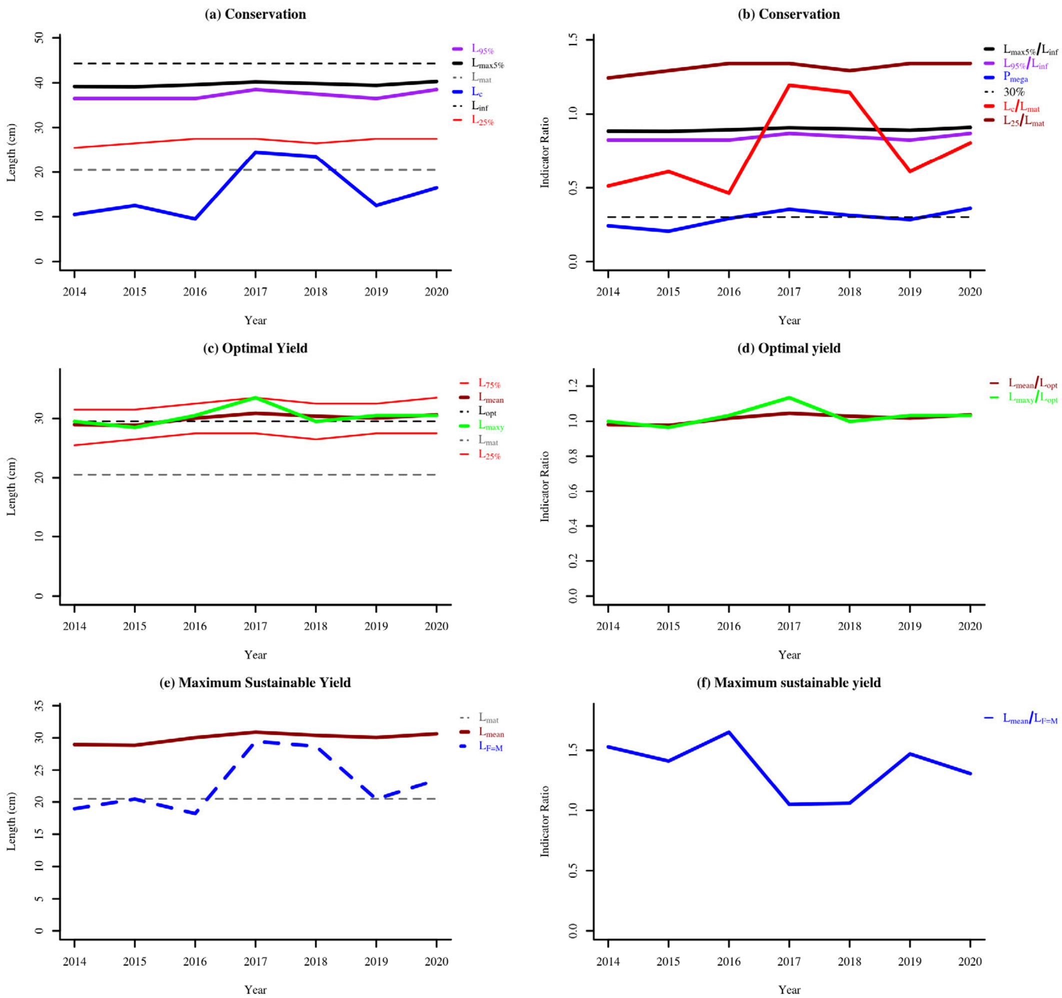


Figure 3.3. fle.27.2223. LBI indicator trends

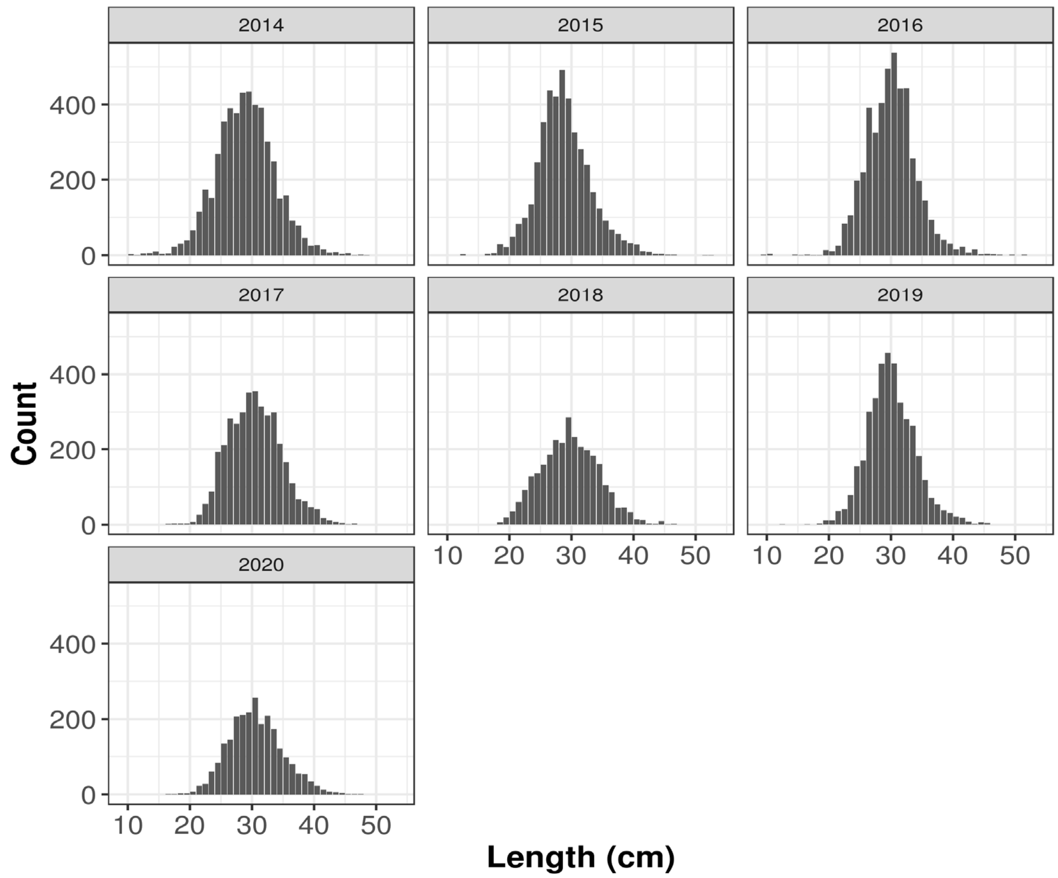


Figure 3.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

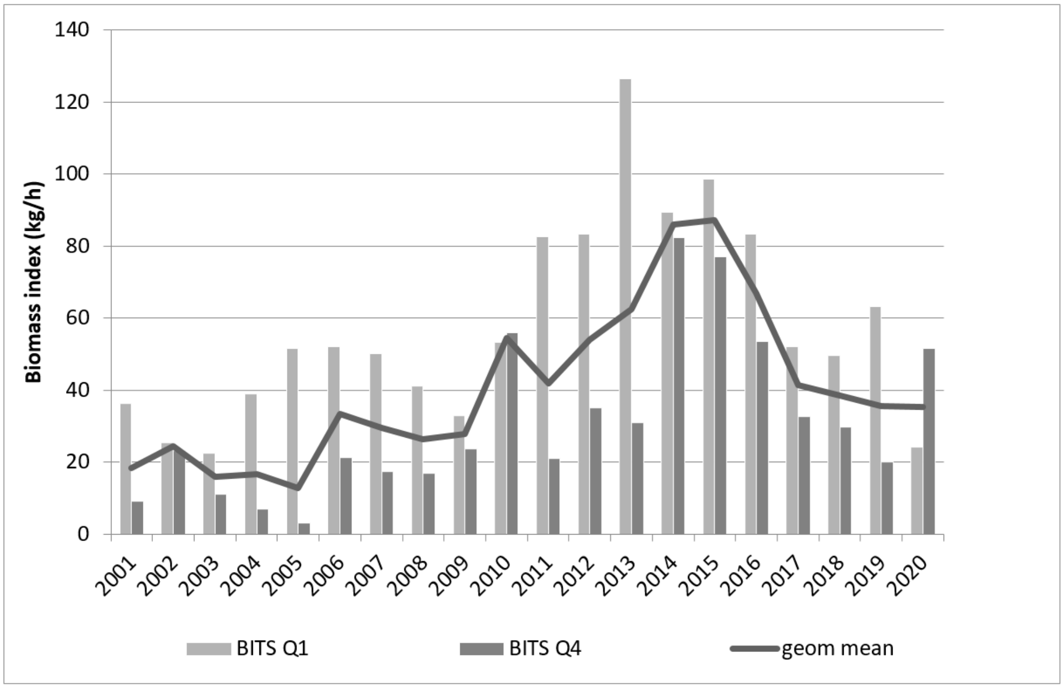


Figure 3.5. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS).

3.3 Flounder in subdivisions 24 and 25

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

Considering contrasting reproductive flounder behaviours in the Baltic Sea, i.e. offshore spawning of pelagic eggs and coastal spawning of demersal eggs, Momigliano *et al.* (2018) genetically 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 European flounder *Platichthys flesus* and the coastal spawning - newly described species, the Baltic flounder *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 the 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 3.6). The majority of landings in both SD's is taken by Poland. The other fishing nations which take significant landings are Germany in SD 24 and Denmark in SD 25 (Figure 3.7, Table 3.7a).

In 2020 abnormally high flounder bycatch from pelagic trawlers (OTM) was reported by Poland in the SD 25. In the SD 24 it was substantially lower. This year, because of lack of observers onboard due to covid-19 restrictions, it was impossible to get any direct and reliable observations on this procedure. However, the perception of this data seems to be unreliable and needs further analysis and verification.

This bycatches from both SD's were included in figures and tables. However, they were excluded from the discard ratio estimation and the assessment because information on the length structure of this bycatch was lacking.

Flounder landings in both SD's are dominated by active gears. Including bycatch from pelagic trawlers, around 78% of total landings were taken by those gears in 2020 (Figure 3.8). If we consider only demersal landings, then the contribution for active gears dropped to 70% of total landings.

In 2020 landings amounted to 12 517 tonnes (3696 and 8821 tonnes for SD 24 and SD 25, respectively). After excluding OTM bycatch, the landings in 2020 were 9112 tonnes (3600 and 5512 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 SD 24–25 reached 13 509 tonnes in 2020 (Figure 3.9).

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. For stratum with no discards estimates available, discard rate was borrowed from other strata according allocation schemes considering differences in discard patterns between subdivisions, countries, gear types and quarters (Table 3.8). Then the discard rate was raised by demersal landings. Such discard estimations have been performed since 2014. The discard ratio in both SD's varies between countries, gear types, and quarters and additionally discarding practices are influenced by factors such as market price and cod catches. Discard estimations in 2020 were available for 31% of the strata with landings and slightly lower than compared to last year (38%). A decrease in reporting discards was caused by COVID-19 related restrictions, which prevented observers from sampling onboard. Due to the fact that the proportions of discarded fish couldn't be observed onboard, some countries, in order to estimate discard for 2020, used the mean discard ratio from years 2017-2019 and applied it to 2020 landings.

In previous years, the highest discards in SD's 24 and 25 could be assigned to Sweden and Denmark. Germany and Poland had moderate discards. However, in 2020 the discards proportion in the catches was similar in all main fishing countries and didn't exceed 15% (Table 3.7b; Figure 3.10). This was likely related to the cod fishery closure in SD 25. As a result, less flounder was discarded by countries (e.g. by Denmark and Sweden) catching flounder as a bycatch in cod fishery.

Mean discard rate for 2020 for both SD's was 0,11, with discard equal to 992 tonnes, which is the lowest estimate in time-series (since 2014).

3.3.1.3 Effort data

Effort data for demersal fleet back to 2009 are available for all countries. As countries have not used the same approach, the effort was standardized within each country and weighted by the national demersal fish (cod and flounder) landings from SD's 24–25.

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

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

where: fc – effort by country c

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

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

Ly,c – landings by country and year

The effort in 2020 has slightly decreased compared to 2019, and it was the lowest in the time-series (Figure 3.11).

3.3.2 Biological information

The number of sampled flounder in SD 24 was slightly higher than in SD 25, even though the landings in SD 25 were much higher (Table 3.9). Most of the samples were analysed by Germany in SD 24 and by Poland in SD 25.

Sampling coverage of discards differs between years and subdivisions and in 2020 was slightly worse than those obtained in 2019. That was due to COVID-19 related restrictions, which prevented observers from sampling onboard. Flounder discard in SD 24 and 25 was sampled by Germany and Denmark.

3.3.3 Fishery independent information

Since 2001 the Baltic International Trawl Survey (BITS) has been carried out using a new (stratified random) design and a new standard gear (TV3). BITS surveys are conducted twice a year, in 1st and 4th quarter. BITS surveys in SD 24 are performed by Germany, Sweden, Denmark, and by Poland from 2016 to Q1 2019 and in SD 25 by Poland, Denmark and Sweden. The number of stations is higher in SD 25 compared to SD 24 (Table 3.10).

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).

The stock trend is estimated using the Biomass Index from BITS-Q1 (G2916) and BITS-Q4 (G8863) surveys. The index is calculated by length-classes for the fish larger or equal to 20 cm total length, and covers the period from 2001 onwards.

Both BITS-Q1 and BITS-Q4 surveys (Figure 3.12) 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 3.12). The advice index for this year is 0.80.

Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25 have been increasing until 2016, then they were showing a decrease until 2018 followed by an increase from 2019 (Figure 3.12).

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 2014–2020 were used to estimate CANUM (Figure 3.13). The biological parameters L_{inf} and L_{mat} were calculated using BITS survey data from DATRAS. For estimating L_{inf}, data for both sexes and both quarters (Q1 and Q4) of 2012–2020 was used. In the case of L_{mat}, data for females was derived from 2001–2020, only from Q1, as distinguishing between mature and immature fish was possible only for this time of the year. Biological parameters mentioned above are as follows:

L_{inf} = 329 mm

L_{mat} = 220 mm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.11).

The results of LBI (Table 3.12) showed a sustainable exploitation pattern, as the stock status of bzq.27.2425 was above possible reference points.

Average $L_{F=M}$ for the three most recent years (2018–2020) was equal to 25.1 cm and L_{mean} - 27.7 cm. Only the indicator ratio L_c / L_{mat} in 2019 was below expected value, which indicated 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 3.14).

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.

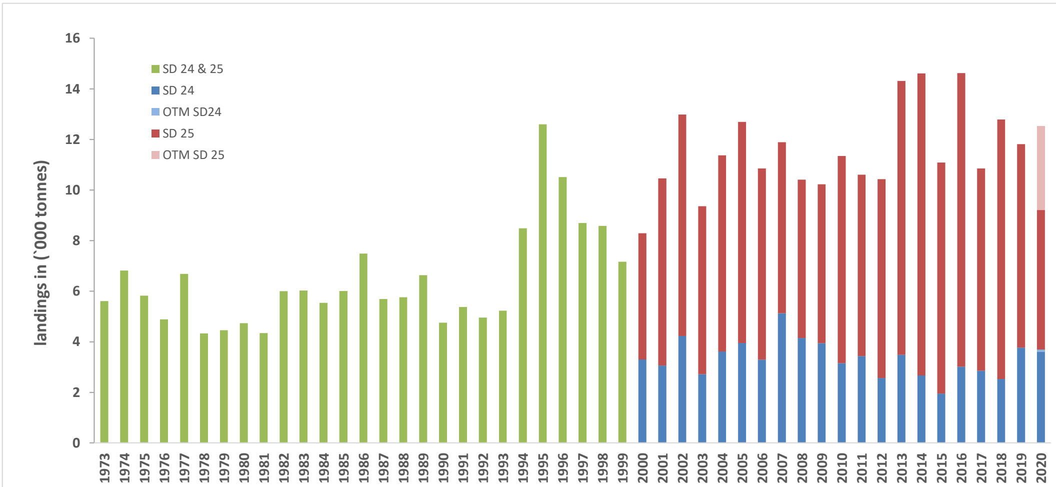


Figure 3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Landings in thousand tonnes; bycatch from pelagic trawlers included in 2020 (light blue and red colour)

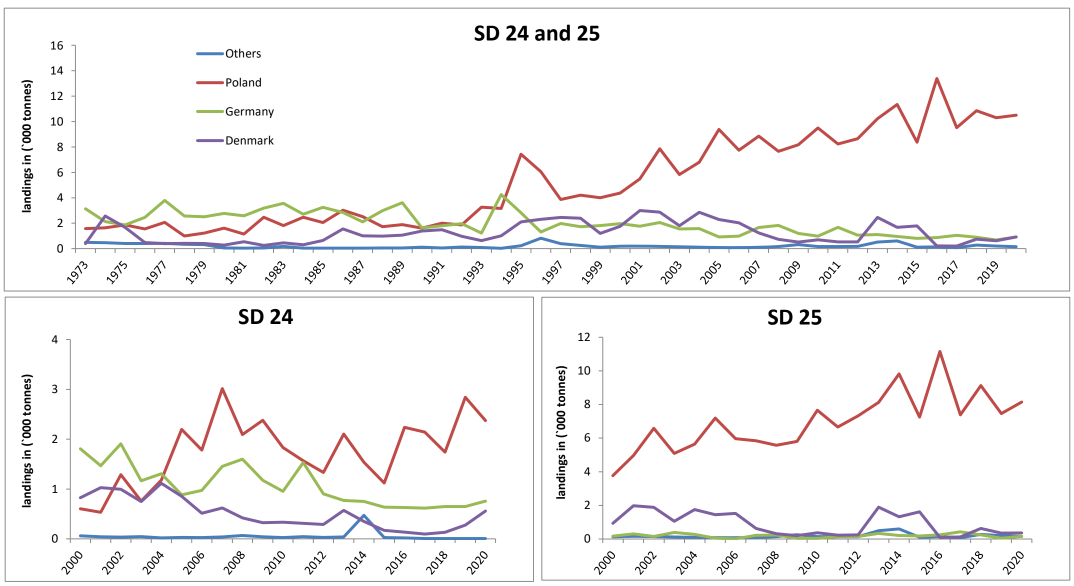


Figure 3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Landings by country in thousand tonnes; bycatch from pelagic trawlers included in 2020 Polish landings (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25 – lower plots)

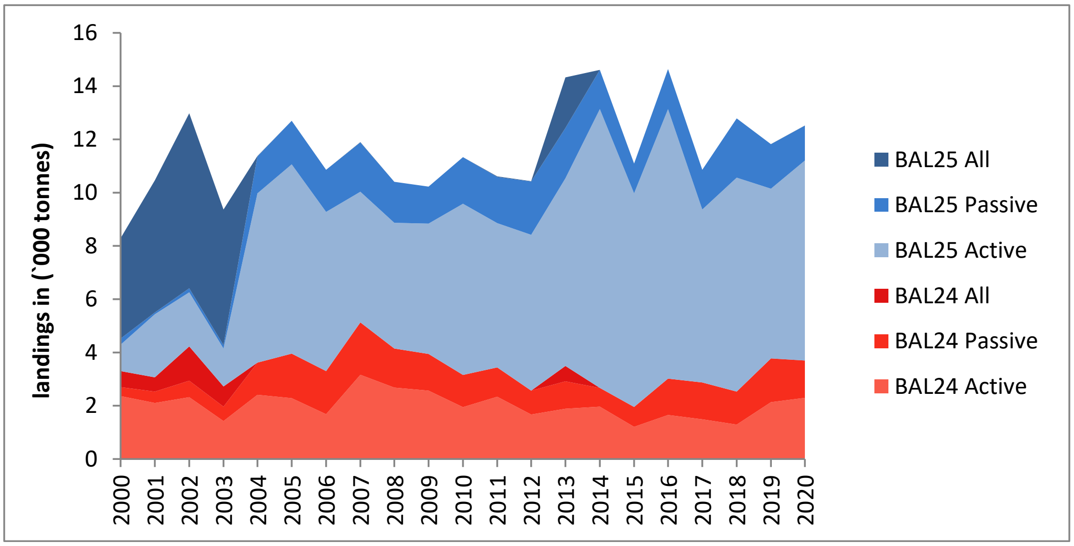


Figure 3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Landings by fleet type in thousand tonnes (SD 24 - reddish colours, SD 25 – bluish); bycatch from pelagic trawlers included in 2020 active gears

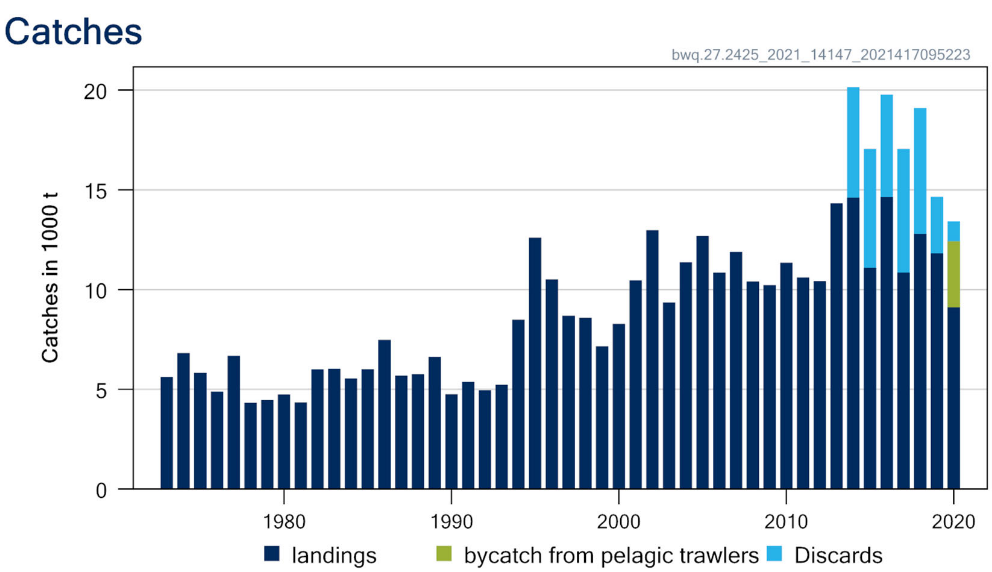


Figure 3.9. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Catches (ICES estimates) in subdivisions 24–25. Discard data have only been included since 2014; 2020 catches include flounder bycatch from pelagic trawlers.

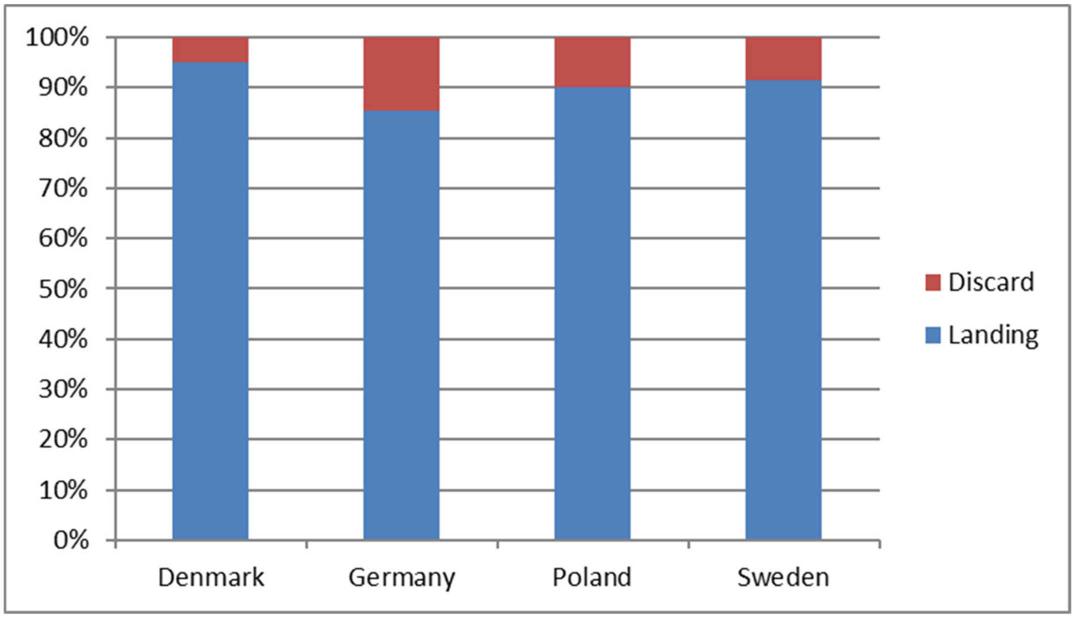


Figure 3.10. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Discard and landing proportion in 2020 catches in main fishing countries

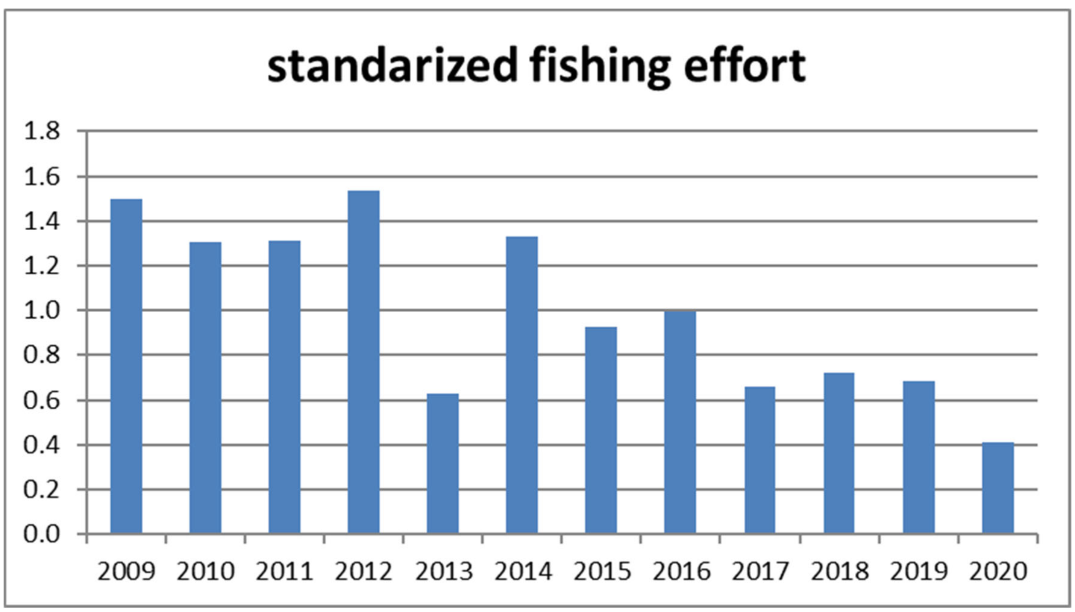


Figure 3.11. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Standardized fishing effort (standardized within each country and weighted by the national demersal fish landings from SD 24–25)

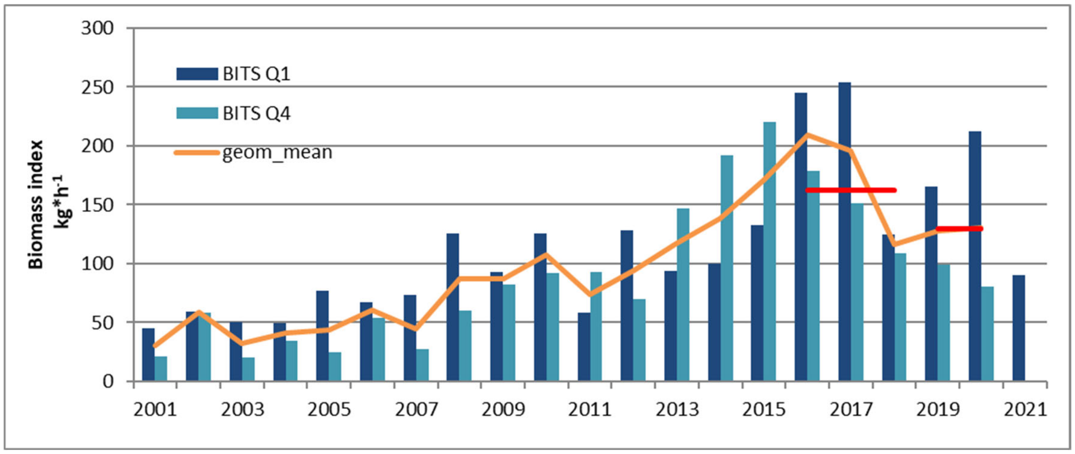


Figure 3.12. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Survey-biomass-index (BITS) for Q1 and Q4 from 2001-2020; Q1 2021 and geometric mean (line); Stock trends from Baltic International Trawl Survey (BITS)

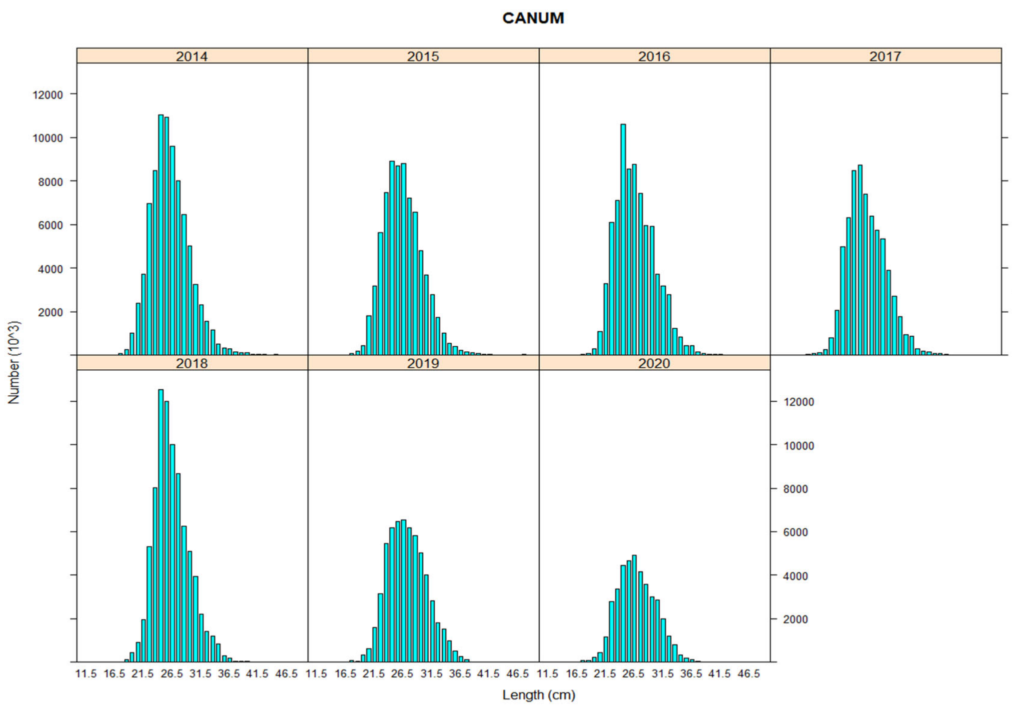


Figure 3.13. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Catch in numbers (CANUM) per length classes

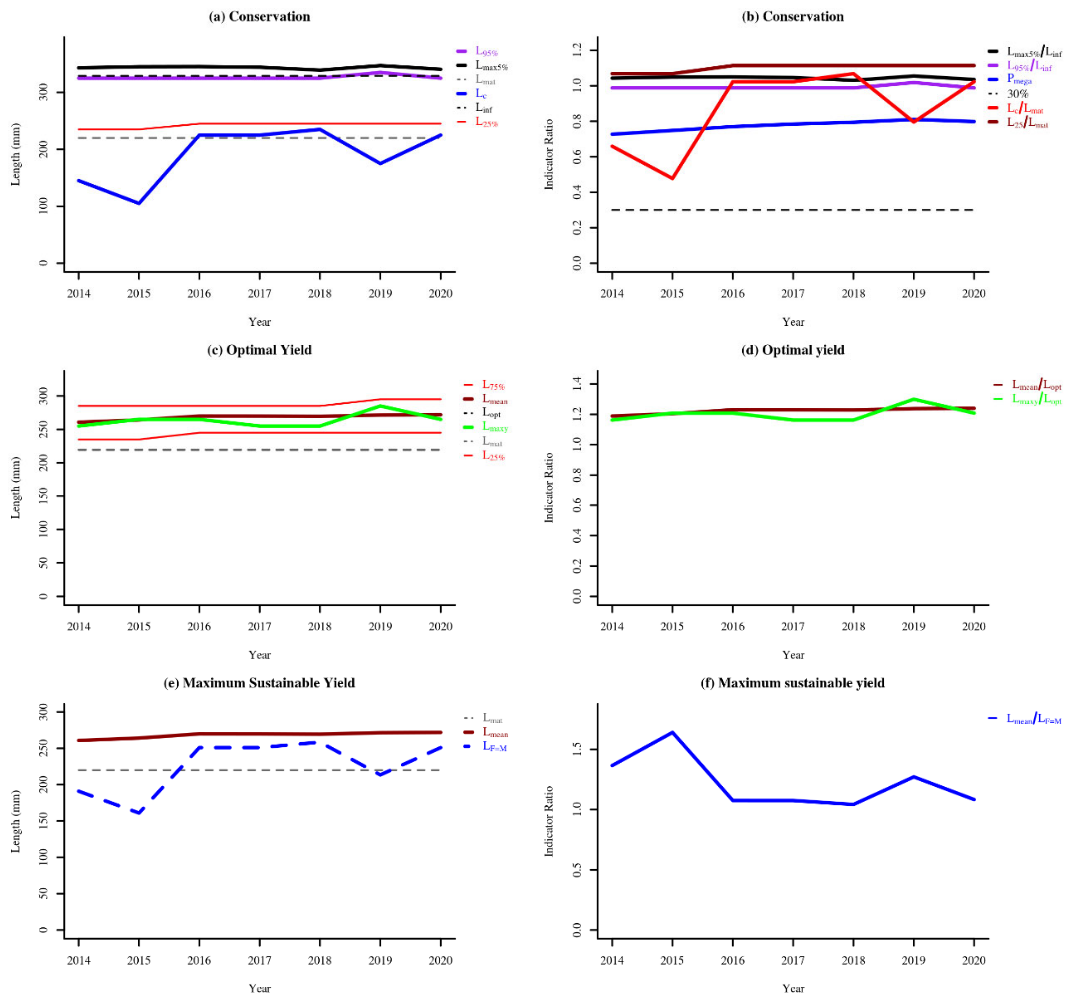


Figure 3.14. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); LBI indicators trends.

Table 3.7a. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Total landings (tonnes) 1973–2020 by Subdivision and country

	Denmark		Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden				Total
Year	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1973			386									3144									1580			502	5612
1974			2578									2139									1635			470	6822
1975			1678									1876									1871			400	5825
1976			482									2459									1549			400	4890
1977			389									3808									2071			416	6684
1978			415									2573									996			346	4330
1979			405									2512									1230			315	4462
1980			286									2776									1613			62	4737
1981			548									2596									1151			51	4346
1982			257									3203									2484			55	5999
1983			450									3573									1828			180	6031
1984			306									2720									2471			45	5542
1985			649									3257									2063			40	6009
1986			1558									2848									3030			51	7487

	Denmark		Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden				Total
Year	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1987			1007									2107									2530			43	5687
1988			990									2986									1728			58	5762
1989			1062									3618									1896			56	6632
1990			1389									1632									1617			120	4758
1991			1497									1814									2008			55	5374
1992			975									1972									1877			129	4953
1993			635									1230									3276			90	5231
1994			1016									4262									3177			38	8493
1995			2110			8						2825									7437			214	12594
1996			2306						1			1322									6069			819	10517
1997			2452			15			1			1982									3877			370	8697
1998			2393			10			2			1729			2						4215			236	8587
1999			1206			8						1825									4015			111	7165
2000	825	923	1748				14	4	18	1809	171	1979							605	3765	4370	49	123	172	8288
2001	1026	1976	3002				9	68	77	1468	299	1766							531	4962	5493	30	95	125	10464
2002	995	1877	2872				5	34	39	1910	154	2064							1288	6577	7865	30	111	141	12982

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2003	750	1052	1802				2	7	8	1165	389	1553							758	5087	5845	45	106	152	9360
2004	1114	1753	2866							1307	275	1582	1	6	7				1177	5633	6810	19	86	105	11370
2005	853	1445	2298				1	2	3	881	43	924	2		2				2194	7192	9386	26	58	84	12696
2006	513	1518	2031				2	3	5	973	7	979		11	11				1782	5959	7741	23	61	84	10852
2007	620	623	1243				2	8	10	1455	215	1670	8	7	15		11	11	3016	5840	8856	27	59	86	11891
2008	422	313	736							1601	238	1840		74	74		4	4	2094	5569	7663	29	66	95	10410
2009	325	199	524				41		41	1175	29	1204		155	155		31	31	2378	5802	8180	27	65	92	10227
2010	333	368	701		16	16	13	2	16	953	31	983		31	31		19	19	1833	7665	9498	21	64	85	11348
2011	310	226	536		20	20	3	2	5	1529	147	1676		39	39		15	15	1567	6666	8233	26	60	86	10610
2012	290	250	540		19	19	20	17	36	904	151	1055		8	8		24	24	1331	7325	8657	23	67	90	10430
2013	572	1889	2460		10	10	1	9	10	771	332	1103	4	76	80		54	54	2104	8118	10222	35	344	379	14318
2014	349	1324	1673		83	83				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				2		2	630	246	876		81	81		9	9	2238	11157	13395	16	41	56	14637
2017	97	112	209				1		1	619	423	1042		2	2		2	2	2143	7383	9525	5	68	73	10855
2018	133	623	756							650	243	893		119	119		61	61	1740	9123	10863	6	90	96	12788

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2019	276	350	626					44	44	650	38	687		36	36		16	16	2480	7459	10300	6	100	106	11815
2020*	559	362	921					1	1	758	162	920		90	90				2 373	8 143	10 516	6	63	69	12 517

Table 3.7b. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Estimated discards (tonnes) 2014–2020 by subdivision and country. Zero values indicate discards under 0.5 tonnes.

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2014	1402	2450	3852				0	0	0	171	15	185	2	35	37		7	7	29	128	157	187	1117	1303	5542
2015	1186	3900	5086				0	0	0	199	35	234	0	0	0		1	1	80	307	387	98	157	255	5965
2016	664	2880	3544				2		2	298	63	360		9	9		0	0	235	391	625	386	216	602	5143
2017	467	3915	4382				0	1	1	121	177	298		6	6				144	767	911	390	212	602	6201
2018	286	4242	4528				0	0	0	80	180	260		13	13		0	0	110	1065	1175	54	288	342	6318
2019	143	733	876					4	4	118	42	160		4	4		1	1	351	1118	1496	101	226	328	2842
2020	37	12	49					0	0	130	28	158		2	2				267	510	776	4	3	6	992

Table 3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Discard allocation scheme for 2020; green cells – reported estimated discard, grey cells – allocated discard.

24		2020					
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland	Latvia
Active	1	DK_A_1_25		PL_A_1_25	SE_A_1_25		
	2	DE_A_2_24		PL_A_2_25	SE_A_2_25		
	3	DE_A_3_24		DE_A_3_24	DE_A_3_24		
	4				DE_A_4_24		
Passive	1	SE_P_1_24	SE_P_1_24	SE_P_1_24			
	2	DE_P_2_24		DE_P_2_24			
	3	DE_P_3_24		DE_P_3_24	DE_P_3_24		
	4	DE_P_4_24		DE_P_4_24	DE_P_4_24		

25		2020					
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland	Latvia
Active	1					SE_A_1_25	SE_A_1_25
	2	PL_A_2_25				SE_A_2_25	SE_A_2_25
	3	DE_A_3_24	DE_A_3_24	DE_A_3_24	DE_A_3_24		
	4	DK_A_4_24			PL_A_4_25		
Passive	1	SE_P_1_25		SE_P_1_25			
	2	SE_P_2_25		SE_P_2_25			
	3	DE_P_3_24		DE_P_3_24	DE_P_3_24		
	4	DE_P_4_24		DE_P_4_24	DE_P_4_24		

Table 3.9. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); The coverage of sampled landings and discards in 2020 in subdivisions 24 and 25

Area: 27.3.d.24

Country	Catch category	Catch t	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	559	1	200
Germany		758	16	3870
Poland		2277	3	89
Sweden		6	0	0
Denmark	Discards	8	1	102
Germany		129	15	1101
Poland		23	0	0
Sweden		2	0	0
	Total	3761	36	5362

Area: 27.3.d.25

Country	Catch category	Catch t	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	362	4	440
Finland		1	0	0
Germany		162	1	355
Latvia		90	0	0
Poland		4834	9	1087
Sweden		63	0	0
Denmark	Discards	7	373	4
Germany		28	108	1
Poland		254	0	0
Sweden		1	0	0
	Total	5803	495	1887

Table 3.10. 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	39	50	110	87
2020	57	51	94	73
average	50	45	97	76

Table 3.11. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic -West); Description of the selected LBI

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > Lc	$L_{opt} = \frac{3}{3+\frac{M}{k}} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+\frac{M}{k}} \times L_{inf}$	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 3.12. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West); Indicator status for the most recent three years; L_{inf} and L_{mat} calculated using both sexes; L_{inf} = 32.9 cm and L_{mat} = 22.0 cm

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
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
2020	1.02	1.11	1.04	0.80	1.24	1.08

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

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

3.4.1 The Fishery

The main fishing countries in Subdivision 26 are Latvia, Poland, Russia, and Lithuania while in Subdivision 28 – Latvia (Table 3.13). In the previous years the Polish fishery was mainly a gillnet fishery targeting flounder along the coast whereas the Latvian, Russian, and Lithuanian landings were mainly in a bottom trawl mix-fishery.

3.4.1.1 Landings

Landings by countries and subdivisions are presented in Table 3.13.

The total landings in SD 26 and 28 combined continued to decrease in 2020 and were 1956 tonnes, lowest in this century. Decrease of landings was observed since 2014 (Figures 3.15 and 3.16.). The highest landings in 2020 were recorded in Latvia (780 tonnes), Russia (770 tonnes), and Poland (273 tonnes). The major part of the landings was realised with active fishing gears (21 588 tonnes or 80.8%).

Major part of the landings was taken in Subdivision 26 (68%) and in trawl fishery (81%). The total landings in Subdivision 28 amounted to about 776 tonnes, which is just below the long-term average. The highest landings in Subdivision 28 were observed in 2015-2016 after which a gradual decrease is observed. The major part of landings was realised by Latvian fishers (715 tonnes) whose landings were below 1000 tonnes for the first time in last five years. The total landings in Subdivision 28 amounted to about 1963 tonnes which is the lowest in this century. The major part of the landings was realised by Russia (1325 tonnes) and Poland (565 tonnes). Flounder fishery in 2020 was heavily affected due to cod fishing restriction and in some countries due to COVID 19 pandemic

3.4.1.2 Unallocated removals

There is no information about unallocated removals for this stock.

3.4.1.3 Discards

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

Discard data of flounder from 2020 according to ICES Data Call was submitted in InterCatch. Discards rates from Denmark, 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 ratio varied significantly by countries, fleets and quarters. The highest discards (by weight) were observed in Poland (82 t), Latvia (9.7 t), and Sweden (5.5 t) (Table 3.14) what was significantly lower than average from 2014. Decrease of discarded amount was observed in all countries. Weighted average of flounder discard in subdivisions 26 and 28 in 2019 was estimated 4.9%, what was the lowest estimated since 2014 when the first discard data is available.

3.4.1.4 Effort and CPUE data

Time-series from 2009–2020 were available from ICES WGBFAS data call where countries were asked to submit flatfish effort data by fishing fleet and subdivision. It should be mentioned that different calculation methods were used by countries to estimate a fishing effort. Some countries reported all of fishing days when flounder were landed; some countries reported number of fishing days were significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet.

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

According to new effort estimates sharp increase of effort was observed in 2020 and was the 2nd highest in time-series since 2009. (Figure 3.17). However it should be mentioned that in Latvia and Lithuania effort was record high, increase from last year – 7-10 times. (Figure 3.18). Effort data from Russia was in range of fluctuation of previous years, while in Poland – decreasing trend continued also in 2020. Effort data from 2020 should be analysed with precautionary, while different factors influenced demersal trawling. EU countries reduced cod TAC and therefore also flounder as bycatch fishery was restricted. No restriction in Russian cod fishery was observed, therefore no major influence to flounder fishery. COVID 19 pandemic influenced fishing activity differently each country.

The highest landings per unit effort in 2019 were registered in Latvia and Russia (Figure 3.19) 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, 1026 otoliths were collected from the catch (1010 from landings and 10 from discards, Table 3.15). 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 4th quarter was used to calculate an index representing flounder abundance by weight, as the stock is defined as a Data limited stock by ICES. Data were compiled from the ICES DATRAS output format "*CPUE_per_length_per_haul*" where the data base provides CPUE by length in numbers. Weight-at-length was estimated as an average weight-at-length for data from 1991–2013, and subdivisions 26+28. Next, to such data weight-length relationships of the form w=a L^b were fitted, were: a = 0.0158 and b = 2.90. Next, biomass for fish longer than 20 cm were summed to get total biomass index by quarters. All fish with length <20 cm were excluded from the calculations, as flounder nurseries are located in shallow coastal areas and are not covered in BITS surveys. Data from 4th quarter only was used while in this time of the season, both flounder species are mixing in survey area.

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, G8863 – Q4,) was used as the index of stock development. The assessment is based on a comparison of the two latest index values (index A) with the three preceding values (index B).

The stock showed a decreasing trend from the beginning of the century although the estimated indices in last years is fluctuating without any trend (Figure 3.20, Table 3.16). The stock abundance is estimated to have increase by 22% between 2016–2018 (average of the three years) and 2019–2020 (average of the two years). For this stock scientific advice on stock status is provided for 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 landings from InterCatch from 2014–2019 were used to estimate CANUM and WECA(figures 3.21 and, 3.22.) whereas the biological parameters: L_{inf} and L_{mat} were calculated using survey data from DATRAS.

For estimating L_{inf} data from 2014–2019 from Q4, and for both sexes were taken. Only age data determined by recommended ageing technique was included in the analyse, 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 Subdvision 25, L_{inf} was 32.46 cm, while for Subdivision 28 – 28.38 cm (Figure 3.23.) Landing proportion between subdivisons in the last five years is 65% (for Subdivision 26) and 35% (for Subdivision 28). As a final weighted L_{inf} was calculated 31.04 cm. Data from BITS Q4 only were used. In Q1 flounder is close to spawning time and both flounder species are separated in this time of the year. In BITS Q1 surveys mainly European flounder (or pelagic flounder) are represented. In Q4 both species is mixing, 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 – reason is described in previous paragraph). Like for L_{inf}, the same approach was used to calculate weighted $L_{mat.}$ L_{mat} for Subdivision 26 was 18.8 cm, for Subdivision 28 – 15.3 cm, while weighted average for the stock – 17.6 cm Figure 3.24).

Accepted biological parameters mentioned above are as follows:

L_{inf} = 31.04 mm

L_{mat} = 17.6 mm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.17).

The results of LBI (Table 3.17, Figure 3.25) show that stock status of fle.27.2628 is above possible reference points (Table 3.18). $L_{max5\%}$ is well above the lower limit of 0.80 (*i.e.* 1.22 in 2020), 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 consistent with F_{MSY} proxy (LF = M).

Table 3.13. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Total ICES landings (tonnes) by Subdivision and country.

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

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

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

Country	2011			2012			2013			2014			2015		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1		1	0		0	22		22	0.872	0	1	0	0	0
Finland	1		1	10		10	8		8	0.459	0	0	0	0	0
Germany			0			0	0		0			0			
Poland	1,437		1,437	1,501		1,501	1,578	3	1,581	1209.7	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	698.08	0	698	258	0	258
Russia	1,139		1,139	1,079		1,079	1,010		1,010	1047.1	0	1,047	1,106	0	1,106
Total	3,127	260	3,387	3,620	339	3,959	4,391	698	5,089	3,281	1,333	4,614	2,628	1,815	4,443

Country	2016			2017			2018			2019			2020		
	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	0	0			0	8		8	1	0	1			0
Finland			0			0			0	11	0	11			0
Germany	1	0	1			0			0	2	0	2		0	0
Poland	912	0	912	701		701	473		473	565	0	565	273		273
Sweden	3	14	16	2	10	12	4	16	20	1	18	19	1	18	19
Estonia	0	52	52		59	59		60	60	0	43	43		46	46
Latvia	161	1683	1,843	190	1386	1,576	171	1036	1,207	38	715	753	227	553	780
Lithuania	295	0	295	255		255	214		214	20	0	20	74	3	77
Russia	1133	0	1,133	1304		1,304	1493		1,493	1325	0	1325	770		770
Total	2503	1748	4,252	2452	1455	3,907	2363	1112	3,475	1963	776	2740	1345	620	1965

Table 3.14. 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 2020.

Country	Landings	Discards	Catch	Discard ratio
Denmark	0.0	0.0	0.0	0.0
Estonia	46.3	0.0	46.3	0.0
Germany	0.1	0.0	0.1	0.0
Latvia	779.9	9.7	789.6	1.2
Lithuania	77.5	3.7	81.2	4.6
Poland	273.0	82.1	355.0	23.1
Russia	770.1	0.0	770.1	0.0
Sweden	18.2	5.5	23.7	23.1
Total	1965.2	100.9	2066.1	4.9

Table 3.15. 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	16	259	275
Russia		751	1074
Total	16	1010	1026

Table 3.16. 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
2000	197.8	65.2	113.5

Year	1st quarter	4th quarter	Combined index
2001	278.9	404	335.8
2002	238.2	317	274.6
2003	159.9	143	151.4
2004	145.6	366	230.9
2005	128.5	307	198.6
2006	119.7	150	134.1
2007	238.7	223	230.8
2008	330.1	199	256.2
2009	160.9	146	153.2
2010	242.2	196	218.1
2011	230.4	210	219.9
2012	211.7	134	168.5
2013	133.7	176	153.3
2014	82.7	96	89.0
2015	102.4	69	83.9
2016	132.6	52	82.7
2017	128.9	106	116.6
2018	87.9	73	79.9
2019	203.9	119	156.0
2020	120.3	69	91.2
2021	242.0		

Table 3.17. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Description of the selected LBI.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > Lc	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	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 3.18. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Indicator status for the last seven years

	Conservation				Optimizing Yield	MSY
Year	**L_c / L_{mat}**	**$L_{25\%}$ / L_{mat}**	**$L_{max 5}$ / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**L_{mean} / $L_{F=M}$**
2014	1.34	1.34	1.01	0.85	1.28	1.05
2015	1.34	1.39	1.15	0.89	1.34	1.09
2016	1.34	1.39	1.08	0.87	1.31	1.07
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
2020	1.22	1.28	1.05	0.68	1.25	1.08

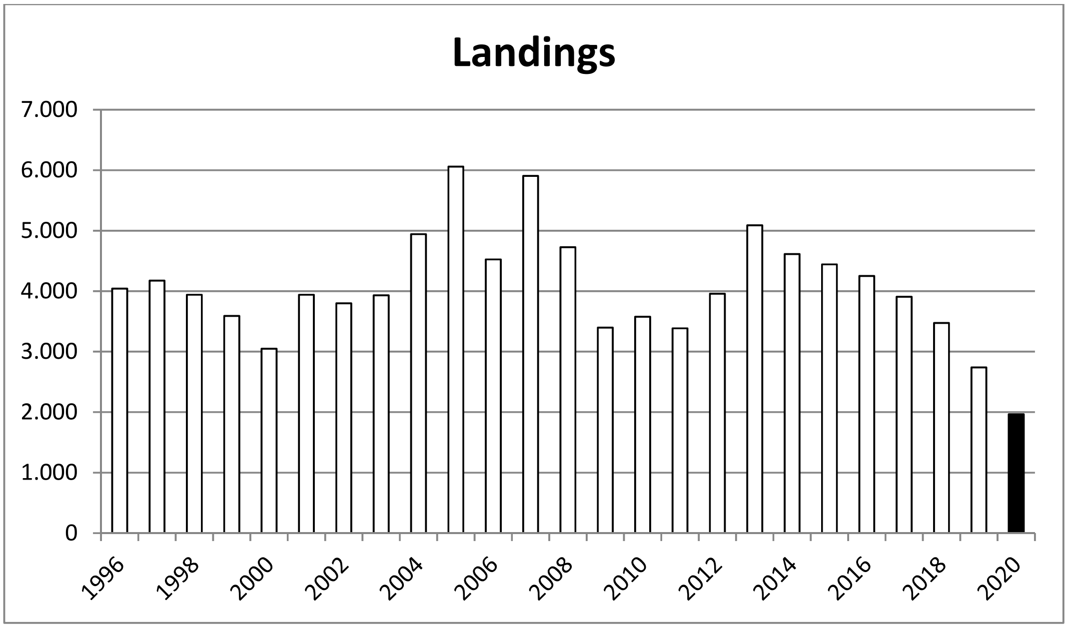


Figure 3.15. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

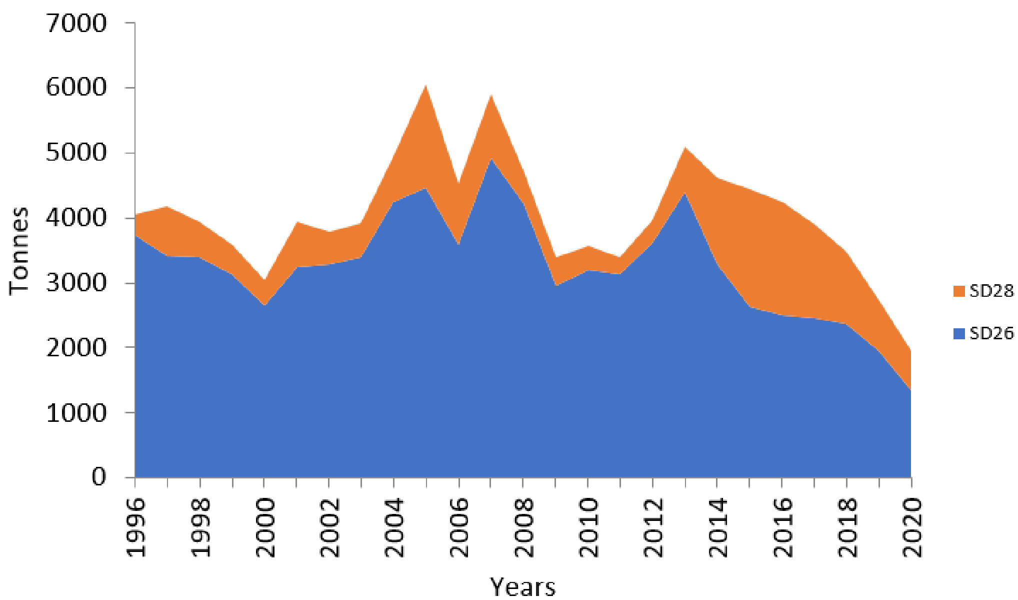


Figure 3.16. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

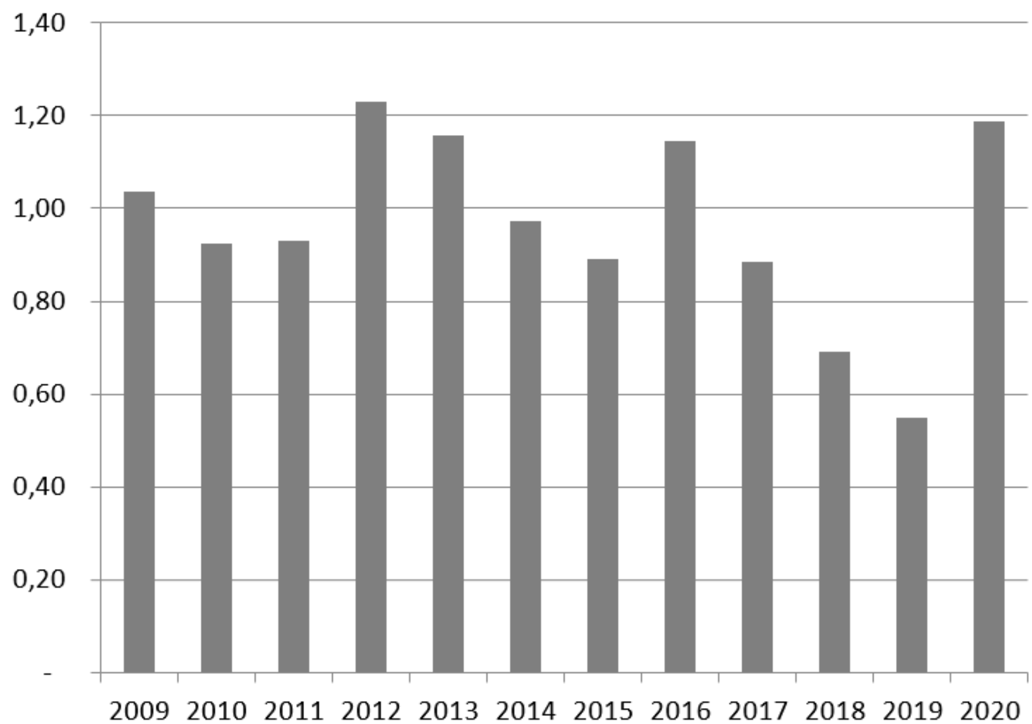


Figure 3.17. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data (days-at-sea) of flounder in subdivisons 26 and 28 (days-at-sea).

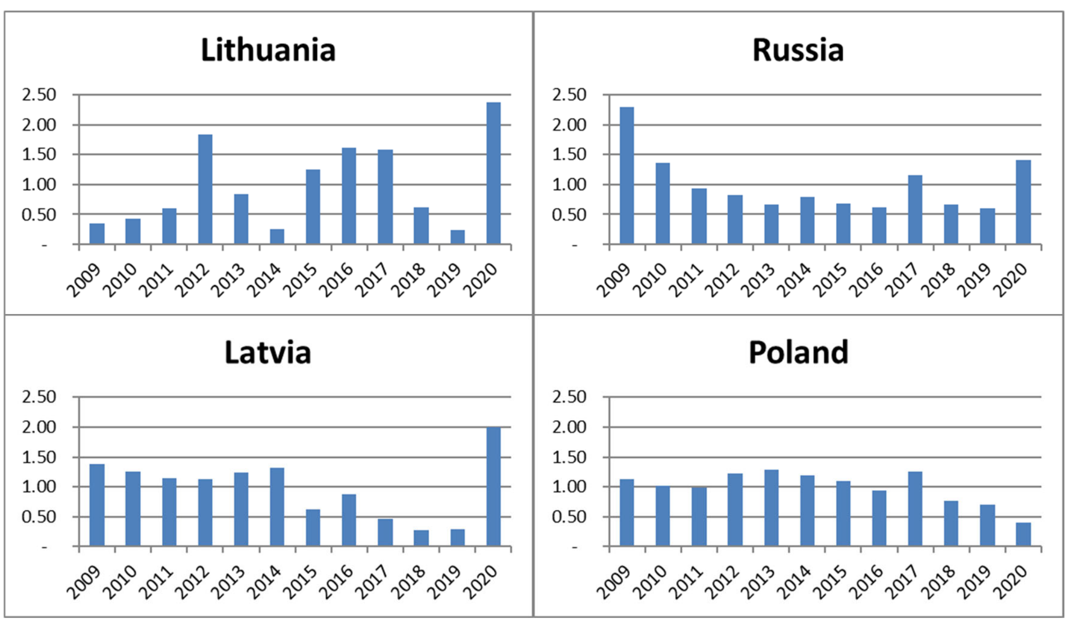


Figure 3.18. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days-at-sea).

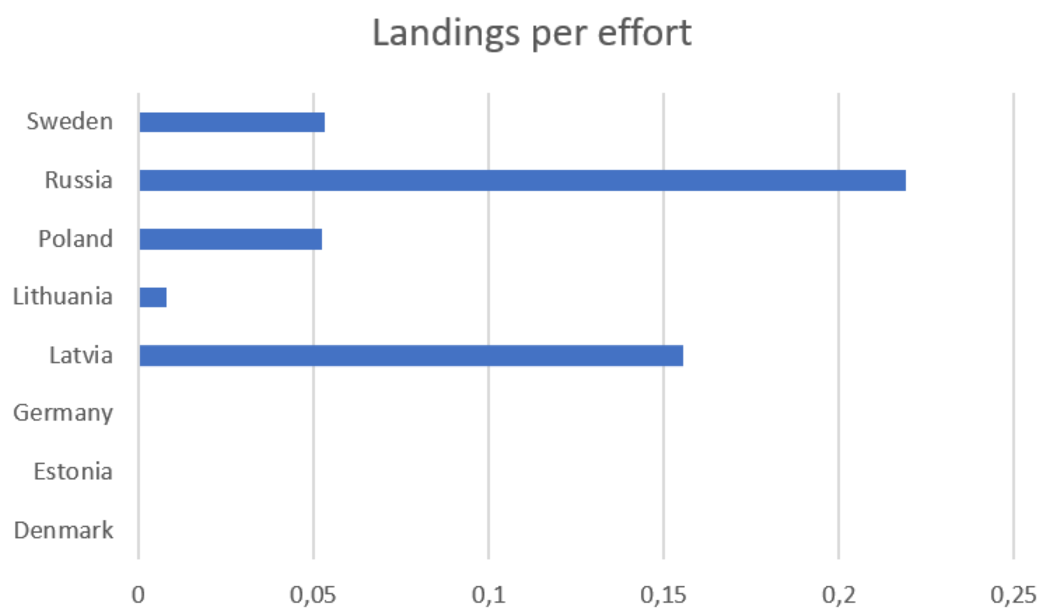


Figure 3.19. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder in tonnes per days-at-sea by country in subdivisions 26 and 28.

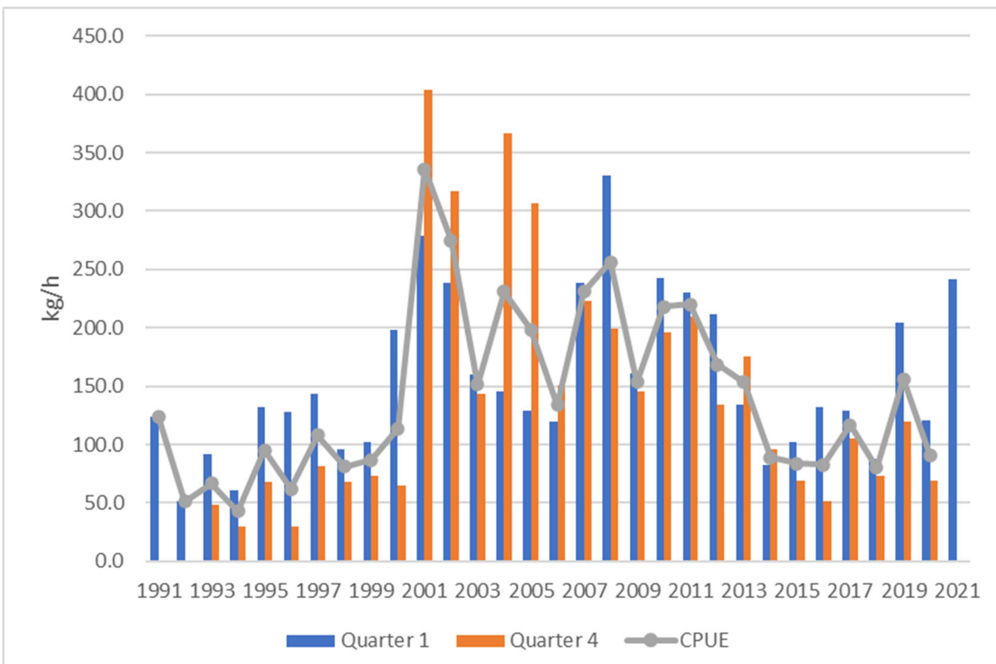


Figure 3.20. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarter, subdivisions 26 and 28.

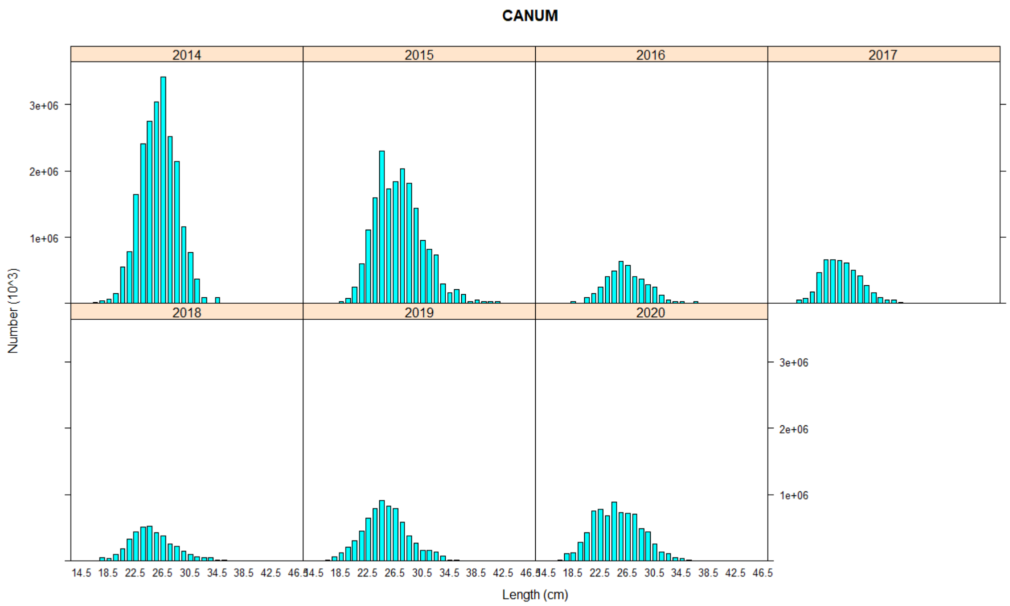


Figure 3.21. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch in numbers (CANUM) per length classes.

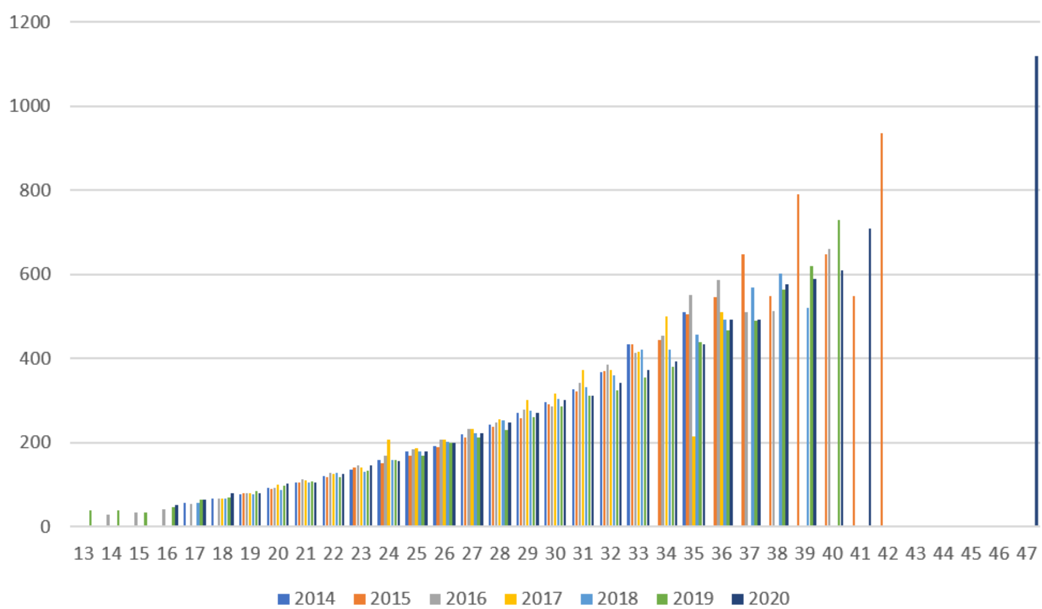


Figure 3.22. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Average weight (WECA) per length classes.

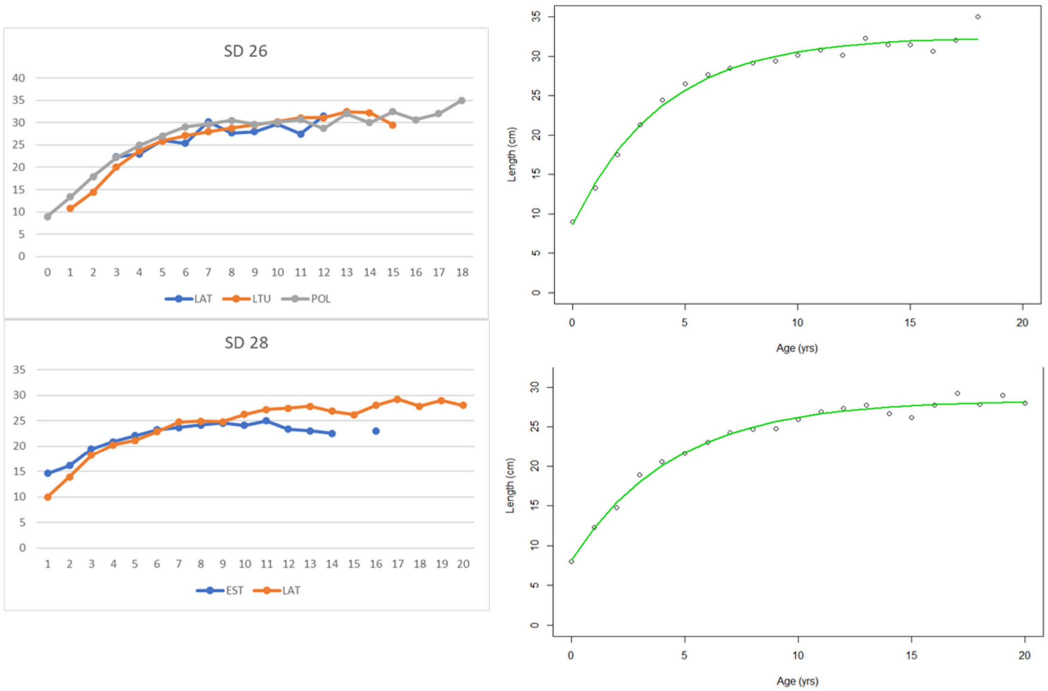


Figure 3.23. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Growth of flounder (Subdivision 26 – 1st line, Subdivision 28 – 2nd line) BIT Survey in 4th Quarter from 2014-2019.

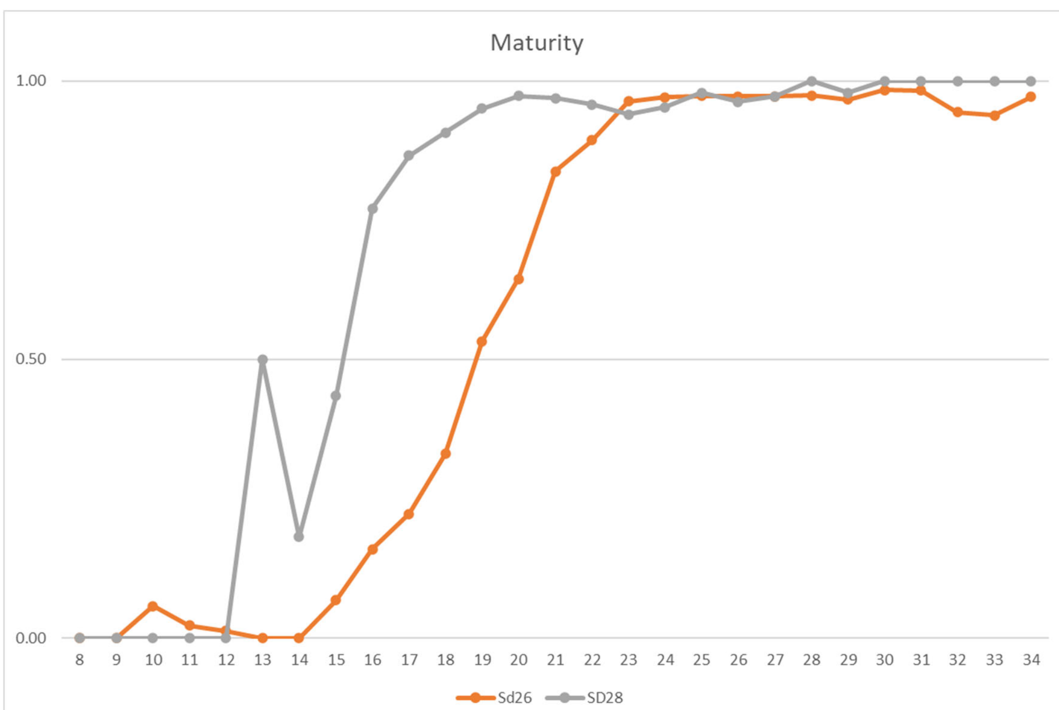


Figure 3.24. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Proportion of mature flounder females by Subdivisions, BIT Survey in 4th Quarter from 2014-2019.

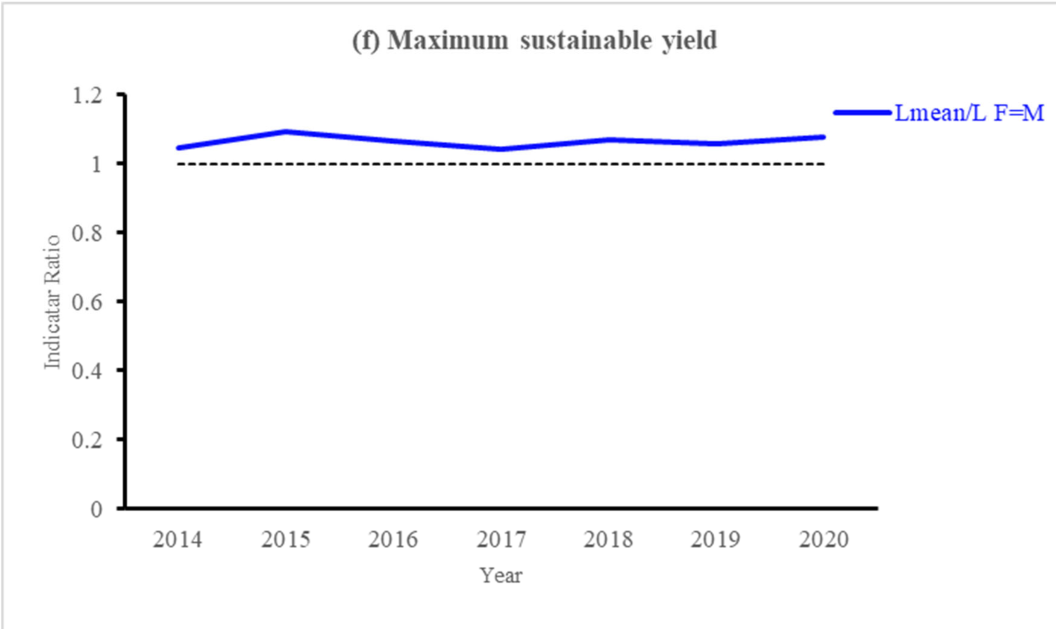


Figure 3.25. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Index ratio L_{mean} / L_F = M from the length-based indicator method (LBI; ICES, 2015) used for the evaluation of the exploitation status. The exploitation status is below the F_{MSY} proxy when the index ratio value is higher than 1.

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

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26-28 November 2013; 27-31 January 2014) flounder with demersal eggs inhabiting mainly the Northern Baltic Proper (SD 27, 29—32) is treated as a separate flounder stock. In the rest of the Baltic Sea flounder with pelagic eggs dominate. 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. Flounder with demersal eggs inhabit also the Central Baltic Sea; however, it is not possible to separate the landings of the two spawning types and in SD 28 presumably pelagic spawning type dominates. Therefore, SD 28 is not included in this stock.

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 and be clearly distinguished only based on gamete physiology or with genetic methods (Momigliano *et al.*, 2018). Momigliano *et al.*, (2019) work based on Finland's historic catches from Gulf of Finland (SD32) showed that in the beginning on 1980s *P. flesus* dominated, however disappeared by 1993 and remained in low proportions (10-11%) thereafter. In the beginning of 1980s over 50% of catches were taken from SD32, however this dynamic has changed and currently >60% of catches are taken from SD29. Unfortunately, SD29 lacks from any quantification of the possible proportions of these two species/ecotypes. However, based on the work done by Momigliano *et al.*, (2019) and INSPIRE BONUS project, it is plausible to assume that the proportion of *P. flesus* in SD29 could be lower than 20%. Hence, this stock unit mainly consist of the new flounder species *P. solemdali*.

3.5.1 The Fishery

3.5.1.1 Landings

In subdivisions 27 and 29—32 flounder is caught mainly in the SDs 29 and 32 (Figure 3.26). The majority (>95% in three latest years) of the catches are taken with passive gears, mostly gillnets. Yearly total landings were above 1000 tonnes in the beginning of 1980s but have been decreasing form end of 1980s, reaching level below 150 tonnes since 2017. Estonia is the major fishing nation, standing for more than 80% of the catches followed by Sweden with a share of 10-15% and the rest is taken by Finland and in some years also Poland (Table 3.19).

3.5.1.2 Discards

Discards probably take place, the extent depending on market price, but the amount is unknown. In the major fishing country, Estonia, discard is not allowed. Survival rate of flounder in discards is unknown for passive gears but can probably be high under certain conditions. In Sweden no discard sampling is made for this stock. Swedish discard rate is calculated using estimates from SD 25 and scaled up to total landings of demersal fish species in the fished strata (passive gear per quarter and SD) by Sweden. Swedish discard can be almost up to the same level as landings. For 2020, no discard estimates from SD25 are available, instead average of three latest years is used. Reported discard in Finland is low, discard rate of <5% is estimated for this stock. Discard estimates for Sweden and Finland are shown in Table 3.20.

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 3.21). In Sweden flounder is not distinguished from the rest of flatfish, which complicates the catch estimates for recreational fishery. Although the species composition is unknown the majority of this is ought to be flounder. Rough calculations have shown that recreational fishery catches for Sweden can be three times higher as commercial landings, same seems to be true for Finland. In Estonia the reported recreational catch is on average equivalent to 20-40% 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, passive gears, is lacking from the dominating fishing nation Estonia (Table 3.22). In addition, 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 is able to provide the effort data on the passive gear.

3.5.2 Biological information

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

3.5.2.1 Catch in numbers

Age information from commercial catches is very limited. Catch in numbers-at-age (CANUM) and mean weight-at-age are available from Estonian commercial trap nets between 2011 and2020 in SD29 and 32. Age data is not sampled in commercial landings in Finland, for Sweden age data exists only for the years 2009-2010.

Currently Estonian commercial age data from trap-nets is not used in the assessment, as the main catches come from gillnets, and the selectivity of these two gears differ. Since 2017, Estonia has been sampling gillnet catches from SD29 and 32, however there is no age data available currently.

3.5.2.2 Mean weights-at-age

The weight per age strongly fluctuates. The high fluctuation of weights per age could be the product of small sample size, especially for older ages. Mean weights per age are also available for survey in SD29 (2000-2012). The survey weight data seems to be more stable compared to commercial data (Figure 3.27).

3.5.3 Fishery independent data

Fishery independent data is gathered form four national gillnet surveys since the BITS survey was deemed inappropriate for this stock (not covering shallow areas, not covering Northern Baltic Sea). From Estonia two surveys were available, one in Muuga bay near Tallinn (mesh size 40—60 mm bar length) in SD 32 ongoing since since 1993, and one in Küdema bay in SD 29 since 2000 (mesh size 21.5, 30, 38, 50 and 60 mm bar length). In Muuga the survey is done weekly from May to October while in Küdema six fixed stations are fished during six nights in October/November in depths 14—20 m. Data 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 biomass index for all four surveys. The arithmetic mean of the two surveys in SD 27 was combined with the biomass indices in 29 and 32. The stock size indicator could be calculated from year 2000 and onwards. For this the indices from these SD-s were combined using the total commercial landings of flounder per SD as a weighting factor (Table 3.23).

3.5.4 Assessment

Assessment method of category 3 for stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES, 2012) was used. From 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 3.28). Extremely high CPUE value for Küdema bay in 2015 is probably not representative, although consistent increase in all survey biomasses (except Muuga bay) is evident for years before 2015. The stock size indicator value seems to show slight increasing trend from 2012 onwards but has been decreasing 2018 onwards.

3.5.5 MSY proxy reference points

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

Length-based indicator (LBI) analysis was done using the Küdema survey data. Length frequency data from the last five years is shown in Figure 3.29. Parameters used in the analysis are shown in Table 3.24.

LBI calculations were made using code that was used by WKIND3.3i group (ICES 2016d). The L_c and L_{mean} calculations differ little bit form the calculations that are presented by WKLIFE V (ICES, 2015). L_c was calculated using mean lengths of all lengths associated with frequencies falling within 20-80% on the left side of the mean maximum frequency, where the mean maximum was taken from the three largest frequencies around the first mode (ICES 2016d). L_{mean} was calculated using all length classes, to make the estimation of this indicator independent of L_c, which tends to be more variable. The reference point $L_{F=M}$ is calculated using formula:

$$L_{F=\gamma M;K=\theta M} = \frac{\theta L_\infty + L_c(\gamma+1)}{\theta+\gamma+1}$$

where γ=1 and θ=1.

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 3.25, Figure 3.30). Length based indicators should be calculated from length data that incorporates discards. In this case actual estimates of discard and corresponding length composition is unknown. However, current length distribution was calculated using survey data and includes also individuals smaller than minimum legal size, lowering the bias of not having estimates of discard.

Table 3.19. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Total landings (tonnes) by Subdivision and country.

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
1980	Finland*		27	14	1	11	53
	Sweden	20	32				52
	USSR		334			1 080	1 414
	Total	20	393	14	1	1 091	1 519
1981	Finland*		67	4		7	78
	Sweden	21	34				55
	USSR		445			1 078	1 523
	Total	21	546	4	0	1 085	1 656
1982	Finland*		38	6		6	50
	Sweden	65	3				68
	USSR		615			1 121	1 736
	Total	65	656	6	0	1 127	1 854
1983	Finland*		28	7		3	38
	Sweden	212	9				221
	USSR		497			1 114	1 611
	Total	212	534	7	0	1 117	1 870
1984	Finland*		27	10		6	43
	Sweden	53	2				55
	USSR		286			1 226	1 512
	Total	53	315	10	0	1 232	1 610
1985	Finland*		21	9		7	37
	Sweden	47	2				49
	USSR		265			806	1 071
	Total	47	288	9	0	813	1 157
1986	Finland*		36	11		5	52
	Sweden	60	3				63
	USSR		281			556	837
	Total	60	320	11	0	561	952

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
1987	Denmark	1					1
	Finland*		37	18		3	58
	Sweden	51	2				53
	USSR		279			397	676
	Total	52	318	18	0	400	788
1988	Finland*		43	21		5	69
	Sweden	68	3				71
	USSR		257			331	588
	Total	68	303	21	0	336	728
1989	Finland*		39	24		6	69
	Sweden	66	3				69
	USSR		214			214	428
	Total	66	256	24	0	220	566
1990	Finland*		35	19		4	58
	USSR		144			141	285
	Total	0	179	19	0	145	343
1991	Finland*		53	17		5	75
	Sweden	88					88
	Estonia		135			51	186
	Total	88	188	17	0	56	349
1992	Finland*		48	10		5	63
	Sweden	86	3				89
	Estonia		47			46	93
	Total	86	98	10	0	51	245
1993	Finland*		52	26		5	83
	Sweden	83					83
	Estonia		86			55	141
	Total	83	138	26	0	60	307
1994	Denmark	9					9

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Finland*		47	24		8	79
	Sweden	33	10				43
	Estonia		3			4	7
	Total	42	60	24	0	12	138
1995	Denmark		1				1
	Finland*		54	29		6	89
	Sweden	81					81
	Estonia		52			35	87
	Total	81	107	29	0	41	258
1996	Finland*		47	36		9	92
	Sweden	114					114
	Estonia		99			145	244
	Total	114	146	36	0	154	450
1997	Finland*		35	32		13	80
	Sweden	105					105
	Estonia		96			125	221
	Total	105	131	32	0	138	406
1998	Finland*		36	21		14	71
	Sweden	70					70
	Estonia		79			87	166
	Total	70	115	21	0	101	307
1999	Denmark	0	1				1
	Finland*		43	22	2	9	76
	Sweden	15					15
	Estonia		150			164	314
	Total	15	194	22	2	173	406
2000	Denmark	1					1
	Finland*		34	13	0	9	56
	Sweden	73					73

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Estonia**		166			126	292
	Total	74	200	13	0	135	422
2001	Denmark	10					10
	Finland*		28	14	0	7	50
	Sweden	85			3		88
	Estonia**		135			220	355
	Total	100	164	14	3	227	503
2002	Finland*		16	8		11	35
	Sweden	90		5			95
	Estonia**		166			226	392
	Total	90	182	13	0	247	523
2003	Denmark	1					1
	Finland*	0	16	9	0	7	31
	Sweden	57					57
	Estonia****		156			128	284
	Total	57	172	9	0	135	374
2004	Finland*		13	18	0	4	34
	Sweden	45					45
	Estonia**		127			167	294
	Total	45	140	18	0	171	373
2005	Finland*		11	10	0	3	23
	Sweden	47	2	0			49
	Estonia		144			114	258
	Total	47	157	10	0	117	330
2006	Finland*		11	4.166	0	2	17
	Sweden	33					33
	Estonia		165			129	294
	Total	33	176	4	0	131	344
2007	Finland*		6	1	0	2	9

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Sweden	39	0	0	0		39
	Estonia**		110			104	214
	Total	39	116	1	0	107	263
2008	Finland		5	1	0	5	11
	Sweden	49	0	0			49
	Estonia**		103			86	189
	Total	49	108	1	0	89	249
2009	Finland		6	1	0	3	10
	Sweden	41	0	0			41
	Estonia**		109			102	210
	Total	41	115	1	0	105	262
2010	Finland	0	6	1	0	3	10
	Sweden	36	0	0			36
	Estonia**		85			96	180
	Total	36	91	1	0	99	227
2011	Finland	0	5	1	0	2	9
	Sweden	34	0	0	1		35
	Estonia**	0	94	0	0	83	177
	Total	34	99	1	1	85	221
2012****	Finland		3	0	0	1	5
	Poland***		3				3
	Sweden	36	0		0		36
	Estonia**		79			67	147
	Total	36	85	0	0	69	190
2013	Finland		3	1	0	1	5
	Poland		3				3
	Sweden	31	0				31
	Estonia		123			75	198
	Total	31	129	1	0	77	237

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
2014	Finland		2	0	0	1	4
	Poland		0				
	Sweden	29	0				29
	Estonia		85			65	150
	Total	29	87	0	0	67	183
2015	Finland		3	0	0	1	4
	Poland		0				0
	Sweden	26	0	0			27
	Estonia		81			64	145
	Total	26	85	0	0	64	176
2016	Finland		2	0	0	1	3
	Poland						0
	Sweden	22	0				22
	Estonia		96			52	148
	Total	22	98	0	0	53	173
2017	Finland		3	0	0	1	4
	Poland						0
	Sweden	18	0				18
	Estonia		95			33	128
	Total	18	98	0	0	34	150
2018	Finland		2	0	0	1	3
	Sweden	14	0				14
	Estonia		78			31	109
	Total	14	80	0	0	32	127
2019	Finland		2	0	0	0	3
	Estonia		76			30	106
	Sweden	12	0				12
	Total	12	79	0	0	31	121
2020	Finland		2	0	0	3	4

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Estonia		96			34	130
	Sweden	15	0				15
	Total	15	98	0	0	36	149

*** 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 3.20. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Discard estimates (in tonnes) for Sweden and Finland.

	Finland	Sweden
2015	0.138	4.4
2016	0.077	29.8
2017	0.008	23.7
2018	0.038	8.2
2019	0.341	13.9
2020	0.014	0.15

Table 3.21. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Recreational fishery catch estimates (in tonnes) for Estonia and Finland.

	Estonia		Finland			
	SD32	SD29	SD32	SD29	SD30	SD31
2000			156	187	30	1
2001						
2002			14	78	63	0
2003						
2004			12	64	3	0
2005						
2006			25	48	2	0
2007						
2008			6	27	7	0
2009						
2010			1	9	0	1
2011						
2012	16.6	15.0	13	24	1	0
2013	19.6	16.9				
2014	16.6	15.0	1	9	1	0
2015	28.0	15.7	1	9	1	0
2016	20.0	15.0	6	5	0	0
2017	13.1	12.9	6	5	0	0
2018	14.8	13.7	6	5	0	0
2019	13.2	11.2	1	4	0	0
2020	9.0	8.3	1	4	0	0

Table 3.22. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Fishing effort (days at sea) per country and gear type (passive/active).

	SWE Active	SWE Passive	EE Active	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
2020	19	683	2	19412	1641.0

Table 3.23. Baltic 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 SD27[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			
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	

SD	32	29	27			Combined[3)]
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[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)
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
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
2020	0.032	1.11	0.26	0.30	0.28	0.76

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

[2)] Arithmetic mean

[3)] Weighted mean with the respective SDs landings.

Table 3.24. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Input parameters for the length-based indicators analysis (LBI).

Data type	Source	Years/Value	Notes
Length frequency distribution	Küdema survey	2000-2020	
L_{inf}	Commercial trapnet data SD29+32 (2011-2016)	27.45 cm	combined sex
K		0.344 $year^{-1}$	
L_{mat}	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
L_{mat95}		20.89 cm	
M/K		1	

Table 3.25. Baltic flounder SD27, 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
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
2020	1.04	1.04	1.03	21.3	20.8

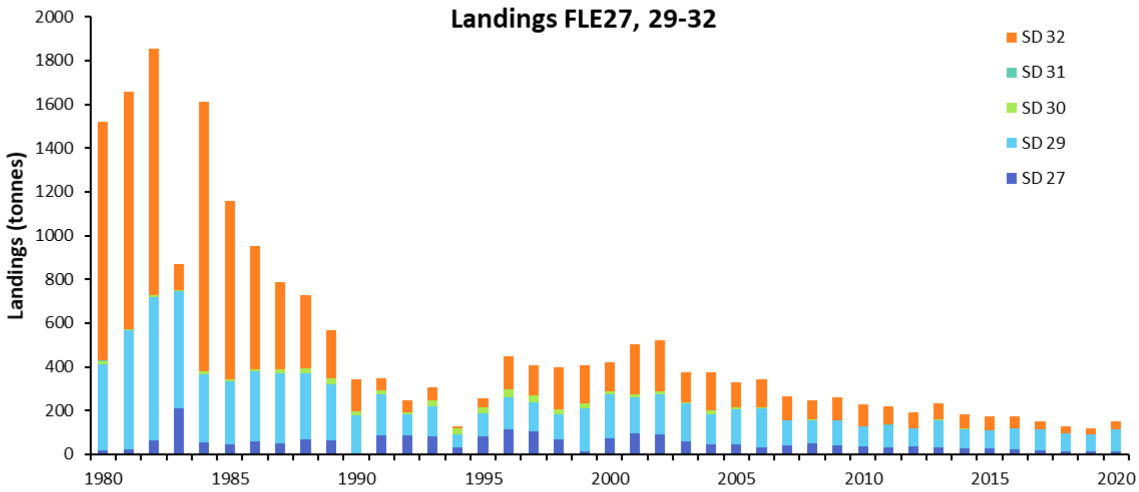


Figure 3.26. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2020.

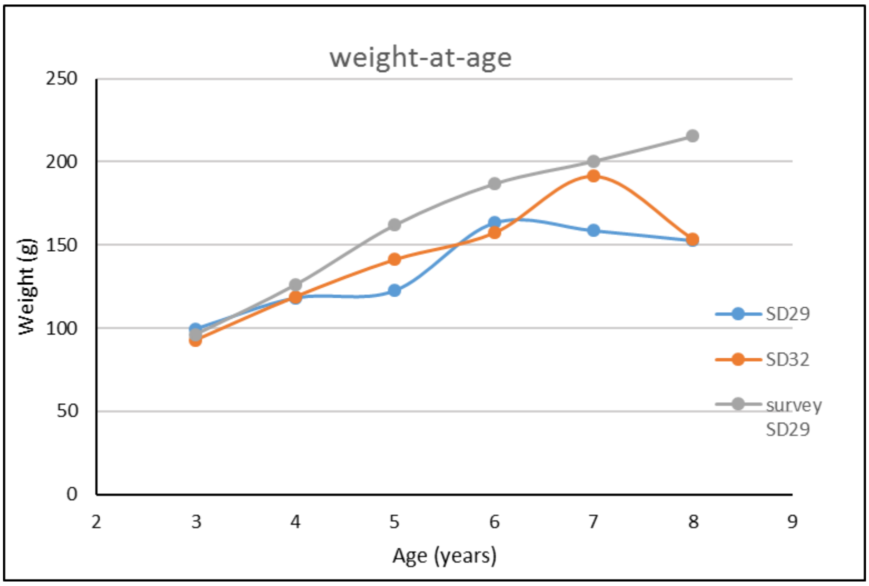


Figure 3.27. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings (2011-2016) per Subdivision (Q3+4) and for survey in SD29 (2000-2012).

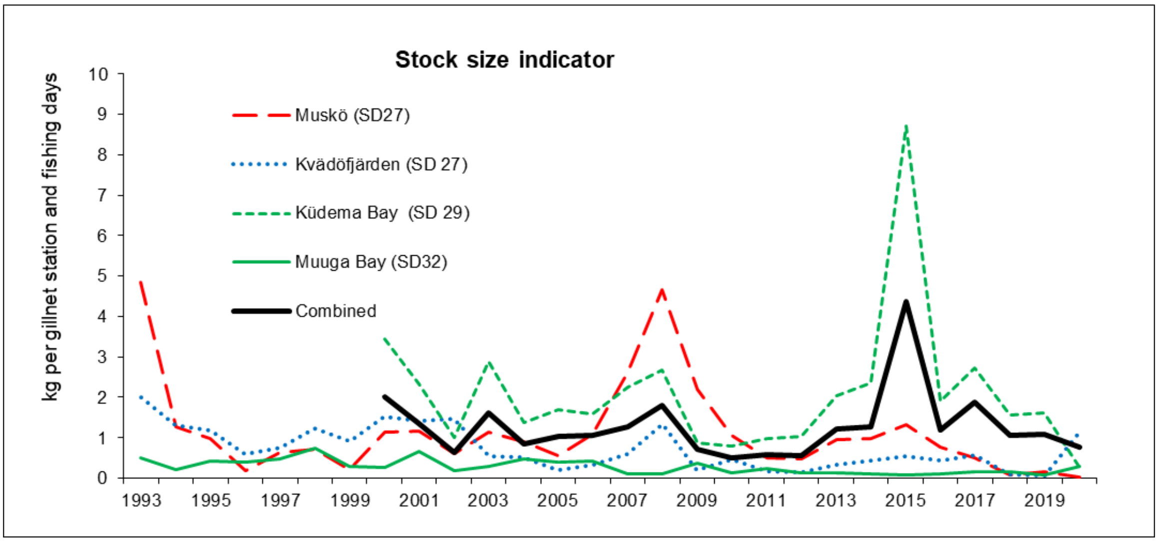


Figure 3.28. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing days).

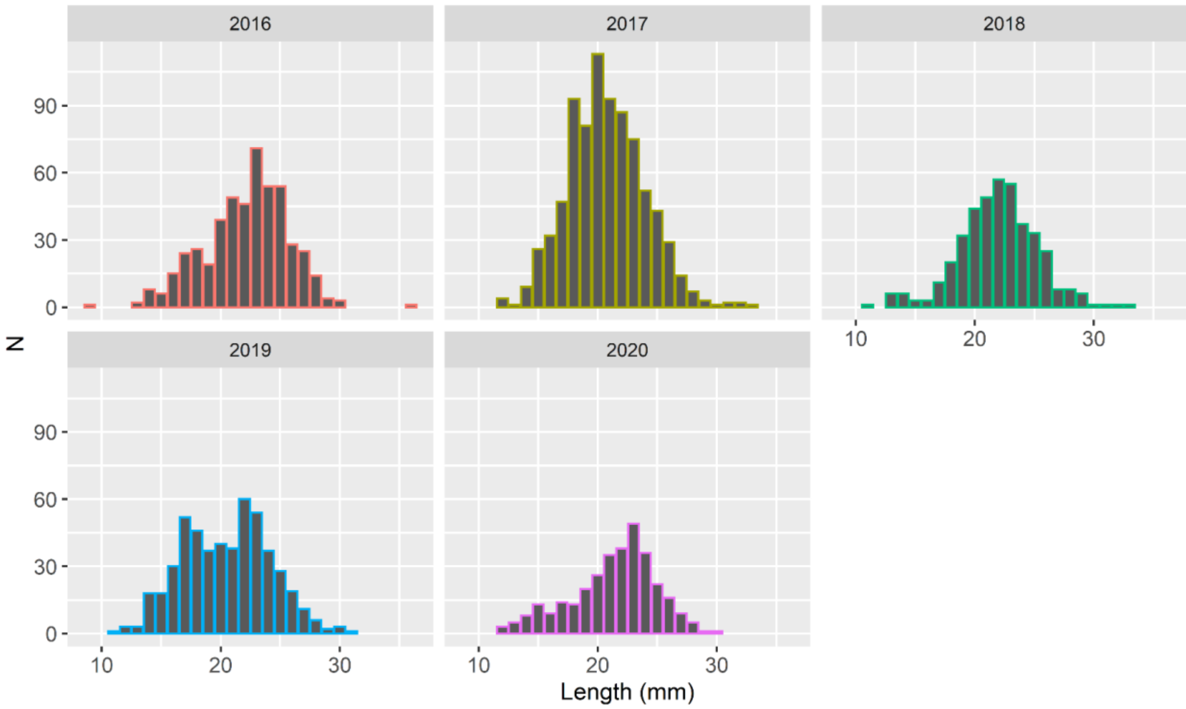


Figure 3.29. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Length frequency distribution from Küdema survey (SD29), years 2016-2020.

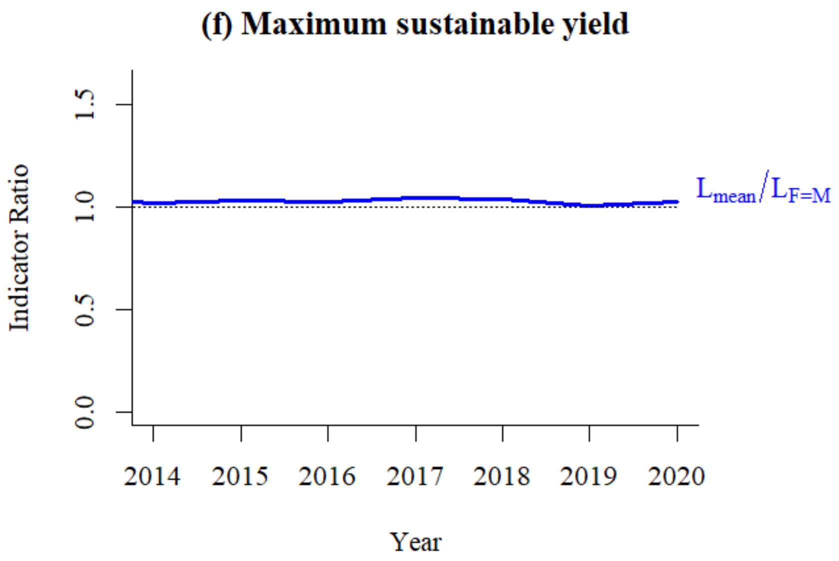


Figure 3.30. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). F_{msy} proxy reference point ($L_{F=M}$) compared to the mean length of catch indicator.

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 2020 is given in Table 4.1.

In Table 4.2 the proportion of herring in landings is given by country, subdivision and quarter for 2020 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 reasonable 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 4.3 shows the total reported landings of herring by quarter for 2020, along with the number of samples, the number of fishes measured and the number of fishes 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 and one Russian quota.

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

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

The units were changed in 2005 to be:

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

The historical development of agreed TACs and reported landings for these management units are illustrated in Figure 4.1.

Management 2020 and 2021 herring – sprat

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

Stock	Stock status ACOM 2020		ICES Advice for 2021 (Basis)	TAC 2021
	in relation to SSB_{2020} MSY & PA & MP	in relation to F_{2019} MSY & PA & MP	(t)	(t)
SPRAT				
SD 22-32	Above trigger and Full reproductivity and Above	Above and Harvested sustainably and Within range	181 567 - 316 833 (MAP applied)	*268458
HERRING				
SD 25–29&32 (excl. GOR)	Below trigger and Increased risk and Below	Above and Increased risk and Above the range	83 971 - 138 183 (MAP applied)	*126 051
SD 28.1 (Gulf of Riga)	Above trigger and Full reproductivity and Above	Below and Harvested sustainablyand Within the ranges	27 702 - 41 423 (MAP applied)	39 446
SD 30–31 (Bothnian Sea)	Unknown and Unknown and Unknown	Unknown and Unknown and 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%
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%
2020	4.0	22.1	18.1%
Mean	31.3	60.7	50.3%

***Finnish data not included.**

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

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

Year	CBH caught in Gulf of Riga (SD 28.1) (1000 tonnes)	Total catches of the CBH stock (SD 25–27, 28.2,29 &32) (1000 tonnes)	% of CBH caught in Gulfof Riga (SD 28.1)
2000	4.6	175.6	2.6%
2001	2.9	148.4	2.0%
2002	3.5	129.2	2.7%
2003	4.3	113.6	3.8%
2004	3.3	93.0	3.5%
2005	2.3	91.6	2.5%
2006	3.2	110.4	2.9%
2007	1.5	116.0	1.3%
2008	6.1	126.2	4.8%
2009	4.9	134.1	3.7%
2010	5.2	136.7	3.8%
2011	5.5	116.8	4.7%
2012	3.8	101.0	3.8%
2013	4.1	101.0	4.1%
2014	4.5	132.7	3.4%
2015	5.0	174.4	2.8%
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%
2020	1.3	177.1	0.7%
Mean	3.9	143.9	2.9%

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	1.1%
2014	0.2	26.3	0.8%
2015	0.3	32.9	0.9%
2016	0.3	30.9	1.0%
2017	0.2	28.1	0.7%
2018	0.5	*25.7	1.9%
2019	1.2	28.9	4.2%
2020	1.2	33.2	3.6%
Mean	0.5	32.1	1.5%

***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 the ICES Herring Assessment Working Group for the Area South of 62˚ N (HAWG).

Table 4.1. Pelagic landings ('000 t) and species composition (%) in 2020 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000 t)	48.98	38.31	6.40	14.78	**108.47**
	Herring (%)	18.65	24.39	83.41	69.23	**31.39**
	Sprat (%)	81.35	75.61	16.59	30.77	**68.61**
SD 26	Landings ('000 t)	61.67	30.33	5.43	27.57	**125.00**
	Herring (%)	22.14	19.97	77.50	43.23	**28.67**
	Sprat (%)	77.86	80.03	22.50	56.77	**71.33**
SD 27	Landings ('000 t)	10.63	2.86	0.26	5.06	**18.81**
	Herring (%)	57.60	64.98	67.10	66.38	**61.22**
	Sprat (%)	42.40	35.02	32.90	33.62	**38.78**
SD 28*	Landings ('000 t)	34.00	22.47	15.08	49.63	**121.18**
	Herring (%)	44.62	67.87	63.80	50.43	**53.70**
	Sprat (%)	55.38	32.13	36.20	49.57	**46.30**
SD 29	Landings ('000 t)	25.09	5.68	4.00	21.00	**55.76**
	Herring (%)	59.27	87.97	44.78	56.57	**60.13**
	Sprat (%)	40.73	12.03	55.22	43.43	**39.87**
SD 30	Landings ('000 t)	28.71	30.87	0.56	12.06	**72.19**
	Herring (%)	98.93	99.70	99.77	97.11	**98.96**
	Sprat (%)	1.07	0.30	0.23	2.89	**1.04**
SD 31	Landings ('000 t)	0.00	1.03	0.25	0.25	**1.54**
	Herring (%)	100.00	98.35	99.09	100.00	**98.74**
	Sprat (%)	0.00	1.65	0.91	0.00	**1.26**
SD 32	Landings ('000 t)	15.06	5.28	3.40	25.64	**49.37**
	Herring (%)	71.32	77.90	33.08	55.85	**61.36**
	Sprat (%)	28.68	22.10	66.92	44.15	**38.64**
Total	Landings ('000 t)	**224.13**	**136.80**	**35.37**	**155.98**	**552.29**
	Herring (%)	**43.76**	**53.64**	**65.19**	**56.86**	**51.28**
	Sprat (%)	**56.24**	**46.36**	**34.81**	**43.14**	**48.72**

* Gulf of Riga included

Table 4.2 Proportion of herring in landings 2020.

COUNTRY	QUARTER	SUBDIVISION							
		25	26	27	28*	29	30	31	32
DEN	1	0.12	0.25	0.48	0.17	0.41			
	2	0.17							
	3	0.54			0.52				
	4	0.60	0.95	0.53	0.54	0.34			
EST*	1				0.74	0.25			0.58
	2				0.92	0.49			0.71
	3				0.65	0.29			0.25
	4				0.57	0.23			0.34
FIN	1	0.90			0.66	0.84	0.99		0.56
	2	0.92			0.18	0.94	1.00	0.98	0.79
	3		1.00		0.84	0.56	1.00	0.99	0.43
	4	0.67	0.52	0.70	0.54	0.71	0.97	1.00	0.62
GER	1	0.10	0.13		0.08	0.09			
	2	0.04							
	3								
	4	0.02			0.07	0.18			
LAT*	1		0.08		0.48				
	2	0.05	0.14		0.53				
	3		0.87		0.58				
	4		0.58		0.47				
LIT	1	0.32	0.31		0.34				
	2	0.22	0.50		0.31				
	3		0.85		0.46				
	4		0.74		0.23				
POL	1	0.20	0.23		0.25				
	2	0.23	0.31	0.33	0.41				
	3	0.82	0.61		0.70				
	4	0.71	0.49		0.25				
RUS	1		0.20						0.95
	2		0.15						0.95
	3		0.86						0.00
	4		0.29						0.92
SWE	1	0.25	0.22	0.59	0.45	0.59	1.00		
	2	0.22		0.66	0.55	1.00	1.00	1.00	
	3	0.97		0.67	0.81	1.00	0.99	1.00	
	4	0.73	0.38	0.67	0.58	0.57	1.00	1.00	
Total	1	0.19	0.22	0.58	0.45	0.59	0.99		0.71
	2	0.24	0.20	0.65	0.68	0.88	1.00	0.98	0.78
	3	0.83	0.77	0.67	0.64	0.45	1.00	0.99	0.33
	4	0.69	0.43	0.66	0.50	0.57	0.97	1.00	0.56
Acoust. Stock**	4	0.62	0.39	0.45	0.31***	0.37	0.99		0.53

* Gulf of Riga included

** The area coverage of the acoustic survey in the SD 32 was relatively low (the easternmost part was not covered)

*** Gulf of Riga excluded

Table 4.3. Herring in subdivisions 25–32. Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group.

	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	9 132	35	1 767	1 273
	2	9 342	13	912	442
	3	5 337	9	1 130	682
	4	10 235	24	2 213	1 215
	Total	34 047	81	6 022	3 612
Subdivision 26	1	13 655	39	8 098	1 567
	2	6 058	26	6 901	1 463
	3	4 205	26	6 992	1 013
	4	11 919	44	9 369	1 568
	Total	35 836	135	31 360	5 611
Subdivision 27	1	6 124	17	820	820
	2	1 856	6	295	295
	3	178	2	100	100
	4	3 358	6	300	298
	Total	11 516	31	1 515	1 513
Subdivision 28*	1	15 172	44	4 423	3 516
	2	15 248	61	6 942	5 775
	3	9 620	14	2 093	1 281
	4	25 029	34	3 379	2 596
	Total	65 068	153	16 837	13 168
Subdivision 29	1	14 867	39	3 912	1 939
	2	4 992	17	3 554	1 088
	3	1 792	3	635	484
	4	11 880	16	2 897	1 142
	Total	33 531	75	10 998	4 653
Subdivision 30	1	28 398	25	6 018	624
	2	30 777	28	8 996	515
	3	554	3	1 139	241
	4	11 710	17	6 152	361
	Total	71 439	73	22 305	1 741
Subdivision 31	1	0	0	0	0
	2	1 012	8	2210	472
	3	251	8	1919	275
	4	253	3	670	138
	Total	1 517	19	4 799	885
Subdivision 32	1	10 740	47	4 360	2 062
	2	4 116	36	5 022	2 328
	3	1 123	7	919	790
	4	14 318	86	4 849	1 723
	Total	30 296	176	15 150	6 903
Subdivisions 25-32	**1**	**98 088**	**246**	**29 398**	**11 801**
	2	**73 402**	**195**	**34 832**	**12 378**
	3	**23 059**	**72**	**14 927**	**4 866**
	4	**88 701**	**230**	**29 829**	**9 041**
	Total	**283 251**	**743**	**108 986**	**38 086**

* Gulf of Riga included

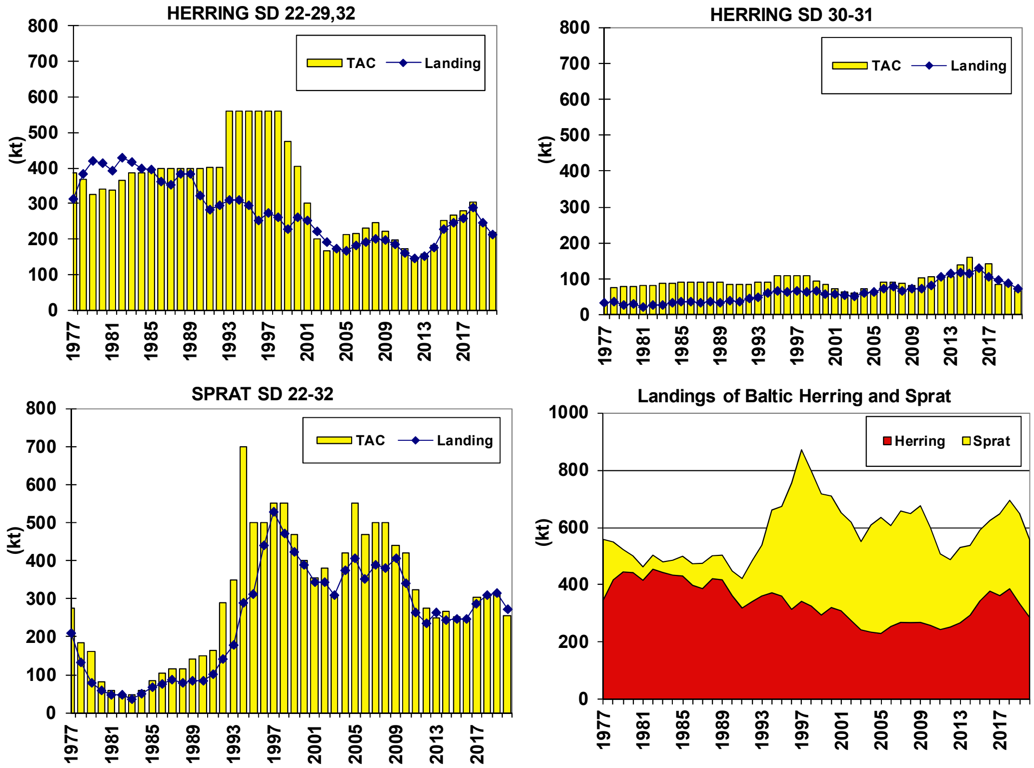


Figure 4.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

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

4.2.1 The Fishery

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 4.4. Catches in 2020 amounted to 177 079 t, which is 13% lower than last year. Catches decreased for most countries: Estonia (-21%), Finland (-14%), Germany (-52%), Latvia (-31%), Lithuania (-9%), Poland (-11%) and Sweden (-19%), except for Denmark (+5%) and Russia (+1%). The largest part of the catches in 2020 was taken by Sweden (26%), followed by Poland (20%) and by Finland (18%).

Catches by country and subdivision are presented in tables 4.5–4.6 (inclunding Central Baltic Herring caught in SD 28.1, see Section 4.1.3). In 2020 the spatial distribution of catches was as follows: 20% in SD 26, 19% in SD 25, 19% in SD 29, 18% in SD 28.2, 17% in SD 32 and 7% in SD27.

4.2.1.1 Discards

There was only one country, Finland, reporting logbook registered discards of 3.9 t (<0.01% of total catch) in 2020. No discards have been reported before 2016. Discarding at sea is regarded to be negligible.

4.2.1.2 Unallocated removals

A working document was presented in 2013 with a compilation on species measurement error for mixed pelagic species (ICES CM 2012/ACOM:10: WD 5 Walther *et al.*). The conclusion was that it is hard to make an accurate estimate on the proportion of herring and sprat in the catches from industrial trawl fisheries with small meshed trawls. In area 24–26 misreporting of herring exists and is accounted for by Denmark and Poland. Some catches are hard to sample because they are landed in foreign ports.

This was followed up by a questionnaire sent out before the benchmarking WKBALT in 2013 (ICES CM 2013/ACOM:43: WD 5 Krumme, Gröhsler). The result of this questionnaire was that, at the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches are dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by country for this misreporting is however variable from year to year and thus misreporting can in recent years (in the years after the benchmark) be a potential problem and should be investigated further.

4.2.1.3 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 16% of the total catches in 2020. All German catches, which only represent a minor part (0.5%) of the total catches, were landed in foreign ports and therefore no age composition of catches could be provided from Germany.

The compilation of 2020 national data was done by subdivision and quarter, but not by fishery (Table 4.7). 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 constitute in 2019 by 84% and in 2020 by 78% of the catches in numbers (Figure 4.2). The strong year class of 2014 is in 2020 6 years old and is still an important contributor to the fishery with 16% 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 4.3). The results (R^2) are similar or overall even slightly better compared to the last year. Table 4.6 gives catches, catch numbers-at-age and mean weight-at-age by subdivision, whereas Table 4.7 shows catch 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 2020 (Table 4.7) and then combined to give the mean weight-at-age for the whole catch. The marked decrease in mean weights at age that started in the early 1980s ceased around the mid-1990s and remains at this low level. When a particular strong year class occurs, like 2002, 2007, and 2014, there may be density dependent effects (Figure 4.4). 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 4.7. 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 4.5). As in the years before, the mean weight in the catch was also used as the mean weight in the stock. There is no survey information in the first quarter available, which could be used to calculate the mean weight in the stock (ICES CM 2013/ACOM:43). The mean weights in the catch from the first quarter could also be a candidate to be taken as mean weight in the stock. However, no corresponding data were available when conducting the benchmark in 2013 (ICES CM 2013/ACOM:43).

4.2.2.3 Maturity-at-age

The constant maturity ogive used by the WG is based on data between 1974–2011, based on the work of the Study Group on Baltic Herring and Sprat Maturity (ICES, 2002).

Source	Age 1	Age 2	Age 3	Age 4	Age 5+
Mean	0.016	0.67	0.90	0.94	0.97
WG ogive	0	0.70	0.90	1.00	1.00

An attempt to update the maturity ogive was done before the benchmark group (see Section 4.2.2.2 and ICES CM 2013/ACOM:43). The new maturity ogive was however not used due to inconsistencies in some parts of the data, a very high maturity at age 1 with a notable year and country effect. The new maturity ogive was also, apart from inconsistencies mentioned, similar to the old ogive and therefore it was decided to keep the old maturity ogive static between 1974 and 2020 (Table 4.11).

4.2.2.4 Natural mortality

As in previous years the natural mortalities used varied between years and ages as an effect of cod predation.

In 2019 new estimates of predation mortality (M2) covering 1974-2018 were available from updated SMS (ICES 2019/ICES Scientific Reports. 1:91), using analytical estimates of cod stock as external variable. The M for 2019 was assumed equal to the 2018 values. At WGBFAS in 2021 the average M_2 for 2020 was estimated from regression of average M_2 in 1974-2018 against biomass of cod at length ≥20 cm (R^2=0.93, Figure 4.6). Next, the average value was distributed into ages following distribution of M_2 by ages in recent 10 years. M was obtained by adding 0.1 to M_2. The resulting M values are given in Table 4.10.

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 2020 is given in Table 4.5. The overall frequency was 3.3 samples, 398 fish measured and 171 fish aged per 1000 tonnes landed. In 2020, sampling was most frequent in SD 28.2 followed by SD 26 and SD 32. Compared to 2018 the sampling has increased in all subdivisions, except SDs 28.2 and 29.

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 and onwards due to the mixing of sprat and herring in the catches. Analysis of a questionnaire answered by all Baltic countries during 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in near shore waters, e.g. archipelago area of Sweden or the Kolobrzeg-Darlowo fishing ground off Poland (further details see Annex H3 of WKBALT 2013/ICES CM 2013/ACOM:43). Countries with major proportions of sprat catches used for industrial purposes are Sweden, Poland and Denmark. Countries with major proportions of herring catches used for industrial purposes are Finland and Sweden. At the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches were dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by 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 last year, the stock abundance estimates from the Baltic International Acoustic October Survey (BIAS) were available to tune the XSA (1991–latest year, ages 1–8+). The tuning index covers the area of SD 25–27, 28.2 and 29. All available data covering the southern and northern 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 an incomplete coverage of the standard survey area. The BIAS index for ages 1–8+ is given in Table 4.14.

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 4.7). Including the 2020 data lead to an overall improvement 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 1991–2020 was used in a RCT3 analysis to estimate the year class 2020 at age 1 for 2021. The RCT3 input and result are presented in tables 4.20 and 4.2.21. The estimate of the year class 2020 (Age 1 in 2021: 12.130 billion) is below the average recruitment of age 1 of the whole time-series (1974–2020: 17.746 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 4.19. The assessment run and the software internal code are available at https:/www.stockassessment.org, CHB_WGBFAS_2021. Results of SAM compared to XSA are presented in Figure 4.12. In general SAM, produces 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 general tendency to underestimate fishing mortality and overestimate spawning stock biomass (Figure 4.13).

4.2.4.3 XSA

An inter-benchmark assessment was carried 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).
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 4.8–4.14, containing catches in numbers-at-age, mean weights at age in the catch and in the stock, tuning fleet and natural mortality by age and year, proportion of F and M before spawning time and the proportion mature fish by age. As in previous years, the mean weight in the stock was taken as the mean weight in the catch.

The diagnostics of the final XSA run, which converged after 51 iterations, are shown in Table 4.15. Since no values corresponding to the regression statistics were printed for the final run, the values could be taken from a run, which was stopped after 50 iterations. Fishing mortalities and stock number are given in Table 4.16 and Table 4.17, respectively. The summary is presented in Table 4.18.

The development of herring biomass as estimated by the acoustic surveys and by XSA is illustrated in Figure 4.8. During the last two years, 2019-2020 acoustic and XSA SSB and total biomass estimates both show a similar slightly decreasing trend.

A retrospective analysis for the whole time-series is given in Figure 4.9. Fishing mortality has been underestimated, whereas the spawning stock biomass has been overestimated comparing the last year. This retrospective pattern is the opposite for the year before, where the fishing mortality has been overestimated, whereas the spawning stock biomass has been underestimated (Mohn's rho: SSB: 0.141, Recruitment: 0.290, F_{bar}: -0.076).

The overall rather small log catchability residuals show some year effects with only positive or negative residuals (Figure 4.10). Last year values are small and positive and negative values are fluctuating without any trend. The catchability residuals are overall considered acceptable.

The abundance by age group of the tuning fleet was plotted against the estimated stock numbers (Figure 4.11). 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 $B_{trigger}$ since 2002. SBB shows a decreasing trend since 2014 and is below MSY $B_{trigger}$ in 2020. Fishing mortality has shown an increasing trend since 2014 and has been above F_{MSY} since 2015 (Figure 4.14). The present low SSB estimate of 365 kt for 2020 is 57% below the long-term average (1974–2020: 842 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 31 billion fish in 2016. Since 2017 the numbers start to decrease again and reached 15 billion fish in 2020 (Figure 4.15).

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 4.4). 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 afterwards (Figure 4.14). Since the mid-1980s recruitment has varied between 8 and 26 billion, without a clear trend. The year class 2014 is, however, estimated to be more than 50 percent higher than the last strong year class 2007, and is one of the largest year classes in the time-series (31.6 billion). The strong year class 2014 was followed by four years of below or on average recruitment. Last year the year class 2019 was estimated to be well above average. However, in this year's assessment, this year class was downscaled and is now estimated to below the long-term average. The stock status in the next years will depend on the further development of the incoming year classes.

4.2.5 Short-term forecast and management options

The input data of the short-term prediction are presented in Table 4.22. The mean weights at age in the prediction, for both catch and stock, were the average of 2018-2020. The estimate of recruitment of age 1 for 2021 was taken from the RCT3 analysis (Tables 4.20 and 4.21: 12.1 billion), whereas recruits in 2022 and 2023 were the GM for 1988–2019, 12.0 billion). The natural mortalities at age were assumed as the average of 2018–2020. The exploitation pattern was taken as the average over 2018–2020. The TAC constraint of 129 726 tonnes (EU share 97 551 tonnes + Russian quota 28 500 tonnes + central Baltic herring stock caught in Gulf of Riga 4189 tonnes (mean 2015–2019) − Gulf of Riga herring stock caught in central Baltic Sea 514 tonnes (mean 2015–2019)) was used in the predictions in the intermediate year 2021 since the total TAC in 2020 was almost fully exploited (and status quo F resulted in 167 kt, which is above this TAC constraint). This resulted in fishing mortality of 0.34 (Table 4.23), which lies below the present estimated F in 2020 of 0.46 but above F_{MSY} (0.21). The SSB is expected to be 365 448 t in 2010, which lies below MSY $B_{trigger}$ (460 000 t).

It should be noted that the large year class 2014 will still an important contributor to the yields in 2021. The stock status in the next years will depend on the further development of the incoming year classes 2019 and 2020. This year classes will contribute to a larger extent to the yield in 2022 and to the SSB in 2022 and 2023.

4.2.6 Reference points

Both MSY and PA reference points were re-estimated during an Inter-Benchmark Process (**IBP**) on **BA**ltic **S**prat (*Sprattus sprattus*) and **H**erring (*Clupea harengus*) (IBPBASH) in March 2020 (ICES 2020/ICES Scientific Reports. 2:34). Following the ACOM's decision in 2020 (see Expert Groups general ToR c) vi)), the basis for F_{pa} was changed in 2021 to $F_{p.05}$. The corresponding value $F_{p.05}$ of 0.32 was also calculated during Inter-Benchmark process in March 2020 (ICES 2020/ICES Scientific Reports. 2:34).

The present reference points are provided in the text table below.

Reference Points	Values	Rationale
Blim	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)
Bpa	460 000 t	1.4* Blim
MSY Btrigger	460 000 t	Bpa
Fmsy	0.21	Estimated by EqSim
FmsyUpper	0.26	Estimated by EqSim as the upper value of F at 95% of the landings of Fmsy
FmsyLower	0.15	Estimated by EqSim as the lower value of F at 95% of the landings of Fmsy
Flim	0.59	Estimated by EqSim as the F with 50% probability of SSB being less than Blim
Fpa	0.32	Fp.05. The F that leads to SSB ≥ Blim with 95% probability

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 and M for 2020 taken from a regression with eastern Baltic cod biomass of individuals ≥20 cm.

Recruitment data are derived from a 0-group acoustic index, which was revised in 2013 (ICES CM 2013/SSGESST:08) and since then includes area corrected values. The 2013-2016 values were revised by WGBFIS in 2020.

Catches of central Baltic spring-spawning herring taken in the Gulf of Riga are included in the assessment.

ICES has been stating for several years that the pelagic fisheries take a mixture of herring and sprat and this causes uncertainties in catch levels. The extent to which species misreporting has occurred is however not well known. Analysis of a questionnaire answered by all Baltic countries during 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in nearshore waters (ICES CM 2013/ACOM:43: WD 5 Krumme, Gröhsler, see also section 4.2.2.5). Countries with major proportions of sprat catches used for industrial purposes are Sweden, Poland and Denmark. Countries with major proportions of herring catches used for industrial purposes are Finland and Sweden. The official catch figures of both sprat and herring are modified by Poland and Denmark, but not currently in Sweden. A worstcase 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 the present assessment resulted in 8% less SSB for 2019. In 2019 $F_{(3–6)}$ was estimated to be 11% higher compared to last year's assessment and recruitment-at-age 1 in 2019 was estimated to be 26% less in this year's assessment.

Category	Parameter	Assessment WGBFAS 2020	Assessment WGBFAS 2021	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	$M_{1974–2018}$ estimated in SMS, M_{2018} = M_{2019} regression of M against cod SSB	$M_{1974–2018}$ estimated in SMS, M_{2018} = M_{2019}, M_{2020} from regression with eastern Baltic cod biomass TL>=20 cm	No
XSA input	Catchability dependent on year class strength	Age < 2	Age < 2	No
	Catchability independent on age	Age > = 6	Age > = 6	No
	SE of the F shrinkage mean	1.5	1.5	No
	Time weighting	Tricubic, 20 years	Tricubic, 20 years	No
	Tuning data	International acoustic autumn	International acoustic autumn	No
XSA results	SSB 2019 (1000 t)	501.973	460.378	-8.3%
	TSB 2019 (1000 t)	758.184	691.214	-8.8%
	F(3–5) 2019	0.4478	0.4951	10.6%
	Recruitment (age 1) 2019 (billions)	8.430689	6.256558	-25.8%

4.2.9 Management considerations

SBB shows a decreasing trend since 2014 and is below MSY $B_{trigger}$ in 2020. The present SSB estimate for 2020 is below the long-term average (1974–2020). Fishing mortality ($F_{3–6}$ of 0.46) is far higher than the adopted F_{MSY} of 0.21 (ICES 2020/ICES Scientific Reports. 2:34). 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 year class 2014 is still an important contributor to the yield in 2021 (Figure 4.16). The strong year class 2014 was followed by four years of below or on average recruitment. The year class 2019, which was estimated to well above average last year, was downscaled during this year's assessment. This year class is now estimated to be below average. The stock status in the next years will depend on the development of incoming year classes.

The fluctuations of the eastern cod stock and sprat stock (see also WKREFBAS 2008/ICES CM 2008/ACOM:28) should be considered 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 since last year's assessment and by this include the predation by the cod stock.

Table 4.4. 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
*2020	9.3	17.1	31.9	0.8	5.2	5.6	35.9	26.0	45.3	177.1

*** Preliminary**

**** In 1977–1990 sum of catches for Estonia, Latvia, Lithuania and Russia**

***** Updated in 2011**

******** Updated in 2013 from 8.3 kt to 11.4 kt and included in 2014 assessment (WGBFAS 2014).**

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group. 1/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	Denmark	1	1 559	7	90	63
		2	701	0	0	0
		3	280	0	0	0
		4	1 392	6	245	245
		Total	3 931	13	335	308
	Finland	1	180	0	0	0
		2	1 843	0	0	0
		3				
		4	8	0	0	0
		Total	2 031	0	0	0
	Germany	1	268	0	0	0
		2	118	0	0	0
		3				
		4	2	0	0	0
		Total	388	0	0	0
	Latvia	1	0.0	0	0	0
		2	23	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	23	0	0	0
	Lithuania	1	259	0	0	0
		2	795	0	0	0
		3				
		4				
		Total	1 054	0	0	0
	Poland	1	4 822	4	738	272
		2	3 921	3	674	206
		3	3 584	2	586	139
		4	6 429	5	1 293	300
		Total	18 757	14	3 291	917
	Sweden	1	2 045	24	939	938
		2	1 942	10	238	236
		3	1 473	7	544	543
		4	2 404	13	675	670
		Total	7 864	54	2 396	2 387
	Total	1	9 132	35	1 767	1 273
		2	9 342	13	912	442
		3	5 337	9	1 130	682
		4	10 235	24	2 213	1 215
		Total	34 047	81	6 022	3 612

(cont').

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group. 2/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 26	Denmark	1	401	2	47	47
		2				
		3				
		4	279	0	0	0
		Total	680	2	47	47
	Finland	1				
		2				
		3	36	0	0	0
		4	51	0	0	0
		Total	87	0	0	0
	Germany	1	55	0	0	0
		2				
		3				
		4				
		Total	55	0	0	0
	Latvia	1	192	0	0	0
		2	62	0	0	0
		3	312	0	0	0
		4	393	0	0	0
		Total	960	0	0	0
	Lithuania	1	1 557	5	1 057	610
		2	345	6	1 286	759
		3	198	1	185	130
		4	965	3	588	347
		Total	3 065	15	3 116	1 846
	Poland	1	6 264	3	582	161
		2	2 383	0	0	0
		3	1 181	8	1 854	524
		4	6 414	8	1 330	309
		Total	16 241	19	3 766	994
	Russia	1	5 089	26	6 344	681
		2	3 267	20	5 615	704
		3	2 479	17	4 953	359
		4	2 723	25	7 146	607
		Total	13 557	88	24 058	2 351
	Sweden	1	98	3	68	68
		2				
		3				
		4	1 093	8	305	305
		Total	1 191	11	373	373
	Total	1	13 655	39	8 098	1 567
		2	6 058	26	6 901	1 463
		3	4 205	26	6 992	1 013
		4	11 919	44	9 369	1 568
		Total	35 836	135	31 360	5 611

(cont').

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group. 3/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 27	Denmark	1	613	1	31	31
		2				
		3				
		4	57	0	0	0
		Total	670	1	31	31
	Finland	1				
		2				
		3				
		4	117	0	0	0
		Total	117	0	0	0
	Lithuania	1				
		2	33	0	0	0
		3				
		4				
		Total	33	0	0	0
	Sweden	1	5 511	16	789	789
		2	1 823	6	295	295
		3	178	2	100	100
		4	3 183	6	300	298
		Total	10 695	30	1 484	1 482
	Total	1	6 124	17	820	820
		2	1 856	6	295	295
		3	178	2	100	100
		4	3 358	6	300	298
		Total	11 516	31	1 515	1 513

(cont').

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 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	715	11	119	119
	2				
	3	259	0	0	0
	4	235	0	0	0
	Total	1 209	11	119	119
Estonia	1	554	16	996	996
	2	1 512	9	749	749
	3	86	1	38	38
	4	716	9	537	537
	Total	2 867	35	2 320	2 320
Finland	1	213	0	0	0
	2	2	0	0	0
	3	75	0	0	0
	4	650	0	0	0
	Total	940	0	0	0
Germany	1	122	0	0	0
	2				
	3				
	4	57	0	0	0
	Total	179	0	0	0
Latvia	1	973	1	200	95
	2	991	2	386	159
	3	336	2	295	185
	4	1 958	3	461	273
	Total	4 258	8	1 342	712
Lithuania	1	394	0	0	0
	2	128	0	0	0
	3	187	0	0	0
	4	730	0	0	0
	Total	1 440	0	0	0
Poland	1	137	0	0	0
	2	197	0	0	0
	3	239	0	0	0
	4	275	0	0	0
	Total	847	0	0	0
Sweden	1	2 885	14	543	542
	2	1 343	8	322	322
	3	3 003	7	323	323
	4	12 880	13	633	633
	Total	20 111	42	1 821	1 820
Total	1	5 992	42	1 858	1 752
	2	4 173	19	1 457	1 230
	3	4 185	10	656	546
	4	17 502	25	1 631	1 443
	Total	31 852	96	5 602	4 971

(cont').

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group. 5/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 29	Denmark	1	2 541	14	869	595
		2				
		3				
		4	244	0	0	0
		Total	2 785	14	869	595
	Estonia	1	774	16	996	996
		2	362	8	781	681
		3	459	1	38	38
		4	842	9	537	537
		Total	2 437	34	2 352	2 252
	Finland	1	8 189	6	1 897	198
		2	4 617	9	2 773	407
		3	1 332	2	597	446
		4	8 532	7	2 360	605
		Total	22 670	24	7 627	1 656
	Germany	1	52	0	0	0
		2				
		3				
		4	160	0	0	0
		Total	212	0	0	0
	Sweden	1	3 311	3	150	150
		2	14	0	0	0
		3	1	0	0	0
		4	2 102	0	0	0
		Total	5 427	3	150	150
	Total	1	14 867	39	3 912	1 939
		2	4 992	17	3 554	1 088
		3	1 792	3	635	484
		4	11 880	16	2 897	1 142
		Total	33 531	75	10 998	4 653

(cont').

Table 4.5. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2020 available to the Working Group. 6/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 32	Estonia	1	4 328	18	1 776	1 776
		2	2 654	19	1 910	1 910
		3	453	4	485	485
		4	4 335	11	1 069	1 069
		Total	11 770	52	5 240	5 240
	Finland	1	1 164	3	204	142
		2	53	5	1 643	226
		3	670	3	434	305
		4	4 156	2	260	518
		Total	6 044	13	2 541	1 191
	Russia	1	5 248	26	2 380	144
		2	1 408	12	1 469	192
		3				
		4	5 826	73	3 520	136
		Total	12 482	111	7 369	472
	Total	1	10 740	47	4 360	2 062
		2	4 116	36	5 022	2 328
		3	1 123	7	919	790
		4	14 318	86	4 849	1 723
		Total	30 296	176	15 150	6 903
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	**60 511**	**219**	**20 815**	**9 413**
		2	**30 538**	**117**	**18 141**	**6 846**
		3	**16 819**	**57**	**10 432**	**3 615**
		4	**69 211**	**201**	**21 259**	**7 389**
		Total	**177 079**	**594**	**70 647**	**27 263**

Table 4.6. Herring in SD 25–29, 32 (excl. GoR). Catch by country and SD and mean weight by SD in 2020.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	9.275	3.931	0.680	0.670	1.209	2.785	0.000
Estonia	17.074	0.000	0.000	0.000	2.867	2.437	11.770
Finland	31.890	2.031	0.087	0.117	0.940	22.670	6.044
Germany	0.833	0.388	0.055	0.000	0.179	0.212	0.000
Latvia*	5.241	0.023	0.960	0.000	4.258	0.000	0.000
Lithuania	5.558	1.054	3.065	0.000	1.440	0.000	0.000
Poland	35.879	18.757	16.241	0.033	0.847	0.000	0.000
Russia	26.039	0.000	13.557	0.000	0.000	0.000	12.482
Sweden	45.289	7.864	1.191	10.695	20.111	5.427	0.000
Total	**177.079**	**34.047**	**35.836**	**11.516**	**31.852**	**33.531**	**30.296**

*Catches in SD 28.2 include 516 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	363377	1919	4978	907	1901	233426	120245
1	1644919	90293	134988	177518	170875	749991	321255
2	781308	58750	39711	79115	100069	222216	281447
3	1423813	126066	169114	108034	189004	316036	515559
4	788676	84850	95395	51650	188282	169777	198723
5	662488	100307	157484	46264	179409	97983	81041
6	1080601	190112	193461	96176	323979	155393	121480
7	199821	47001	76300	9349	26501	21563	19105
8	175049	32881	46991	1644	18456	53786	21293
9	29670	7432	14893	400	3398	1987	1560
10+	23751	4744	13451	0	3113	1343	1100
Total N	**7173473**	**744356**	**946767**	**571056**	**1204987**	**2023501**	**1682807**
CATON	**177.079**	**34.047**	**35.836**	**11.516**	**31.852**	**33.531**	**30.296**
Mean weight (g)							
AGE	Mean	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	5.3	15.3	13.4	13.2	10.6	4.9	5.3
1	11.6	25.0	19.5	8.8	11.6	9.8	10.1
2	20.3	37.8	33.5	19.3	21.9	17.6	16.6
3	26.1	45.6	38.0	23.7	26.2	21.9	20.4
4	29.7	45.8	36.9	26.6	28.8	26.5	23.8
5	35.0	51.3	40.5	28.5	30.5	27.8	26.2
6	34.3	46.6	41.4	28.7	31.2	27.1	25.6
7	45.6	64.3	47.3	34.6	35.8	31.2	27.7
8	43.5	60.8	48.7	33.2	36.8	36.6	29.7
9	56.5	71.9	57.1	30.0	49.6	32.1	30.2
10+	61.7	98.0	58.5	0.0	44.0	33.5	29.3

CATON is given in 1000 tons

Table 4.7. Herring in SD 25–29, 32 (excl. GoR). Catch in number-at-age (millions) per SD and quarter in 2020. CATON in 1000 t). 1/2

Quarter:	1						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	729.474	30.871	60.629	118.822	51.645	353.151	114.356
2	256.474	13.397	6.642	47.784	14.365	110.480	63.806
3	626.567	42.377	59.447	63.001	33.970	181.132	246.640
4	304.881	23.431	37.070	28.435	28.893	88.995	98.057
5	234.057	20.752	73.967	17.500	32.900	49.741	39.196
6	418.171	49.900	70.608	62.765	85.133	101.089	48.676
7	70.274	13.214	37.320	3.180	5.042	7.994	3.525
8	63.320	13.139	22.194	1.190	4.674	18.373	3.749
9	11.665	2.506	7.715	0.400	0.142	0.203	0.700
10+	12.453	2.079	9.488	0.000	0.284	0.203	0.400
Total N	2727.335	211.666	385.082	343.076	257.047	911.361	619.103
CATON	60.511	9.132	13.655	6.124	5.992	14.867	10.740
Quarter:	2						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	175.990	24.457	30.070	9.888	40.677	34.560	36.338
2	101.100	13.184	5.823	11.863	17.114	30.835	22.280
3	306.696	25.535	49.012	23.727	36.132	58.054	114.237
4	113.629	14.489	10.208	11.293	18.230	35.409	24.000
5	141.228	34.962	24.640	10.733	27.567	27.490	15.836
6	151.143	52.113	23.164	13.839	37.606	9.703	14.718
7	37.382	13.488	6.874	1.976	4.188	6.042	4.814
8	44.149	7.927	7.430	0.000	4.764	21.286	2.743
9	7.540	3.115	2.233	0.000	1.385	0.208	0.600
10+	6.196	1.848	2.046	0.000	1.595	0.208	0.500
Total N	1085.054	191.118	161.499	83.319	189.258	223.795	236.065
CATON	30.538	9.342	6.058	1.856	4.173	4.992	4.116
Quarter:	3						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	3.627	0.156	0.347	0.000	0.059	0.102	2.963
1	93.830	14.714	10.187	4.610	20.459	17.221	26.639
2	53.323	9.392	6.183	1.240	16.621	14.231	5.656
3	91.253	21.184	17.880	0.800	24.317	14.870	12.201
4	69.452	16.579	10.554	0.530	25.095	11.606	5.088
5	59.051	14.967	16.880	0.710	20.788	4.161	1.547
6	107.885	27.777	24.472	0.890	40.319	10.395	4.031
7	20.371	4.998	9.065	0.090	3.655	1.698	0.865
8	13.332	1.791	5.189	0.000	1.679	4.157	0.516
9	4.082	0.190	2.057	0.000	0.775	1.001	0.060
10+	2.701	0.501	1.281	0.000	0.420	0.500	0.000
Total N	518.908	112.247	104.095	8.870	154.185	79.942	59.567
CATON	16.819	5.337	4.205	0.178	4.185	1.792	1.123
Quarter:	4						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	359.750	1.764	4.632	0.907	1.841	233.324	117.282
1	645.625	20.252	34.101	44.198	58.094	345.059	143.922
2	370.411	22.777	21.062	18.228	51.970	66.669	189.706
3	399.298	36.970	42.775	20.506	94.584	61.980	142.481
4	300.714	30.352	37.562	11.392	116.064	33.766	71.578
5	228.151	29.626	41.998	17.321	98.154	16.590	24.462
6	403.403	60.322	75.217	18.681	160.921	34.208	54.054
7	71.793	15.301	23.041	4.103	13.617	5.829	9.903
8	54.248	10.024	12.178	0.454	7.340	9.969	14.284
9	6.383	1.621	2.889	0.000	1.097	0.576	0.200
10+	2.401	0.317	0.637	0.000	0.815	0.432	0.200
Total N	2842.177	229.325	296.090	135.791	604.496	808.403	768.072
CATON	69.211	10.235	11.919	3.358	17.502	11.880	14.318

Table 4.7. Herring in SD 25–29, 32 (excl. GoR). Mean weight-at-age per SD and quarter in 2020. Mean weight (g). 2/2

Quarter:	1						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	NA	NA	NA	NA	NA	NA	NA
1	6.2	15.3	9.7	5.6	5.6	5.4	5.3
2	16.9	34.2	23.4	17.4	18.6	15.9	13.7
3	23.4	43.6	35.4	22.9	23.1	21.4	18.7
4	27.5	40.7	36.4	25.7	26.2	26.9	22.3
5	33.1	47.3	40.3	27.8	29.5	27.2	25.0
6	32.2	46.9	40.3	28.6	29.7	26.7	25.4
7	45.3	69.0	44.4	36.9	34.3	28.3	27.5
8	44.7	64.3	46.9	35.3	35.1	34.3	29.2
9	57.1	69.9	58.0	30.0	33.8	28.6	30.2
10+	58.8	86.1	55.4	0.0	38.9	32.0	25.8
Quarter:	2						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	NA	NA	NA	NA	NA	NA	NA
1	11.2	25.1	20.8	8.2	6.1	5.7	5.7
2	18.5	32.5	30.1	18.2	15.4	15.4	14.2
3	25.2	45.6	38.7	22.1	23.7	20.8	18.3
4	29.8	52.6	38.8	25.7	28.3	25.3	21.7
5	36.6	53.5	40.2	28.4	30.2	28.9	24.0
6	38.6	49.3	43.2	26.7	33.2	29.7	24.1
7	49.3	69.0	49.4	35.5	35.5	36.7	27.8
8	47.0	67.4	50.3	0.0	36.8	43.1	27.5
9	65.1	83.3	58.7	0.0	53.5	34.0	31.5
10+	68.8	114.6	61.9	0.0	42.1	32.3	28.0
Quarter:	3						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	6.8	23.5	10.0	0.0	15.7	4.1	5.5
1	19.7	35.5	28.1	15.2	16.2	14.1	14.7
2	27.4	46.4	32.3	22.0	23.4	20.6	20.1
3	33.6	50.6	39.0	21.3	26.1	23.6	23.8
4	33.8	47.6	38.1	24.4	28.7	25.7	24.7
5	38.5	54.1	39.7	30.4	29.7	27.7	26.4
6	36.7	46.1	41.8	30.0	30.8	26.9	26.2
7	48.7	68.3	48.2	28.0	37.9	28.4	28.0
8	42.9	55.8	53.7	0.0	34.6	28.8	30.2
9	50.4	69.0	57.8	0.0	50.4	32.3	37.3
10+	63.0	95.2	69.2	0.0	42.3	32.3	0.0
Quarter:	4						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	5.2	14.5	13.7	13.2	10.4	4.9	5.3
1	16.5	31.9	33.0	17.1	19.1	14.5	14.2
2	22.1	39.6	38.0	25.1	24.5	20.9	17.8
3	29.2	44.9	40.2	28.1	28.4	24.1	24.6
4	31.1	45.5	36.6	29.9	29.6	26.9	26.6
5	34.8	50.0	41.2	29.1	31.0	28.1	29.5
6	34.3	44.2	41.7	30.4	31.6	27.7	26.2
7	43.0	54.8	50.8	32.5	36.0	30.4	27.8
8	39.5	51.9	48.9	27.6	38.3	30.4	30.2
9	49.4	53.5	53.4	0.0	46.1	32.2	24.5
10+	56.8	83.1	71.2	0.0	50.3	36.3	39.8

Table 4.8. Herring in SD 25–29, 32 (excl. GoR). XSA input: Catch in numbers (thousands).

	CANUM: Catch in numbers (Total International Catch) (Total) (Thousands)								
Year	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8+**	**SOPCOF %**
1974	2436300	1553800	1090600	1347900	483100	343500	619000	285100	99.5
1975	1861800	1229200	1405600	829900	870700	364000	274800	546800	100.2
1976	2093100	1114800	1034000	907300	476800	558500	246500	494400	100.0
1977	1258500	1825900	773600	608300	621700	365300	284000	545400	99.9
1978	1044000	1298700	1575100	436800	355100	370700	186800	478300	100.0
1979	405300	1195500	873200	1159500	338900	278700	281200	478500	100.0
1980	1037000	907100	977400	524600	654900	182500	204400	550500	100.0
1981	1325500	1523500	680000	615000	343600	436300	146600	527500	100.2
1982	867000	2277000	810100	334200	312000	188100	250500	420700	99.6
1983	744300	1698700	1875700	625300	233100	245700	162500	433400	100.3
1984	822000	1177900	1282900	1145700	374300	165500	166300	421100	100.0
1985	1237800	2124100	1076100	867300	707200	240300	131000	346900	99.9
1986	552824	1733617	1601914	838843	614707	320221	114772	208901	100.4
1987	920000	726000	1445000	1237000	607000	461000	238000	194000	100.1
1988	474000	2091300	746300	1009600	849400	354300	254200	210100	100.1
1989	792900	540600	1988300	580000	840700	695100	266500	336600	99.9
1990	643300	1194800	585500	1245900	419400	541100	370500	306000	100.4
1991	372900	1571700	1286100	512700	807700	278400	265900	238200	100.1
1992	1112600	1139400	1696900	702900	324100	422300	157700	218600	100.7
1993	826300	1852600	1503000	1473400	615700	274000	197500	140100	99.8
1994	486870	1138560	1559930	1068900	1057400	495520	213790	282450	100.5
1995	820500	960200	1742700	1555400	645700	440400	205200	212100	100.5
1996	985800	1441300	1095900	1216600	798100	492000	301100	223800	99.3
1997	549200	1350300	1738700	1173900	904800	492600	244200	186100	99.9
1998	1873286	947360	1810804	1781642	813071	481770	211361	186102	100.1
1999	628815	1660328	949293	1307772	950155	340256	185943	119952	102.9
2000	1842170	940000	1682170	818970	864530	567220	191280	185030	99.9
2001	1052466	1930067	605055	1010660	375834	391122	303247	199646	99.4
2002	1034640	1012975	1339851	456838	522442	179710	169851	230139	98.6
2003	1347364	782607	687478	686673	261252	226812	89925	202367	101.1
2004	656630	1242941	673629	568055	384598	162350	119700	129883	100.0
2005	326272	753498	1187077	557148	378447	219723	82530	159318	101.2
2006	808387	505592	754016	1104978	409059	264865	154493	147666	100.8
2007	457582	920291	630258	703185	823805	268661	135977	112019	101.2
2008	789388	735511	968418	461494	485798	711012	165897	215625	99.4
2009	653043	1395081	745935	855049	302486	340499	486075	239340	100.0
2010	546352	645269	1357314	661735	630229	283763	283721	362390	101.0
2011	293118	568892	770797	1130531	415505	312765	128881	235287	101.0
2012	333355	317009	416640	517743	642002	234424	160708	208441	100.0
2013	470327	655679	260040	410703	467439	403588	172879	224139	100.0
2014	470062	902642	1003705	385671	488077	409753	285297	250759	100.0
2015	1415576	745130	1264634	1252762	378036	384811	369954	473420	100.0
2016	602141	3014945	934748	1188734	838456	331740	465961	629002	100.0
2017	983743	823614	2898360	840730	923686	527598	248465	411819	100.0
2018	1737640	1280367	1174100	2637412	789008	663989	398905	335250	99.9
2019	416846	1561422	1127576	891782	1957135	485302	396557	239356	98.8
2020	1644919	781308	1423813	788676	662488	1080601	199821	228471	99.8

Table 4.9. Herring in SD 25–29, 32 (excl. GoR). XSA input: Mean weight in the catch and in the stock (Kilograms).

	WECA (= WEST): Mean weight in Catch (Total International Catch) (Total) (Kilograms)							
Year	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8+**
1974	0.0300	0.0350	0.0430	0.0460	0.0710	0.0790	0.0830	0.0750
1975	0.0300	0.0340	0.0520	0.0520	0.0540	0.0790	0.0780	0.0790
1976	0.0230	0.0380	0.0400	0.0600	0.0580	0.0570	0.0800	0.0810
1977	0.0290	0.0310	0.0500	0.0580	0.0690	0.0610	0.0720	0.0910
1978	0.0270	0.0440	0.0430	0.0560	0.0620	0.0730	0.0730	0.0810
1979	0.0240	0.0420	0.0590	0.0530	0.0660	0.0720	0.0770	0.0860
1980	0.0240	0.0370	0.0540	0.0680	0.0630	0.0770	0.0800	0.0940
1981	0.0260	0.0350	0.0530	0.0700	0.0790	0.0770	0.0860	0.1000
1982	0.0220	0.0390	0.0530	0.0650	0.0750	0.0840	0.0800	0.1010
1983	0.0180	0.0310	0.0560	0.0590	0.0770	0.0870	0.0910	0.1030
1984	0.0160	0.0300	0.0460	0.0650	0.0670	0.0820	0.0890	0.1010
1985	0.0160	0.0230	0.0420	0.0580	0.0670	0.0750	0.0850	0.1020
1986	0.0180	0.0250	0.0330	0.0510	0.0630	0.0690	0.0790	0.0990
1987	0.0150	0.0330	0.0380	0.0450	0.0590	0.0640	0.0710	0.0920
1988	0.0200	0.0260	0.0470	0.0510	0.0530	0.0650	0.0710	0.0900
1989	0.0230	0.0360	0.0370	0.0520	0.0570	0.0590	0.0670	0.0820
1990	0.0180	0.0310	0.0420	0.0390	0.0600	0.0620	0.0640	0.0770
1991	0.0230	0.0240	0.0350	0.0490	0.0410	0.0600	0.0560	0.0690
1992	0.0130	0.0230	0.0310	0.0420	0.0570	0.0500	0.0670	0.0710
1993	0.0130	0.0210	0.0320	0.0350	0.0440	0.0510	0.0500	0.0660
1994	0.0160	0.0210	0.0280	0.0380	0.0420	0.0520	0.0610	0.0640
1995	0.0110	0.0210	0.0240	0.0320	0.0410	0.0420	0.0490	0.0540
1996	0.0110	0.0170	0.0240	0.0280	0.0330	0.0370	0.0400	0.0510
1997	0.0110	0.0170	0.0220	0.0260	0.0300	0.0350	0.0400	0.0440
1998	0.0100	0.0180	0.0210	0.0280	0.0330	0.0370	0.0410	0.0460
1999	0.0130	0.0160	0.0220	0.0250	0.0290	0.0360	0.0390	0.0540
2000	0.0130	0.0230	0.0260	0.0280	0.0310	0.0360	0.0410	0.0460
2001	0.0140	0.0190	0.0290	0.0300	0.0340	0.0370	0.0440	0.0470
2002	0.0133	0.0216	0.0271	0.0330	0.0366	0.0392	0.0438	0.0454
2003	0.0094	0.0242	0.0298	0.0355	0.0388	0.0446	0.0501	0.0549
2004	0.0086	0.0143	0.0265	0.0304	0.0389	0.0418	0.0474	0.0540
2005	0.0122	0.0152	0.0193	0.0292	0.0356	0.0434	0.0481	0.0561
2006	0.0120	0.0234	0.0237	0.0263	0.0339	0.0435	0.0486	0.0553
2007	0.0123	0.0215	0.0254	0.0300	0.0330	0.0427	0.0497	0.0603
2008	0.0133	0.0222	0.0257	0.0302	0.0370	0.0335	0.0439	0.0498
2009	0.0112	0.0199	0.0268	0.0295	0.0354	0.0418	0.0357	0.0464
2010	0.0120	0.0183	0.0258	0.0322	0.0332	0.0385	0.0450	0.0450
2011	0.0125	0.0215	0.0246	0.0317	0.0375	0.039	0.0474	0.0475
2012	0.0142	0.0291	0.0268	0.0329	0.0417	0.0458	0.0511	0.0597
2013	0.0120	0.0210	0.0351	0.0324	0.0386	0.0480	0.0505	0.0566
2014	0.0118	0.0201	0.0294	0.0390	0.0350	0.0446	0.0492	0.0553
2015	0.0071	0.0217	0.0272	0.0331	0.0399	0.0403	0.0471	0.0512
2016	0.0086	0.0123	0.0256	0.0293	0.0339	0.0374	0.0407	0.0470
2017	0.0109	0.0192	0.0208	0.0321	0.0347	0.0403	0.0482	0.0518
2018	0.0111	0.0187	0.0279	0.0284	0.0398	0.0408	0.0432	0.0521
2019	0.0118	0.0203	0.0242	0.0312	0.0314	0.0404	0.0441	0.0490
2020	0.0116	0.0203	0.0261	0.0297	0.0349	0.0343	0.0456	0.0471

Table 4.10. Herring in SD 25–29, 32 (excl. GoR). XSA input: Natural mortality.

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
**2020	0.2630	0.1970	0.1750	0.1620	0.1530	0.1470	0.1430	0.1390

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,**

****2020 from regression with eastern Baltic cod biomass TL>20 cm.**

Table 4.11. 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+
1974-2020	0.0	0.7	0.9	1.0	1.0	1.0	1.0	1.0

Table 4.12. 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+
1974-2020	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 4.13. 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+
1974-2020	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Table 4.14. 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
2020	1	6916	3725	6332	3985	3270	4662	488	908

*not used due to incomplete coverage **revised by WGBIFS 2020 (WGBFAS 2020)

Table 4.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 1/3

Lowestoft VPA Version 3.1
6/04/2021 11:56
Extended Survivors Analysis
-Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)
CPUE data from file BIAS_CBH_WGBFAS 2021.tun

Catch data for 47 years. 1974 to 2020. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BIAS SD 25-27&28.2&29S&N	1991	2020	1	7	0.8	0.9

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :
Catchability dependent on stock size for ages < 2
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 2
Catchability independent of age for ages >= 6

Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.500
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning converged after 51 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.058	0.029	0.038	0.056	0.053	0.073	0.124	0.195	0.078	0.156
2	0.099	0.093	0.081	0.106	0.129	0.167	0.143	0.243	0.274	0.211
3	0.141	0.103	0.102	0.175	0.214	0.235	0.247	0.306	0.34	0.423
4	0.236	0.136	0.14	0.209	0.337	0.313	0.334	0.363	0.385	0.405
5	0.256	0.203	0.172	0.241	0.312	0.38	0.411	0.569	0.474	0.523
6	0.287	0.221	0.183	0.214	0.292	0.47	0.416	0.553	0.782	0.489
7	0.318	0.229	0.241	0.181	0.29	0.65	0.735	0.599	0.707	0.828

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2011	6.31E+06	6.94E+06	6.67E+06	6.02E+06	2.04E+06	1.38E+06	5.19E+05
2012	1.40E+07	3.99E+06	4.75E+06	4.49E+06	3.80E+06	1.29E+06	8.50E+05
2013	1.50E+07	9.43E+06	2.94E+06	3.45E+06	3.23E+06	2.61E+06	8.73E+05
2014	1.03E+07	1.01E+07	6.90E+06	2.22E+06	2.48E+06	2.29E+06	1.86E+06
2015	3.16E+07	6.82E+06	7.19E+06	4.76E+06	1.53E+06	1.64E+06	1.58E+06
2016	9.84E+06	2.23E+07	4.89E+06	4.83E+06	2.88E+06	9.57E+05	1.05E+06
2017	9.65E+06	6.86E+06	1.46E+07	3.21E+06	2.97E+06	1.67E+06	5.12E+05
2018	1.11E+07	6.52E+06	4.83E+06	9.39E+06	1.95E+06	1.68E+06	9.49E+05
2019	6.26E+06	7.15E+06	4.24E+06	3.03E+06	5.57E+06	9.60E+05	8.39E+05
2020	1.30E+07	4.53E+06	4.50E+06	2.57E+06	1.76E+06	3.01E+06	3.81E+05

Estimated population abundance at 1st Jan 2021

0.00E+00	8.64E+06	2.75E+06	2.45E+06	1.44E+06	8.81E+05	1.63E+06

Taper weighted geometric mean of the VPA populations:

1.18E+07	7.92E+06	5.71E+06	3.85E+06	2.49E+06	1.53E+06	8.19E+05

Standard error of the weighted Log(VPA populations) :

0.4309	0.449	0.4141	0.4089	0.3941	0.4129	0.4798

Table 4.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 2/3

Log catchability residuals.
Fleet :
BIAS SD 25-27&28.2&29S&N

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	-0.14	-0.49	0.52	-0.23	-0.74	0.06	-0.04	-0.45	-0.16	-0.34
2	0.15	-0.22	0.53	0.06	0.08	0.45	-0.27	-0.02	-0.07	-0.11
3	-0.23	0	0.63	0.14	0.12	0.42	-0.61	-0.19	-0.1	-0.13
4	0.06	-0.12	0.28	0	0.4	0.63	-0.51	-0.21	-0.27	-0.19
5	-0.29	-0.08	0.02	-0.4	0.28	0.8	-0.14	-0.04	-0.46	-0.31
6	-0.39	-0.29	0.25	-0.24	0.03	0.45	-0.12	-0.24	-0.08	-0.08
7	-0.56	-0.27	0.08	-0.27	0.15	0.06	-0.31	-0.2	-0.05	0.07

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	-0.27	0.73	-0.29	-0.35	0.61	0.28	-0.11	0.14	-0.07	0.06
2	-0.15	-0.1	-0.09	-0.15	0.33	0.31	-0.22	0.43	-0.26	-0.12
3	0.08	-0.02	-0.33	0.25	0.32	-0.01	-0.05	0.19	-0.23	0.09
4	0.12	0	-0.12	0.27	0.59	-0.19	-0.39	0.47	-0.29	-0.09
5	0.23	0.04	-0.1	0.16	0.51	-0.36	-0.47	0.5	-0.16	0.04
6	0.1	-0.1	0.11	0.11	0.28	0.1	-0.6	0.43	-0.05	-0.19
7	0.29	0.14	0.06	0.02	0.02	-0.16	-0.22	0.21	-0.11	-0.1

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

Age	2	3	4	5	6	7
Mean Log q	-6.6394	-6.1497	-5.8913	-5.7458	-5.7384	-5.7384
S.E(Log q)	0.2471	0.2345	0.3361	0.3479	0.2719	0.1645

Regression statistics (no output values (technical issue) from converged run after 51 iterations. Therefore missing values taken from run stopped after 50 iterations!)

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.73	1.51	9.65	0.76	20	0.25	-7.24

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	0.91	0.589	7.48	0.81	20	0.23	-6.64
3	0.85	1.016	7.53	0.83	20	0.20	-6.15
4	0.73	1.647	8.44	0.78	20	0.23	-5.89
5	1.62	-1.521	0.20	0.38	20	0.53	-5.75
6	1.05	-0.234	5.31	0.68	20	0.30	-5.74
7	0.93	0.690	6.28	0.91	20	0.16	-5.75

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength
Year class = 2019

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	9018337	0.38	0	0	1	0.523	0.148
P shrinkage mean	7916725	0.45				0.438	0.167
F shrinkage mean	12997620	1.5				0.039	0.105

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
8641444	0.29	0.08	3	0.279	0.156

Age 2 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
BIAS SD 25-27&28.2&29S&N	2731004	0.236	0.025	0.11	2	0.97	0.231
F shrinkage mean	3344631	1.5				0.03	0.192

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2747871	0.23	0.03	3	0.131	0.211

Table 4.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 3/3

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 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	2417465	0.188	0.123	0.65	3	0.972	0.432
F shrinkage mean	4214544	1.5				0.028	0.27

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2454880	0.19	0.11	4	0.598	0.423

Age 4 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	1435995	0.17	0.148	0.87	4	0.975	0.41
F shrinkage mean	1747821	1.5				0.025	0.348

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1443159	0.17	0.13	5	0.75	0.405

Age 5 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	874584	0.159	0.102	0.65	5	0.972	0.532
F shrinkage mean	1137993	1.5				0.028	0.431

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
881002	0.16	0.09	6	0.578	0.523

Age 6 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	1631499	0.152	0.127	0.83	6	0.975	0.48
F shrinkage mean	1527358	1.5				0.025	0.505

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1628789	0.15	0.11	7	0.748	0.489

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

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	139790	0.164	0.087	0.53	7	0.958	0.846
F shrinkage mean	306116	1.5				0.042	0.475

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
144429	0.17	0.1	8	0.586	0.828

Table 4.16. Herring in SD 25–29, 32 (excl. GoR). Fishing Mortality (F) at age.

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	0.2823	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	0.1467	0.1243	0.1531	0.1541	0.1859	0.1629	0.2194	0.2565	0.2770
Age 8+	0.1653	0.1771	0.1629	0.1467	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	0.0494	0.0674	0.0776	0.0469	0.0352	0.0817	0.0654	0.0493	0.0578	0.0847	0.0830
Age 2	0.1583	0.1289	0.1955	0.1255	0.1816	0.1611	0.1457	0.1993	0.1312	0.1400	0.1430	0.1631
Age 3	0.1891	0.2203	0.2105	0.3370	0.2034	0.2995	0.2574	0.2928	0.2689	0.3178	0.2390	0.2563
Age 4	0.2381	0.2435	0.2542	0.2683	0.3857	0.2669	0.2532	0.3664	0.3530	0.4806	0.3850	0.4271
Age 5	0.2439	0.2858	0.2785	0.3653	0.3197	0.4538	0.2535	0.3527	0.4865	0.3725	0.4826	0.5384
Age 6	0.2347	0.3007	0.2756	0.3996	0.4209	0.3461	0.4322	0.3349	0.5219	0.3781	0.5309	0.6040
Age 7	0.2402	0.2781	0.2709	0.3465	0.3773	0.3571	0.3141	0.3532	0.4565	0.4128	0.4690	0.5263
Age 8+	0.2402	0.2781	0.2709	0.3465	0.3773	0.3571	0.3141	0.3532	0.4565	0.4128	0.4690	0.5263
FBAR 3-6	**0.2265**	**0.2626**	**0.2547**	**0.3426**	**0.3324**	**0.3416**	**0.2990**	**0.3367**	**0.4076**	**0.3872**	**0.4094**	**0.4564**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	0.1779	0.1108	0.1705	0.1394	0.1443	0.0860	0.0682	0.0511	0.0732	0.0509	0.0461	0.0536
Age 2	0.2023	0.2415	0.2523	0.2957	0.2122	0.1667	0.1147	0.1125	0.1138	0.1230	0.1204	0.1221
Age 3	0.3386	0.3178	0.4206	0.2622	0.3578	0.2229	0.2111	0.1608	0.1670	0.2105	0.1930	0.1823
Age 4	0.4405	0.4289	0.5006	0.4918	0.3262	0.3135	0.2854	0.2707	0.2303	0.2380	0.2417	0.2719
Age 5	0.5718	0.4292	0.5580	0.4531	0.5123	0.3085	0.2808	0.3069	0.3286	0.2733	0.2581	0.2511
Age 6	0.5884	0.4749	0.4806	0.5273	0.4019	0.4266	0.3079	0.2473	0.3587	0.3698	0.4048	0.2885
Age 7	0.5367	0.4468	0.5166	0.5038	0.4496	0.3476	0.3997	0.2428	0.2665	0.3056	0.4022	0.5427
Age 8+	0.5367	0.4468	0.5166	0.5038	0.4496	0.3476	0.3997	0.2428	0.2665	0.3056	0.4022	0.5427
FBAR 3-6	**0.4848**	**0.4127**	**0.4900**	**0.4336**	**0.3995**	**0.3179**	**0.2713**	**0.2464**	**0.2712**	**0.2729**	**0.2744**	**0.2485**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	F_{BAR} 18-20
Age 1	0.0624	0.0584	0.0291	0.0382	0.0562	0.0533	0.0733	0.1239	0.1948	0.0783	0.1565	0.1432
Age 2	0.0797	0.0991	0.0925	0.0813	0.1058	0.1289	0.1670	0.1430	0.2428	0.2742	0.2110	0.2427
Age 3	0.1807	0.1407	0.1030	0.1017	0.1749	0.2142	0.2352	0.2468	0.3059	0.3401	0.4230	0.3564
Age 4	0.2542	0.2356	0.1359	0.1403	0.2092	0.3369	0.3130	0.3340	0.3627	0.3846	0.4052	0.3842
Age 5	0.3417	0.2557	0.2035	0.1716	0.2411	0.3116	0.3804	0.4112	0.5686	0.4736	0.5234	0.5219
Age 6	0.4006	0.2875	0.2207	0.1831	0.2145	0.2917	0.4696	0.4162	0.5526	0.7822	0.4886	0.6078
Age 7	0.4124	0.3183	0.2290	0.2405	0.1809	0.2896	0.6498	0.7346	0.5987	0.7069	0.8277	0.7111
Age 8+	0.4124	0.3183	0.2290	0.2405	0.1809	0.2896	0.6498	0.7346	0.5987	0.7069	0.8277	
FBAR 3-6	**0.2943**	**0.2299**	**0.1658**	**0.1492**	**0.2099**	**0.2886**	**0.3496**	**0.3520**	**0.4474**	**0.4951**	**0.4600**	

Table 4.17. 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	1986
Age 1	2415228	1837793	3676347	2089779	2659308	2335561	3148312	4682995	4315132	2964250	3709688	2564575	1210750
Age 2	1743314	1370218	995006	2264590	1212921	1278193	973728	1253155	2029824	1841111	1375427	1943194	1430730
Age 3	902145	1149200	871578	639103	1488837	718204	742927	501399	626871	1037938	927233	752023	1099841
Age 4	846391	605692	747967	582491	420287	924840	429068	403563	277663	345083	544663	524533	452385
Age 5	395704	550505	395440	507901	399535	267397	554389	248416	231213	166164	185332	300312	321034
Age 6	274683	274282	354637	271983	345134	264859	162616	320074	150281	141308	99585	103636	171473
Age 7	450037	189871	182677	232502	182145	229110	167678	99917	193751	95037	83630	60809	59787
Age 8+	203538	369788	359680	437945	457524	378685	440906	350459	314135	247660	207630	158281	107007
TOTAL	**7231041**	**6347351**	**7583331**	**7026295**	**7165691**	**6396849**	**6619625**	**7859978**	**8138868**	**6838551**	**7133188**	**6407364**	**4853006**

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Age 1	2437653	932487	1307031	1614471	1207832	1599941	1513899	1180847	1672234	1365402	767384	1284623	680364
Age 2	703526	1419905	529762	798653	1163074	927367	1159879	1052578	826084	1203621	991796	569605	861226
Age 3	836873	449960	803400	349639	540399	816221	658294	742292	713904	568314	842237	689833	383608
Age 4	650553	512024	278285	429163	236156	338580	529710	397353	450729	417795	368219	543343	410702
Age 5	272978	394783	306495	166887	240114	155337	226467	301842	228330	227989	236028	202060	296263
Age 6	196891	164118	234123	170864	102274	129717	104705	133212	153454	130101	117646	116812	97398
Age 7	108064	118509	100084	127512	95290	62652	72470	63320	66159	87387	64484	54856	55767
Age 8+	86827	96356	124449	104308	84565	86349	50590	83008	67803	64144	48654	47701	35557
TOTAL	**5293366**	**4088143**	**3683630**	**3761497**	**3669703**	**4116165**	**4316012**	**3954453**	**4178698**	**4064753**	**3436447**	**3508833**	**2820885**

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age 1	1369657	947983	908451	1891264	1140244	769898	1359606	1095047	2102406	1507701	1105363	630605	1395312
Age 2	472871	850515	599980	564772	1297258	813068	529625	897661	737783	1395140	983097	694063	398709
Age 3	546125	291924	497274	378293	389453	904446	551330	372170	622510	504821	934136	667176	474605
Age 4	230628	288672	181318	279043	250316	260513	600929	368822	240058	403346	330584	602405	449153
Age 5	222960	113660	143378	107242	170521	157165	161565	381542	235652	151137	243692	203908	380437
Age 6	162880	104893	59508	70963	66324	109297	96006	95038	236741	149493	95494	138275	128758
Age 7	51722	83879	51244	33157	39235	41579	71864	56189	54896	128525	92552	51858	85009
Age 8+	49599	54709	68856	74060	42179	79537	68065	45718	70467	62025	117138	94120	109296
TOTAL	**3106442**	**2736235**	**2510009**	**3398795**	**3395529**	**3135502**	**3438989**	**3312187**	**4300513**	**4302189**	**3902055**	**3082409**	**3421278**

YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	GMST 74-18	AMST 74-18
Age 1	1497239	1026542	3162888	983886	965490	1109164	625656	1295035	0	1563184	1780947
Age 2	942758	1010441	681824	2225855	685541	652474	715209	453297	864146	984039	1074487
Age 3	294337	689888	719327	489237	1461041	483095	424100	450499	274787	643383	691632
Age 4	344643	221851	476096	482545	321391	939284	302569	256687	245488	411249	443085
Age 5	322614	248191	152593	287632	296513	195324	556941	175511	144316	246166	265659
Age 6	260829	229494	164373	95699	166880	167825	95974	300914	88100	149040	164103
Age 7	87293	185824	158445	105160	51191	94926	83875	38126	162879	90849	107290
Age 8+	112351	162346	201292	140250	83961	78960	50048	43061	30820		
TOTAL	**3862064**	**3774577**	**5716838**	**4810263**	**4032008**	**3721051**	**2854372**	**3013130**	**1810536**		

Age 1 Geometric mean 1988-2019: 11 950 996 thousands

Table 4.18. Herring in SD 25–29, 32 (excl. GoR). Output from XSA: Stock Summary.

Run title : Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)
At 6/04/2021 11:59
Table 16 Summary (without SOP correction)

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 6
1974	24152282	3136125	1932041	368652	0.1908	0.1603
1975	18377934	2883945	1864349	354851	0.1903	0.1700
1976	36763464	2890054	1672273	305420	0.1826	0.1579
1977	20897792	3047748	1944689	301952	0.1553	0.1469
1978	26593082	3130479	1905001	278966	0.1464	0.1263
1979	23355610	2880545	1814679	278182	0.1533	0.1533
1980	31483122	2831895	1626604	270282	0.1662	0.1593
1981	46829944	3083512	1438139	293615	0.2042	0.1839
1982	43151316	3025605	1520902	273134	0.1796	0.1648
1983	29642494	2481612	1421057	307601	0.2165	0.2255
1984	37096876	2276706	1266502	277926	0.2194	0.2369
1985	25645752	1969416	1177136	275760	0.2343	0.2524
1986	12107496	1643018	1090921	240516	0.2205	0.2265
1987	24376526	1652246	1011718	248653	0.2458	0.2626
1988	9324873	1515060	1013695	255734	0.2523	0.2547
1989	13070311	1415237	856321	275501	0.3217	0.3426
1990	16144712	1220402	714642	228572	0.3198	0.3324
1991	12078317	1133318	647277	197676	0.3054	0.3416
1992	15999409	1073204	675487	189781	0.2810	0.2990
1993	15138988	1059103	649195	209094	0.3221	0.3367
1994	11808468	1056608	651524	218260	0.3350	0.4076
1995	16722343	900091	539582	188181	0.3488	0.3872
1996	13654020	799230	483859	162578	0.3360	0.4094
1997	7673839	693232	452706	160002	0.3534	0.4564
1998	12846227	682326	417827	185780	0.4446	0.4848
1999	6803642	575242	363049	145922	0.4019	0.4127
2000	13696567	665160	354724	175646	0.4952	0.4900
2001	9479832	605650	339899	148404	0.4366	0.4336
2002	9084510	574525	332746	129222	0.3884	0.3995
2003	18912640	656776	367432	113584	0.3091	0.3179
2004	11402440	598300	377935	93006	0.2461	0.2713
2005	7698982	636147	424888	91592	0.2156	0.2464
2006	13596055	744894	461102	110372	0.2394	0.2712
2007	10950468	754850	478633	116030	0.2424	0.2729
2008	21024062	901582	477803	126155	0.2640	0.2744
2009	15077013	891428	536040	134127	0.2502	0.2485
2010	11053626	872037	565200	136706	0.2419	0.2943
2011	6306050	782817	557749	116785	0.2094	0.2299
2012	13953118	915426	598115	100893	0.1687	0.1658
2013	14972388	950025	629339	100954	0.1604	0.1492
2014	10265418	984004	695343	132700	0.1908	0.2099
2015	31628882	1030582	643874	174433	0.2709	0.2886
2016	9838860	867041	579087	192056	0.3317	0.3496
2017	9654899	882234	597533	202517	0.3389	0.3520
2018	11091636	875028	581015	244365	0.4206	0.4474
2019	6256558	691214	460378	204438	0.4441	0.4951
2020	12950346	638194	364981	177079	0.4852	0.4600
Arith. Mean	17460277	1395188	842021	202418	0.2782	0.2927
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 4.19. 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 4.20. Herring in SD 25–29, 32 (excl. GoR). Input for RCT3 analysis.

Yearclass	VPA Age 1 backshift. (millions)	Acoustic (SD 25-29S+N) Age 0 (millions)	
1991	15999	13733	
1992	15139	1608	
1993	11808	-11	
1994	16722	6122	
1995	13654	-11	
1996	7674	336	
1997	12846	-11	
1998	6804	508	
1999	13697	2591	
2000	9480	1319	
2001	9085	2123	
2002	18913	16046	
2003	11402	9067	
2004	7699	1587	
2005	13596	5568	
2006	10950	1990	
2007	21024	12197	
2008	15077	8673	
2009	11054	3366	
2010	6306	1178	
2011	13953	10098	
2012	14972	11141	
2013	10265	**2582**	
2014	31629	**30301**	
2015	9839	**7175**	**revised by WGBIFS 2020**
2016	9655	**2956**	
2017	11092	7184	
2018	6257	2052	
2019	-11	22620	
2020	-11	5763	

Table 4.21. 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 30 years : 1991 - 2020
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		**2014**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.40	6.02	0.18	0.8	20	10.32	10.16	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	0.45	5.64	0.19	0.854	21	8.88	9.61	0.214	0.802
					VPA	Mean =	9.46	0.43	0.198
Yearclass =		**2016**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.48	5.32	0.22	0.8	22	7.99	9.15	0.258	0.73
					VPA	Mean =	9.45	0.425	0.27
Yearclass =		**2017**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.49	5.27	0.21	0.814	23	8.88	9.57	0.241	0.753
					VPA	Mean =	9.44	0.421	0.247
Yearclass =		**2018**							
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	0.795	24	7.63	8.93	0.26	0.712
					VPA	Mean =	9.43	0.41	0.288
Yearclass =		**2019**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.53	4.82	0.22	0.811	25	10.03	10.15	0.281	0.714
					VPA	Mean =	9.37	0.443	0.286
Yearclass =		**2020**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.54	4.77	0.23	0.816	25	8.66	9.41	0.26	0.750
					VPA	Mean =	9.37	0.451	0.250

Year Class	**Weighted Average Prediction**	**Log WAP**	**Int Std Error**	**Ext Std Error**	**Var Ratio**	**VPA**	**Log VPA**
2014	20052	9.91	0.19	0.37	3.58	31629	10.36
2015	14484	9.58	0.19	0.06	0.09	9840	9.19
2016	10236	9.23	0.22	0.13	0.36	9656	9.18
2017	13910	9.54	0.21	0.06	0.08	11093	9.31
2018	8693	9.07	0.22	0.23	1.08	6258	8.74
2019	20476	9.93	0.24	0.35	2.18		
2020	12130	9.40	0.23	0.02	0.01		

Table 4.22. Herring in SD 25–29, 32 (excl. GoR). Input data for short-term predictions.

MFDP version 1a
Run: WGBFAS 2021_TAC constraint
Time and date: 11:24 08/04/2021
Fbar age range: 3-6

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	12130000	0.2503	0	0.35	0.3	0.0115	0.1432	0.0115
2	8641460	0.1910	0.7	0.35	0.3	0.0198	0.2427	0.0198
3	2747870	0.1663	0.9	0.35	0.3	0.0261	0.3563	0.0261
4	2454880	0.1607	1	0.35	0.3	0.0298	0.3842	0.0298
5	1443160	0.1457	1	0.35	0.3	0.0354	0.5219	0.0354
6	881000	0.1430	1	0.35	0.3	0.0385	0.6078	0.0385
7	1628790	0.1403	1	0.35	0.3	0.0443	0.7111	0.0443
8	308200	0.1350	1	0.35	0.3	0.0494	0.7111	0.0494

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	11950996	0.2503	0	0.35	0.3	0.0115	0.1432	0.0115
2		0.1910	0.7	0.35	0.3	0.0198	0.2427	0.0198
3		0.1663	0.9	0.35	0.3	0.0261	0.3563	0.0261
4		0.1607	1	0.35	0.3	0.0298	0.3842	0.0298
5		0.1457	1	0.35	0.3	0.0354	0.5219	0.0354
6		0.1430	1	0.35	0.3	0.0385	0.6078	0.0385
7		0.1403	1	0.35	0.3	0.0443	0.7111	0.0443
8		0.1350	1	0.35	0.3	0.0494	0.7111	0.0494

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	11950996	0.2503	0	0.35	0.3	0.0115	0.1432	0.0115
2		0.1910	0.7	0.35	0.3	0.0198	0.2427	0.0198
3		0.1663	0.9	0.35	0.3	0.0261	0.3563	0.0261
4		0.1607	1	0.35	0.3	0.0298	0.3842	0.0298
5		0.1457	1	0.35	0.3	0.0354	0.5219	0.0354
6		0.1430	1	0.35	0.3	0.0385	0.6078	0.0385
7		0.1403	1	0.35	0.3	0.0443	0.7111	0.0443
8		0.1350	1	0.35	0.3	0.0494	0.7111	0.0494

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_{2021} Age 1:	Output form RCT3 Analysis (Table 6.2.17)
N_{2021} Age 2-8+:	Output from VPA (Table 6.2.14)
$N_{2022/2023}$ Age 1:	Geometric Mean from VPA-Output of age 1 (Table 6.2.14) for the years **1988-2019**
Natural Mortality (M):	Average of 2018-2020
Weight in the Catch/Stock (CWt/SWt):	Average of 2018-2020
Expoitation pattern (Sel):	Average of 2018-2020

Table 4.23. Herring in SD 25–29, 32 (excl. GoR). Output from short-term predictions with management option table for *'TAC constraint' in 2021.

MFDP version 1a
Run: WGBFAS 2021_TAC Constraint
Herring in Sd 25-32 (excl. GOR).
Time and date: 12:19 08/04/2021
Fbar age range: 3-6

2021

Biomass	SSB	FMult	FBar	Landings
627348	365448	0.7345	0.3434	129726

2022					**2023**	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
674008	448099	0	0	0	858157	616565
	443261	0.1	0.0343	15718	840947	594445
	438482	0.2	0.0687	30950	824259	573276
	433763	0.3	0.1030	45715	808074	553010
	429102	0.4	0.1374	60029	792373	533604
	424497	0.5	0.1717	73908	777141	515015
	419950	0.6	0.2060	87369	762359	497202
	415457	0.7	0.2404	100427	748011	480129
	411020	0.8	0.2747	113096	734083	463760
	406637	0.9	0.3091	125390	720560	448061
	402308	1.0	0.3434	137322	707427	433000
	398031	1.1	0.3778	148906	694671	418546
	393806	1.2	0.4121	160153	682278	404672
	389632	1.3	0.4464	171076	670236	391350
	385509	1.4	0.4808	181686	658534	378554
	381436	1.5	0.5151	191993	647158	366260
	377411	1.6	0.5495	202008	636100	354445
	373436	1.7	0.5838	211742	625346	343088
	369508	1.8	0.6181	221203	614888	332166
	365628	1.9	0.6525	230402	604716	321662
	361794	2.0	0.6868	239346	594819	311555

Input units are thousands and kg - output in tonnes

*'TAC constraint' in 2021:	
EU	97 551 t
+ EU/Russia	28 500 t
+ CBH in GOR	4 189 t (= mean catches 15-19)
- GORH	514 t (= mean catches 15-19)
Total	129 726 t

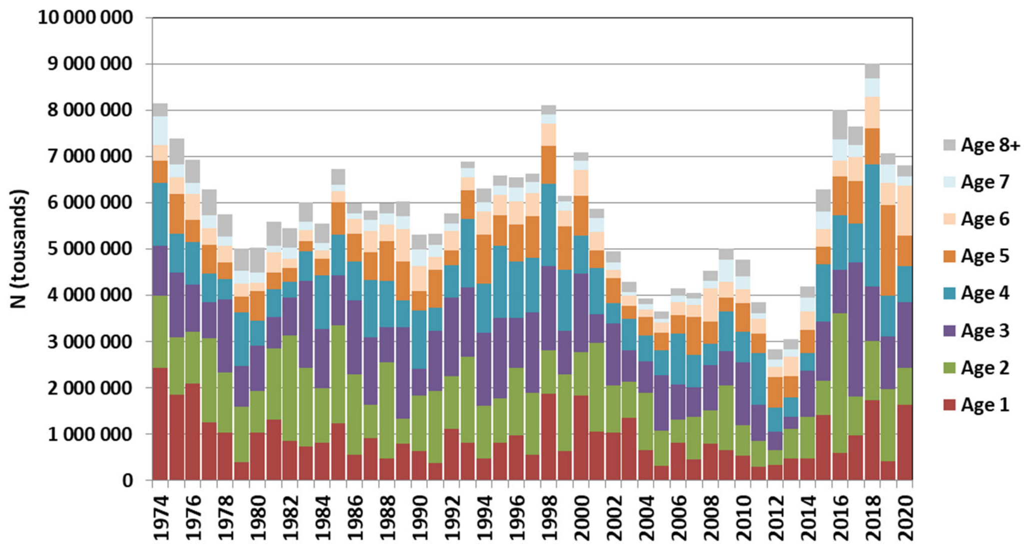


Figure 4.2. Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).

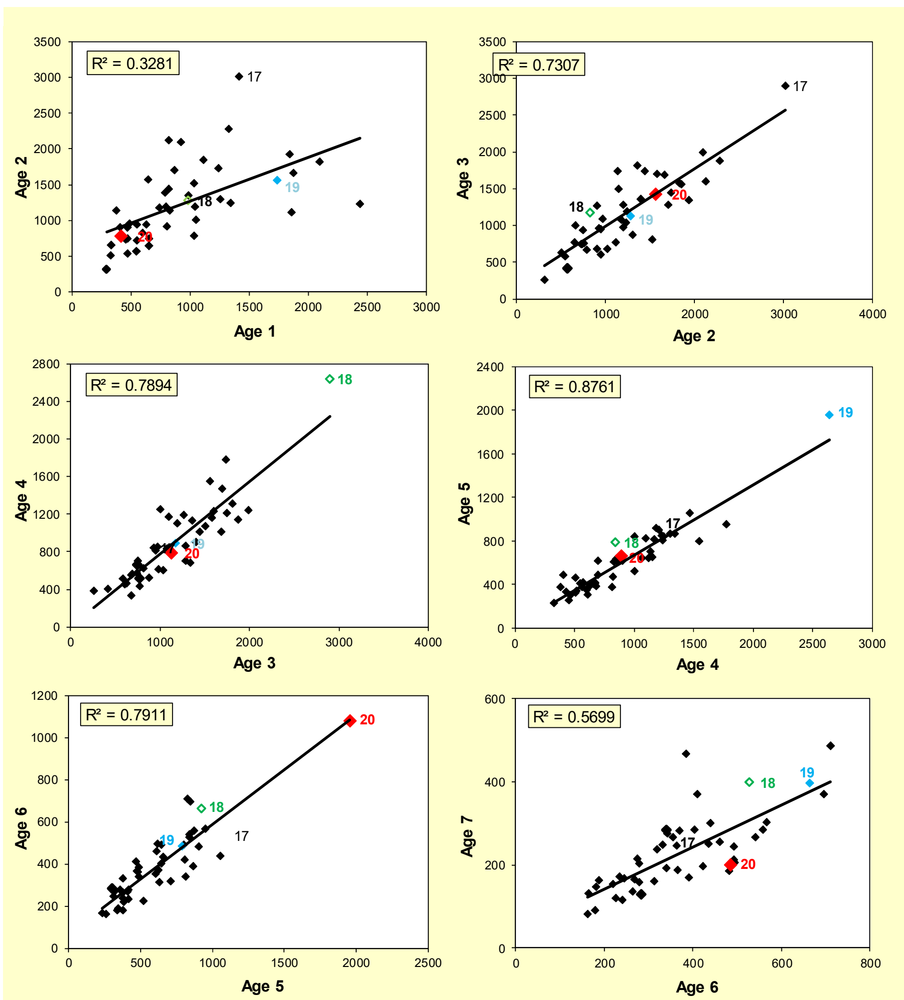


Figure 4.3. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2020.

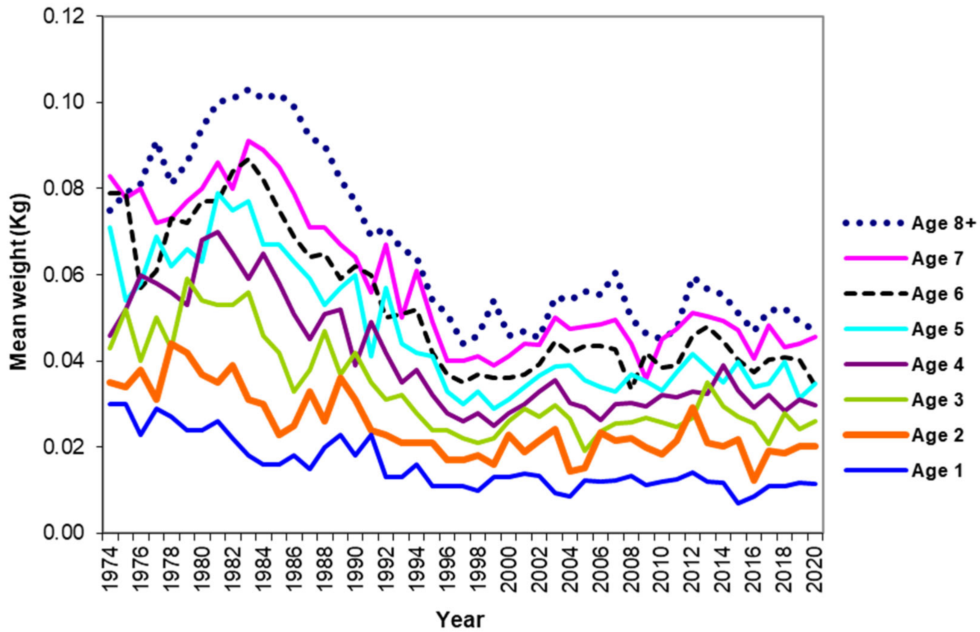


Figure 4.4. Herring in SD 25–29, 32 (excl. GoR). Trends in the mean weights at age (kg) in the catch (WECA).

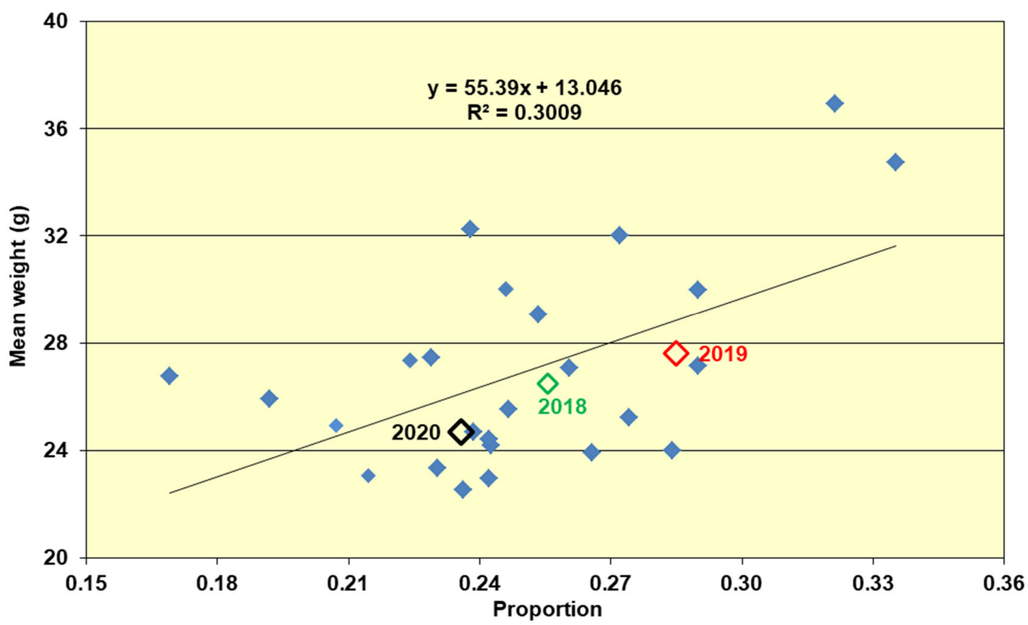


Figure 4.5. Herring in SD 25–29, 32 (excl. GoR). Average individual weight in catches vs. the proportion of catches taken in SD 25 and plus SD 26 (1993–2020).

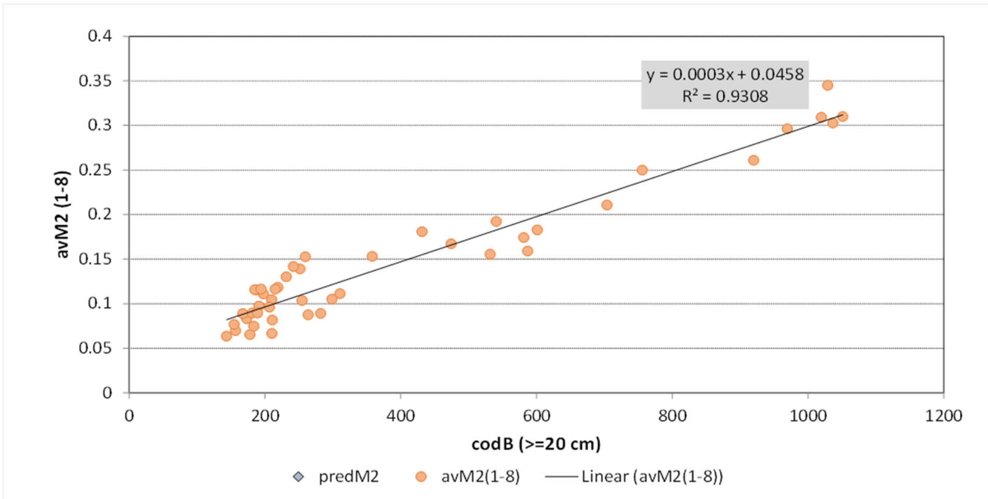


Figure 4.6. Herring in SD 25-29, 32 (excl. GOR). Regression of average M2 in 1974-2018 against biomass of cod at length ≥20 cm.

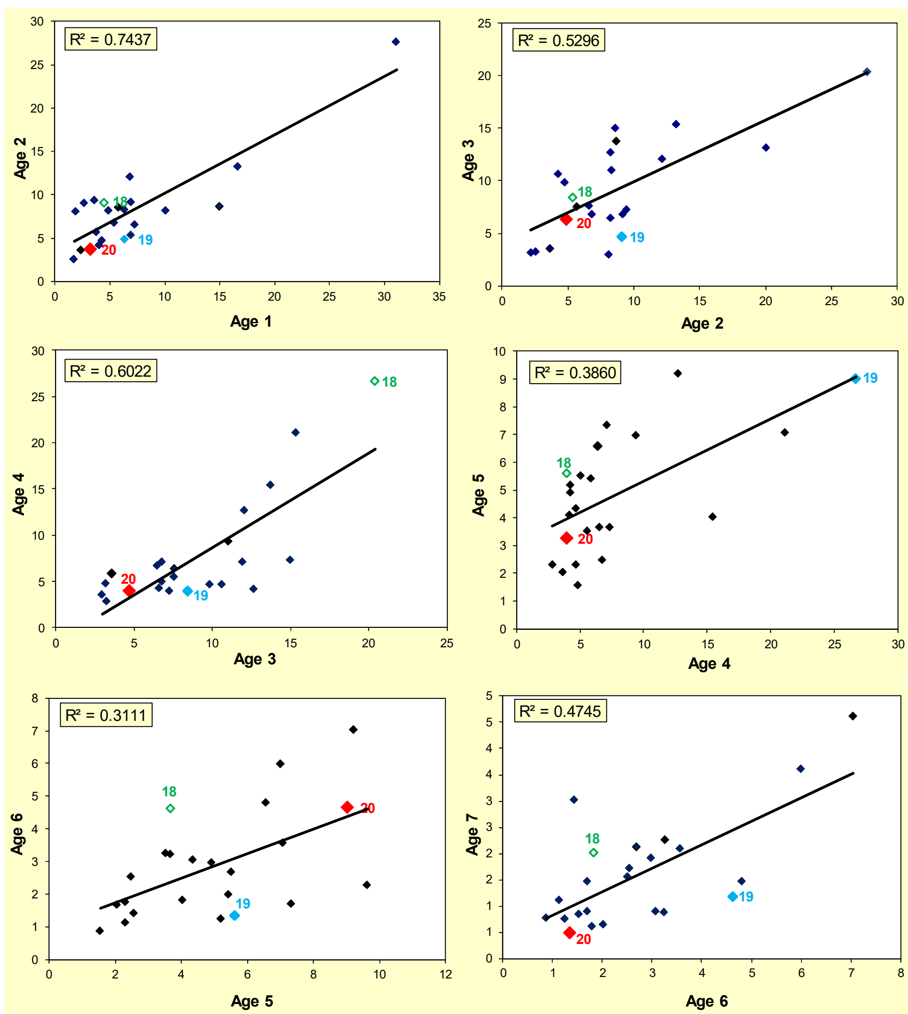


Figure 4.7. Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year in the period 1991–2020 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.

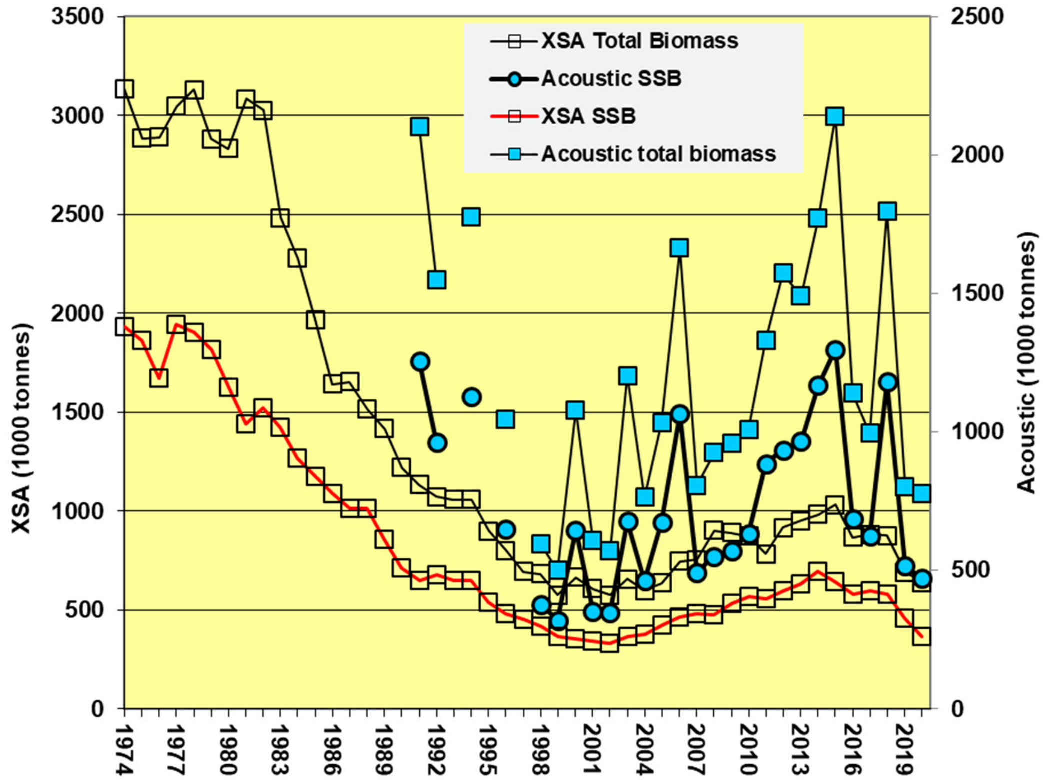


Figure 4.8. Herring in SD 25-29, 32 (excl. GOR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA. Acoustic biomasses = Acoustic abundances x WECA ; Acoustic SSB = Acoustic abundances x WECA x MATPROP

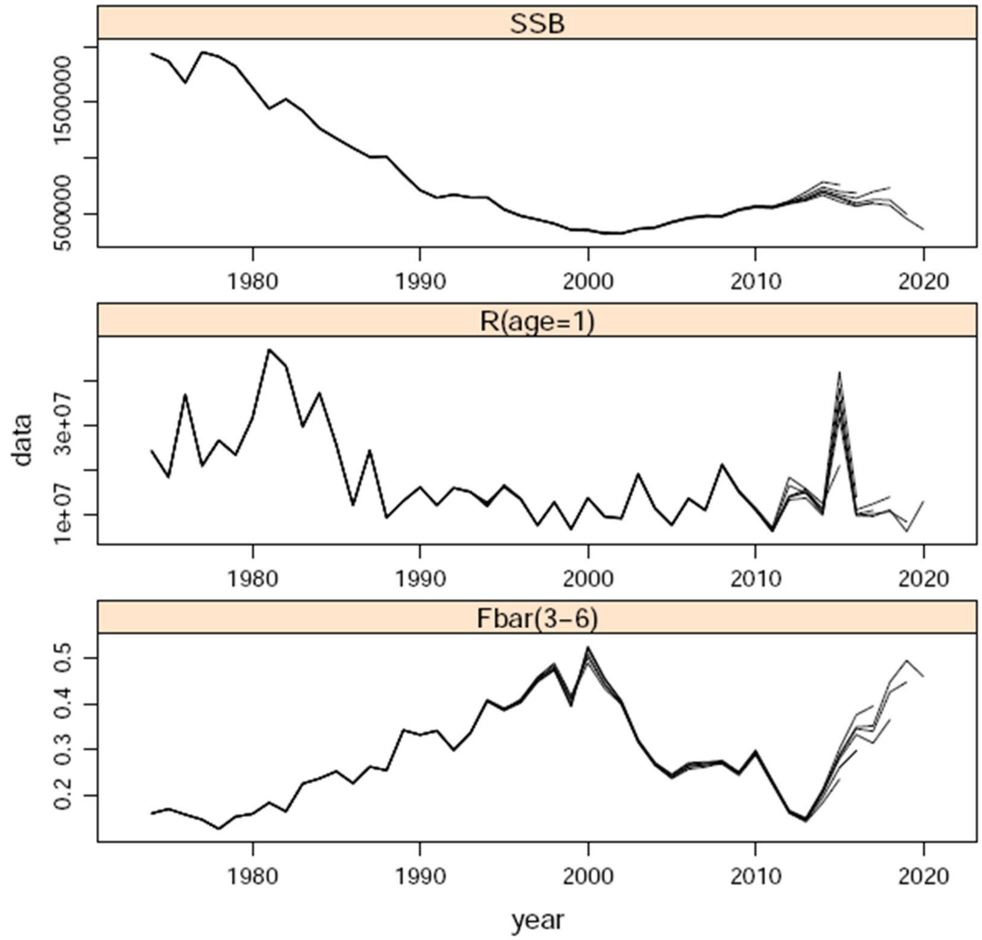


Figure 4.9. Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.

Mohn’s rho
SSB: 0.1412914
Recruitment: 0.2899711
Fbar: -0.0763018

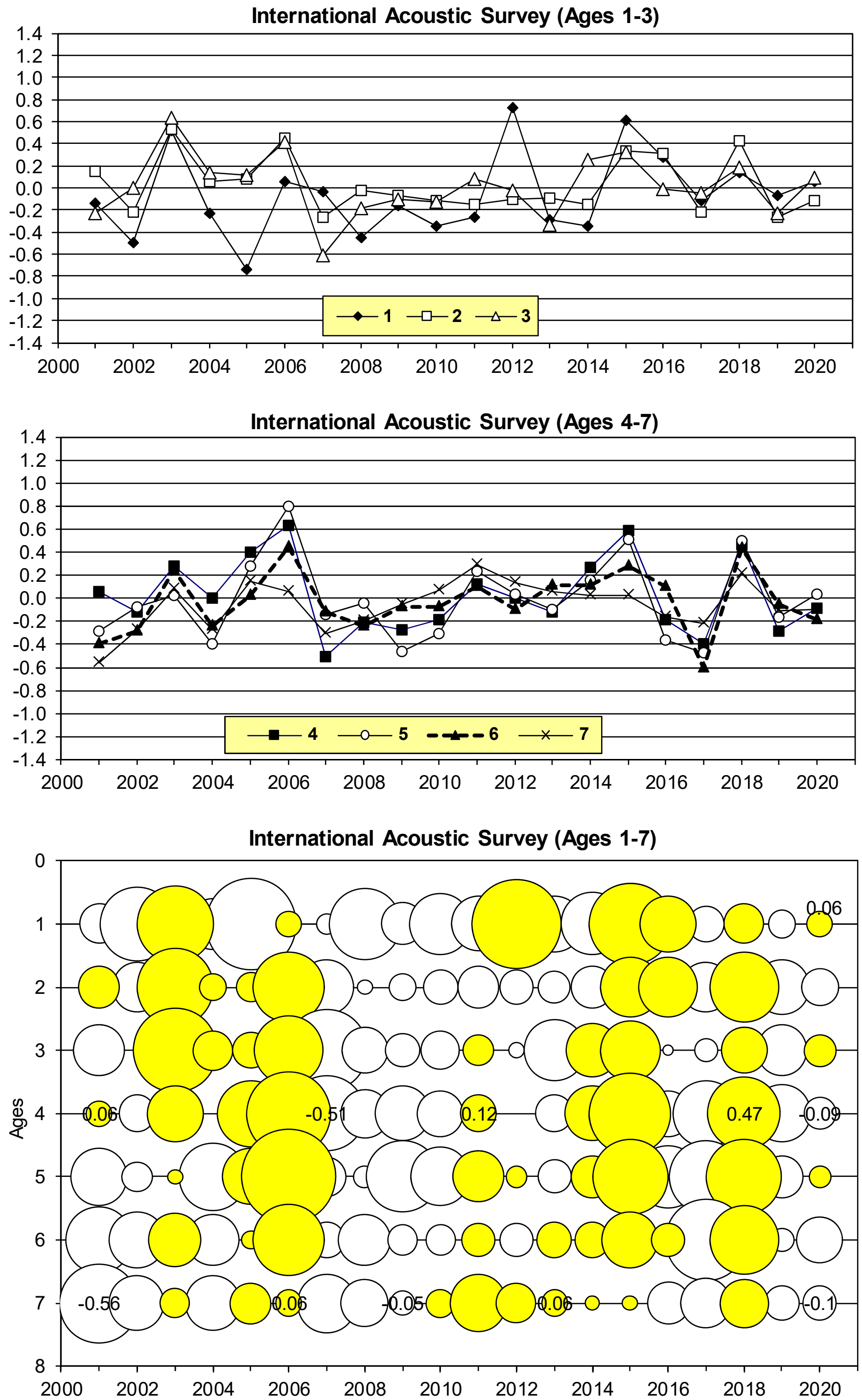


Figure 4.10. Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log Catchability residuals. Standardized log catchability residuals (top figure). Observed (circles) vs predicted (line) numbers (bottom figure).

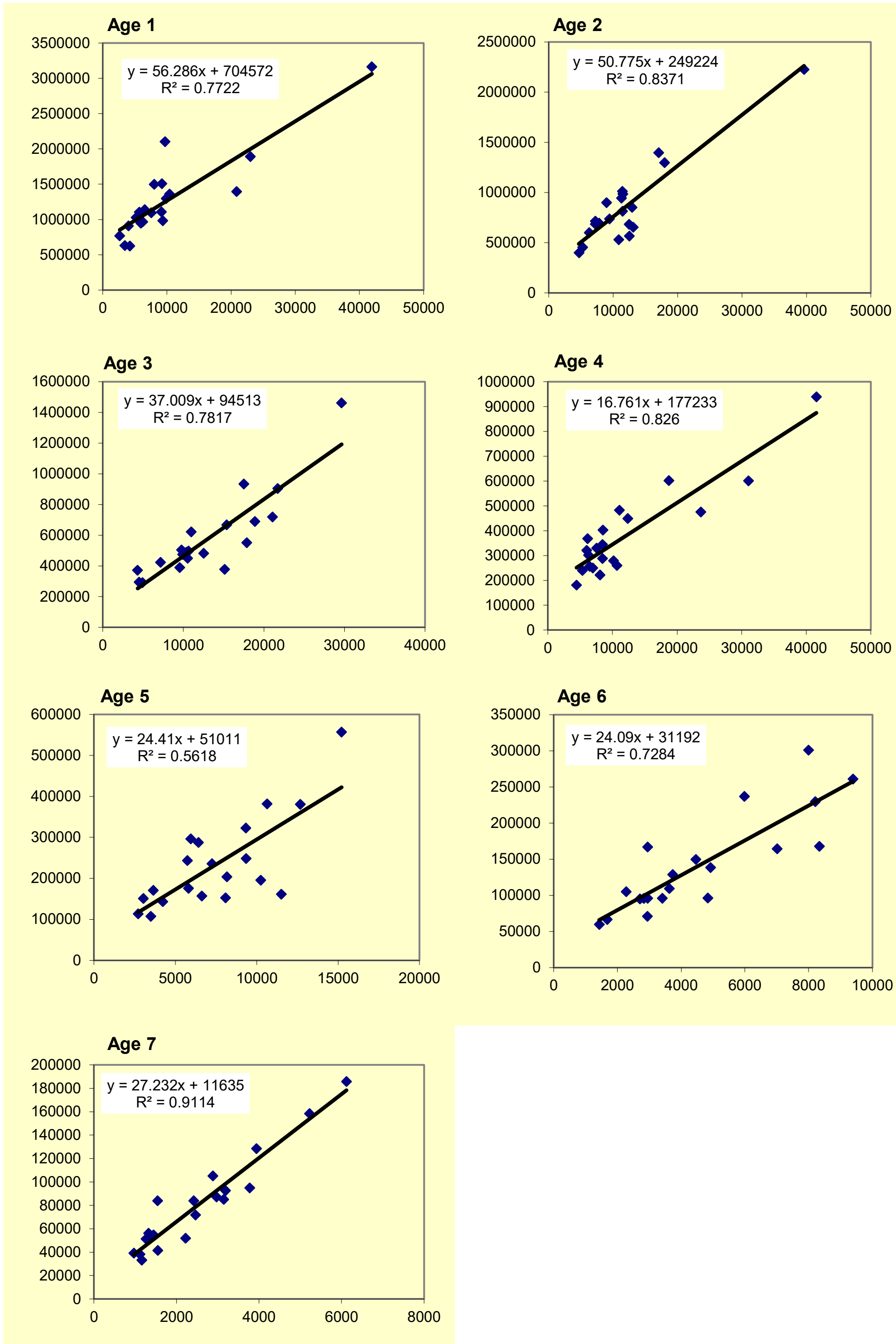


Figure 4.11. Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.

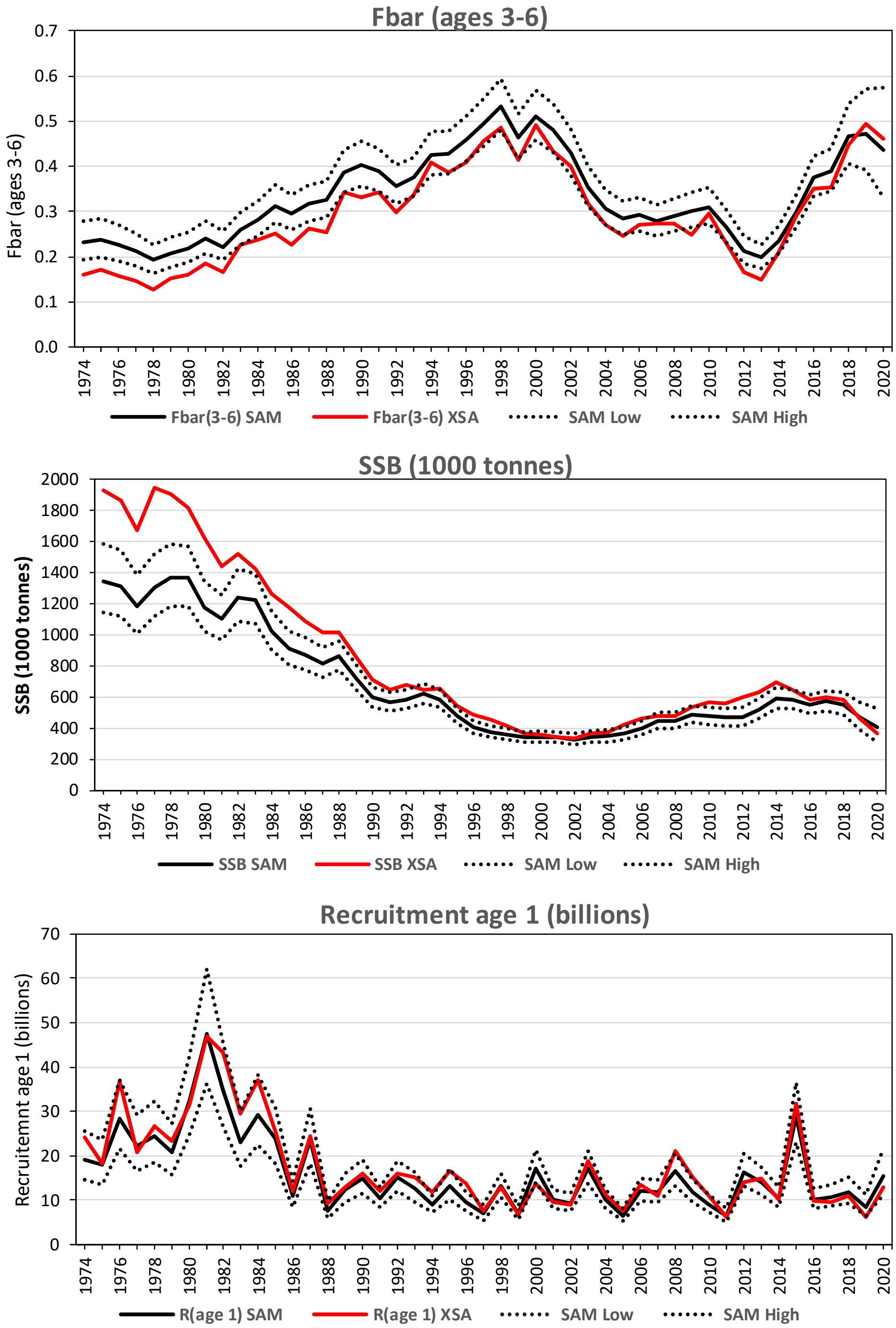


Figure 4.12. Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning stock biomass (SSB) and recruitment (age 1) from XSA and SAM (the dotted line represents the 95% confidence intervals of the SAM results).

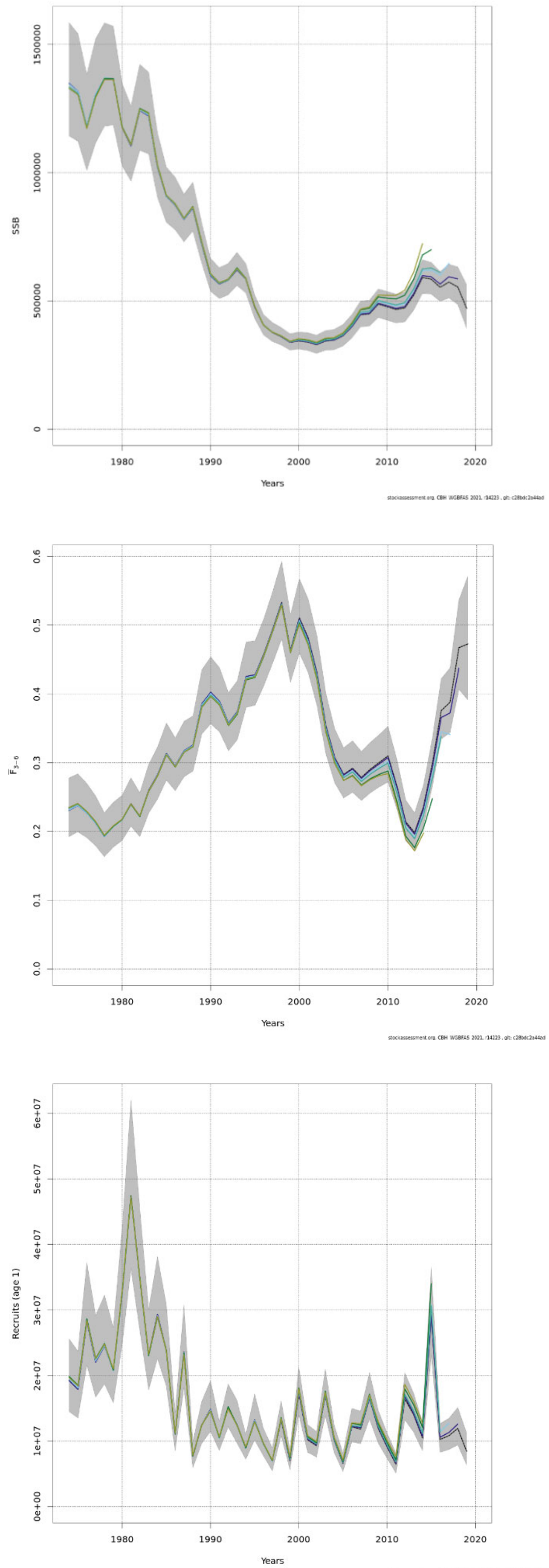


Figure 4.13. Herring in SD 25–29, 32 (excl. GoR). Retrospective of SAM.

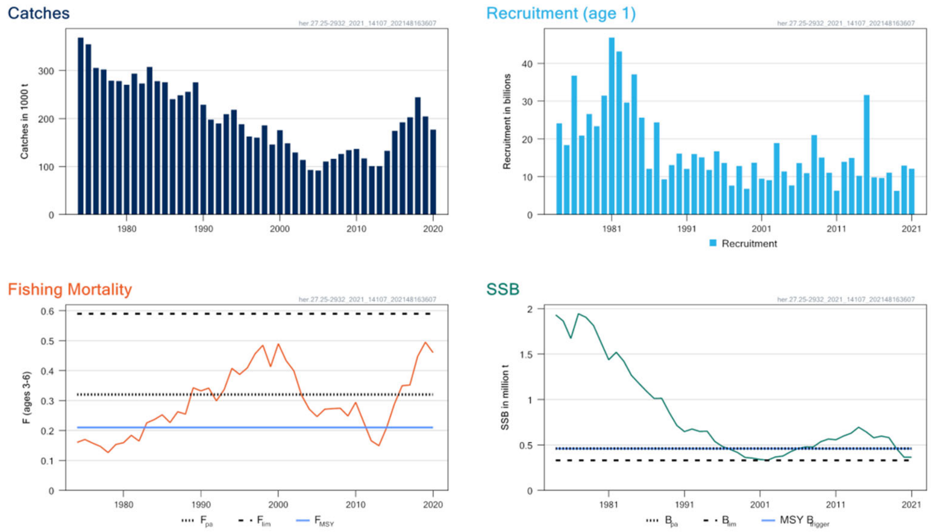


Figure 4.14. Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2021 from RCT3 & SSB in 2021 predicted)

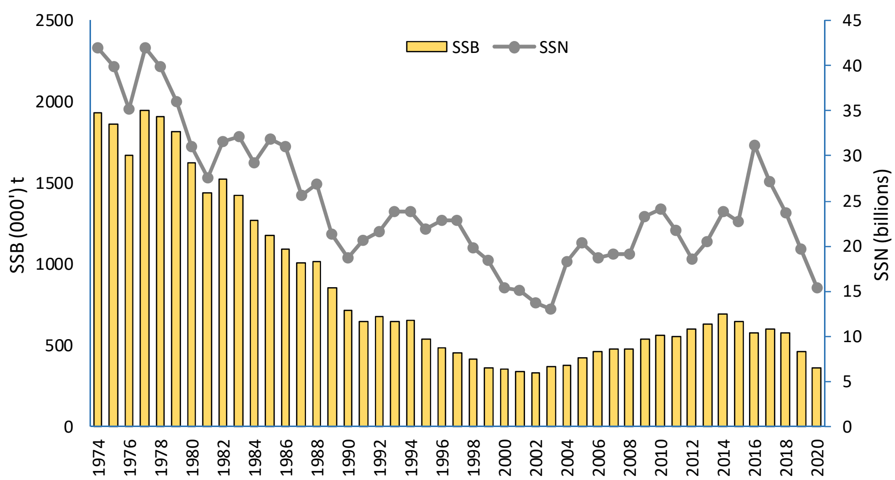


Figure 4.15. Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).

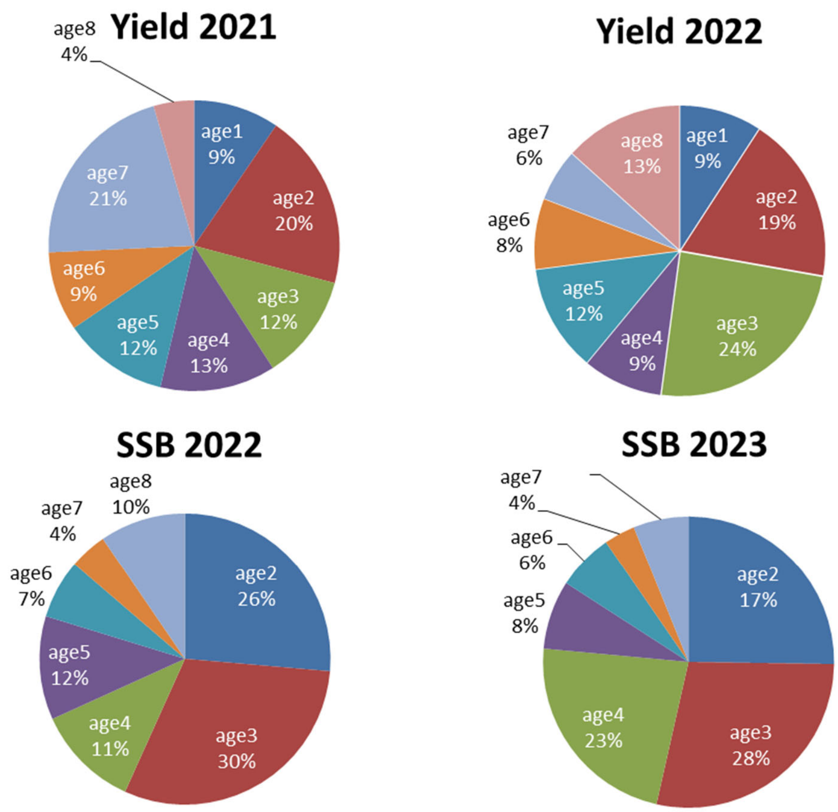


Figure 4.16. Herring in SD 25–29, 32 (excl. GoR). Yield and SSB at age 1-8+ as estimated in the short-term forecast for 2021-202

4.3 Gulf of Riga herring (Subdivision 28.1) (update assessment)

Gulf of Riga herring is a separate population of Baltic herring (*Clupea harengus*) that is met in the Gulf of Riga (ICES Subdivision 28.1). It is a slow-growing herring with one of the smallest length and weight-at-age in the Baltic and thus differs considerably from the neighbouring herring stock in the Baltic Proper (Subdivisions 25–28.2, 29 and 32) (ICES, 2001; Kornilovs, 1994). The differences in otolith structure serve as a basis for discrimination of Baltic herring populations (ICES, 2005, Ojaveer *et al.* 1981, Raid *et al.* 2005). When fish are aged they are also assigned their population belonging. The stock does not migrate into the Baltic Proper; only minor part of the older herring leaves the gulf after spawning season in summer –autumn period but afterwards returns to the gulf. There is evidence, that the migrating 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 fish 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 2020 these catches were 1229 t, while the average catches in the last five years were 696 t. These catches are included in the total Gulf herring landings (Table 4.24b) and CATON (Table 4.27).

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 2020 the total catches of herring in the Gulf of Riga were 33 249 t (Table 4.24a).

The landings from the Gulf of Riga herring stock showed similar pattern as the total caches of herring in the Gulf of Riga. They were the highest in the beginning of 2000s and then gradually decreased. In 2019 and 2020 the catches of the Gulf of Riga herring stock were 28 922 t and 33 215 t respectively (Table 4.24b).

The landings of open-sea herring in the Gulf of Riga decreased since 2018 and were 1264 t in 2020 (Table 4.24b). The average catch of open-sea herring in the last five years was 3448 t.

The trap-net catches of Gulf herring were 7135 t or 20% higher than in 2019. The fishing effort in trap-net fishery has remained the same since 2015. The trap-net catches comprised 21% of the total catches of Gulf of Riga herring in 2020.

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 2011–2020. The level of misreporting in Estonian herring fishery has been low in 1995–2020 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 2020 the number of trap-nets remained at the same level as in the previous year (Table 4.31). 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 22 active vessels in 2020. 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 in both Latvia (12 May -10 June) and Estonia (20 April - 22 May) 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 4.26, figures 4.17 and 4.18). 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 4.25. In 2020 the sample number per 1000 t was as follows: in Estonia 2.9 samples and in Latvia 3.0 samples. The check of consistency of catch-at-age data is shown in Figure 4.19.

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 4.29, Figure 4.20.). 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 2020 the mean weight-at age was slightly higher for younger age groups (ages 1- 4) and lower for older age groups than in 2019 but still close to the values of the previous years (Figure 4.20.)

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 4.28).

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 4.30). 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 4.31 and 4.32. The check of internal consistency of tuning data is shown in figures 4.21 and 4.22.

In trap-net fleet (Figure 4.21) the internal consistencies between age groups in 2020 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 4.23 and 4.24b). 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 2020 survey confirmed that the abundance of 2017 year class is well above the average and the incoming 2019 year class is also abundant.

4.3.4 Assessment (update assessment)

4.3.4.1 Recruitment estimates

The historical dynamics of the recruitment (age 1) reveal a trend rather similar to that of the spawning stock biomass. The recruitment fluctuated between 500–3000 millions in the 1970s and 1980s mainly having the values at the lower end. In the 1990s the reproduction of Gulf of Riga herring improved and recruitment had values above long-term average in most of the years (Table 4.36). In 2000s three record high year classes appeared reaching values over 7000 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 year class 2020 in this year short-term forecast is 3243.3million of age group 1 in the beginning of 2021. The same value for recruitment was used also for year classes 2021 and 2022.

4.3.4.2 Assessment (Update)

The assessment was performed with the same settings in XSA as in the previous year and in accordance with the stock annex. The tuning used in the assessment were the effort in the commercial trap-nets directed at the Gulf herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf herring in trap-net catches and the data from the hydroacoustic survey (tables 4.31 and 4.32). 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 4.33 and the XSA results are shown in tables 4.34–4.3.35. 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 4.24a,b and 4.25. For acoustic fleet some year effect is seen in 2010–2011 and on 2017-2020 (Figure 4.24b). The retrospective analysis is shown in Figure 4.26. 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 4.37 The assessment run and the software internal code are available at https:/www.stockassessment.org, GoRH_2021. Log catchability residuals of SAM run by fleets are shown in Figure 4.27. Results of SAM and its comparison with updated XSA run are presented in Figure 4.28. In general SAM produces slightly lower estimates of SSB, fishing mortality ($F_{3–7}$) and recruitment (age 1). The Mohn's Rho index (average for last 5 years) for fishing mortality, SSB and recruitment is 0.06, -0.06 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 4.36, Figure 4.29 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 9265t 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 143 791 t in 2014 but has decreased since then. In 2016–2020 the SSB increased again, reaching 146 956 t in 2020 that is historical high. 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 2017-2020 the fishing mortality was in the range of 0.21-0.26 that is below the F_{MSY}(0.32). The estimate for 2020 was 0.243.

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 4.38- 4.39. For prediction the mean weights-at-age were taken to be equal to the average of the last three years 2018–2020. The exploitation pattern was taken equal to the average of 2018–2020 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 age group 1 in 2021–2023 (year classes of 2020, 2021, and 2022) were taken to be equal to the geometric mean of year classes over the period 1989–2018.

Taking into account that the herring TAC for the Gulf of Riga is usually almost utilised the catch constraint of 35 771 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 2021 would be 176.6 thousand t (according to the 2020 prediction 131 thousand t). Under MSY scenario, SSB in 2022–2023 will remain on high level of 168 and 148 thousand tonnes, respectively. The catch corresponding to F_{MSY} (0.32) would be 44.9 thousand t in 2022. In 2021 the catches will be dominated by year classes of 2016-2018 by 67%. The SSB in 2022 will be dominated by year classes of 2017 and 2019-2020 (74%). SSB in 2023 will be dominated by age groups of 2-4 (68%) (Figure 4.30). The share of younger age groups (1–3) in the yield of 2021–2022 will be 49% and 52% 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). Following the ACOM's decision in 2020 (see Expert Groups general ToR c) vi)), the basis for F_{pa} was changed in 2021 to $F_{p.05}$, the F that leads SSB ≥ B_{lim} with 95% probability. The new corresponding F_{pa} = 0.38 (ICES, 2015).

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.

Instead of MBAL estimate of 50 000 t used previously, the MSY $B_{trigger}$ 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 4.25.). 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. This 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 0.25, -0.17 and -0.16 respectively. If index is obtained as average for last 3 years then for fishing mortality, SSB and recruitment it is 0.16, -0.13 and -0.08 respectively.

4.3.8 Comparison with the previous assessment

Compared to last year, the present assessment resulted in 5.5% increase in SSB for 2019, and 14.4% increase for 2018 year class estimate. $F_{(3\text{-}7)}$ estimate in 2019 was lowered by 9.7% in this year's assessment.

Comparison of XSA settings from assessments performed in 2019 and 2020

Category	Parameter	Assessment 2020	Assessment 2021	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	1996–2019	1996–2020	No
	Acoustic survey	1999–2019	1999–2020	No

Comparison of SSB and F estimates from assessments performed in 2020 and 2021

Assessment year	**Tuning fleet**	**SSB (2019) (t)**	**FBAR3-7 (2019)**	**Recruitment (age1)**
2020 (update)	Trap-nets+acoustics	136 095	0.28	2 611 633
2021(update)	Trap-nets+acoustics	143 579	0.26	2 988 617
Diff. (+/-)%		+5.5%	-9.7%	+ 14.4%
Comparison of predictions	**Prediction in 2020**	**Prediction in 2021**	**Actual yield 2020 (t)**	**Diff. (+/-)%**
Yield 2020 (t)	30 382		33 215	+9.3
SSB 2021 (t)	129 580	176 560		+36.3
Yield 2021(t)	35 771	35 771		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 subdivisions 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 2022 (Subdivision 28.1) is 3448 tonnes (average 2016–2020);
2. Gulf of Riga herring assumed to be taken in Subdivision 28.2 in 2022 is 696 tonnes (average 2016–2020).

As an example, following the ICES MSY approach (here identical to the MAP F_{MSY}), catches from the Gulf of Riga herring stock in 2022 should be no more than 44 945 tonnes. The corresponding TAC in the Gulf of Riga management area for 2022 would be calculated as 44 945 tonnes – 696 tonnes + 3448 tonnes = 47 697 tonnes.

4.3.10 Gulf of Riga herring fisheries management

The herring fishery in the Gulf of Riga is based on TAC distribution between two countries: Estonia and Latvia. National quotas are distributed between trawl fishery in open areas of the Gulf of Riga and the stationary coastal net fishery. As the national management of herring fishery have differences between the countries, this is shown by countries separately.

Year	Country	Coastal fishery			Trawl fishery
		Number of allowed fishing gears in the specialized herring fishery	Total limit	Regulations	Closures
2020	Latvia	In total 117 pound-nets and 529 herring gillnets.	No less than 15% of the Latvian quota. 4 % of the total coastal limit is allocated to the gillnet fishery.	The total herring coastal limit in the Gulf of Riga is distributed by three coastal areas (Eastern, Southern and Western). When the area limit is reached, the fishery is ceased in a given area. In a situation, when there are indications that the total limit in the area will not be taken, it is possible to allocate part of this limit to the area where it has been already reached.	12th May - 10th June
2020	Estonia	In total 175 herring pound-nets	Division of total EST quota in the Gulf of Riga is divided between trawl and coastal fishery according to historical share companies/fishers involved. Currently 46%for coastal fishery and 54% for trawls. The quota for coastal fishers is divided between Saaremaa Island (9%) and Pärnu county 93%.	The total herring quota for coastal fishery within area is distributed between fishing companies/fishers according their historical share (90%). The rest 10% is distributed between companies/fishers through open auctions.	20th April-22th May, 31 days, can be shifted depending on ice conditions in winter; Additional closure in certain rectangles from 1st April to 20 May. "Unofficial" (not established by the authorities) closure for trawl fishery 15th June -15th September.

4.24a. Total catches of herring in the Gulf of Riga by nation (official + unallocated landings). All weights are in tonnes.

Year	Estonia	Latvia	Unallocated landings	Total
1991	7410	13481	-	20891
1992	9742	14204	-	23946
1993	9537	13554	2209	25300
1994	9636	14050	3514	27200
1995	16008	17016	3332	36356
1996	11788	17362	3534	32684
1997	15819	21116	4308	41243
1998	11313	16125	3305	30743
1999	10245	20511	3077	33803
2000	12514	21624	2631	36769
2001	14311	22775	3399	40485
2002	16962	22441	3398	42801
2003	19647	21780	3276	44703
2004	18218	20903	3094	42215
2005	11213	19741	3071	34025
2006	11924	19186	2922	34032
2007	12764	19425	2953	35142
2008	15877	19290	1970	37137
2009	17167	18323	1864	37354
2010	15422	17751	1791	34974
2011	14721	20218	-	35039
2012	13789	17926	-	31715
2013	11898	18413	-	30311
2014	10541	20012	-	30553
2015	16509	21010	-	37519
2016	15814	19066	-	34880
2017	13772	17948	-	31720
2018	12521	16904	-	29424
2019	13320	17961	-	31281
2020	12231	21019	-	33249

Table 4.24b. Herring caught in the Gulf of Riga and Gulf of Riga herring catches in central Baltic. All weights are in tonnes.

Year	Catches in the Gulf of Riga			Gulf of Riga herring catches	
	Gulf of Riga herring	Central Baltic herring	Total	In the Central Baltic	Total
1977	24186	2400	26586	-	24186
1978	16728	6300	23028	-	16728
1979	17142	4700	21842	-	17142
1980	14998	5700	20698	-	14998
1981	16769	5900	22669	-	16769
1982	12777	4700	17477	-	12777
1983	15541	4800	20341	-	15541
1984	15843	3800	19643	-	15843
1985	15575	4600	20175	-	15575
1986	16927	1300	18227	-	16927
1987	12884	4800	17684	-	12884
1988	16791	3000	19791	-	16791
1989	16783	5900	22683	-	16783
1990	14931	6000	20931	-	14931
1991	14791	6100	20891	-	14791
1992	18700	3500	23946	1300	20000
1993	21000	4300	25300	1200	22200
1994	22200	5000	27200	2100	24300
1995	30256	6100	36356	2400	32656
1996	28284	4400	32684	4300	32584
1997	36943	4300	41243	2900	39843
1998	26643	4100	30743	2800	29443
1999	29503	4300	33803	1900	31403
2000	32169	4600	36769	1900	34069
2001	37585	2900	40485	1200	38785
2002	39301	3500	42801	400	39701
2003	40403	4300	44703	400	40803
2004	38915	3300	42215	200	39115

Year	Catches in the Gulf of Riga			Gulf of Riga herring catches	
	Gulf of Riga herring	Central Baltic herring	Total	In the Central Baltic	Total
2005	31725	2300	34025	500	32225
2006	30832	3200	34032	400	31232
2007	33642	1500	35142	100	33742
2008	31037	6100	37137	100	31137
2009	32454	4900	37354	100	32554
2010	29774	5200	34974	400	30174
2011	29539	5500	35039	100	29639
2012	27915	3800	31715	200	28115
2013	26211	4100	30311	300	26511
2014	26053	4500	30553	200	26253
2015	32551	4968	37519	316	32851
2016	30565	4315	34880	289	30865
2017	27824	3896	31720	234	28058
2018	25217	4208	29424	530	25747
2019	27721	3560	31281	1200	28922
2020	31986	1264	33249	1229	33215

Table 4.25. Sampling of herring landings in the Gulf of Riga in 2020

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	3051	11	1100	1100
	II	7425	16	1350	1204
	III	606	4	395	395
	IV	1148	5	500	499
	Total	12231	36	3345	3198
Latvia	I	6147	9	1959	1201
	II	4484	38	4606	3818
	III	4675	8	1403	701
	IV	5712	9	1468	879

Country	Quarter	Landings	Samples	Measured	Aged
	Total	21019	64	9436	6599
Total	I	9198	20	3059	2301
	II	11910	54	5956	5022
	III	5281	12	1798	1096
	IV	6860	14	1968	1378
Grand total	Total	33249	100	12781	9797

Table 4.26. Gulf of Riga herring. Catch in numbers 1977-2020 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

Year	1	2	3	4	5	6	7	8+
1997	204200	930700	559700	345400	242800	186700	90600	61100
1998	239360	282060	505410	274890	172470	114020	90230	67650
1999	361890	446500	157050	316480	157200	83650	60670	81050
2000	259030	552300	359430	123730	258070	83980	35120	53370
2001	819480	461570	378160	261040	81170	120980	56040	70710
2002	304160	1182680	360540	202120	118950	36310	48060	44940
2003	596730	396180	922840	231180	107440	70510	19990	58640
2004	166760	1342020	306210	505770	129160	64390	33200	62270
2005	383307	197546	873585	171434	186054	50952	27898	28826
2006	787870	600120	113610	467380	100900	70420	16470	20010
2007	305070	1145970	441270	83890	303940	59690	33710	24170
2008	599430	340150	707460	166050	21870	112520	11600	26250
2009	284970	787100	206390	505640	109220	20860	101490	29430
2010	469190	407890	515480	109990	275720	55630	7760	75000
2011	94610	346460	325910	398850	86030	168030	35030	44130
2012	458920	123970	276010	196090	245430	39330	90650	33980
2013	435220	596630	95600	143650	86850	128500	21350	57920
2014	76960	553760	443440	68530	115750	62060	80660	58830
2015	277380	141080	575230	394950	68160	82500	63190	117450
2016	467310	287890	110350	427240	291430	43770	50850	94760
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
2020	623754	285022	512507	192367	158621	85216	23743	109093

Table 4.27. Gulf of Riga herring. Catch in tonnes (CATON).

Year	Catch
1977	24186
1978	16728
1979	17142
1980	14998
1981	16769
1982	12777
1983	15541
1984	15843
1985	15575
1986	16927
1987	12884
1988	16791
1989	16783
1990	14931
1991	14791
1992	20000
1993	22200
1994	24300
1995	32656
1996	32584
1997	39843
1998	29443
1999	31403
2000	34069
2001	38785
2002	39701
2003	40803
2004	39115
2005	32225

Year	Catch
2006	31232
2007	33742
2008	31137
2009	32554
2010	30174
2011	29639
2012	28115
2013	26511
2014	26253
2015	32851
2016	30865
2017	28058
2018	25747
2019	28922
2020	33215

Table 4.28. Gulf of Riga herring. Proportion of mature at beginning the year in 1977-2020.

Period	1	2	3	4	5	6	7	8+
1977-2020	0	0.93	0.98	0.98	1	1	1	1

Table 4.29. Gulf of Riga herring. Weights (kg) in catch and stock in 1977-2020.

Year	Age 1	2	3	4	5	6	7	8+
1977	0.0132	0.0160	0.0227	0.0269	0.0295	0.0312	0.0294	0.0508
1978	0.0098	0.0177	0.0219	0.0273	0.0311	0.0304	0.0381	0.0504
1979	0.0122	0.0162	0.0234	0.0276	0.0298	0.0340	0.0368	0.036
1980	0.0145	0.0201	0.0241	0.0321	0.0393	0.0456	0.0533	0.0711
1981	0.0121	0.0216	0.0288	0.0334	0.0390	0.0439	0.0499	0.0595
1982	0.0141	0.0214	0.0287	0.0357	0.0372	0.0451	0.0503	0.06837
1983	0.0138	0.0193	0.0276	0.0379	0.0416	0.0509	0.0610	0.0913
1984	0.0100	0.0150	0.0215	0.0281	0.0343	0.0391	0.0491	0.0559
1985	0.0129	0.0172	0.0208	0.0278	0.0358	0.0487	0.0531	0.0665
1986	0.0126	0.0198	0.0256	0.0314	0.0402	0.0462	0.0639	0.0709
1987	0.0101	0.0154	0.0197	0.0263	0.0303	0.0379	0.0431	0.0905
1988	0.0117	0.0186	0.0210	0.0273	0.0368	0.0434	0.0586	0.075
1989	0.0120	0.0148	0.0166	0.0196	0.0230	0.0315	0.0382	0.0364
1990	0.0146	0.0178	0.0198	0.0269	0.0306	0.0331	0.0522	0.0554
1991	0.0119	0.0154	0.0178	0.0199	0.0214	0.0225	0.0269	0.0336
1992	0.0112	0.0136	0.0177	0.0215	0.0236	0.0250	0.0264	0.0359
1993	0.0125	0.0136	0.0161	0.0201	0.0247	0.0263	0.0275	0.0352
1994	0.0112	0.0146	0.0162	0.0188	0.0215	0.0252	0.0263	0.03
1995	0.0104	0.0136	0.0164	0.0179	0.0209	0.0229	0.0263	0.0291
1996	0.0105	0.0125	0.0157	0.0177	0.0189	0.0215	0.0235	0.028
1997	0.0097	0.0124	0.0149	0.0178	0.0191	0.0196	0.0212	0.0242
1998	0.0101	0.0133	0.0169	0.0182	0.0203	0.0213	0.0225	0.024
1999	0.0131	0.0155	0.0189	0.0221	0.0231	0.0245	0.0265	0.0289
2000	0.0125	0.0165	0.0201	0.0229	0.0254	0.0264	0.0282	0.0296
2001	0.0102	0.0160	0.0205	0.0230	0.0245	0.0277	0.0283	0.0307
2002	0.0100	0.0153	0.0193	0.0236	0.0250	0.0271	0.0280	0.0309
2003	0.0075	0.0153	0.0199	0.0223	0.0248	0.0263	0.0268	0.0276
2004	0.0086	0.0101	0.0165	0.0210	0.0242	0.0268	0.0271	0.0331
2005	0.0120	0.0142	0.0159	0.0204	0.0244	0.0260	0.0298	0.0308

Year	Age 1	2	3	4	5	6	7	8+
2006	0.0086	0.0132	0.0178	0.0191	0.0228	0.0266	0.0275	0.0296
2007	0.0089	0.0117	0.0154	0.0202	0.0196	0.0237	0.0271	0.0278
2008	0.0098	0.0148	0.0173	0.0204	0.0238	0.0233	0.0286	0.0327
2009	0.0092	0.0140	0.0176	0.0191	0.0218	0.0207	0.0244	0.0294
2010	0.0091	0.0138	0.0169	0.0194	0.0209	0.0237	0.0231	0.026
2011	0.0118	0.0153	0.0184	0.0211	0.023	0.0255	0.0262	0.0324
2012	0.0094	0.0159	0.0203	0.0232	0.0258	0.0277	0.0299	0.0334
2013	0.0097	0.0146	0.0197	0.0227	0.0257	0.0282	0.0295	0.0319
2014	0.0098	0.0138	0.0176	0.0216	0.0236	0.0253	0.0271	0.0302
2015	0.0089	0.0150	0.0182	0.0211	0.0230	0.0252	0.0272	0.0295
2016	0.0086	0.0152	0.0181	0.0204	0.0223	0.0239	0.0260	0.0283
2017	0.0087	0.0147	0.0185	0.0209	0.0225	0.0241	0.0248	0.0276
2018	0.0097	0.0153	0.0191	0.0216	0.0230	0.0245	0.0256	0.0284
2019	0.0087	0.0136	0.0181	0.0207	0.0232	0.0237	0.0248	0.0262
2020	0.0090	0.0154	0.0189	0.0212	0.0231	0.0250	0.0247	0.0260

Table 4.30. Gulf of Riga herring. Natural mortality.

Year	1	2	3	4	5	6	7	8+
1977-1978	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
1979	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1980	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1981	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
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
1984-2020	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 4.31. 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
2019	43.0	93.15	59.61	75.4	30.14	8.13	29.05	11.53
2020	43.0	53.68	136.63	50	49.23	23.9	4.97	14.04

***Age 8 is true age group**

Table 4.32. 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
2020	1	9947	2659	3641	1234	1131	403	201	585

***Age 8 is true age group**

Table 4.33. Gulf of Riga herring. XSA diagnostics.

Lowestoft VPA Version 3.1
8/04/2021 11:36

Extended Survivors Analysis
Index File; Gulf of Riga herring
CPUE data from file Tuning.dat

Catch data for 44 years. 1977 to 2020. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Trap-nets	1996	2020	2	7	0.33	0.58
Acoustics	1999	2020	1	7	0.55	0.6

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 44 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99
	0.997	1	1			

Fishing mortalities

Age	2011	2012	2013	2014	2015	2016
	2017	2018	2019	2020		
1	0.092	0.093	0.083	0.076	0.124	0.127
	0.107	0.066	0.067	0.102		

2	0.217	0.168	0.168	0.143	0.194	0.184
	0.174	0.15	0.158	0.148		
3	0.309	0.269	0.189	0.181	0.218	0.229
	0.209	0.187	0.188	0.187		
4	0.3	0.309	0.218	0.201	0.243	0.25
	0.185	0.216	0.228	0.211		
5	0.354	0.306	0.218	0.275	0.315	0.286
	0.228	0.216	0.26	0.204		
6	0.317	0.271	0.259	0.24	0.322	0.342
	0.293	0.205	0.363	0.306		
7	0.305	0.282	0.231	0.258	0.41	0.337
	0.32	0.225	0.245	0.308		

XSA population numbers (Thousands)

YEAR/AGE	1	2	3	4	5	6	7
2011	1.19E+06	1.96E+06	1.35E+06	1.70E+06	3.19E+05	6.83E+05	1.47E+05
2012	5.72E+06	8.88E+05	1.29E+06	8.14E+05	1.03E+06	1.83E+05	4.08E+05
2013	6.07E+06	4.27E+06	6.15E+05	8.09E+05	4.89E+05	6.21E+05	1.14E+05
2014	1.16E+06	4.58E+06	2.96E+06	4.17E+05	5.32E+05	3.22E+05	3.93E+05
2015	2.62E+06	8.84E+05	3.25E+06	2.02E+06	2.79E+05	3.31E+05	2.07E+05
2016	4.31E+06	1.89E+06	5.96E+05	2.14E+06	1.30E+06	1.67E+05	1.96E+05
2017	3.18E+06	3.11E+06	1.29E+06	3.88E+05	1.36E+06	7.98E+05	9.70E+04
2018	6.19E+06	2.34E+06	2.14E+06	8.57E+05	2.64E+05	8.89E+05	4.87E+05
2019	2.99E+06	4.75E+06	1.65E+06	1.45E+06	5.65E+05	1.74E+05	5.93E+05
2020	7.10E+06	2.29E+06	3.32E+06	1.12E+06	9.48E+05	3.57E+05	9.91E+04

Estimated population abundance at 1st Jan 2021

0.00E+00	5.25E+06	1.62E+06	2.25E+06	7.41E+05	6.33E+05	2.15E+05

Taper weighted geometric mean of the VPA populations:

3.47E+06	2.38E+06	1.58E+06	9.38E+05	5.64E+05	3.17E+05	1.78E+05

Standard error of the weighted Log(VPA populations) :

0.6048	0.5991	0.6469	0.6555	0.7059	0.7439	0.8681

Log catchability residuals.

Fleet : Trap-nets

Age	1996	1997	1998	1999	2000
1	No data for this fleet at this age				

2	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99

Age	2001	2002	2003	2004	2005	2006
	2007	2008	2009	2010		
1	No data for this fleet at this age					
2	0.23	0.08	0.1	-0.52	0.27	0.37
	-0.17	0.59	0.21	-0.13		
3	0.35	0.13	0.41	0.32	0.09	0.44
	0.48	0.17	-0.07	-0.17		
4	0.48	0.04	0.29	0.45	0.16	0.04
	0.68	0.23	0.25	-0.21		
5	0.42	0.09	-0.32	0.3	0.67	0.92
	0.26	0.1	0.29	0.07		
6	0.57	-0.19	0.4	0.22	0.61	0.63
	0.93	0.01	0.46	0.14		
7	0.52	-0.19	-0.47	0.2	0.27	0.6
	0.25	-0.31	0.27	0.1		

Age	2011	2012	2013	2014	2015	2016
	2017	2018	2019	2020		
1	No data for this fleet at this age					
2	-0.14	-0.07	0.02	0.27	-0.25	0.13
	-0.2	0.04	-0.18	-0.01		
3	0.08	-0.09	-0.05	-0.11	-0.07	0
	0.04	0.08	-0.17	-0.05		
4	0.12	0.2	-0.13	-0.25	-0.26	0.11
	-0.3	0.13	0.04	-0.12		
5	-0.15	0	-0.09	-0.29	-0.4	0.29
	0.13	-0.24	-0.02	-0.07		
6	0.16	-0.25	0.01	-0.76	-0.39	0.21
	0.28	-0.11	-0.11	0.23		
7	-0.07	-0.01	-0.34	-0.38	-0.2	0.16
	-0.01	0.05	-0.11	-0.06		

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	-14.2545	-13.6374	-13.4718	-13.3703	-13.3703	-13.3703
S.E(Log q)	0.2198	0.157	0.2365	0.2756	0.3822	0.2285

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	0.99	0.077	14.26	0.88	20	0.23	-14.25
3	1.06	-0.801	13.6	0.94	20	0.17	-13.64
4	0.97	0.266	13.48	0.89	20	0.24	-13.47
5	0.91	0.852	13.36	0.9	20	0.25	-13.37
6	1.13	-0.744	13.42	0.76	20	0.44	-13.34
7	1.03	-0.356	13.45	0.93	20	0.24	-13.41

Fleet : Acoustics

Age	1996	1997	1998	1999	2000
1	99.99	99.99	99.99	99.99	99.99
2	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99

Age	2001	2002	2003	2004	2005	2006
	2007	2008	2009	2010		
1	-0.11	0.23	0.19	0.82	0.6	0.19
	-0.64	0.15	0.45	0.3		
2	-0.02	0.33	-0.03	0.65	0.8	-0.17
	-0.4	0.35	0.05	0.05		
3	0.33	0.02	0.12	-0.22	0.44	-0.52
	0.08	0.37	0.07	-0.37		

4	0.34	0.07	-0.14	0.54	-0.15	-0.47
	-0.12	0.32	0.04	-0.56		
5	0.12	-0.31	-0.07	-0.09	0.59	-0.63
	0.02	0.3	-0.31	-0.56		
6	0.17	-0.03	0.61	0.34	-0.17	0.16
	0.32	-0.48	-0.7	-0.73		
7	-0.75	0.3	0.04	0.35	0.1	-0.47
	0	-0.91	-0.43	-0.91		

Age	2011	2012	2013	2014	2015	2016
	2017	2018	2019	2020		
1	0.61	-0.32	0.07	-0.42	-0.14	-0.29
	-0.34	0.22	0.12	-0.02		
2	0.89	-0.29	0.13	-0.32	-0.61	-0.68
	-0.03	0.52	0.25	0.01		
3	0.66	0.19	-0.06	-0.31	-0.54	-0.17
	-0.4	0.5	0.28	0.07		
4	0.7	0.1	0.53	-0.32	-0.48	-0.32
	0.12	0	0.02	0.2		
5	0.71	0.05	-0.02	0.1	-0.04	-0.59
	0.18	0.25	-0.15	0.17		
6	0.29	0.74	0.31	0.33	0.1	-0.02
	0.25	0.47	0.35	0.17		
7	0.15	-0.24	0.5	0.19	-0.03	-0.48
	0.4	0.44	0.15	0.76		

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	-6.3762	-6.5633	-6.6601	-6.7695	-6.6671	-6.6671	-6.6671
S.E(Log q)	0.3457	0.4482	0.3717	0.3636	0.3509	0.4245	0.4895

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	1.02	-0.1	6.22	0.75	20	0.37	-6.38
2	0.88	0.596	7.55	0.71	20	0.41	-6.56
3	0.98	0.104	6.8	0.76	20	0.38	-6.66
4	1	0.015	6.79	0.77	20	0.38	-6.77
5	1.22	-1.231	5.23	0.76	20	0.42	-6.67
6	0.85	1.087	7.42	0.84	20	0.33	-6.52
7	0.87	0.837	7.32	0.82	20	0.43	-6.63

Terminal year survivor and F summaries:

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

Year class = 2019

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	5141464	0.36	0	0	1	0.636	0.104
F shrinkage mean	5445332	0.5				0.364	0.099

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
5250173	0.29	0.03	2	0.119	0.102

Age 2 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	1601274	0.3	0	0	1	0.403	0.149
Acoustics	1741543	0.285	0.055	0.19	2	0.429	0.138
F shrinkage mean	1366514	0.5				0.168	0.173

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
1616299	0.19	0.06	4	0.296	0.148

Age 3 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	2020268	0.213	0.069	0.32	2	0.488	0.207
Acoustics	2655838	0.231	0.057	0.25	3	0.397	0.161
F shrinkage mean	2017077	0.5				0.114	0.207

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
2251859	0.15	0.07	6	0.452	0.187

Age 4 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	676174	0.175	0.061	0.35	3	0.524	0.229
Acoustics	855302	0.2	0.167	0.84	4	0.384	0.185
F shrinkage mean	688319	0.5				0.092	0.225

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
741292	0.13	0.08	8	0.652	0.211

Age 5 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	612836	0.154	0.057	0.37	4	0.539	0.21
Acoustics	700882	0.179	0.12	0.67	5	0.382	0.186
F shrinkage mean	478676	0.5				0.079	0.262

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
632593	0.11	0.07	10	0.572	0.204

Age 6 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	236353	0.147	0.045	0.31	5	0.527	0.282
Acoustics	189102	0.171	0.109	0.63	6	0.383	0.342
F shrinkage mean	214644	0.5				0.09	0.307

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
215117	0.11	0.06	12	0.529	0.306

Age 7 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
Trap-nets	51524	0.139	0.048	0.34	6	0.567	0.349
Acoustics	70775	0.169	0.163	0.97	7	0.343	0.265
F shrinkage mean	78538	0.5				0.091	0.242

Weighted prediction :

Survivors et end of year	Int s.e	Ext s.e	N	Var ratio	F
59677	0.11	0.08	14	0.776	0.308

Table 4.34. 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	0.0460	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	0.3510	0.3470	0.4624	0.4555	0.4464	0.2946
4	0.6180	0.3809	0.5812	0.2419	0.4407	0.4030	0.4370	0.7187	0.4097	0.4665
5	0.6456	0.4184	0.3965	0.4997	0.3946	0.4594	0.4467	0.6948	0.5520	0.4124
6	0.8246	0.3452	0.4304	0.3523	0.5949	0.4484	0.5205	0.8899	0.7179	0.8087
7	0.7027	0.3840	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5645	0.5673
8 +	0.7027	0.3840	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	0.0364	0.0392	0.0674	0.0673	0.0769	0.1071
2	0.0614	0.0718	0.1226	0.096	0.0932	0.1377	0.1323	0.1368	0.1792	0.2096
3	0.1612	0.196	0.2570	0.2557	0.1509	0.2087	0.1726	0.1829	0.2554	0.2394
4	0.4268	0.2462	0.4088	0.2125	0.2438	0.2134	0.1890	0.2274	0.3337	0.2776
5	0.6778	0.6137	0.2633	0.3398	0.2207	0.3208	0.2389	0.2462	0.3977	0.4001
6	0.3567	0.9443	0.4873	0.1428	0.3563	0.3053	0.3070	0.258	0.3602	0.5033
7	0.4909	0.6067	0.3891	0.2329	0.2751	0.2813	0.2463	0.2451	0.3662	0.3963
8+	0.4909	0.6067	0.3891	0.2329	0.2751	0.2813	0.2463	0.2451	0.3662	0.3963
FBAR 3- 7	0.4227	0.5214	0.3611	0.2367	0.2494	0.2659	0.2308	0.2319	0.3426	0.3634

YEAR/AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.1521	0.1006	0.1485	0.1145	0.161	0.1586	0.0965	0.1962	0.1412	0.1305
2	0.3560	0.3247	0.2760	0.3546	0.3066	0.3682	0.3195	0.3260	0.3763	0.3426
3	0.4373	0.3336	0.3023	0.3748	0.4399	0.4191	0.5520	0.4390	0.3658	0.3870
4	0.5201	0.3990	0.3607	0.4150	0.5163	0.4474	0.5238	0.6796	0.4731	0.3406
5	0.4832	0.5379	0.4194	0.5667	0.5312	0.4719	0.4562	0.6344	0.5749	0.5707
6	0.4870	0.4406	0.5483	0.4154	0.5737	0.4829	0.5737	0.5501	0.5566	0.4450
7	0.5007	0.4626	0.4460	0.4692	0.5444	0.4716	0.5402	0.5899	0.4913	0.3482

8+	0.5007	0.4626	0.4460	0.4692	0.5444	0.4716	0.5402	0.5899	0.4913	0.3482
FBAR 3- 7	0.4857	0.4348	0.4153	0.4482	0.5211	0.4586	0.5292	0.5786	0.4923	0.4183
YEAR/AGE	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1	0.1789	0.1249	0.1114	0.1959	0.0921	0.0928	0.0825	0.0758	0.1245	0.1275
2	0.2846	0.3104	0.2326	0.2409	0.2171	0.1677	0.1677	0.1435	0.1941	0.1840
3	0.4572	0.2853	0.3039	0.2426	0.3091	0.2691	0.1887	0.1812	0.2179	0.2289
4	0.5555	0.3098	0.3314	0.2717	0.3003	0.3094	0.2185	0.2006	0.2434	0.2495
5	0.3890	0.2698	0.338	0.3112	0.3542	0.3055	0.2184	0.2748	0.3146	0.2856
6	0.8118	0.2421	0.4374	0.2937	0.3171	0.2710	0.2594	0.2396	0.3221	0.3424
7	0.3971	0.3527	0.353	0.2929	0.3046	0.2821	0.2311	0.2576	0.4104	0.3370
8 +	0.3971	0.3527	0.353	0.2929	0.3046	0.2821	0.2311	0.2576	0.4104	0.3370
FBAR 3- 7	0.5221	0.292	0.3527	0.2824	0.3171	0.2874	0.2232	0.2308	0.3017	0.2887

YEAR/AGE	2017	2018	2019	2020	FBAR
1	0.1069	0.066	0.0667	0.1021	0.0783
2	0.1738	0.1505	0.1585	0.148	0.1523
3	0.2087	0.1865	0.1879	0.1873	0.1872
4	0.1853	0.2158	0.2276	0.2109	0.2181
5	0.2278	0.2163	0.2601	0.2045	0.2269
6	0.2929	0.2048	0.3634	0.3064	0.2915
7	0.3200	0.2251	0.2445	0.3075	0.259
8+	0.3200	0.2251	0.2445	0.3075	
FBAR 3- 7	0.2469	0.2097	0.2567	0.2433	

Table 4.35. Gulf of Riga herring. XSA output: Stock numbers at age (start of year) (10^4)

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	94322	107648	97694	111034	90842	168900	125365	202721	138805	112034
2	283694	70936	78001	69316	77560	65232	124479	93249	161993	111545
3	32331	152182	49273	45171	42873	45181	42331	77062	62583	106940
4	26299	13676	88050	29214	26389	23505	24870	20762	40011	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	334241	343303	417816	420386	392467

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	392862	56097	129239	364549	368991	431931	325725	278838	346954	466804
2	90893	315315	45385	100283	290496	291292	340036	249290	213433	263034
3	81671	69984	240269	32869	74586	216665	207807	243887	178002	146070
4	65215	56913	47100	152134	20840	52515	143975	143164	166301	112890
5	16838	34844	36426	25623	100715	13370	34734	97572	93371	97528
6	11787	6999	15444	22919	14934	66126	7943	22394	62449	51363
7	1425	6755	2229	7767	16267	8562	39897	4784	14165	35665
8+	564	1417	1837	2169	18632	21316	13542	28381	18419	19093
TOTAL	661255	548323	517929	708315	905461	1101777	1113657	1068310	1093094	1192447

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	159898	276327	289739	264555	608873	229172	717207	103466	321635	711626
2	343387	112437	204579	204473	193162	424353	160109	533205	69621	228649
3	174627	196928	66533	127094	117434	116383	240418	95238	315120	39126
4	94130	92329	115500	40262	71533	61930	62663	113335	50267	178953
5	70023	45814	50719	65927	21769	34947	32415	30386	47027	25644
6	53519	35361	21903	27301	30625	10478	17849	16818	13191	21668
7	25422	26924	18634	10364	14754	14127	5293	8233	7943	6190

8+	16975	19999	24669	15602	18418	13086	15364	18001	8128	7465
TOTAL	937980	806118	792277	755580	1076568	904475	1251318	918683	832934	1219321

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	205777	564177	287476	291526	118864	572446	607278	116467	261907	431462
2	511341	140872	407670	210546	196227	88757	427154	457817	88391	189333
3	132901	314959	84558	264512	135473	129308	61451	295739	324722	59603
4	21754	68882	193853	51086	169921	81426	80894	41661	202006	213811
5	104224	10220	41371	113948	31873	103030	48923	53233	27909	129652
6	11865	57830	6388	24158	68345	18311	62147	32197	33110	16682
7	11368	4314	37166	3377	14745	40752	11433	39254	20745	19643
8+	8084	9692	10693	32745	18455	15175	30847	28461	38233	36341
TOTAL	1007315	1170946	1069176	991898	753904	1049206	1330127	1064828	997024	1096528

Year	2017	2018	2019	2020	2021	GMST	AMST
1	317970	619323	298862	710176	0	242176	297346
2	310967	233931	474678	228909	525017	177310	216011
3	128964	213971	164773	331673	161630	110981	137686
4	38814	85695	145376	111797	225186	63433	81365
5	136396	26403	56541	94791	74129	34055	46537
6	79781	88924	17413	35690	63259	17580	26114
7	9698	48733	59320	9912	21512	8496	13528
8+	38037	19860	30726	45237	33200		
TOTAL	1060626	1336841	1247688	1568186	1103933		

Table 4.36. 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	66131	46739	17142	0.3668	0.431
1980	1110340	69530	46712	14998	0.3211	0.3498
1981	908421	65532	47221	16769	0.3551	0.4525
1982	1689000	72906	42758	12777	0.2988	0.4198
1983	1253653	76284	50858	15541	0.3056	0.4679
1984	2027213	66159	39914	15843	0.3969	0.7068
1985	1388054	77482	51937	15575	0.2999	0.5381
1986	1120343	86764	64284	16927	0.2633	0.5099
1987	3928624	97611	51522	12884	0.2501	0.4227
1988	560967	116327	96701	16791	0.1736	0.5214
1989	1292385	86105	63293	16783	0.2652	0.3611
1990	3645492	139190	77332	14931	0.1931	0.2367
1991	3689914	141619	87277	14791	0.1695	0.2494
1992	4319311	167232	106141	20000	0.1884	0.2659
1993	3257248	175763	120787	22200	0.1838	0.2308
1994	2788376	170444	124965	24300	0.1945	0.2319
1995	3469542	166971	116708	32656	0.2798	0.3426
1996	4668037	168011	105795	32584	0.3080	0.3634
1997	1598978	134226	103574	39843	0.3847	0.4857
1998	2763269	120637	82140	29443	0.3585	0.4348
1999	2897394	136916	84194	31403	0.3730	0.4153
2000	2645554	133067	84025	34069	0.4055	0.4482
2001	6088728	157184	79443	38785	0.4882	0.5211
2002	2291719	144524	101021	39701	0.3930	0.4586
2003	7172071	158496	86918	40803	0.4694	0.5292
2004	1034657	122317	93406	39115	0.4188	0.5786

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
2005	3216351	127561	75411	32225	0.4273	0.4923
2006	7116258	148048	73416	31232	0.4254	0.4183
2007	2057771	131570	95052	33742	0.3550	0.5221
2008	5641770	165120	95083	31137	0.3275	0.2920
2009	2874764	157940	112381	32554	0.2897	0.3527
2010	2915262	149032	106631	30174	0.2830	0.2824
2011	1188641	139431	108524	29639	0.2731	0.3171
2012	5724457	161970	94730	28115	0.2968	0.2874
2013	6072780	195051	118689	26511	0.2234	0.2232
2014	1164668	175583	143791	26253	0.1826	0.2308
2015	2619073	169975	128582	32851	0.2555	0.3017
2016	4314619	168581	114876	30865	0.2687	0.2887
2017	3179703	168165	123092	28058	0.2279	0.2469
2018	6193234	201219	124599	25747	0.2066	0.2097
2019	2988617	190480	143579	28921	0.2014	0.2567
2020	7101760	230584	146956	33215	0.2260	0.2433
Arith. Mean	3067628	135017	90112	26109	0.3036	0.3865

Table 4.37. The configuration of SAM model for Gulf of Riga herring

```
$minAge
# The minimium age class in the assessment
 1
$maxAge
# The maximum age class in the assessment
 8
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  6  6
 -1 -1 -1 -1 -1 -1 -1 -1
```

-1 -1 -1 -1 -1 -1 -1 -1

$corFlag

Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

2

$keyLogFpar

Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1 -1 -1 -1 -1 -1 -1 -1

-1 0 1 2 3 4 5 6

7 8 9 10 11 12 13 14

$keyQpow

Density dependent catchability power parameters (if any).

-1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1

$keyVarF

Coupling of process variance parameters for log(F)-process (nomally only first row is used)

0 0 0 0 0 0 0 0

-1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN

Coupling of process variance parameters for log(N)-process

0 1 1 1 1 1 1 1

$keyVarObs

Coupling of the variance parameters for the observations.

0 1 1 1 1 1 1 1

2 2 2 2 2 2 2 2

3 3 3 3 3 3 3 3

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "ID" "ID"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#1-2 2-3 3-4 4-5 5-6 6-7 7-8

NA NA NA NA NA NA NA

-1 NA NA NA NA NA NA

NA NA NA NA NA NA NA

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).

2

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar

3 7

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1

$obsLikelihoodFlag

Option for observational likelihood | Possible values are: "LN" "ALN"

"LN" "LN" "LN"

$fixVarToWeight

If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).

0

$fracMixF

The fraction of t(3) distribution used in logF increment distribution

0

$fracMixN

The fraction of t(3) distribution used in logN increment distribution

0

$fracMixObs

A vector with same length as number of fleets, where each element is the fraction of t(3) distribution 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 4.38. Gulf of Riga herring. Short-term forecast input.

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3243312	0.2	0	0.2	0.3	0.0091	0.0783	0.0091
2	5250170	0.2	0.93	0.2	0.3	0.0148	0.1523	0.0148
3	1616300	0.2	0.98	0.2	0.3	0.0187	0.1872	0.0187
4	2251860	0.2	0.98	0.2	0.3	0.0212	0.2181	0.0212
5	741290	0.2	1	0.2	0.3	0.0231	0.2270	0.0231
6	632590	0.2	1	0.2	0.3	0.0244	0.2915	0.0244
7	215120	0.2	1	0.2	0.3	0.0250	0.2590	0.0250
8	332000	0.2	1	0.2	0.3	0.0269	0.2590	0.0269

2022								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3243312	0.2	0	0.2	0.3	0.0091	0.0783	0.0091
2	.	0.2	0.93	0.2	0.3	0.0148	0.1523	0.0148
3	.	0.2	0.98	0.2	0.3	0.0187	0.1872	0.0187
4	.	0.2	0.98	0.2	0.3	0.0212	0.2181	0.0212
5	.	0.2	1	0.2	0.3	0.0231	0.2270	0.0231
6	.	0.2	1	0.2	0.3	0.0244	0.2915	0.0244
7	.	0.2	1	0.2	0.3	0.0250	0.2590	0.0250
8	.	0.2	1	0.2	0.3	0.0269	0.2590	0.0269

2023								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3243312	0.2	0	0.2	0.3	0.0091	0.0783	0.0091
2	.	0.2	0.93	0.2	0.3	0.0148	0.1523	0.0148
3	.	0.2	0.98	0.2	0.3	0.0187	0.1872	0.0187
4	.	0.2	0.98	0.2	0.3	0.0212	0.2181	0.0212
5	.	0.2	1	0.2	0.3	0.0231	0.2270	0.0231
6	.	0.2	1	0.2	0.3	0.0244	0.2915	0.0244
7	.	0.2	1	0.2	0.3	0.0250	0.2590	0.0250
8	.	0.2	1	0.2	0.3	0.0269	0.2590	0.0269

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)

$N_{2021\text{-}2022}$ Age1: geometric mean from XSA-estimates at age 1 for the year classes 1989-2018

N_{2020} Age 2-8+: survivors estimates from XSA

Natural mortality (M): average 2018-20120

CWt/SWt=average 2018-2020

Sel=average 2018-2020

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

2021						
Biomass	SSB	FMult	FBar	Landings		
231903	176560	1.029	0.2434	35771		
2022					2023	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
222195	177244	0	0	0	245931	199221
.	176496	0.1	0.0243	3854	241970	194673
.	175752	0.2	0.0487	7630	238089	190238
.	175010	0.3	0.073	11330	234287	185913
.	174272	0.4	0.0973	14956	230561	181694
.	173537	0.5	0.1217	18510	226911	177580
.	172805	0.6	0.146	21992	223334	173567
.	172076	0.7	0.1704	25405	219829	169653
.	171351	0.8	0.1947	28750	216395	165835
.	170628	0.9	0.219	32029	213029	162110
.	169909	1.0	0.2434	35242	209731	158477
.	169193	1.1	0.2677	38392	206499	154933
.	168480	1.2	0.292	41479	203332	151475
.	167771	1.3	0.3164	44505	200227	148102
.	167064	1.4	0.3407	47472	197185	144810
.	166360	1.5	0.3651	50380	194203	141599
.	165660	1.6	0.3894	53231	191280	138465
.	164962	1.7	0.4137	56026	188415	135408
.	164268	1.8	0.4381	58766	185607	132424
.	163576	1.9	0.4624	61453	182855	129513
.	162888	2.0	0.4867	64087	180156	126671

Input units are thousand and kg – output in tonnes

Table 4.39. Gulf of Riga herring. Short-term results as used in ICES advice.

Basis	Total catch (2022)	F (2022)	SSB (2022)	SSB (2023)	%SSB change**	%Advice change***
ICES advice basis						
EU MAP *: F_{MSY}	44 945	0.32	167 666	147 612	-12.0%	26%
EU MAP *: F_{MSY}§	42 925	0.30	168 143	149 861	-11%	20%
EU MAP*: F_{lower}	34 797	0.24	170 010	158 979	-6.5%	26%^
EU MAP *: F_{upper}	52 132	0.38	165 931	139 671	-15.8%	26%^^
Other options						
ICES MSY approach: F_{MSY}	44 945	0.32	167 666	147 612	-12.0%	26%
F= 0	0	0	177 244	199 221	12.4%	-100%
F_{pa}	52 132	0.38	165 931	139 671	-15.8%	46%
F_{lim}	100 226	0.88	152 173	89 128	-41%	180%
SSB (2023) = B_{lim}	152 363	1.81	129 575	40 800	-69%	326%
SSB (2023) = B_{pa}	133 758	1.40	139 098	57 100	-59%	274%
SSB (2023) = MSY $B_{trigger}$	130 579	1.34	140 527	60 000	-57%	265%
F=F_{2021}	35 242	0.24	169 909	158 477	-6.7%	-1.48%

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

**** SSB 2023 relative to SSB 2022.**

*****Total catch in 2022 relative to ICES advice for 2021 (35 771 tonnes for the Gulf of Riga herring stock).**

^ ICES advice for F_{lower} in 2021 relative to ICES advice for F_{lowe}r in 2020 (27 702 tonnes)

^^ ICES advice for F_{upper} in 2021 relative to ICES advice for F_{upper} in 2020 (41 423 tonnes)

§ F_{MSY} advice capped by a 20% increase in advised catch according to the MAP

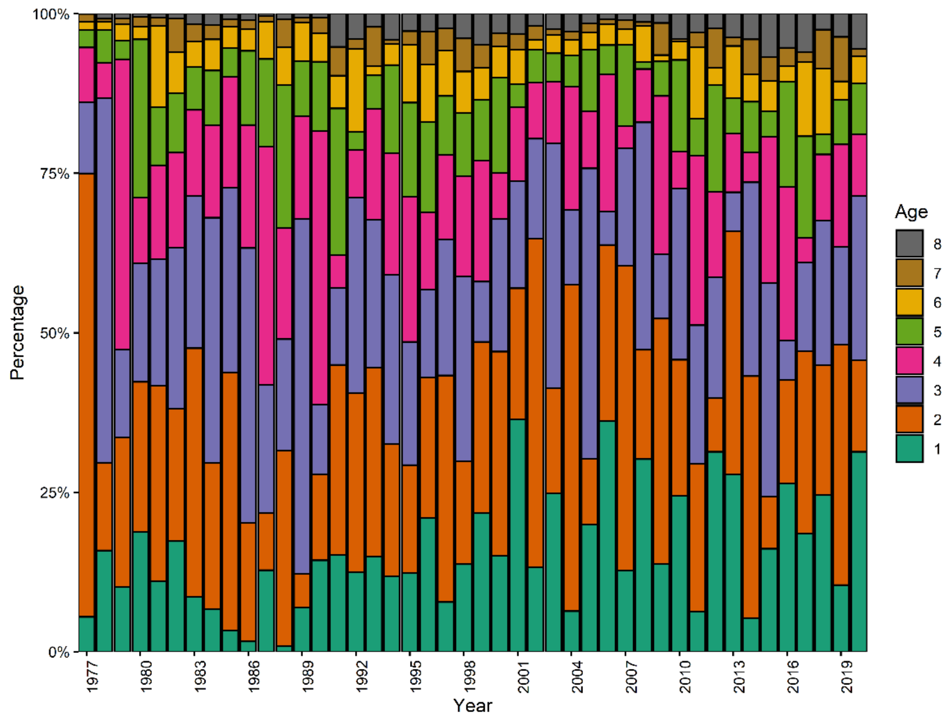


Figure 4.17. Gulf of Riga herring. Relative catch at age in numbers in 1977-2020.

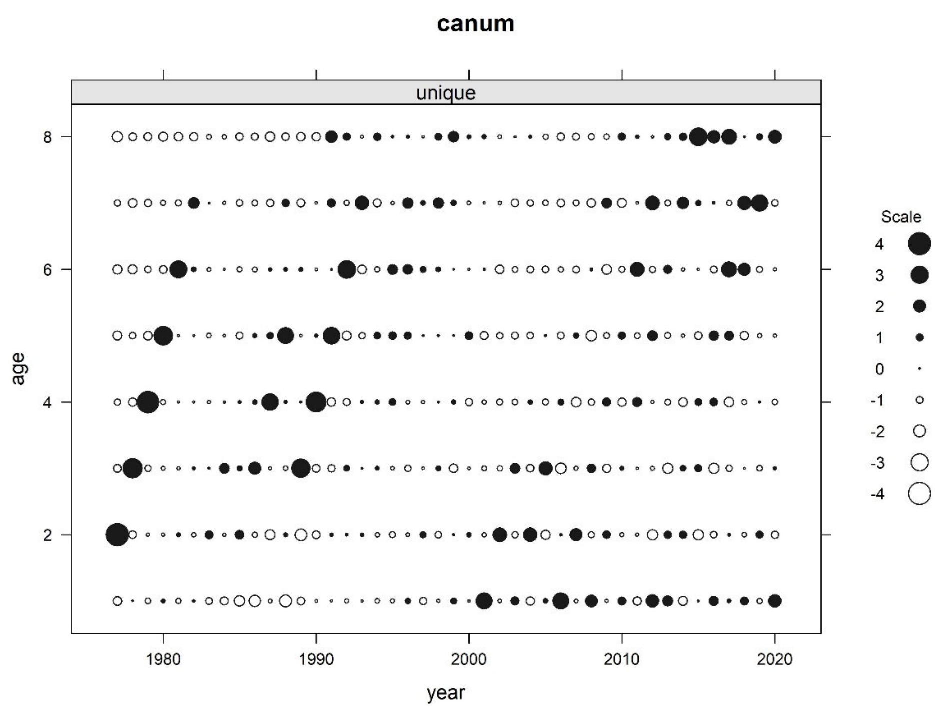


Figure 4.18. Gulf of Riga herring. Catch proportion at age.

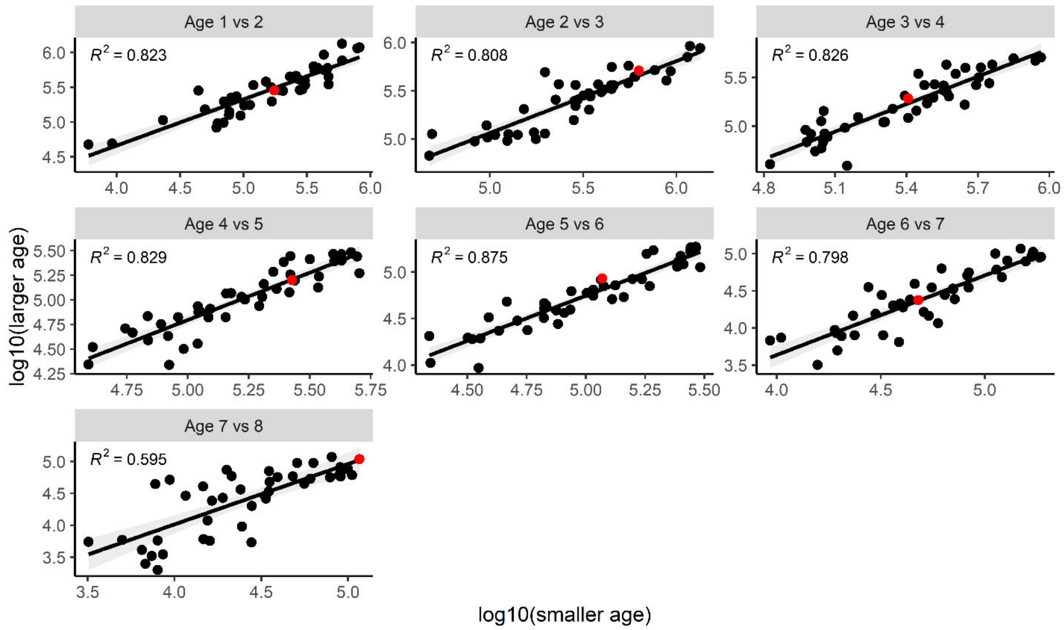


Figure 4.19. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

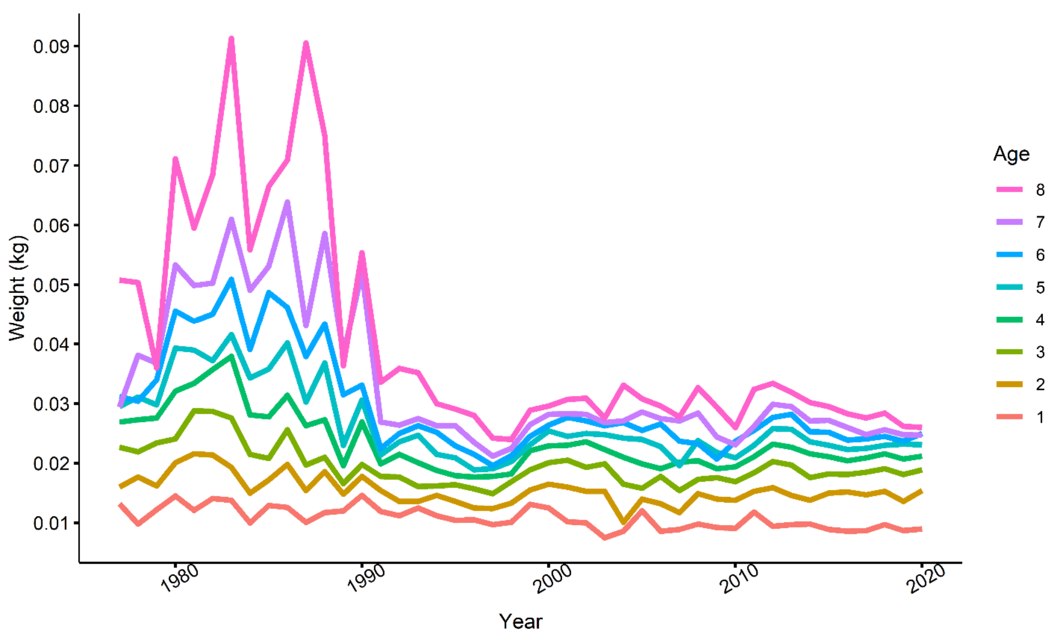


Figure 4.20. Gulf of Riga herring. Mean weight at age in the catches.

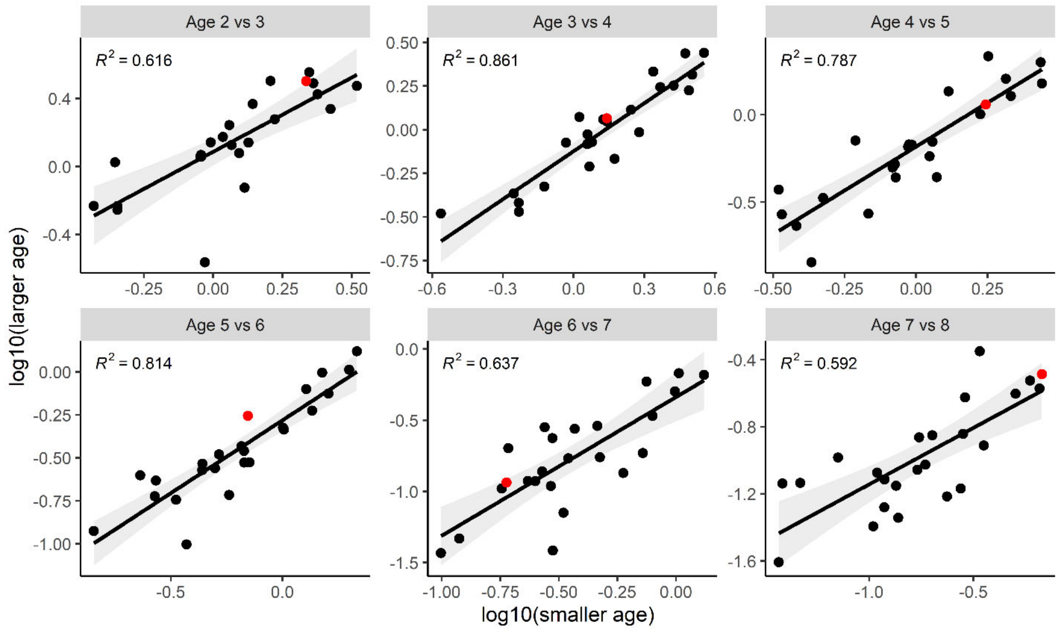


Figure 4.21. Gulf of Riga herring. Internal consistency in trap-net tuning fleet. Latest year is shown in red.

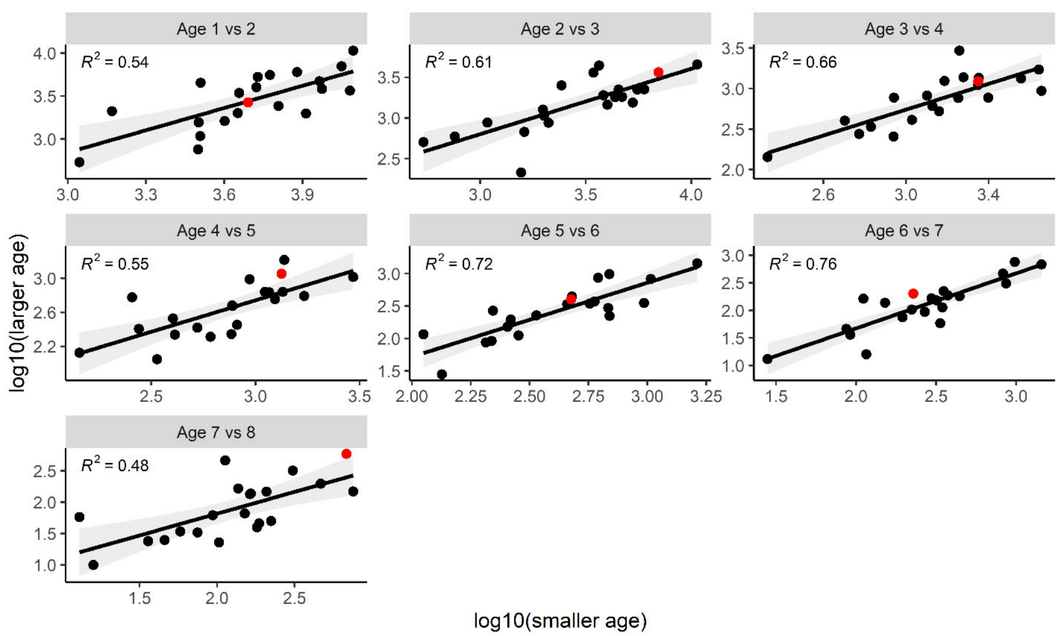


Figure 4.22. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

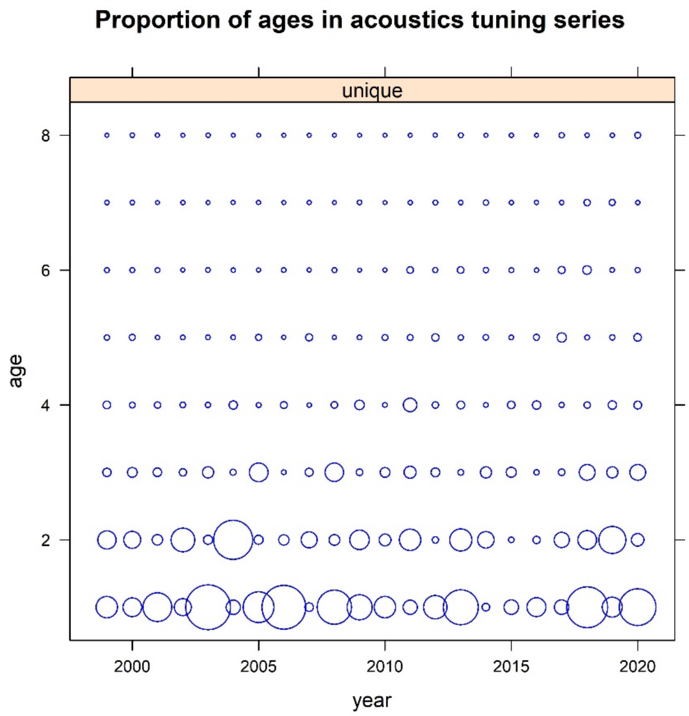
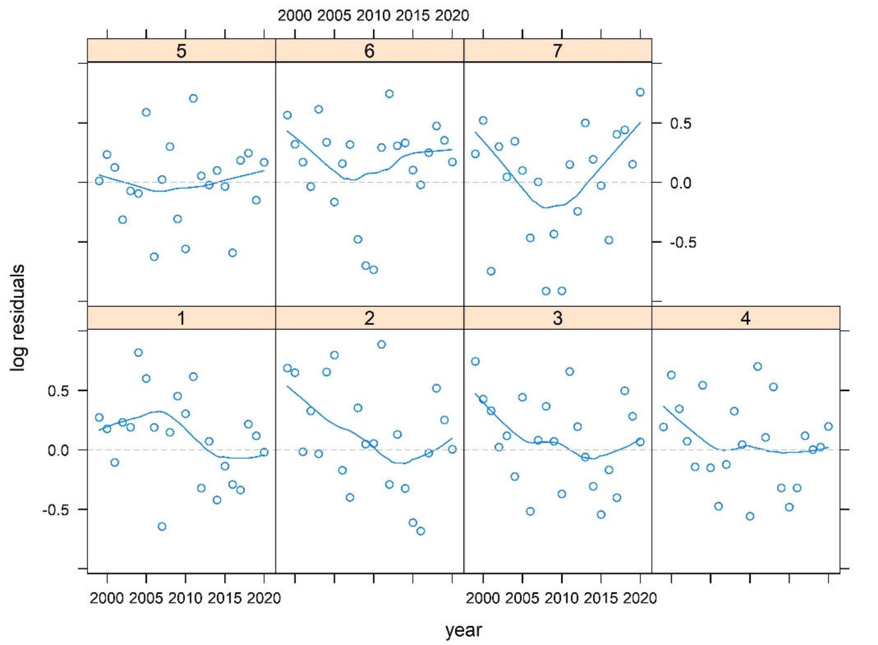


Figure 4.23. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.



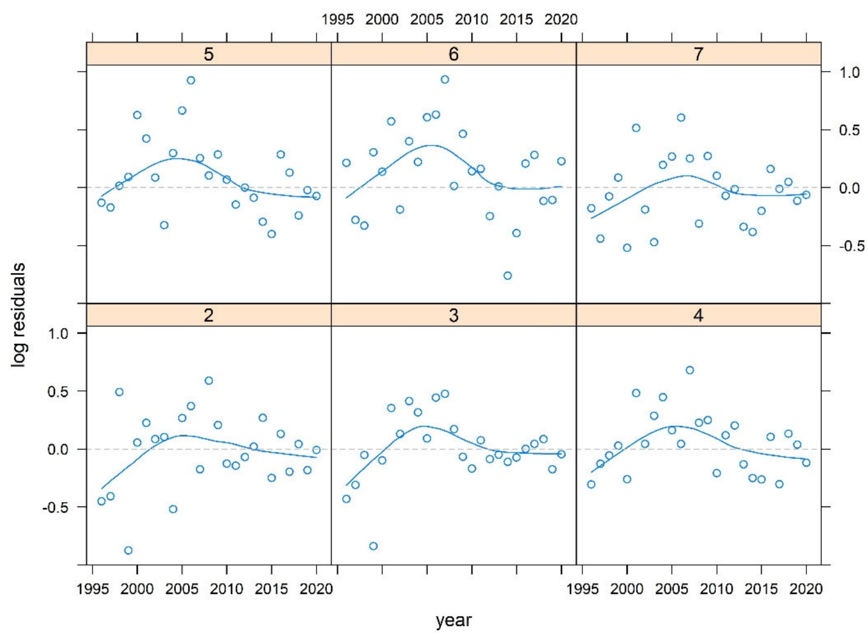


Figure 4.24a. Gulf of Riga herring. Log catchability residuals for acoustics survey (top) and trap-nets (bottom).

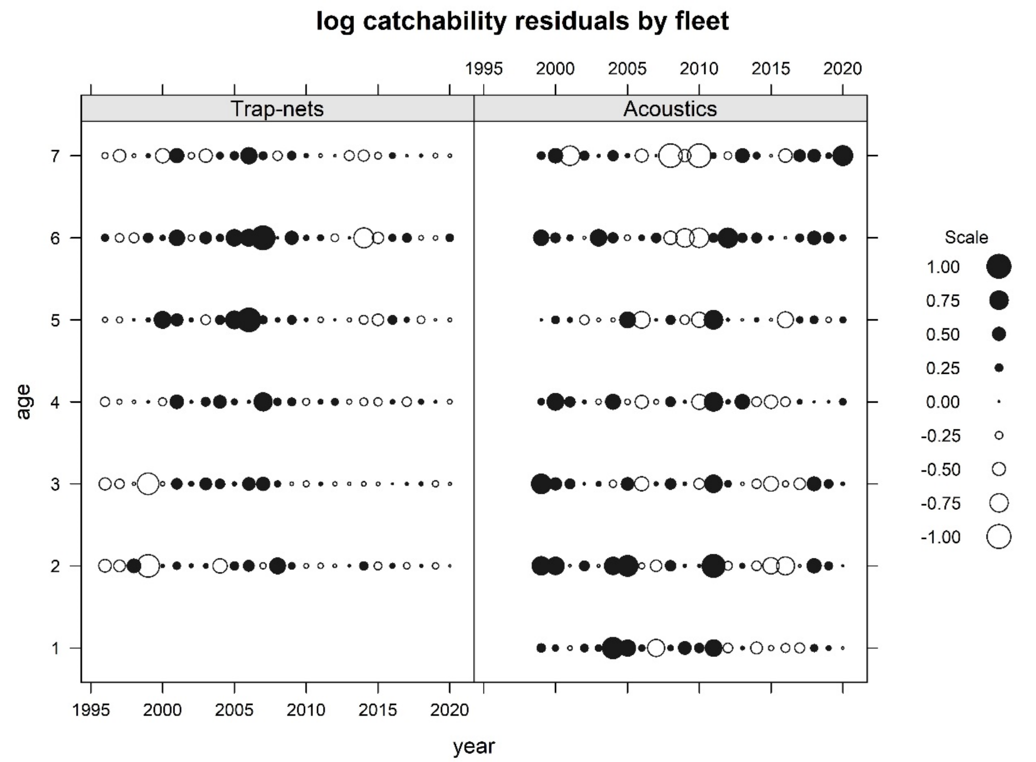


Figure 4.24b. Gulf of Riga herring. Log catchability residuals of trap-net fleet (left) and hydro-acoustics fleet (right).

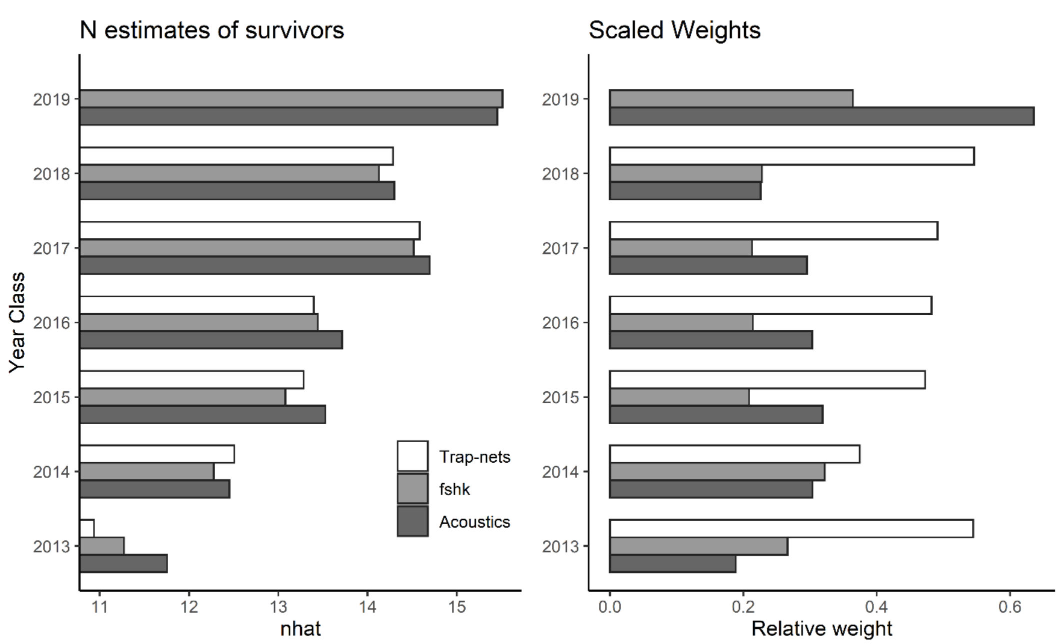


Figure 4.25. Gulf of Riga herring. Survivors' estimates and scaled weights for both tuning fleets.

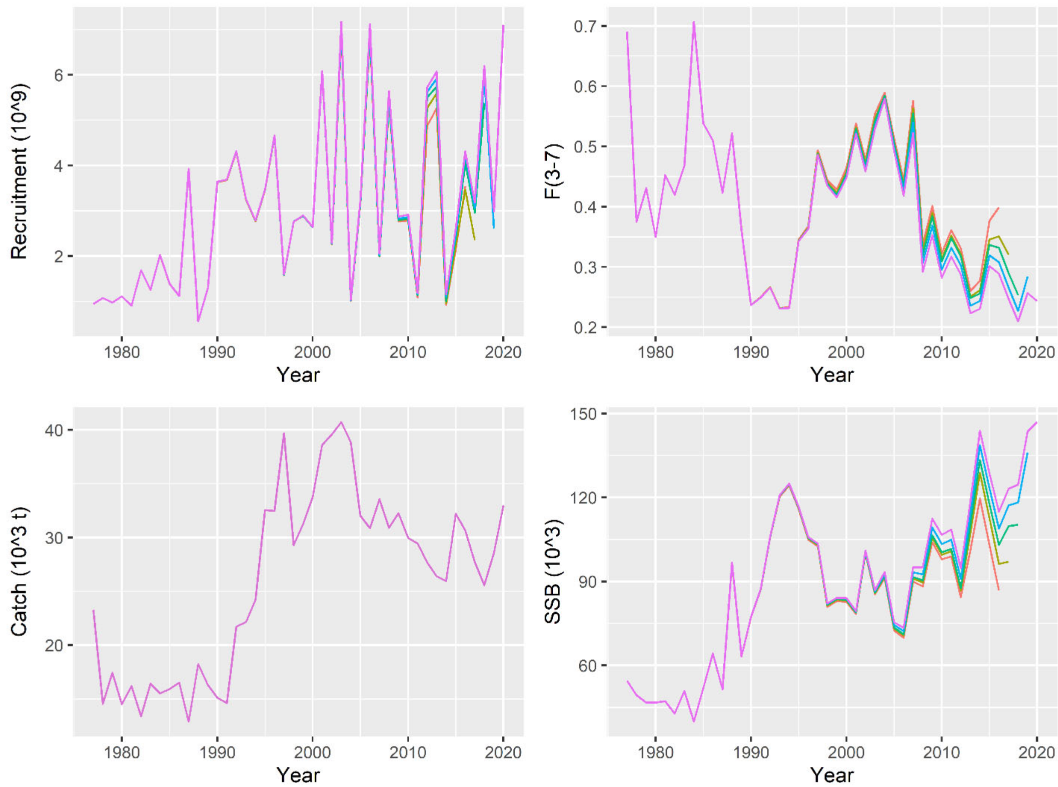


Figure 4.26. Gulf of Riga herring. Retrospective analysis (5 years).

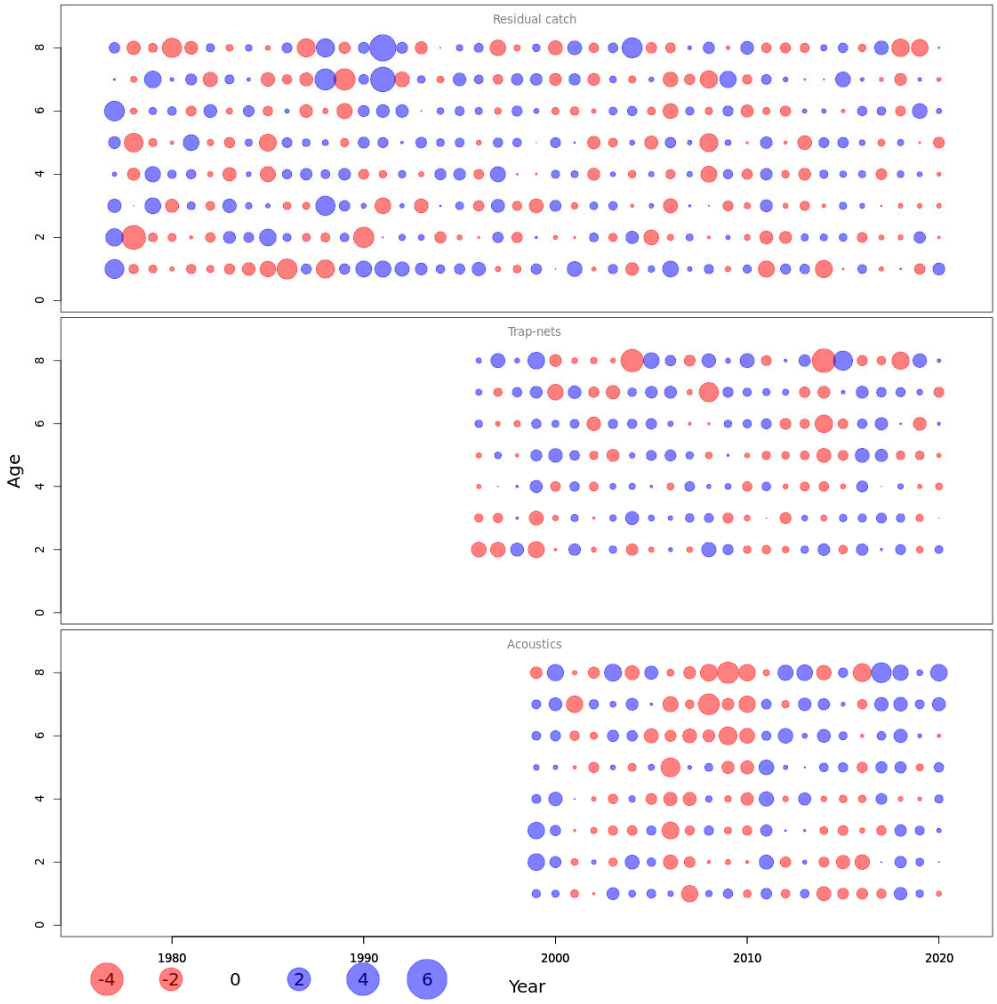


Figure 4.27. Gulf of Riga herring. Log catchability residuals from SAM run by fleet and catch.

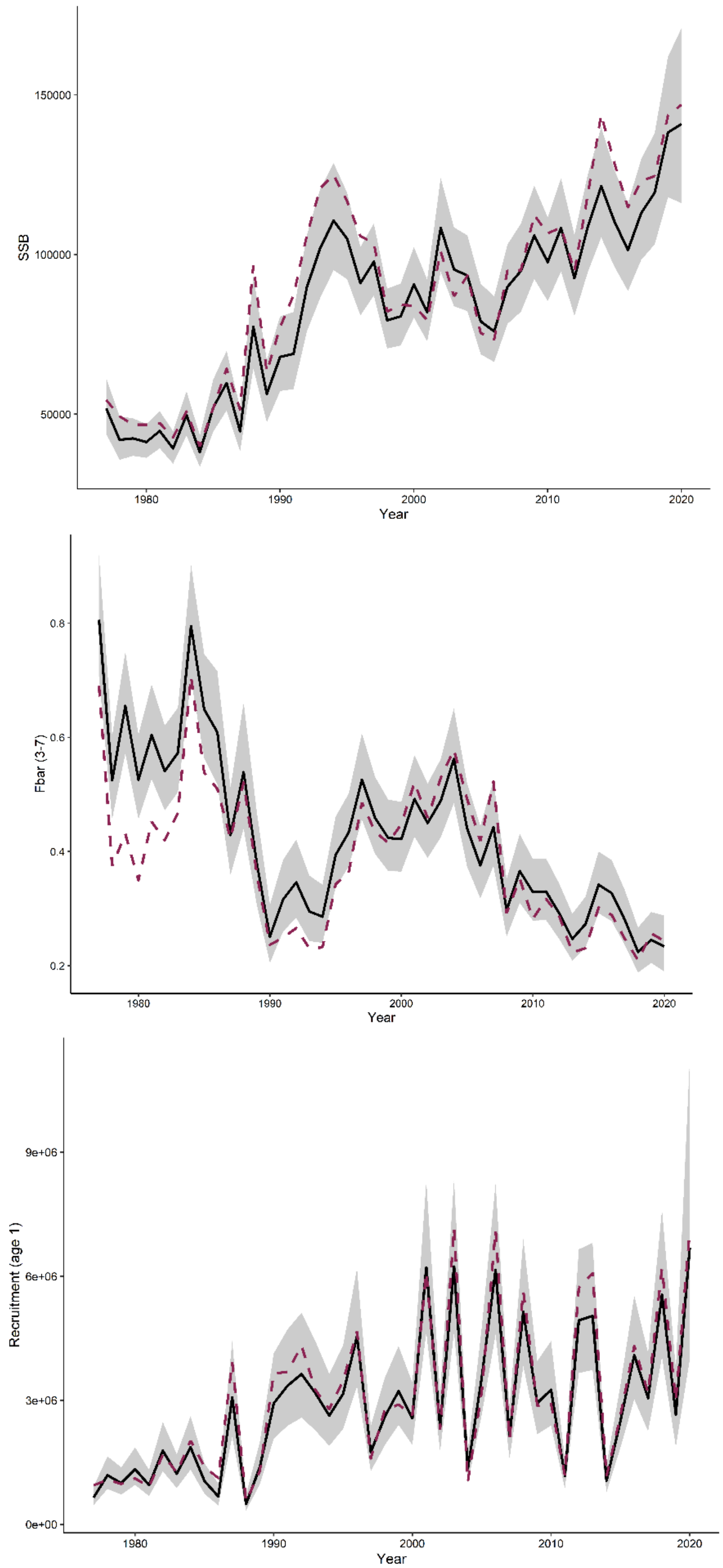


Figure 4.28. Gulf of Riga herring. Comparison of spawning stock biomass (SSB in tonnes), fishing mortality ($F_{3\text{-}7}$) and recruitment (age 1 in thousands) from XSA (dashed purple line) and SAM (back, grey shading represents the 95% confidence intervals of the SAM results).

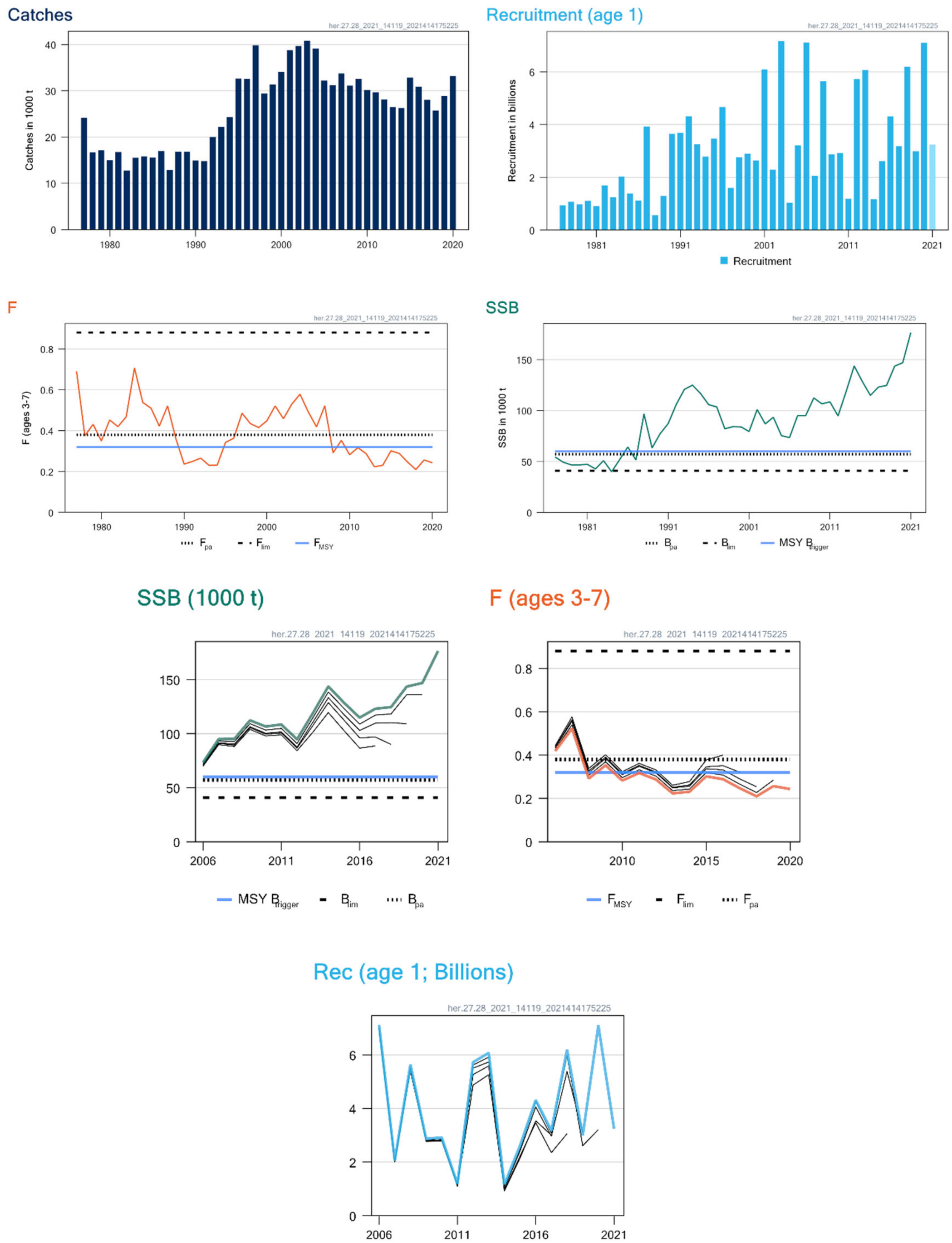


Figure 4.29. Gulf of Riga herring. Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment and SSB in 2021 is predicted). Historical assessment results.

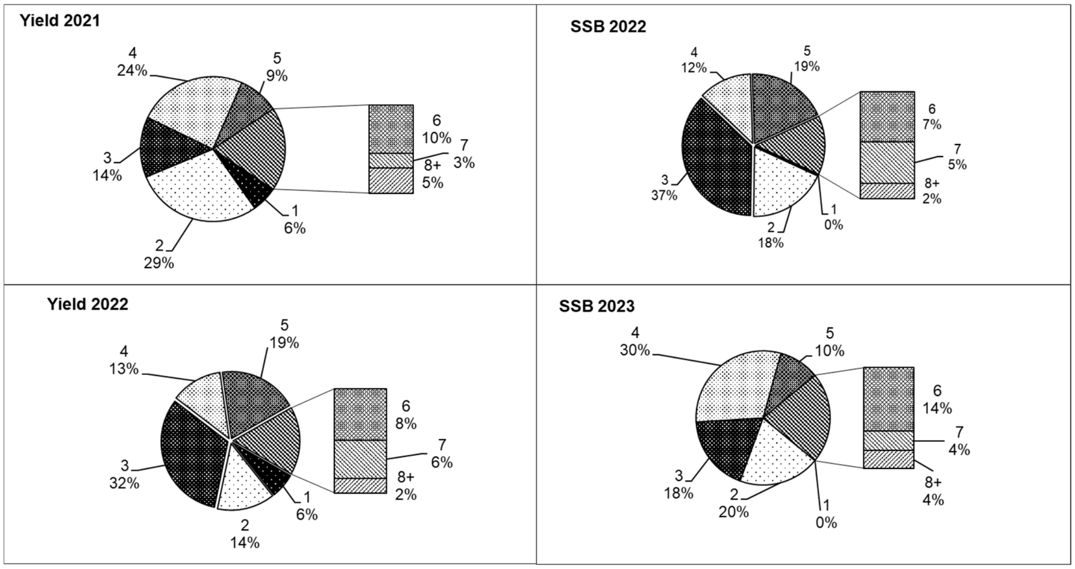


Figure 4.30. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

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 2020, 94.0% of the Finnish landings came from trawl fishery, 5.8% with trapnets, and 0.2% with gill-nets. In 2020, 95.7% of the Swedish catches came from trawls, 4.2% with gill-nets and 0.1% with other fishing gears.

4.4.1.1 Landings

The total catch in the Gulf of Bothnia decreased by 15 951 tonnes (18%) from 2019 to 72 956 tonnes in 2020 (Figure 4.31), of which 83% (60 545 tonnes) was Finnish catch and 17% (12 412 tonnes) was Swedish catch (Table 4.40). The Finnish catch decreased by 17% (12 725 tonnes) while the Swedish catch decreased by 21% (3252 tonnes) compared to 2019.

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 0.2% 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 previously made interviews of fishers indicated that they estimated the discard rate to be about 10% for the entire year.

Based on the Swedish official statistics and informal interviews 6–12% of Swedish herring catches taken from SD 30 have been discarded in the past years. This has constituted at most up to 1% of the total herring catches in SD 30 and discards are therefore regarded as negligible.

4.4.1.4 Effort and CPUE data

One commercial tuning series is used in the assessment, a trapnet CPUE time-series 1990–2006 from Bothnian Sea. In the trapnet fisheries the number of trapnets set is used as effort. Throughout the 1980s the number of set trap nets decreased drastically, in 1991 the amount of set nets had declined by 80% in comparison to 1980. Since then the amount remained more or less stable.

The trapnet-tuning fleet was renewed in 2013 according to recommendations from WKPELA 2012 (see also IBP her-30 report). It is consisting of gapless catch and effort times series, combined from three areas within the Finnish coast of Bothnian Sea (rectangles 23, 42 and 47) (Figure 4.32). Since 2015, however, the area 23 did not have a qualified trapnet fishery anymore, i.e. catch and effort were 0. The time-series was further shortened from originally 1990–2014 to 1990–2006, due to a declining effort trend).

Assessment input_ Trapnet-fleet 1990-2006, ages groups ?-?

4.4.2 Biological information

As the result of the recent benchmark (WKClub, ICES 2021), the stock was upgraded to category 1.

4.4.2.1 Catch in numbers

During the WKCluB meeting in 2021 the age- matrix was expanded from age 10+ to 15+. (Figure 4.32). 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 2020 Finnish and Swedish unsampled catches were mostly allocated in InterCatch according to the Finnish sampling and mostly from respective fisheries. Finnish and Swedish sampled catches are shown in There were no samples from Q 3 Finnish commercial fisheries in SD 30.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-group in catches (both in numbers and in terms of biomass) during 2020 catches was age-group 2, and the largest in terms of biomass age-group 6. The total catch in numbers is shown in Table 4.42.

4.4.2.2 Mean weight-atage

The average weight at age has decreased for all ages since about the end of 1990s (Table 4.43 and Figure 4.33), but stabilized in the the 2000s. During recent years weights-at-age have been quite stable for all age-groups, however, there is a slight increase in the oldest age groups.

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 since 1980 are shown in Table 4.44 and Figure 4.34. 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, 77 samples were taken during 2020, as well as 13 samples from the Swedish fisheries. In total, during 2020, 27 104 herring were length-measured and 2626 were aged (Table 4.41). There were no samples from third quarter catches in Finnish commercial fisheries in SD 30.

4.4.3 Fishery independent information

A joint Finnish - Swedish –hydroacoustic survey has been annually conducted in late September – early October in the Bothnian Sea. Vessels used during the periods: 2007-2010: Swedish RV Argos and continued in 2011-2012 with Danish RV Dana, during: 2013-2016 with Finnish RV Aranda, in late October 2017 with RV Dana and in 2018-2020 with RV Aranda. This survey is coordinated by ICES within the frame of Baltic International Acoustic Surveys (BIAS, ICES Code A1588). The survey covers most of the SD 30 area, excluding only the shallow areas mainly along the Finnish coast and SD 31, which has not been surveyed. The survey generally tracks all age groups well, with the exception of the ages 1 and 2 (Figure 4.35). The survey is providing yearly estimates of abundance. In the 2017 benchmark the age-group 1 was included in the survey-index because it was concluded that it had similar consistency within the age-matrix as the other age groups (ICES 2017).

In 2012 the survey was not performed according to standard coverage (60 nmi per 1000 nmi^2 = statistical rectangle), instead only half of it and with 50% less control trawl hauls (normally 2 per rectangle) due to the withdrawal of the Swedish half of the total funds to the survey. In 2015 a part of the Bothnian Sea was not covered due to breakdown of the research vessel, but the acoustic index was accepted by WGBIFS to be used in assessment (ICES 2016). In 2016-2020 the survey coverage was good. Acoustic surveys have shown to be essential for the assessment of this stock, and therefore they should be continued with the required effort-level.

The biological samples for ages from the surveys in 2013–2019 have been used for 3rd and/or 4th quarter ALK's for length distributions from commercial sampling and calculations for mean weights at age in the input data.

Assessment input: Acoustic-Index, 2007-2020. ages 1-15+

4.4.4 Assessment

4.4.4.1 SS3

After the benchmark (WKCluB) in 2021, the assessment for the Gulf of Bothnia herring (SD 3031) was upgraded from category 5 to category 1. In the benchmark a new model, Stock Synthesis (SS3 v. 3.30, Method & Wetzel, 2013), was evaluated and taken into use for the assessment of Gulf of Bothnia Herring SD 30-31 in order to minimize the retrospective pattern previously observed. A mistake in the survey input data in the 2019 assessment was detected and found to be the cause to the earlier high Mohn's rho values.

The model starts in 1963 and the initial population age structure was assumed to be in an exploited state, so that the initial catches was assumed to be the average of last three years (1963–1965) in the time-series. Fishing mortality was modelled using hybrid F method (Methot & Wetzel, 2013). Option 5 was selected for the F report basis; this option represents a recent addition to SS3 and corresponds to the fishing mortality requested by the ICES framework (i.e. simple unweighted average of the F of the age classes chosen to represent the F_{bar} (age 3–7)). Further details on model settings can be found in the benchmark report (ICES, 2019).

The spawning stock of Gulf of Bothnia herring diminished from early 1960s to a relatively low level in the beginning of the 1970s until the beginning of 1980s, from which it started to increase and peaked in 1994 (Figure 4.37, Table 4.49). From there it decreased again until early 2000s and levelled down until a small peak in 2010, after which the spawning stock has again showed a decreasing trend. SSB in 2020 is estimated to have increased from 2019. Recruitment has been on average higher since the higher biomass period starting from the late 1980s (Figure 4.37, Table 4.49). Fishing mortality has historically been at a low level (F <0.1) which started to increase in the early 2000s, peaked in 2016 (F_{2016} = 0.26), and is now decreasing again (Figure 4.37, Table 4.49).

The fit of the model is good with age compositions well reconstructed (figures 4.37-38). Pearson residuals are within the range [-2.2 2.2] without any particularly worrying patterns. Note that a positive residual pattern by cohort for acoustics, and a residual pattern with negative residuals in the historical part followed by positive residuals in recent years for older ages, changing from negative to positive around year 2000, was pointed out and discussed in the benchmark (ICES, 2021). These patterns are still seen in the latest analyses after adding the 2020 data (Figure 4.39). A non-random pattern of residuals may indicate that some heteroscedasticity is present, or there is some leftover serial correlation in sampling/observation error or model misspecification. We used the Runs test (RMSE and ordinary Runs test) to evaluate the residuals of surveys and age frequency distributions (e.g. SEDAR 40, 2015; Winker *et al.*, 2018), presented in Figure 4.40 A-B.

The ordinary Runs test was passed for both acoustic and trapnet surveys residuals and also for all age frequency distributions with the exception of the trapnet (Figure 4.40 A). The RMSE runs test indicated that the fit of the CPUE index was good because no residuals were larger than 1 and the root-mean square error (RMSE) was less than 30% (Figure 4.40 B), indicating a random pattern of the survey's residuals and the age frequency distributions.

A retrospective analysis was conducted for the last five years of the assessment time horizon, to evaluate whether there were any strong changes in model results (Figure 4.41). The estimated Hurtado-Ferro *et al.* (2014) Mohn's rho indices were inside the bounds of recommended values for SSB (-0.18) but outside the bounds for F (0.29), however for a three year retrospective analysis, the values for both SSB (-0.11) and F (0.14) were inside the recommended bounds. Forecast Mohn's rho values were -0.17 and 0.15 for SSB and F respectively, indicating good predictive power of the model.

4.4.4.2 Short-term forecast and management options

The short-term projections were performed following the same procedures as set out by the benchmark (ICES, 2021), with SS3 using MCMC or the delta-multivariate log-normal (delta-MVLN) estimator (Walter and Winker, 2019; Winker *et al.*, 2019) to provide stochastic forecasts. Recruitment in the forecast period is set to the average of the last ten years for which recruitment deviations are estimated in the SS3 model. For maturity and weight-at-age an average of the last three years is used. Constant selectivity was used. Probabilistic forecasts were used.

ICES received a special request from EU;

MSY advice for herring in the Gulf of Bothnia

Until the fishing year 2019 ICES provide category 1 MSY advice for herring in the Gulf of Bothnia. In 2019 ICES had to change its advice due to the insufficient quality of the assessment. The advice for the fishing year 2020 was category 3 precautionary advice, and category 5 precautionary advice for the fishing year 2021.

ICES is requested to do its utmost to provide again category 1 MSY advice for the fishing year 2022, and if possible, to modify its advice for the fishing year 2021 in view of a possible adjustment of the TAC level

In response to this special request, an updated assessment and forecast for 2021 was produced, using the latest available data (including the year 2020). The short-term forecasts performed here shows that with fishing mortality estimated in 2020 to F = 0.160 and at the F ranges in the multi-annual plan (F_{lower} = 0.206; F_{upper} = 0.272; F_{MSY} = 0.271) during 2021, the updated 2021 herring catches in the Gulf of Bothnia would be between 91 494 tonnes and 117 875 tonnes (tables 4.45-46). In sum-mary, the benchmark changed the perception of the stock with higher biomass levels and new reference points (see also annex 7 of the current report). The updated 2021 catches at MSY (117 485tonnes) represent an increase of 81% relative to the advice catches in 2020 (65 018 tonnes).

The assumed fishing mortality for 2021 was based on fishing at F_{MSY} (Table 4.4.8). The short-term forecasts show that with a fishing mortality at the F ranges in the multiannual plan (F_{lower} = 0.206; F_{upper} = 0.272: F_{MSY} = 0.271), herring catches in the Gulf of Bothnia in 2022 would be between 86 729tonnes and 111 714 tonnes (Table 4.48). The resulting catches at MSY in 2020 decrease by 5.2% relative to the catches at MSY in 2021.

4.4.4.3 Reference points

Reference points for the GoB herring stock were calculated in the 2021 WKCluB benchmark (ICES, 2021) with upper and lower ranges. However, they were updated at The advice Drafting Group ADGBS in 2021 (see annex 7 for more details).

4.4.4.4 Quality of the assessment

The tuning is based on acoustic surveys in the Bothnian Sea since 2007 and commercial trapnet data from the Bothnian Sea herring stock assessments from the years 1990–2006. Trapnet data from later years have not been included in the assessment, because the effort decreased a lot in later years, and they are considered to be too unreliable. Yet the trapnet tuning indices are statistically sound and they are anchoring the model to the past.

Due to an error, which was found in the time-series, the acoustic indices were examined thoroughly and recalculated with ICES StoX-program in 2020 and the assessment was benchmarked early 2021.

The acoustic survey time-series is still relatively short. Thus, it is expected that extending the acoustic survey time-series will improve the quality of the assessment.

4.4.4.5 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 4.40. Herring in GOB (SD's 30 and 31) Landings (tonnes)

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

Year	Finland	Sweden	Total
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
2020	60518	12412	72 956

Table 4.41. Herring in the Gulf of Bothnia. Catches and sampling in 2020 by country and SD.

Country	ICES SubDivision	Quarter	Catches	Number of samples	Number of fish measured	Number of fish aged
FINLAND	30	1	21 664	24	5 368	624
		2	26 749	23	6 860	319
		3	474			
		4	10 470	13	4 636	361
		Total	59 357	60	16 864	1 304
SWEDEN	30	1	6 734	1	650	
		2	4 028	5	2 136	196
		3	80	3	1 139	241
		4	1 240	2	1 516	
		Total	12 082	11	5 441	437
FINLAND	31	1				
		2	971	7	1 814	323
		3	194	7	1 040	128
		4	23	3	670	138
		Total	1 187	17	3 524	589
SWEDEN	31	1				
		2	41	1	396	149
		3	58	1	879	147
		4	230			
		Total	330	2	1 275	296
FINLAND and SWEDEN	30+31	1	28 398	25	6 018	624
		2	31 790	36	11 206	987
		3	805	11	3 058	516
		4	11 964	18	6 822	499
		Total	72 956	90	27 104	2 626

There were no samples from Q 3 Finnish commercial fisheries in SD 30.

Table 4.42. 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	459170	216637	134556	108043	44082	42040	24349	22425	25410	5233	39223
2020	460473	673491	444079	371701	238534	328573	130323	52863	51067	21263	30618	26237	9398	13312	14796

Table 4.43. Herring in SD's 30 and 31. Weight at age in the catches (g).

	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
2020	7	17	24	30	34	36	39	47	48	51	57	60	58	48	68

Table 4.44. **Herring in SD's 30 and 31. Maturity at age.**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1980	0,00	0,31	0,92	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1981	0,00	0,31	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1982	0,00	0,29	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1983	0,00	0,21	0,92	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1984	0,00	0,23	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1985	0,00	0,20	0,92	0,99	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1986	0,00	0,28	0,91	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1987	0,00	0,32	0,89	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1988	0,00	0,10	0,85	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1989	0,00	0,23	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1990	0,00	0,59	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1991	0,00	0,59	0,94	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1992	0,00	0,50	0,90	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1993	0,00	0,44	0,82	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1994	0,00	0,63	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1995	0,00	0,35	0,91	0,95	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1996	0,00	0,66	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1997	0,00	0,32	0,84	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1998	0,03	0,33	0,72	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1999	0,01	0,38	0,88	0,99	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2000	0,11	0,65	0,93	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2001	0,01	0,61	0,97	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2002	0,03	0,58	0,96	0,97	0,99	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2003	0,00	0,56	0,94	0,97	0,96	1,00	1,00	0,89	0,89	1,00	1,00	1,00	1,00	1,00	1,00
2004	0,02	0,34	0,91	0,97	1,00	1,00	1,00	1,00	1,00	0,96	1,00	1,00	1,00	1,00	1,00
2005	0,02	0,28	0,86	0,96	0,94	0,97	1,00	1,00	1,00	0,96	1,00	1,00	1,00	1,00	1,00
2006	0,02	0,37	0,92	0,91	1,00	0,94	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2007	0,02	0,56	0,87	1,00	0,96	1,00	1,00	0,90	1,00	0,97	1,00	1,00	1,00	1,00	1,00
2008	0,00	0,50	0,91	1,00	0,93	1,00	1,00	1,00	1,00	0,94	1,00	1,00	1,00	1,00	1,00
2009	0,00	0,51	0,91	0,95	0,95	0,91	0,97	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2010	0,05	0,87	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2011	0,01	0,46	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,97	1,00	1,00	1,00	1,00	1,00
2012	0,01	0,75	0,97	0,98	1,00	1,00	0,94	1,00	1,00	0,99	1,00	1,00	1,00	1,00	1,00
2013	0,11	0,78	0,98	1,00	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2014	0,16	0,71	1,00	1,00	1,00	1,00	0,94	0,95	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2015	0,13	0,80	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2016	0,05	0,72	0,90	1,00	1,00	1,00	1,00	1,00	1,00	0,92	1,00	1,00	1,00	1,00	1,00
2017	0,11	0,76	0,98	0,99	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2018	0,16	0,88	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2019	0,08	0,83	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,94
2020	0,06	0,89	0,93	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Table 4.45. Herring in subdivisions 30 and 31. The basis made for the interim year 2020 and in the forecast for 2021.

Variable	Value	Notes
$F_{age\ 3\text{-}7}$ (2020)	0.160	Assessment estimate
SSB (2021)	663 182	Assessment estimate; Tonnes.
$R_{age\ 0}$ (2021)	29 689 960	Average of recruitment (2011-2020); Thousands

Table 4.46. Herring in subdivisions 30 and 31. Annual catch scenarios for the updated 2021 advice. All weights are in tonnes.

Basis	Total catch (2021)	F (2021)	SSB (2022) *	% SSB change **	% Advice change ***
EU MAP^^ : F_{MSY}	117485	0.271	598969	-7.5	81
EU MAP^^ : F_{lower}	91494	0.206	630452	-3.5	41
EU MAP^^ : F_{upper}	117875	0.272	603719	-7.0	81

*** Based on stochastic calculations.**

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

***** Advice value in 2021 relative to advice value in 2020 (65 018 tonnes).**

^^ MAP multiannual plan (EU, 2016).

Table 4.47. Herring in subdivisions 30 and 31. Assumptions made for the interim year 2021 and in the forecast for 2022.

Variable	Value	Notes
$F_{ages\ 3\text{–}7}$ (2021)	0.271	$F_{2021}= F_{MSY}$
SSB (2021)	663 182	Assessment estimates; Tonnes.
$R_{age\ 0}$ (2021-2023)	29 689 960	Average of recruitment (2011-2020); Thousands.
Total catch (2021)	117 485	Based on updated F_{MSY} advice for 2021; Tonnes.

Table 4.48. Herring in subdivisions 30 and 31. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	F (2022)	SSB (2022)*	SSB (2023)	% SSB change **	% Advice change ***
ICES advice basis						
EU MAP[#] : F_{MSY}	111345	0.271	598969	579522	-3.2	-5.2^
EU MAP[#]: F_{lower}	86729	0.206	599117	608030	1.5	-5.2^^
EU MAP[#]: F_{upper}	111714	0.272	600221	581962	-3.0	-5.2^^^
Other scenarios						
F_{MSY}	111345	0.271	598969	579522	-3.2	-5.2
F = 0	0	0	605437	688221	14	-100
F = F_{pa}	111714	0.272	600221	581962	-3.0	-4.9
F = F_{lim}	187695	0.496	600820	505496	-16	60
SSB (2023) = B_{lim}	331309	1.06	601324	368407[##]	-39	182
SSB (2023) = B_{pa}	171191	0.44	602045	523586[##]	-13	46
SSB (2023) = MSY $B_{trigger}$	171191	0.44	602045	523586[##]	-13	46
SSB (2023) = SSB (2022)	90018	0.21	599960	601967[##]	0.33	-23
F = F_{2021}	111345	0.27	598969	579522	-3.2	-5.2

*** Based on stochastic calculations.**

**** SSB 2023 relative to SSB 2022.**

***** Advice value in 2022 relative to advice value for EU MAP: F_{MSY} 2021 (117 485 tonnes, updated in May 2021).**

^^ Advice value for 2022 relative to advice value for EU MAP: F_{lower} 2021 (91 494 tonnes, updated in May 2021).

^^^ Advice value for 2022 relative to advice value for EU MAP: F_{upper} 2021 (117 875 tonnes, updated in May 2021).

[#] MAP multiannual plan (EU, 2016).

[##] Based on stochastic forecasts, using the F with 3 decimals getting the closest to the biomass target. SSB (2023) = B_{lim}: -2.2%; SSB (2023) = B_{pa} = MSY $B_{trigger}$: -1.9%; SSB(2023) = SSB(2022): 0.33%.

Table 4.49 Herring in subdivisions 30 and 31. Assessment summary. Weights are in tonnes. Recruitment in thousands.

Year	Recruit-ment Age 0	High	Low	SSB*	High	Low	Total Catch	F Ages	High	Low
19633	20042700	42909495	9361793	1120390	1278714	962066	29739	0.028	0.032	0.024
1964	18345200	38611686	8716179	1118500	1275924	961076	25204	0.024	0.028	0.021
1965	16755300	34686095	8093736	1094410	1249470	939350	27541	0.028	0.032	0.024
1966	15211300	30993690	7465508	1008850	1170713	846987	22164	0.024	0.028	0.020
1967	13569300	27173263	6775995	925738	1089548	761928	27772	0.032	0.038	0.027
1968	12502200	24413368	6402435	839426	1000324	678528	28966	0.037	0.044	0.031
1969	11893200	22446431	6301590	745927	898132	593722	35996	0.053	0.063	0.042
1970	17882800	30125008	10615583	686162	838067	534257	32790	0.052	0.063	0.041
1971	13382600	22614428	7919457	526683	644273	409093	36347	0.076	0.092	0.059
1972	17808000	27527364	11520350	562187	695470	428904	34092	0.065	0.080	0.050
1973	23848400	34275363	16593440	604242	755187	453297	26507	0.047	0.058	0.035
1974	19106300	27376785	13334316	518804	646041	391567	26776	0.053	0.066	0.040
1975	40777900	53533221	31061780	551700	684392	419008	21811	0.041	0.050	0.031
1976	14930800	20599883	10821847	560580	694895	426265	30520	0.056	0.070	0.042
1977	9577780	13388299	6851794	604148	747400	460896	33634	0.056	0.070	0.042
1978	9400640	12869628	6866712	684082	847662	520502	34873	0.057	0.072	0.043
1979	24405900	31191892	19096243	626874	781396	472352	26109	0.046	0.058	0.034
1980	13724500	18129907	10389568	549730	687815	411645	29809	0.057	0.072	0.043
1981	20733600	26676418	16114688	561098	703401	418795	21526	0.039	0.049	0.029
1982	33777200	42349558	26940051	579980	723969	435991	26499	0.049	0.061	0.037
1983	44027800	54398285	35634343	633687	791129	476245	26208	0.042	0.052	0.031
1984	36592000	45324750	29541795	694068	859397	528739	34545	0.048	0.060	0.036
1985	15387700	19996532	11841119	761597	934862	588332	35432	0.046	0.057	0.035
1986	30432600	37689574	24572927	854736	1039583	669889	35579	0.045	0.055	0.034
1987	14645200	19138802	11206652	946747	1148513	744981	32628	0.038	0.046	0.029
1988	62998900	75576437	52514535	919398	1116283	722513	36418	0.040	0.048	0.031
1989	57505900	69286126	47728581	1049680	1265015	834345	33086	0.033	0.040	0.026
1990	32177500	39707485	26075474	1180220	1404381	956059	39180	0.037	0.044	0.030
1991	37347400	45664647	30545036	1314930	1550399	1079461	33419	0.029	0.035	0.024
1992	39778500	48155901	32858466	1277320	1502761	1051879	46610	0.041	0.049	0.033
1993	25092500	31288489	20123489	1229060	1446279	1011841	49314	0.043	0.051	0.035
1994	32287800	39463599	26416800	1354170	1586972	1121368	61986	0.053	0.063	0.044
1995	25833100	32054468	20819221	1197740	1410096	985384	65547	0.060	0.071	0.049
1996	22709800	28491945	18101081	1179880	1386984	972776	61303	0.060	0.071	0.049
1997	41708700	50346200	34553068	988876	1167915	809837	69808	0.076	0.090	0.062
1998	24160500	30725424	18998265	945061	1123644	766478	62474	0.070	0.083	0.057
1999	36018700	44304241	29282677	921555	1094880	748230	66502	0.078	0.093	0.063

Year	Recruit-ment Age 0	High	Low	SSB*	High	Low	Total Catch	F Ages	High	Low
2000	29106600	36505376	23207381	855817	1010414	701220	58852	0.081	0.096	0.065
2001	44024300	53614113	36149791	838760	988278	689242	57806	0.080	0.095	0.065
2002	88089100	102861248	75438415	847048	997804	696292	53969	0.073	0.086	0.059
2003	20017400	26224694	15279351	858220	1006125	710315	53644	0.067	0.080	0.055
2004	21364200	27718237	16466741	899777	1047330	752224	61423	0.071	0.084	0.059
2005	29210000	36297711	23506278	911411	1052754	770068	62911	0.077	0.090	0.064
2006	40683600	48874780	33865223	815494	942211	688777	71318	0.096	0.112	0.080
2007	29437900	36237534	23914154	795393	917962	672824	78678	0.110	0.128	0.092
2008	39391500	47339103	32778194	756804	872813	640795	67914	0.100	0.116	0.084
2009	32614800	39774559	26743858	750026	861865	638187	71248	0.104	0.121	0.088
2010	22225700	28200776	17516601	898799	1024222	773376	72590	0.104	0.120	0.088
2011	30526100	37463127	24873599	798376	911837	684915	81850	0.120	0.139	0.102
2012	22906900	28837307	18196084	807161	922799	691523	106007	0.162	0.187	0.136
2013	26605500	33319166	21244608	804867	920138	689596	114396	0.185	0.22	0.155
2014	46862800	57212139	38385595	743725	860050	627400	115366	0.20	0.24	0.165
2015	24770400	32142657	19089048	703018	818601	587435	114942	0.22	0.26	0.175
2016	32958300	43166963	25163909	664108	783619	544597	130029	0.26	0.31	0.20
2017	21415300	29998801	15287780	648924	782246	515602	104358	0.22	0.27	0.164
2018	28864300	41964475	19853645	667541	821012	514070	97366	0.21	0.26	0.152
2019	38197600	61125444	23869874	595463	752692	438234	88907	0.197	0.26	0.139
2020	23792400	60100201	9418909	602967	783942	421992	72956	0.160	0.21	0.108
2021	29689960**			663182	883600	442764				

*** 1 January.**

**** Average of years 2011-2020.**

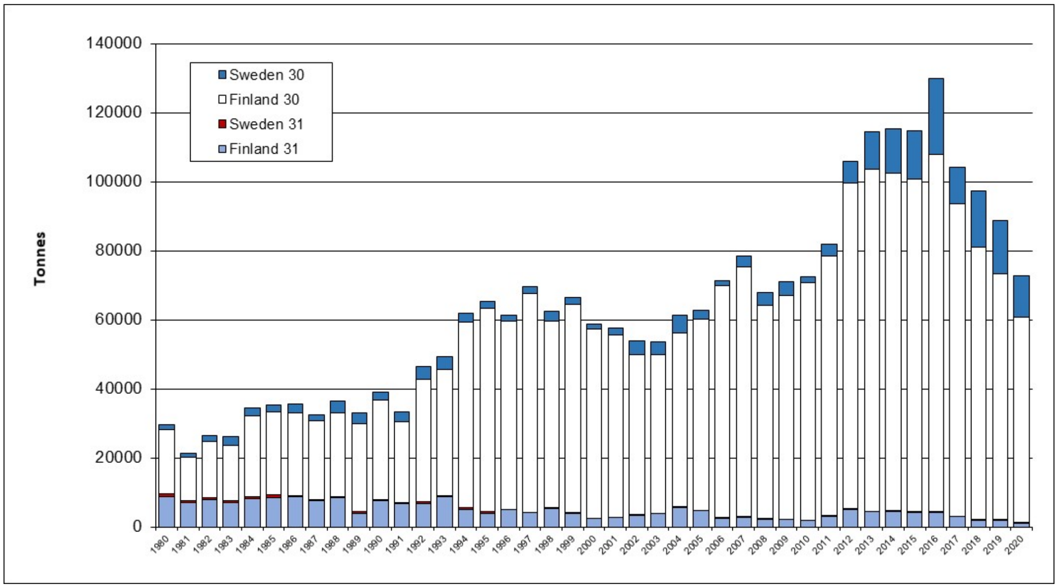


Figure 4.31.Herring in SD's 30 and 31. Catches (tonnes) by country

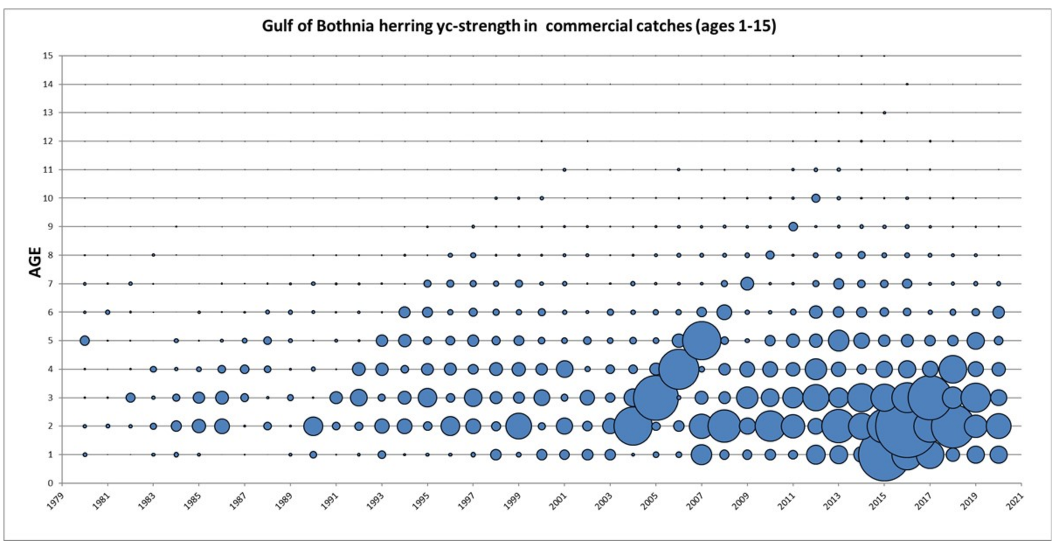


Figure 4.32. Herring in SD's 30 and 31. Age composition in commercial catch.

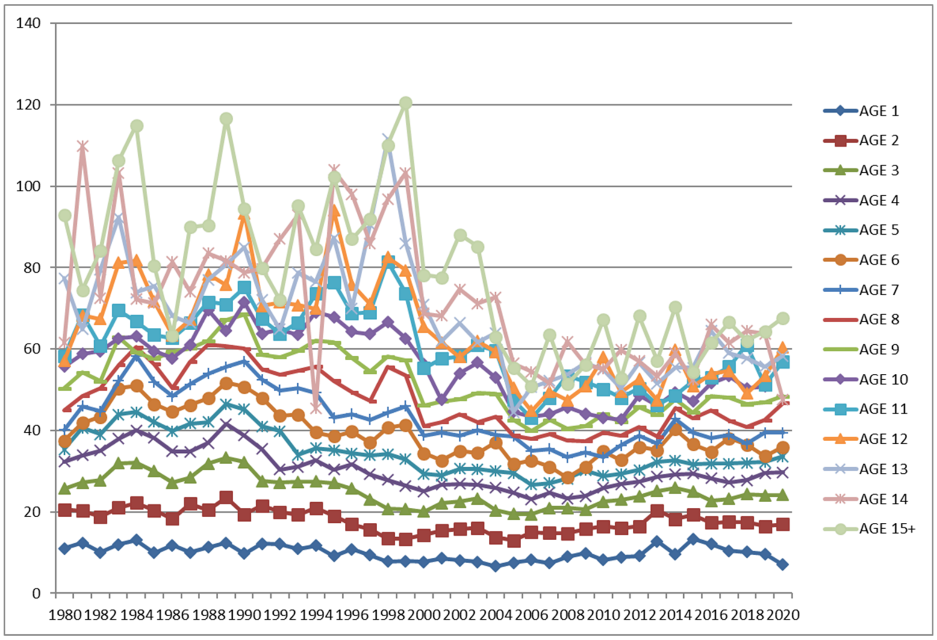


Figure 4.33. Herring in SD's 30 and 31. Weights at age (g) in catches.

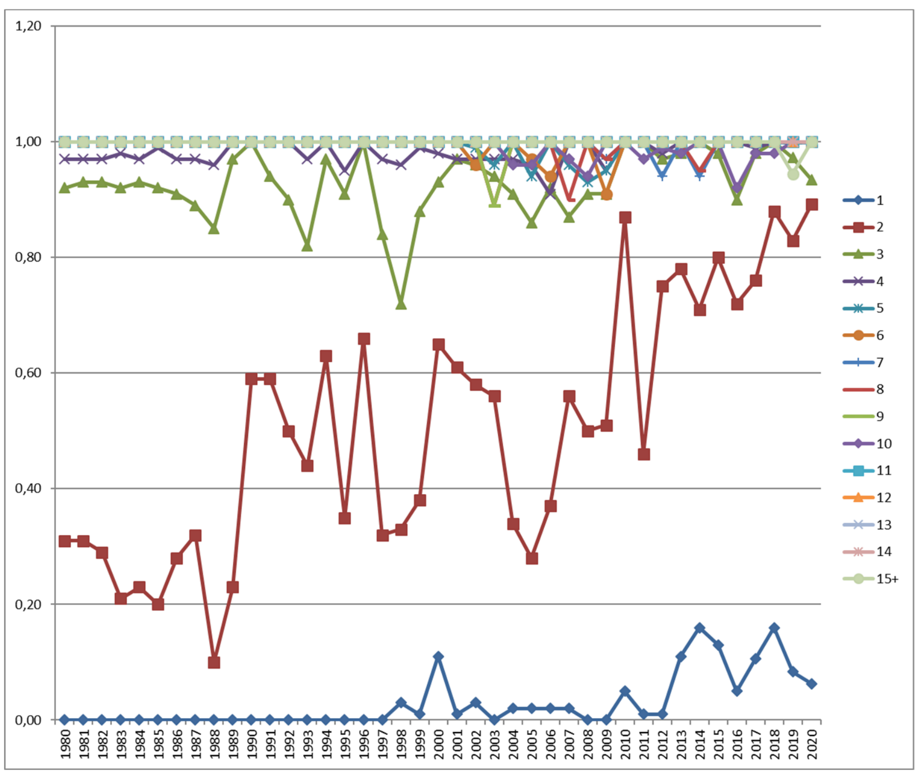


Figure 4.34. Herring in SD’s 30 and 31. Maturity ogives 1980-2020.

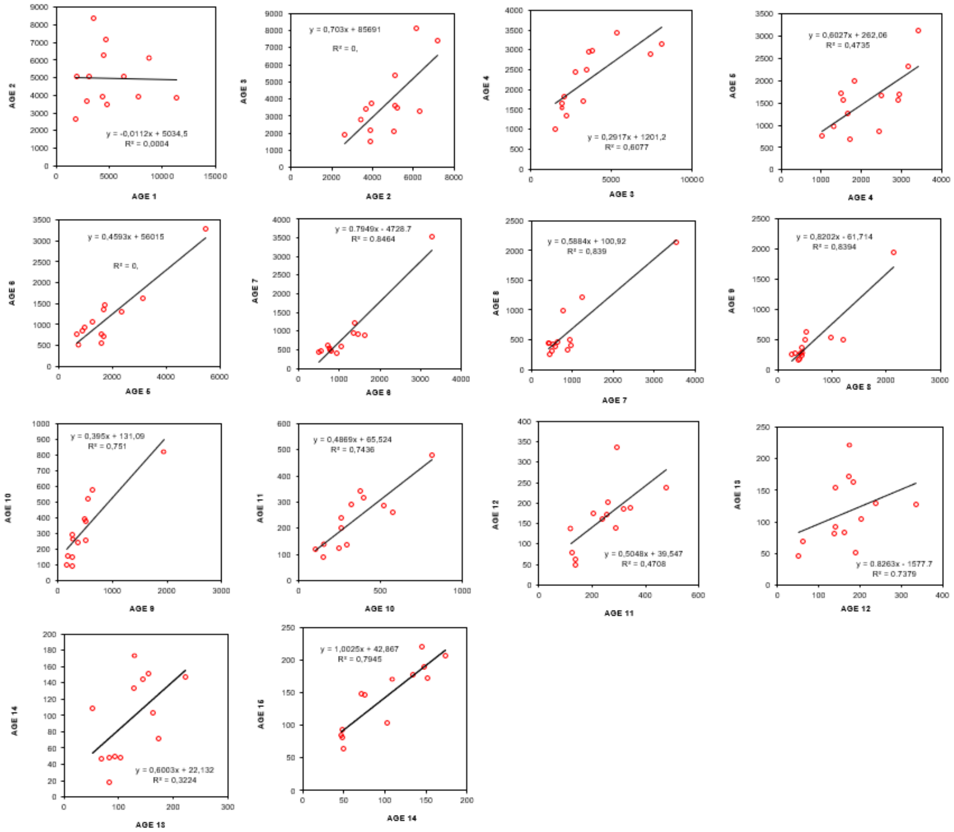


Figure 4.35. Herring in SD's 30 and 31. Internal Consistency in age estimates from acoustic fleet.

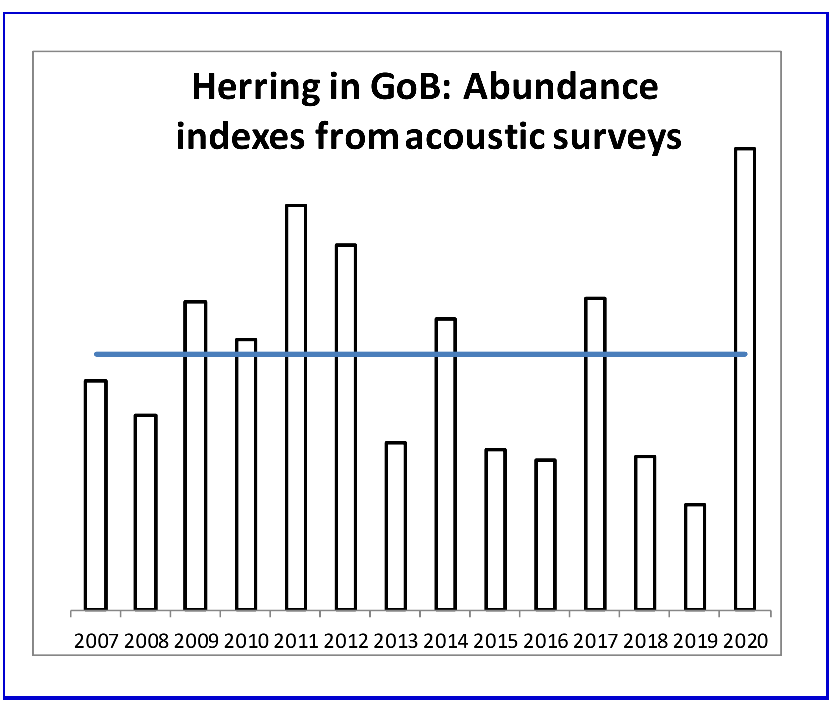


Figure 4.36. Herring in SD's 30 and 31. Abundance indexes from 2007-2020 Bothnian Sea acoustic surveys (blue line is the average of the time-series)

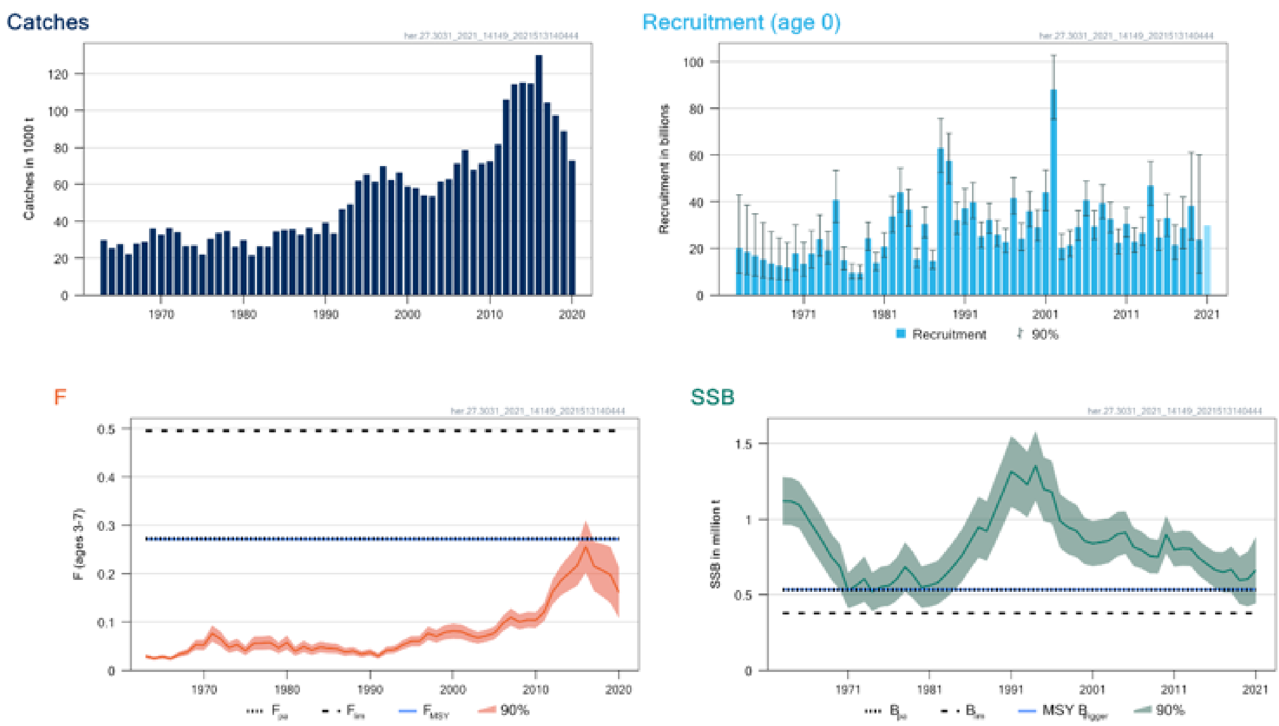


Figure 4.37. Herring in SD's 30 and 31. Stock summary. Estimated spawning-stock biomass (SSB), recruitment (R) and fishing pressure (F) for herring in subdivisions 30 and 31. R, F, and SSB show confidence intervals (90%) in the plot. The assumed recruitment for 2021 is shaded in a lighter colour.

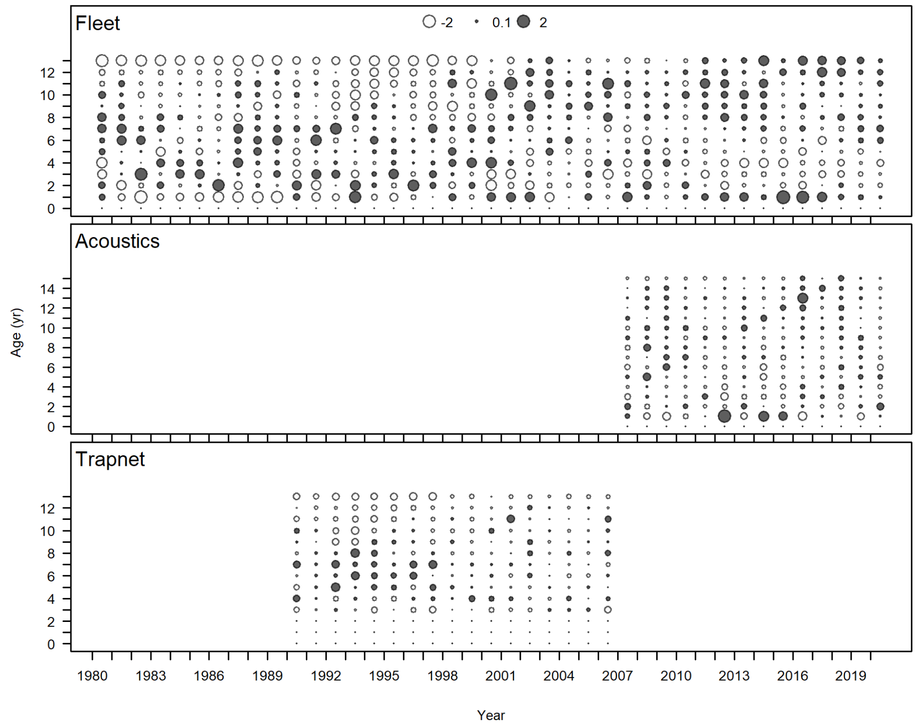


Figure 4.38. Herring in SD's 30 and 31. Pearson residuals for commercial (upper), acoustic (middle) and trapnet (lower) data, in 1980-2021. Residuals are within the range [-2.2 2.2]. Filled and open bubbles denote positive and negative residuals respectively.

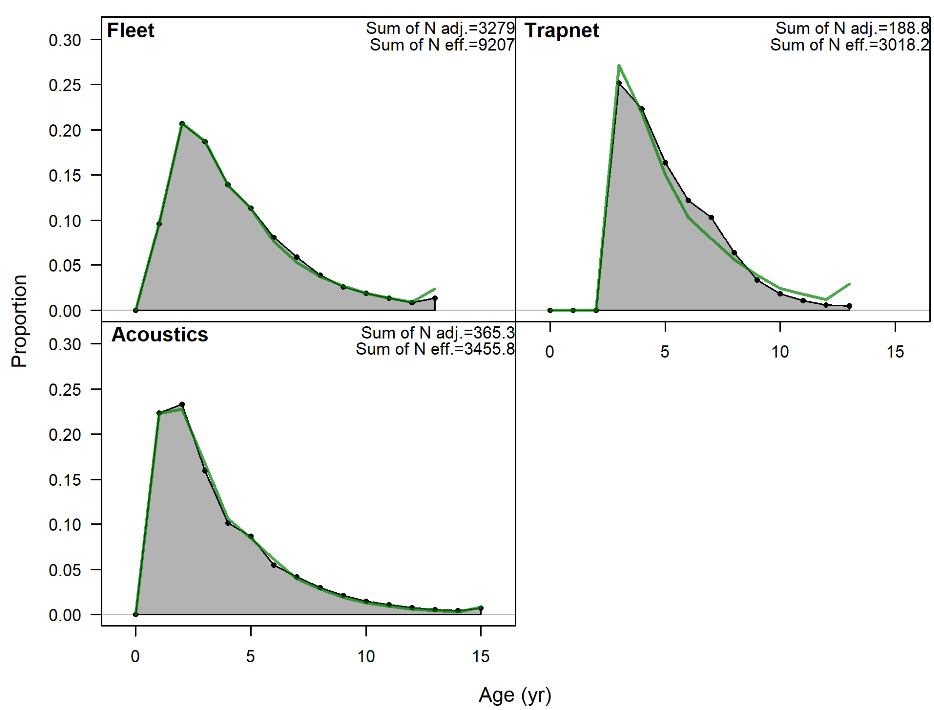
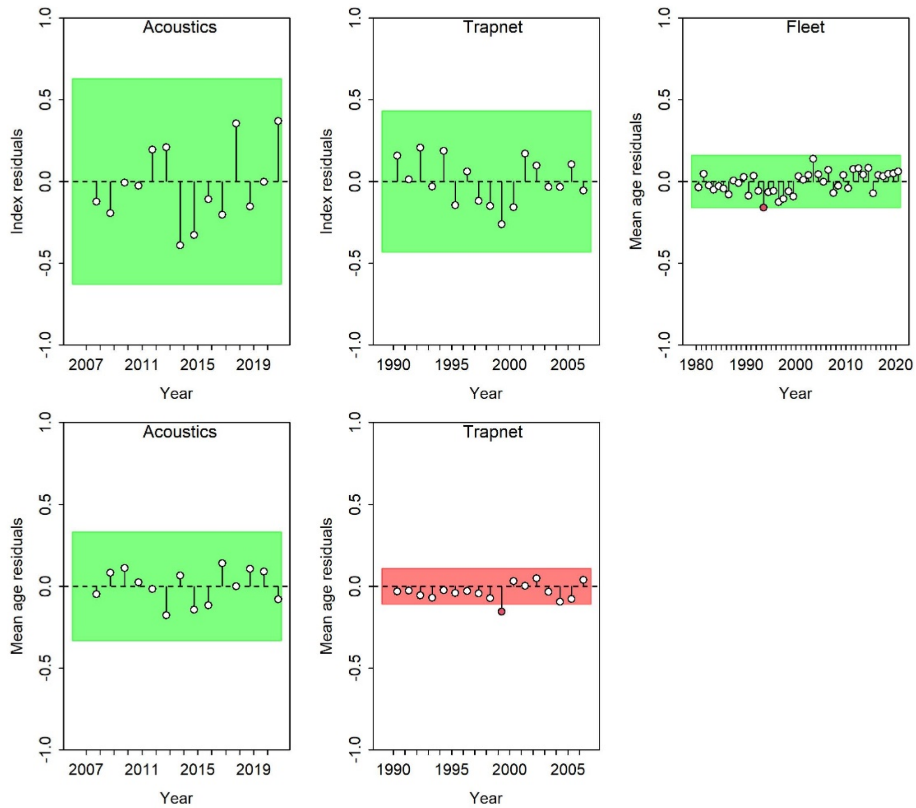


Figure 4.39. Herring in SD's 30 and 31. Age-composition fit of model (green line) with commercial (upper left), acoustic (upper right) and trapnet (lower) data, aggregated across time.

A



B

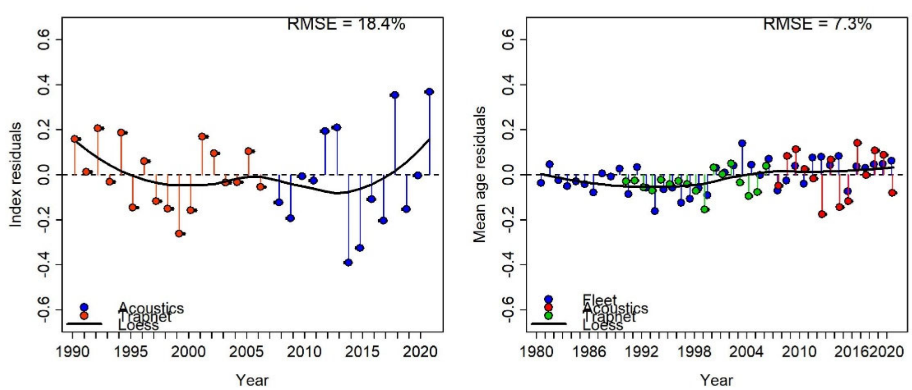


Figure 4.41. Herring in SD's 30 and 31. Residuals from Runs test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (A) and from the JABBA runs test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (B).

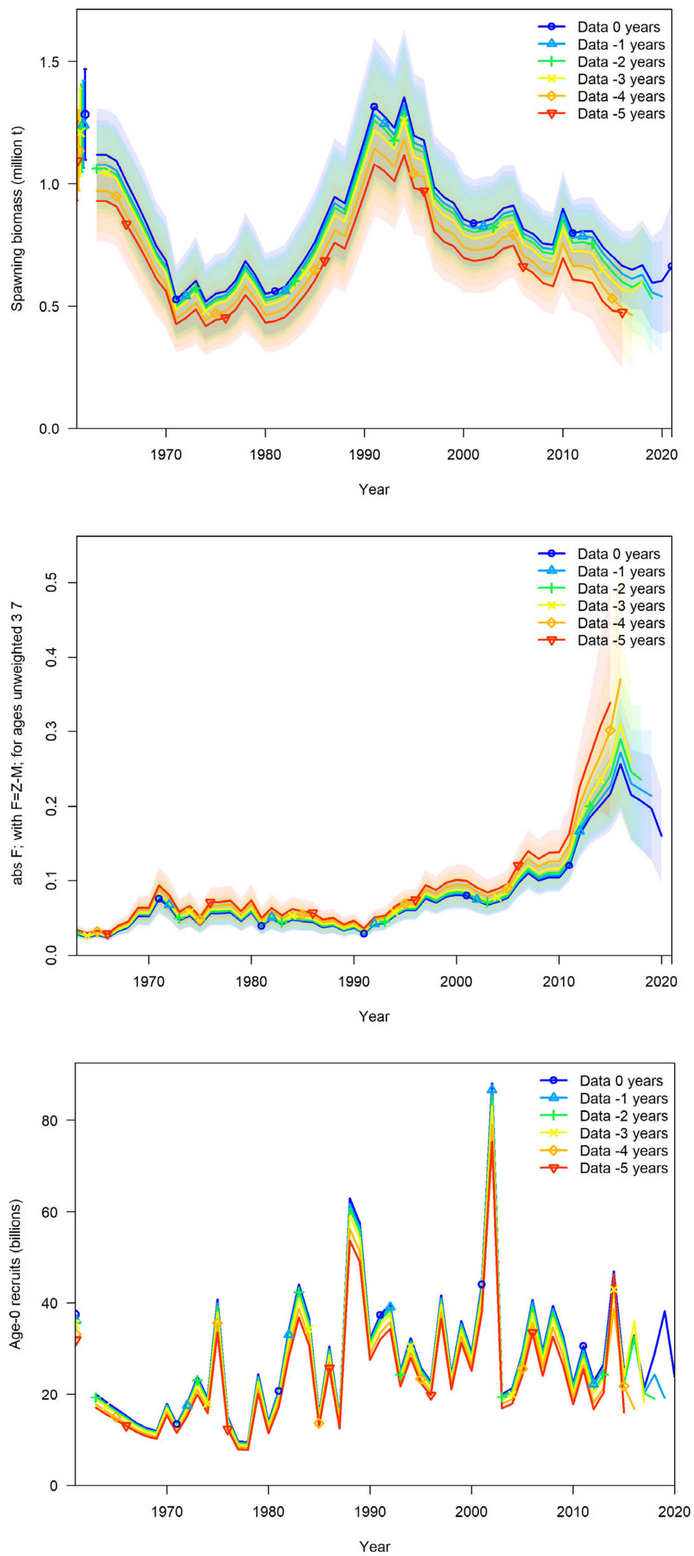


Figure 4.42. Herring in SD's 30 and 31. Retrospective analyses for spawning-stock biomass (upper), fishing pressure (middle) and recruitment (lower), showing 5 years peels with 95% confidence bands for SSB and F.

5 Plaice

5.1 Introduction

5.1.1 Biology

5.1.1.1 Assessment units for plaice stocks

The plaice stocks within inner Danish waters and the Baltic consists of two stocks. One stock (ple.27.21–23) is defined by the Subdivision 21 (= Kattegat), Subdivision 23 (= the Sound) and Subdivision 22 (= Belt area and western part of the Baltic Sea). The other stock (ple.27.24–32) is defined by the area south of Subdivision 22 and eastward into the remainder of 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 and subsequently selected as the method 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 January to 30 April, which was introduced in the mid-1960s has been abandoned since 2017.

In the Sound (SD 23) trawling is only allowed in the northern-most part. Additionally, this area was also included in the closed areas to protect spawning cod in Kattegat, so trawling is forbidden in February and March were the cod is on spawning migration.

In SD 22 the BACOMA exit window is implemented. This is a square mesh window inserted in the top panel of the 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 was very much connected to the cod fishery and as part of the Danish cod recovery plan introduced in 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with 180 mm panel during the first three quarters of a year. In 2009, as part of the attempts to rebuild of the cod stock in Kattegat, Denmark, and Sweden, introduced protected areas on historically important spawning grounds in South East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year. As the cod fishery in the Kattegat has collapsed, the majority of plaice caught in active gears in SD21 now come as bycatch from the *Nephrops* fishery.

From 1 January 2017 the EU landing obligation was introduced in SD 22 and 23. In the Kattegat, the landing obligation applies as part of the discards plan for the North Sea. In 2018, (Commission Delegated Regulation (EU) 2018/45 of 20 October 2017), plaice was subjected to the landing obligation in TR1 (trawls and seines ≥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 management since 2017, but because of the insignificant amount of the landings below minimum size (BMS) so far (14 t in 2021), 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 5.1 and figures 5.1 and 5.2. The landings by country and for each subdivision is given in Figure 5.3.

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 dataseries but cannot handle long periods of missing data. As discard information are only available back to 2002, the discard time-series is extended three years back to 1999 (based on average discards from 2002–2004) in order to provide a time-series sufficiently long for the assessment. The discard estimates are processed in InterCatch and consistent throughout the whole time-series (2002–2019). The practice of utilizing the artificially extended time-series should be reviewed at the next benchmark.

Discard and landings (2021) by gear type and quarter is given in Table 5.2. Discards by gear type and area are given in Figure 5.4a.

After raising, the discard ratio across the whole stock was 24% in 2020; up slightly from 20% in 2019, but remaining lower than 2018 and lower than the median of the time-series (36%) (Figure 5.4b).

In 2020, the discards ratio was estimated as 67% in Kattegat (SD 21), 13% in SD 22 and 26% in SD 23 (Figure 5.4c).

5.2.1.5 Effort and CPUE data

Effort data from Sweden and Denmark only are available in InterCatch back to 2013. Data from Germany are available from 2002 and on although the units are not consistent throughout the series.

5.2.2 Biological information

5.2.2.1 Age composition

Since 2004, Denmark and Sweden have put a significant amount of effort into increasing the quality of age reading for plaice in Kattegat through a series of workshops and otolith exchanges between age readers. During the WGBFAS in 2015 it was demonstrated that significant inconsistencies occur between readers particularly from Denmark, and circulation of otoliths between the three countries were initiated. The results of the exercise were available in March 2016. The results show varying levels of accuracy and precision depending on reader expertise, method applied and sample origin, but there were no consistent patterns where one method always produced better results compared to the other. Results of Swedish inter-calibration studies in 2017 and 2018 showed that most uncertainty (differences between readers) appear for ages 4-5. 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 the period following this report, Denmark participated in a North Sea / Skagerrak plaice otolith exchange programme which has increased uniformity for age-reading methodology for this stock. A similar exercise would be beneficial for ple.27.21-23 and ple27.24-32.

Catch-at-age data were raised using ICES InterCatch database. Age-distribution information was available for most strata (Table 5.3), summing up to 96% of the total landings, and 79% of the discards.

The proportion of landed fish by age are presented in Table 5.4a and the relative age distributions in the landing and discard by year are presented in figures 5.5a and 5.5b, respectively.

Total catch numbers are presented in Table 5.4h. The proportion of older fish age 5 and above has decreased in recent years as strong year classes are coming up from 2017, 2018, and 2020.

5.2.2.2 Mean weight-at-age

Weight-at-age in catch is presented in Table 5.4c (landings), Table 5.4e (discards) and Table 5.4g (catch). Mean weight-at-age in catch over the entire time-series and for 2020 is presented in Figure 5.6.

Mean weight in stock is obtained from Combined 1 quarter surveys but is used as an average from 1999–2020. The procedure for calculating this average was updated in 2019 (the same procedure as used for Western Baltic cod) (Table 5. 4f and Figure 5.7).

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 5.4d).

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 2002–2020 from information from the Combined 1q survey Table 5.4b.

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 very few by Sweden (Table 5.3). The low sampling for area 23 should be considered in the context of the relatively limited catches from that area (3.1% of total catch in 2020).

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 5.8).

5.2.3 Fishery independent information

Only scientific tuning fleets are used. Two tuning series are produced (Table 5.4i). 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 catches for all age groups were 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. From 2020 onwards, the Q3/4 indices for plaice have been calculated without the 2019 data and this year's indices are considered missing in the assessment (i.e. set to "-9"). A project has been initiated in Denmark (HypCatch) to investigate the possibility of using hydrographic data to reduce the variability in survey tuning indices and was presented at the WGBFAS group in 2020.

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 5.9), and its consistency with other ages is rather good (Figure 5.10, 5.11, and 5.12).

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 2021 followed this method and only survey data until 2020 have been included in this assessment. At the conclusion of the WGBFAS meeting in 2020, Denmark have 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 and 2021 assessments.

The SPALY assessment had minor deviations from last year (Figure 5.13), and performed reasonably well. This is observed in retrospective patterns, with a Mohn's rho estimate of 9% for the SSB and -2% for F (Figure 5.14).

Investigation of the residuals revealed large positive residuals in the combined Q3 IBTS and Q4BITS survey indices across older age classes in 2020 (Figure 5.15). These residuals were investigated and it was discovered that while the 2019 Q3/4 indices were not utilized in the assessment model, they were still used to compute the remainder of the survey indices for Q3/4 over the time-series. Indices were then re-calculated without the 2019 Q3/Q4 data and the assessment was run again. Due to the construction of the model producing the indices, this change had very little effect on the assessment outcome (compared in Figure 5.16) and an indistinguishable improvement in the model fit (figures 5.17 and 5.18). This change made this year's assessment consistent with last year's decision to consider this survey non-representative.

This SPALY run in SAM is named: ple.27.21-23_WGBFAS_2021_SPALY_V1. The assessment is available at "stockassessment.org" and is visible for everybody.

This year's final assessment run in SAM (with full exclusion of 2019's Q3/4 survey data) is named: ple.27.21-23_WGBFAS_2021_Annex_v2. The assessment is marked as "final" at "stockasssessment.org" and is visible for everybody.

The input data for the final run ("…Annex_v2") are given in Tables 5.4a to 5.4i, and the summary of the results is given Table 5.5. Estimated fishing mortality is given on Table 5.6 and stock numbers at age in Table 5.7.

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 revised estimates for 2019 remain very low at ~24.5 million, but are followed by the absolute highest age 1 recruitment for this stock in 2020 (~147 million). While not utilized in the assessment, this large pulse appears to be true with the same cohort tracking in the 2021 Q1 survey (Figure 5.11) as well as in the neighbouring ple.27.24-32 stock.

5.2.4.2 Historical stock trends

The stock is in good condition, and remains above MSY $B_{trigger}$ since 2014. The result shows that an increases in biomass that began ~2010, have continued from a lowest observed SSB at 3.6 kt in 2009, to the highest observed SSB at ~15000 tonnes in 2020. This population growth is boosted by sporadically large recruitment pulses which seem to be increasing in frequency with SSB.

As a large portion of the fishery for this stock is either as bycatch (in *Nephrops* or cod fisheries) or as part of a mixed demersal fishery, the increase in SSB has led to a decrease in F, albeit coupled to increased landings and decreased discard rates.

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 2020 as the base year and project until 2023. Intermediate year (2021) assumption is status quo F (0.292 in 2021, = F_{2020}). Recruitment for 2021 and 2022 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 (2018-2020).

As described above, this stock is doing well with two-three good recruitment years over the past five. The large recruitment pulse observed in 2020 is expected to begin to enter the fishery in 2022 and contributes to the increase in advice. Furthermore, advice for this stock changed from a decrease (2020 advice) which was due to a change in the basis of the advice (precautionary to MSY approach) to an increase this year (2021 advice) as the stock continues to develop.

5.2.6 Reference points

Reference points were reviewed, together with assessment changes, in 2019. The 2021 assessment uses these same reference point values which are available in Table 5.8. One exception is the value of F_{pa}, which was changed to equal $F_{p=0.05}$ in 2020 (upon request from ACOM). In 2020, this was set to the $F_{p=0.05}$ estimated without the advice rule of $B_{trigger}$ (0.68) and this was corrected in 2021 to match the value of $F_{p=0.05}$ estimated with the advice rule (0.809). As the basis for the advice for this stock over this period was the MSY approach and the SSB and F were far from either value of F_{pa}, this oversight had no effect on the advice provided in 2020.

5.2.7 Quality of assessment

The quality of the assessment has improved in 2021, probably due to having access to Q3/4 survey indices from the last data year, which were removed in the 2020 assessment.

The 2021 assessment, with the anomalous survey indices removed, matches 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 is now just below F_{MSY}. The retrospective analyses of this assessment are acceptable.

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 20120. This procedure was adopted in 2016 and used since then.

The catch ratio between SD 21 and SDs 22–23 in 2020 was used to calculate a split of the advised catches for 2022, and a similar calculation was done for the landings only. The advised catch for the stock in SDs 24–32 (Section 5.3) was added to the calculated catch for SDs 22–23 to obtain plaice catches by management area that would be consistent with the ICES advice for the two stocks. This results in catches of no more than 1695 tonnes in SD 21 and 11 082 tonnes in SDs 22–32 (Table 5.9).

5.2.9 Evaluation of Potential Survey Duplication in the Kattegat

As an outcome of STECF EWG 19-05: 'Evaluation of mandatory surveys under the DCF' (13-17 May 2019, Brussels) potential duplicate surveys that require further evaluation were identified. The surveys IBTS_Q1; IBTS_Q3; BITS_Q1; BITS_Q4 were flagged as needing further expert review to determine if any of them are duplicates. All four of these surveys are used for the assessment of plaice in Kattegat, Belt Seas, and the Sound (ple.27.21-23).

For the stock ple.27.21-23, we determine that there is no duplication.

Spatially, this stock spans two survey areas, where the combination of IBTS and BITS surveys provide coverage of different areas with different fishing and stock trends.

Temporally, the Q1 surveys (both) provide biological data (Stock-weight at age and maturity) utilized in the assessment, while the combined Q3+4 surveys provide important information on stock development immediately preceding assessment as well as indications of upcoming recruitment.

Leave-one out analyses (Figure 5.19) show that without the Q3+4 survey tuning indices, the assessment can deviate substantially from a fully informed assessment model which would have a large impact on advice provided. While the assessment model performs reasonably well after the removal of the Q1 surveys' tuning indices, as previously stated, key biological information utilized in the assessment is derived from this survey period and data on age1 fish provide more information regarding potential future changes in recruitment. Furthermore, with variable environmental conditions (namely oxygen and temperature) potentially influencing the indices from Q3+4 surveys, indices from Q1 provide a mediating and supporting role in ensuring consistent and more accurate assessments and advice (see ICES 2020).

Table 5.1. Plaice in SD 27.21–23. Official landings (t) by Subdivision and country. 1970–2019.

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1970				3757	202				3959
1971				3435	160				3595
1972	15504	77	348	2726	154				18809
1973	10021	48	231	2399	165				12864
1974	11401	52	255	3440	202				15350
1975	10158	39	296	2814	313				13620
1976	9487	32	177	3328	313				13337
1977	11611	32	300	3452	353				15748
1978	12685	100	312	3848	379				17324
1979	9721	38	333	3554	205				13851
1980	5582	40	313	2216	89				8240
1981	3803	42	256	1193	80				5374
1982	2717	19	238	716	45				3735
1983	3280	36	334	901	42				4593
1984	3252	31	388	803	30				4504
1985	2979	4	403	648	94				4128
1986	2470	2	202	570	59				3303
1987	2846	3	307	414	18				3588
1988	1820	0	210	234	10				2274
1989	1609	0	135	167	7				1918
1990	1830	2	202	236	9				2279
1991	1737	19	265	328	15				2364
1992	2068	101	208	316	11				2704
1993	1294	0	175	171	16			2	1658
1994	1547	0	227	355	1			6	2130
1995	1254	0	133	601	75		64	12	2127
1996	2337	0	205	859	43	1	81	13	3526
1997	2198	25	255	902	51			13	3431

	21			22			23		Total
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	4334
2020	264	2	17	2201	824	0	87	14	3409

Table 5.2. Plaice in SD 27.21–23. Landings (tonnes) and discard (tonnes) in 2020 by Subdivision, fleet, and quarter.

	1	2	3	4	Total
27.3.a.21	**158.01158**	**100.39527**	**387.25811**	**213.13963**	**858.80459**
Discards	**65.96618**	**50.58337**	**327.38571**	**132.01413**	**575.94939**
Active	64.3412	48.62137	325.9456	128.49099	567.39916
Passive	1.62498	1.962	1.44011	3.52314	8.55023
Landings	**92.0454**	**49.8119**	**59.8724**	**81.1255**	**282.8552**
Active	83.8044	37.9889	52.7524	68.7555	243.3012
Passive	8.241	11.823	7.12	12.37	39.554
27.3.b.23	**37.50145**	**31.55348**	**46.16312**	**22.11171**	**137.32976**
Discards	**17.52445**	**3.25518**	**12.10492**	**3.57171**	**36.45626**
Active	9.6307	0.42108	3.41896	1.99028	15.46102
Passive	7.89375	2.8341	8.68596	1.58143	20.99524
Landings	**19.977**	**28.2983**	**34.0582**	**18.54**	**100.8735**
Active	12.544	0.329	2.082	1.065	16.02
Passive	7.433	27.9693	31.9762	17.475	84.8535
27.3.c.22	**1190.14299**	**553.41354**	**511.67047**	**1217.81363**	**3473.04063**
Discards	**84.65799**	**55.19154**	**84.49647**	**223.82063**	**448.16663**
Active	72.897	18.313	32.177	194.12124	317.50824
Passive	11.76099	36.87854	52.31947	29.69939	130.65839
Landings	**1105.485**	**498.222**	**427.174**	**993.993**	**3024.874**
Active	879.358	244.633	162.091	765.955	2052.037
Passive	226.127	253.589	265.083	228.038	972.837
Total	**1385.65602**	**685.36229**	**945.0917**	**1453.06497**	**4469.17498**

Table 5.3. Plaice in SD 27.21–23. Sampling effort 2020 by country, gear type and area.

Row Labels	Sum of Catch (t)	Length Samples	Lengths Measured	Age Samples	Age Readings
27.3.a.21	**858.80459**	**98**	**12008**	**98**	**3124**
Discards	**575.94939**	**56**	**3586**	**56**	**1238**
Denmark	522.6394	45	3143	45	752
Active	515.998	45	3143	45	752
Passive	6.6414	0	0	0	0
Germany	7.5102	0	0	0	0
Active	7.28078	0	0	0	0
Passive	0.22942	0	0	0	0
Sweden	45.79979	11	443	11	486
Active	44.12038	6	374	6	216
Passive	1.67941	5	69	5	270
Landings	**282.8552**	**42**	**8422**	**42**	**1886**
Denmark	264.069	42	8422	42	1886
Active	228.578	21	4211	21	943
Passive	35.491	21	4211	21	943
Germany	1.998	0	0	0	0
Active	1.193	0	0	0	0
Passive	0.805	0	0	0	0
Sweden	16.7882	0	0	0	0
Active	13.5302	0	0	0	0
Passive	3.258	0	0	0	0
27.3.b.23	**137.32976**	**2**	**11**	**2**	**11**
Discards	**36.45626**	**2**	**11**	**2**	**11**
Denmark	29.41686	2	11	2	11
Active	15.46102	0	0	0	0
Passive	13.95584	2	11	2	11
Sweden	7.0394	0	0	0	0
Passive	7.0394	0	0	0	0
Landings	**100.8735**	**0**	**0**	**0**	**0**

Row Labels	Sum of Catch (t)	Length Samples	Lengths Measured	Age Samples	Age Readings
Denmark	86.657	0	0	0	0
Active	16.02	0	0	0	0
Passive	70.637	0	0	0	0
Sweden	14.2165	0	0	0	0
Passive	14.2165	0	0	0	0
27.3.c.22	**3473.04063**	**128**	**22034**	**128**	**5221**
Discards	**448.16663**	**35**	**2744**	**35**	**610**
Denmark	302.15141	14	1303	14	168
Active	187.54824	13	1205	13	147
Passive	114.60317	1	98	1	21
Germany	146.01522	21	1441	21	442
Active	129.96	16	1302	16	436
Passive	16.05522	5	139	5	6
Landings	**3024.874**	**93**	**19290**	**93**	**4611**
Denmark	2200.664	54	12000	54	2576
Active	1477.143	27	6000	27	1288
Passive	723.521	27	6000	27	1288
Germany	824.21	39	7290	39	2035
Active	574.894	17	3604	17	952
Passive	249.316	22	3686	22	1083
Sweden	0	0	0	0	0
Passive	0	0	0	0	0
Grand Total	**4469.17498**	**228**	**34053**	**228**	**8356**

Table 5.4a.Plaice in SD 27.21–23. Landing fraction.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	0.00	0.24	0.30	0.59	0.80	0.55	0.64	0.89	0.98	0.99
2000	0.14	0.23	0.48	0.49	0.78	0.85	0.81	0.94	0.97	0.97
2001	0.02	0.44	0.51	0.41	0.64	0.83	0.85	0.93	0.99	0.98
2002	0.09	0.09	0.38	0.34	0.47	0.42	0.62	1.00	0.78	0.91
2003	0.06	0.24	0.50	0.67	0.74	0.67	0.59	1.00	1.00	1.00
2004	0.05	0.29	0.52	0.67	0.75	0.92	1.00	0.99	1.00	1.00
2005	0.12	0.34	0.76	0.82	0.73	0.72	0.75	0.49	0.38	0.68
2006	0.00	0.18	0.37	0.56	0.90	0.77	0.79	0.96	1.00	1.00
2007	0.02	0.37	0.44	0.68	0.80	0.67	0.55	0.57	0.78	0.98
2008	0.00	0.07	0.53	0.78	0.87	0.95	0.97	0.88	0.93	0.98
2009	0.07	0.15	0.35	0.61	0.53	0.32	0.37	0.15	1.00	0.37
2010	0.08	0.14	0.45	0.63	0.71	0.91	0.97	0.97	0.98	0.99
2011	0.07	0.15	0.28	0.42	0.56	0.55	0.73	0.73	0.86	0.98
2012	0.02	0.23	0.46	0.63	0.82	0.96	0.99	0.93	1.00	0.83
2013	0.01	0.16	0.47	0.59	0.57	0.85	0.88	0.82	1.00	0.87
2014	0.00	0.20	0.42	0.42	0.49	0.55	0.56	0.54	0.68	0.83
2015	0.00	0.20	0.50	0.58	0.74	0.85	0.93	0.88	0.84	0.82
2016	0.02	0.23	0.49	0.61	0.62	0.73	0.86	0.94	0.90	1.00
2017	0.01	0.27	0.58	0.80	0.81	0.95	0.92	0.89	0.83	0.94
2018	0.01	0.24	0.41	0.66	0.86	0.97	0.88	0.99	0.96	0.97
2019	0.00	0.18	0.57	0.74	0.89	0.85	0.93	0.99	1.00	0.98
2020	0.03	0.11	0.51	0.81	0.78	0.93	0.96	0.98	0.92	0.94

Table 5.4b. Plaice in SD 27.21–23. Maturity ogive (corrected methodology in 2021)

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (2002-2020)	0.239	0.528	0.696	0.798	0.892	0.946	0.97	0.967	0.982	0.971

Table 5.4c. Plaice in SD 27.21–23. Landings mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.220	0.283	0.291	0.329	0.374	0.371	0.412	0.862	0.569	1.274
2000	0.220	0.276	0.289	0.309	0.334	0.447	0.569	0.648	1.016	1.221
2001	0.227	0.264	0.271	0.304	0.323	0.397	0.457	0.596	0.851	1.190
2002	0.239	0.261	0.279	0.265	0.317	0.363	0.432	0.424	0.533	0.523
2003	0.272	0.275	0.283	0.308	0.300	0.474	0.468	0.498	0.548	0.746
2004	0.257	0.242	0.266	0.302	0.324	0.373	0.426	0.618	0.478	1.195
2005	0.202	0.256	0.270	0.308	0.326	0.319	0.350	0.411	0.598	1.451
2006	0.166	0.243	0.294	0.313	0.335	0.316	0.344	0.451	0.530	0.884
2007	0.238	0.236	0.273	0.323	0.455	0.482	0.515	0.540	0.398	0.773
2008	0.225	0.225	0.256	0.303	0.376	0.442	0.499	0.558	0.481	0.529
2009	0.212	0.240	0.280	0.316	0.430	0.577	0.621	0.877	0.644	1.152
2010	0.227	0.292	0.292	0.310	0.379	0.403	0.399	0.372	0.369	0.421
2011	0.237	0.308	0.322	0.343	0.340	0.427	0.481	0.462	0.446	0.441
2012	0.265	0.300	0.335	0.393	0.404	0.462	0.426	0.466	0.565	0.546
2013	0.241	0.301	0.317	0.390	0.489	0.565	0.574	0.562	0.648	0.807
2014	0.241	0.270	0.308	0.341	0.408	0.433	0.509	0.682	1.106	0.780
2015	0.241	0.274	0.303	0.327	0.374	0.441	0.536	0.782	0.792	0.868
2016	0.213	0.295	0.298	0.346	0.376	0.415	0.534	0.518	0.753	0.649
2017	0.126	0.254	0.307	0.333	0.383	0.438	0.458	0.598	0.615	0.771
2018	0.211	0.254	0.295	0.300	0.360	0.422	0.504	0.477	0.568	0.553
2019	NA	0.248	0.270	0.296	0.361	0.378	0.448	0.528	0.479	0.701
2020	0.173	0.228	0.258	0.306	0.329	0.384	0.450	0.471	0.680	0.575

Table 5.4d. 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 5.4e. Plaice in SD 27.21–23. Discard mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2000	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2001	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2002	0.082	0.104	0.124	0.171	0.193	0.353	0.321	0.519	0.189	0.913
2003	0.081	0.120	0.149	0.165	0.138	0.110	0.136	0.436	0.622	1.154
2004	0.089	0.127	0.175	0.297	0.249	0.159	0.294	0.168	0.622	1.154
2005	0.091	0.141	0.177	0.224	0.300	0.394	0.535	0.724	1.054	1.394
2006	0.061	0.110	0.154	0.183	0.561	0.192	0.159	0.331	0.622	1.154
2007	0.044	0.088	0.132	0.176	0.323	0.437	0.636	0.824	1.052	1.732
2008	0.102	0.136	0.157	0.287	0.365	0.388	0.111	0.104	0.126	0.132
2009	0.086	0.118	0.139	0.194	0.168	0.139	0.148	0.161	0.622	0.210
2010	0.095	0.121	0.130	0.159	0.187	0.353	0.513	0.452	0.955	0.185
2011	0.066	0.113	0.206	0.233	0.213	0.167	0.276	0.274	0.333	0.217
2012	0.070	0.131	0.244	0.320	0.298	0.183	0.181	0.643	0.178	0.586
2013	0.074	0.106	0.206	0.332	0.390	0.207	0.295	0.242	0.411	0.789
2014	0.087	0.130	0.171	0.279	0.339	0.335	0.424	0.405	1.140	0.465
2015	0.077	0.100	0.144	0.160	0.212	0.235	0.321	0.200	0.130	0.321
2016	0.070	0.107	0.140	0.175	0.275	0.376	0.281	0.182	0.246	0.305
2017	0.072	0.118	0.157	0.206	0.301	0.382	0.333	0.490	0.579	0.460
2018	0.075	0.116	0.142	0.215	0.257	0.175	0.463	0.204	0.152	0.215
2019	0.065	0.102	0.126	0.135	0.156	0.136	0.167	0.354	0.170	0.350
2020	0.068	0.105	0.193	0.276	0.294	0.375	0.450	0.468	0.643	0.573

Table 5.4f. Plaice in SD 27.21–23. Mean weight (kg) in stock by age.

	1	2	3	4	5	6	7	8	9	10+
Mean (2002–2020)	0.036	0.075	0.133	0.2	0.256	0.305	0.399	0.429	0.419	0.49

Table 5.4g.Plaice in SD 27.21–23. Mean weight (kg) in catch by age.

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.159	0.196	0.280	0.356	0.313	0.368	0.806	0.563	1.263
2000	0.101	0.156	0.220	0.258	0.324	0.416	0.515	0.631	0.994	1.199
2001	0.084	0.184	0.215	0.248	0.311	0.371	0.432	0.578	0.843	1.172
2002	0.097	0.117	0.182	0.202	0.252	0.357	0.390	0.424	0.458	0.559
2003	0.092	0.157	0.216	0.261	0.258	0.355	0.331	0.498	0.548	0.746
2004	0.097	0.161	0.222	0.300	0.305	0.355	0.426	0.613	0.478	1.195
2005	0.104	0.180	0.248	0.293	0.319	0.340	0.397	0.570	0.881	1.432
2006	0.061	0.133	0.205	0.255	0.358	0.287	0.306	0.447	0.530	0.884
2007	0.047	0.143	0.195	0.276	0.429	0.467	0.569	0.661	0.540	0.794
2008	0.102	0.142	0.210	0.299	0.375	0.439	0.489	0.502	0.455	0.520
2009	0.096	0.137	0.189	0.268	0.306	0.280	0.322	0.267	0.644	0.556
2010	0.105	0.158	0.240	0.259	0.325	0.396	0.403	0.374	0.381	0.419
2011	0.077	0.141	0.239	0.280	0.284	0.311	0.425	0.411	0.430	0.437
2012	0.074	0.169	0.286	0.366	0.384	0.452	0.423	0.478	0.564	0.553
2013	0.076	0.138	0.259	0.366	0.446	0.511	0.540	0.503	0.647	0.804
2014	0.087	0.159	0.229	0.305	0.373	0.388	0.471	0.556	1.117	0.727
2015	0.077	0.135	0.223	0.256	0.332	0.410	0.521	0.715	0.689	0.768
2016	0.074	0.150	0.218	0.280	0.338	0.404	0.498	0.498	0.701	0.648
2017	0.073	0.146	0.238	0.307	0.367	0.435	0.448	0.586	0.609	0.753
2018	0.076	0.150	0.205	0.271	0.345	0.415	0.499	0.475	0.551	0.543
2019	0.065	0.128	0.208	0.255	0.338	0.341	0.427	0.526	0.478	0.695
2020	0.068	0.105	0.193	0.276	0.294	0.375	0.450	0.468	0.643	0.573

Table 5.4h. Plaice in SD 27.21–23. Total catches (CANUM).

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	1377659	7286520	7123406	6540780	2427443	355338	167828	60681	39013	89466
2000	1610659	7179902	9714540	5232865	2256294	1057577	316913	112681	24920	39940
2001	1405659	9931207	10245755	4543348	1356553	940961	409406	92047	50314	48320
2002	4435651	8578400	20441469	12680459	1269575	292505	129360	58473	8181	5161
2003	946442	12394512	4692894	6070359	3079534	399508	101550	31089	8697	4837
2004	1015923	2702712	6024522	3791879	2375641	916596	171059	3396	1358	2795
2005	774005	7254148	3086708	2166619	991902	776303	330360	56681	3068	16163
2006	321609	4580833	9969825	2896298	1208044	867801	611949	105917	13137	11880
2007	267054	3636564	7725502	3650027	1054350	522184	97803	83092	26152	22273
2008	2147170	7356643	4817249	2517528	973474	379320	154559	41156	67899	105171
2009	681346	5923506	4454970	2925220	1266692	463083	66854	146568	516	10243
2010	1007663	6382103	4475417	1781851	574649	207700	128380	106640	74233	35767
2011	2681908	6570857	5962611	1686722	679439	490565	257862	141363	74256	70418
2012	990000	3978884	4597271	2014708	477022	150657	106988	70967	56634	67134
2013	1778988	5835653	4700512	2424381	785435	203019	81130	34499	30040	32541
2014	446667	3373311	5047504	4184430	1521451	530256	116942	40482	5390	19456
2015	268363	3195165	4417121	3785213	2402626	747101	352195	61537	15351	5859
2016	1258096	4309152	6803758	3340644	2161240	1063172	294669	152507	56218	54383
2017	1298124	2985733	4028499	3913709	1721828	1028901	623925	218615	132563	82287
2018	665693	6292779	4775073	3661795	2587740	1151678	557017	189004	104599	138207
2019	302677	2950727	10360430	4532742	1998352	1247147	578394	262947	194713	140809
2020	2619018	3801778	5455340	6047568	1755936	780805	334362	219039	93177	139420

Table 5.4i. Plaice in SD 27.21–23. Survey indices NS-IBTS and BITS combined.

1st quarter

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	1217.529	9369.3424	4104.0913	997.9936	509.5053	48.9802
2000	3050.6185	23961.4332	10269.5005	1567.0985	467.2435	279.9372
2001	1030.7618	13621.7109	13202.0611	2912.6422	405.1443	169.9928
2002	1625.9323	3890.8484	9839.5308	4791.6797	959.7934	228.2523
2003	1544.8906	16426.7797	6891.2376	6960.1436	3503.9798	504.4494
2004	1038.3014	5884.4718	11314.5551	4770.2737	2920.1395	1873.212
2005	1234.4159	13087.9	10973.8276	5393.403	1817.0103	1655.6384
2006	316.7429	8053.3576	16508.5961	6179.736	2444.414	499.9129
2007	1089.446	7187.6632	12154.5263	8696.6753	2126.2237	918.2039
2008	1530.1588	5537.8643	6694.2176	3292.7534	1059.3655	369.8199
2009	924.6901	4565.8054	7297.9451	3337.9253	1177.0738	438.3103
2010	3488.9911	8909.8635	10882.7895	5301.172	1951.0457	462.4514
2011	1438.1577	13846.747	11096.0502	5026.3908	2237.9184	903.1694
2012	2394.1464	11879.7879	12047.6974	4541.1932	1123.2671	401.7726
2013	473.5593	6784.6197	17570.1575	8368.2109	4613.5265	1066.4212
2014	251.2152	8395.9958	13009.6396	11571.6904	5359.4948	1926.0222
2015	909.6603	12500.0075	14690.0385	9871.1462	6542.1441	3126.804
2016	1144.5114	16406.3825	21146.1743	11354.1541	5583.4831	3113.0616
2017	4361.717	16288.3785	20938.5593	9665.1074	4854.849	2296.7121
2018	4441.0141	27217.8995	25655.4939	13923.3776	8390.199	2353.9893
2019	685.8759	22390.0373	28383.3825	11018.6354	3130.199	2400.0247
2020	13568.9887	6939.6353	16333.8166	18643.7006	9321.154	2291.2072

3rd and 4th quarter (2019 set to "missing" with "-9")

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	25884.2076	15892.0559	2660.3395	300.6579	385.3437	81.9081
2000	11378.5315	19657.8346	6626.6724	96.5317	69.7835	117.8227
2001	4490.2461	12142.4953	5023.056	1246.091	137.7595	185.1233
2002	8889.8684	4795.3742	4931.9991	3502.3333	754.9798	139.518
2003	4019.2675	12713.0007	3175.3719	2423.9501	1312.3705	230.2498
2004	7343.3518	7288.5069	10345.0302	3126.8406	1961.5709	1461.1017
2005	7567.7941	10023.342	2590.7607	1391.8333	409.3759	513.1891
2006	6627.5439	9139.8939	7397.0772	1800.043	861.0957	539.2375
2007	5728.2237	9573.4034	3383.2863	2186.9551	598.9617	301.1152
2008	2531.1082	9443.9671	7076.8328	2820.1557	760.2691	181.5502
2009	4898.2789	9316.4308	8912.4734	1687.6175	349.4083	205.762
2010	5297.8264	6918.0181	4246.5336	3380.2959	1038.9549	559.3277
2011	13444.1538	11918.4811	7218.8015	2416.992	545.8117	258.1975
2012	10368.5213	12476.2685	9803.5829	4447.9509	1055.9151	284.9795
2013	5027.492	9550.8793	9052.1572	3929.3022	1925.9735	807.9839
2014	10989.5398	10774.6387	8790.624	5390.9651	2885.9446	795.8438
2015	7145.6743	14854.9821	10166.5744	7885.3846	4054.4953	1017.9177
2016	12609.2811	12637.897	9603.3769	4276.3685	2149.2433	1191.7771
2017	34869.8949	15085.747	7598.2012	4734.4595	1948.0622	1348.9857
2018	18070.6601	23999.1522	9165.576	3383.2117	1239.9579	1140.5931
2019	-9	-9	-9	-9	-9	-9
2020	19073.1947	14449.8087	4508.8618	14379.9339	8957.7737	7549.0117

Table 5.5 Plaice in SD 27.21–23. SAM results from the final assessment (Annex_v2). Estimated recruitment (000s), total stock biomass (TBS in tonnes), spawning stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 (F_{35}).

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High	TSB	Low	High
1999	50839	36520	70771	4580	3702	5666	1.021	0.83	1.256	7762	6364	9468
2000	46637	34387	63250	5161	4277	6229	1.036	0.87	1.234	8864	7363	10671
2001	24938	18253	34072	5906	4872	7159	0.982	0.829	1.163	9320	7717	11255
2002	40845	28488	58564	6054	4976	7365	0.929	0.78	1.107	9360	7732	11331
2003	22591	16613	30719	5444	4557	6504	0.824	0.692	0.982	8132	6830	9681
2004	29123	21526	39402	4940	4179	5840	0.765	0.636	0.921	7369	6267	8666
2005	24237	17916	32790	4637	3929	5472	0.756	0.624	0.916	6964	5920	8193
2006	16214	11403	23056	4574	3839	5450	0.804	0.669	0.966	6666	5625	7901
2007	18634	13701	25343	4074	3430	4839	0.799	0.663	0.962	5948	5035	7027
2008	23208	16702	32248	3749	3163	4443	0.817	0.68	0.98	5654	4786	6679
2009	23430	17358	31626	3573	3010	4241	0.764	0.633	0.922	5495	4651	6493
2010	35041	25552	48053	3695	3125	4370	0.692	0.563	0.85	5978	5066	7056
2011	37150	27376	50414	4311	3637	5110	0.68	0.539	0.858	7059	5960	8361
2012	35190	25539	48489	5033	4222	5998	0.524	0.403	0.683	8012	6751	9507
2013	29435	21665	39990	6090	5101	7270	0.461	0.348	0.609	9147	7718	10840
2014	24039	17197	33602	6987	5812	8400	0.419	0.315	0.558	9930	8351	11807
2015	26038	18985	35711	7616	6268	9253	0.404	0.305	0.535	10515	8777	12598
2016	34988	25421	48155	8223	6678	10125	0.415	0.316	0.545	11401	9411	13812
2017	62277	44478	87200	9035	7239	11277	0.38	0.285	0.507	13150	10724	16125
2018	49402	34042	71694	10634	8385	13486	0.35	0.257	0.477	15335	12270	19165
2019	24517	15437	38938	12637	9648	16552	0.315	0.222	0.447	17136	13228	22199
2020	147261	82059	264270	15011	11001	20481	0.291	0.194	0.436	22310	16410	30332
2021	29435*	147261	16214	18946	27365	12960						

* **Median resampled from the entire time-series of recruitment.**

Table 5.6. Plaice in SD 27.21–23. Estimated fishing mortality (F) at-age.

Year Age	1	2	3	4	5	6	7
1999	0.052	0.405	0.807	1.156	1.099	0.984	0.984
2000	0.053	0.412	0.819	1.172	1.117	1.002	1.002
2001	0.051	0.396	0.78	1.11	1.057	0.95	0.95
2002	0.049	0.381	0.745	1.048	0.995	0.892	0.892
2003	0.044	0.341	0.664	0.929	0.88	0.788	0.788
2004	0.041	0.317	0.617	0.862	0.815	0.728	0.728
2005	0.04	0.314	0.611	0.852	0.806	0.718	0.718
2006	0.043	0.334	0.65	0.906	0.856	0.76	0.76
2007	0.043	0.334	0.648	0.9	0.848	0.749	0.749
2008	0.045	0.346	0.666	0.919	0.864	0.758	0.758
2009	0.042	0.328	0.627	0.859	0.805	0.703	0.703
2010	0.039	0.3	0.572	0.778	0.726	0.632	0.632
2011	0.039	0.297	0.563	0.764	0.713	0.619	0.619
2012	0.03	0.231	0.436	0.588	0.549	0.476	0.476
2013	0.027	0.204	0.384	0.517	0.481	0.416	0.416
2014	0.024	0.185	0.349	0.47	0.438	0.378	0.378
2015	0.023	0.177	0.336	0.453	0.423	0.365	0.365
2016	0.024	0.182	0.345	0.465	0.434	0.374	0.374
2017	0.022	0.166	0.316	0.426	0.399	0.344	0.344
2018	0.02	0.153	0.291	0.393	0.367	0.317	0.317
2019	0.018	0.139	0.263	0.353	0.33	0.285	0.285
2020	0.017	0.129	0.244	0.326	0.303	0.261	0.261

Table 5.7. Plaice in SD 27.21–23. Estimated stock numbers at age.

Year / Age	1	2	3	4	5	6	7
1999	50839	30692	10246	4882	2925	321	1057
2000	46637	41829	18008	3998	1479	907	498
2001	24938	37298	26762	7097	1171	486	498
2002	40845	18225	23871	12790	2124	389	345

2003	22591	29668	11255	10515	4563	708	272
2004	29123	16631	16761	5671	3886	1853	398
2005	24237	23664	10878	7237	2132	1597	967
2006	16214	19276	15893	5500	2754	883	1122
2007	18634	14107	12298	7144	1982	1036	801
2008	23208	15359	10146	5724	2403	748	775
2009	23430	16686	10262	4977	1977	890	634
2010	35041	18154	10355	4770	1958	772	700
2011	37150	26765	12750	4941	1821	860	734
2012	35190	27838	16961	6800	1948	734	760
2013	29435	26213	20428	9425	3481	984	793
2014	24039	23999	18472	12544	5102	1909	1003
2015	26038	21854	17162	11473	6930	2906	1748
2016	34988	23029	17531	10655	6251	3913	2791
2017	62277	27978	17432	11342	5783	3504	4069
2018	49402	47634	22614	11200	6877	3336	4689
2019	24517	38085	37215	16465	6614	4312	5138
2020	147261	19399	27272	26070	11028	4325	6131

Table 5.8. Plaice in SD 27.21–23. Reference points for 2021, retained from 2019 review and with Fpa updated to the correct Fp=0.05.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	4 730	= B_{pa}
	F_{MSY}	0.31	Equilibrium scenarios stochastic recruitment.
Precautionary approach	B_{lim}	3 635	B_{loss} (lowest observed biomass=Biomass in 2009)
	B_{pa}	4 730	$B_{lim} \times e^{1.645\sigma}$, σ = 0.16
	F_{lim}	1.00	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic re-cruitment.
	F_{pa}	0.809	$F_{pa} = F_{p=0.05}$ (with $B_{trigger}$)

Table 5.9. Plaice in SD 27.21–32. Potential allocation of catches by management area.

Basis		**Catch 2020**	**Landings 2020**	**ICES stock advice 2022 (catch)**
Stock area-based	SDs 21-23	4469	3409	8821
	SDs 24-32	1247	1024	3956
Total advised catch, 2022 (SDs 21-32)				12777
Management area-based	SD 21	859	283	
	SDs 22-23	3610	3126	
	SDs 22-32	4857	4150	

	Calculation	Result
Share of SD 21 of the total catch in SDs 21–23 in 2020	= 859 / 4469 (catch in 2020 SD 21 / catch in 2020 SDs 21–23)	0.192
Catch in 2022 for SD 21	= 8821 * 0.192 (ICES stock advice in 2022 (catch) for SDs 21–23 × share)	1695
Catch in 2022 for SDs 22–32	= 12777 - 1695 (total advised catch in 2022 SDs 21–32 – catch SD 21)	11082
Share of SD 21 of the total landings in SDs 21–23 in 2020	= 283 / 3409 (landings in 2020 SD 21 / landings in 2020 SDs 21–23)	0.083

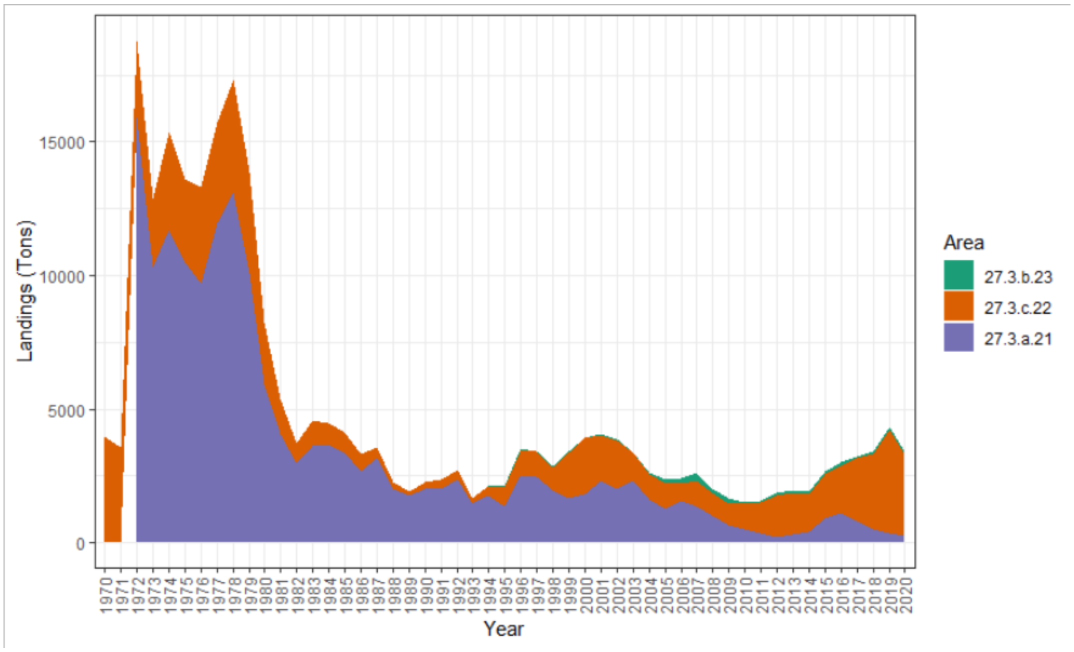


Figure 5.1. Plaice in SD 27.21–23. Landings by subdivision by year.

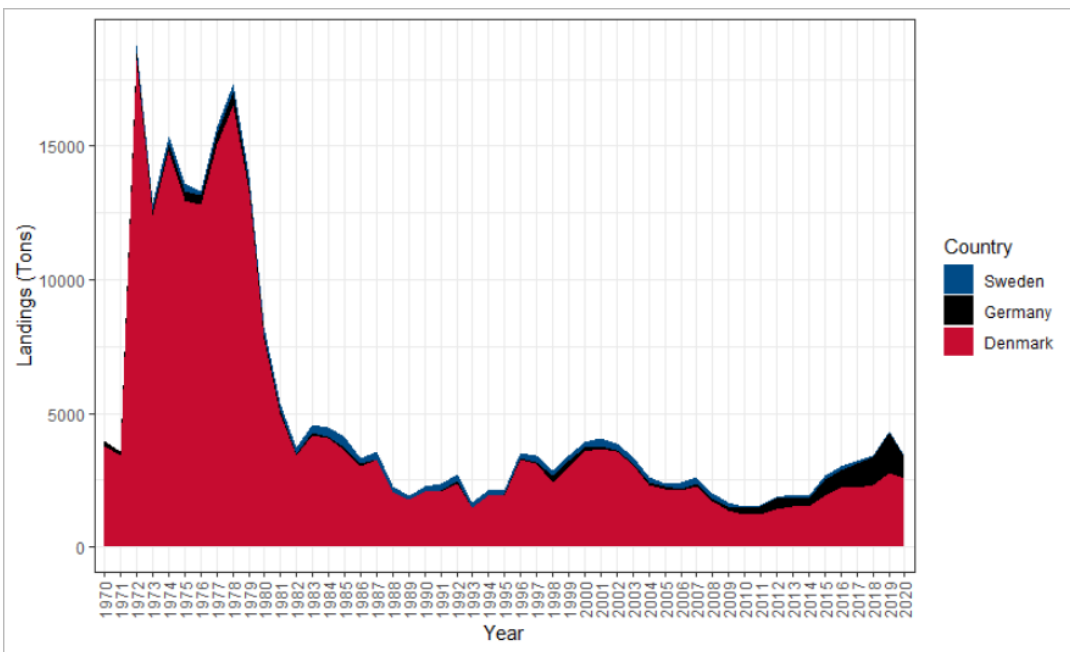


Figure 5.2. Plaice in SD 27.21–23. Landings (t) by country by year.

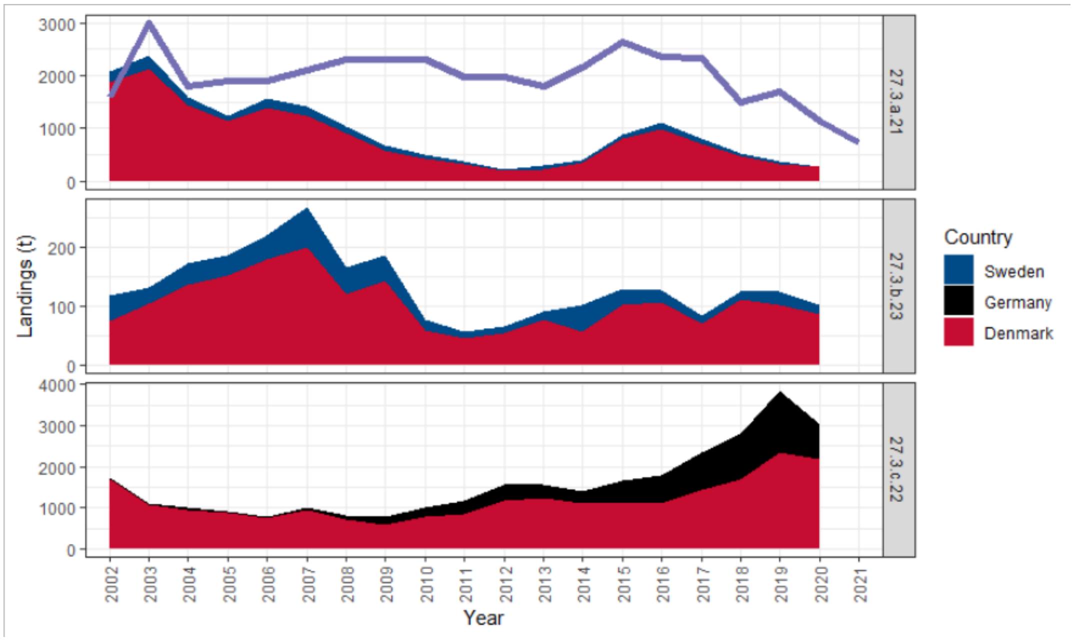


Figure 5.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 shown as a purple line.

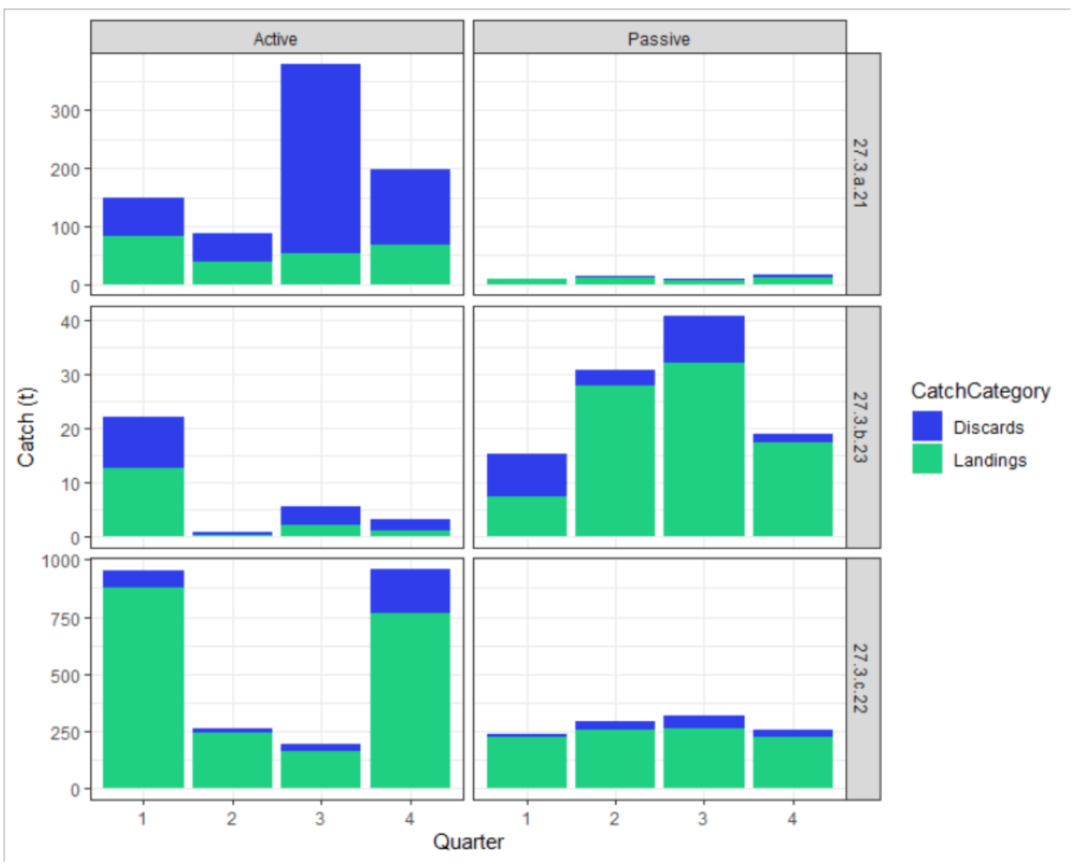


Figure 5.4a. Plaice in SD 27.21–23. Catches (t) in 2019 by gear type, area, quarter and catch category. Note varying y-axis values by area.

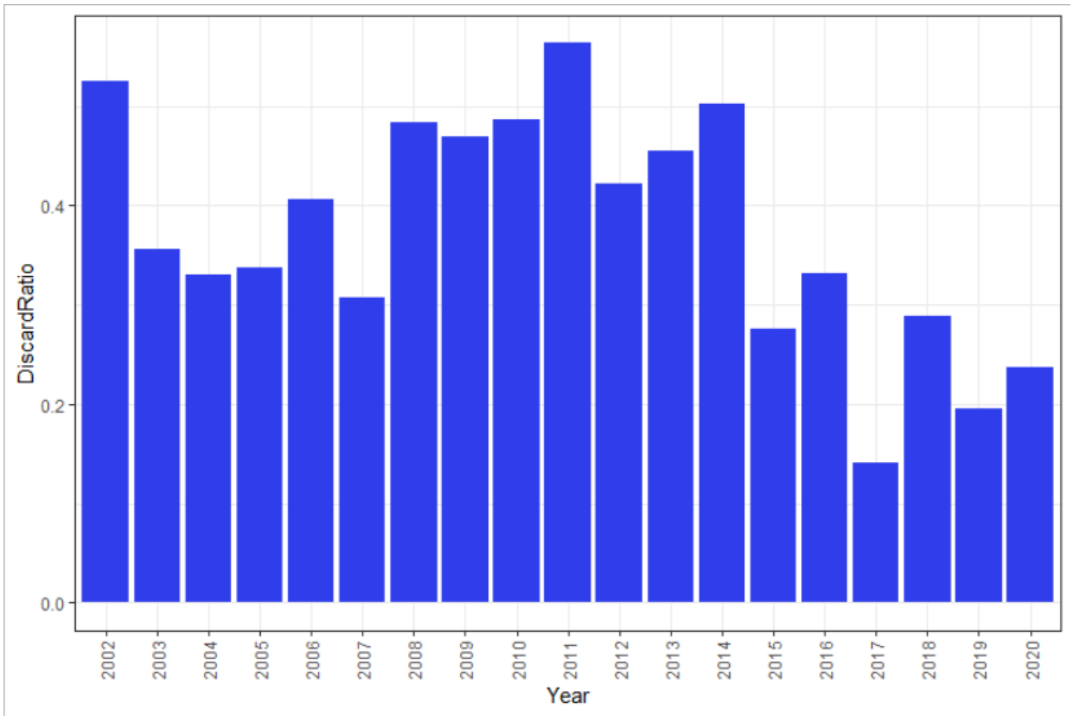


Figure 5.4b. Plaice in SD 27.21–23. Discard ratio over time.

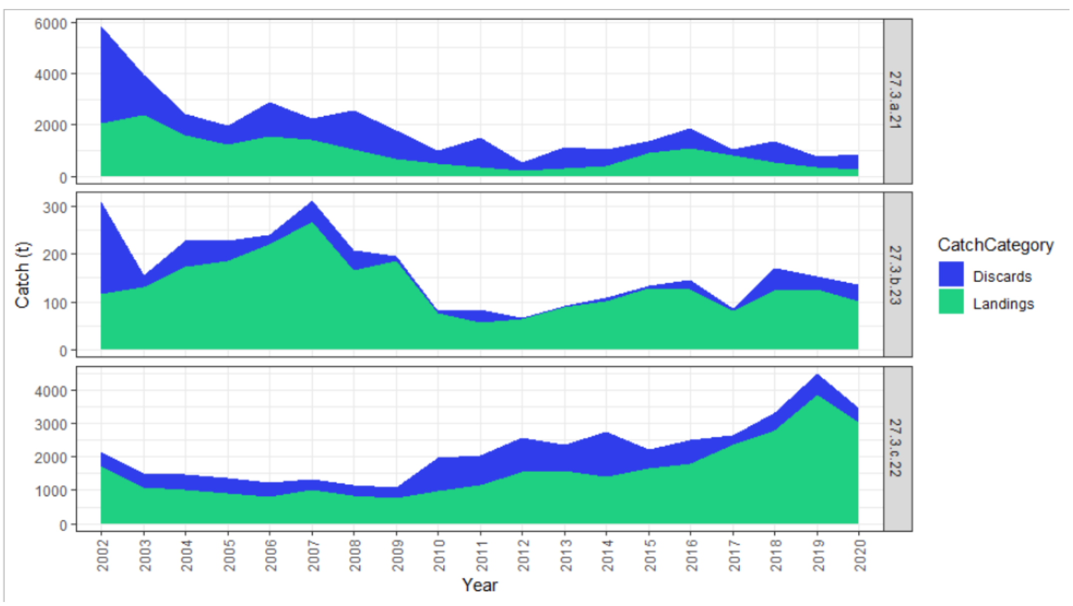


Figure 5.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

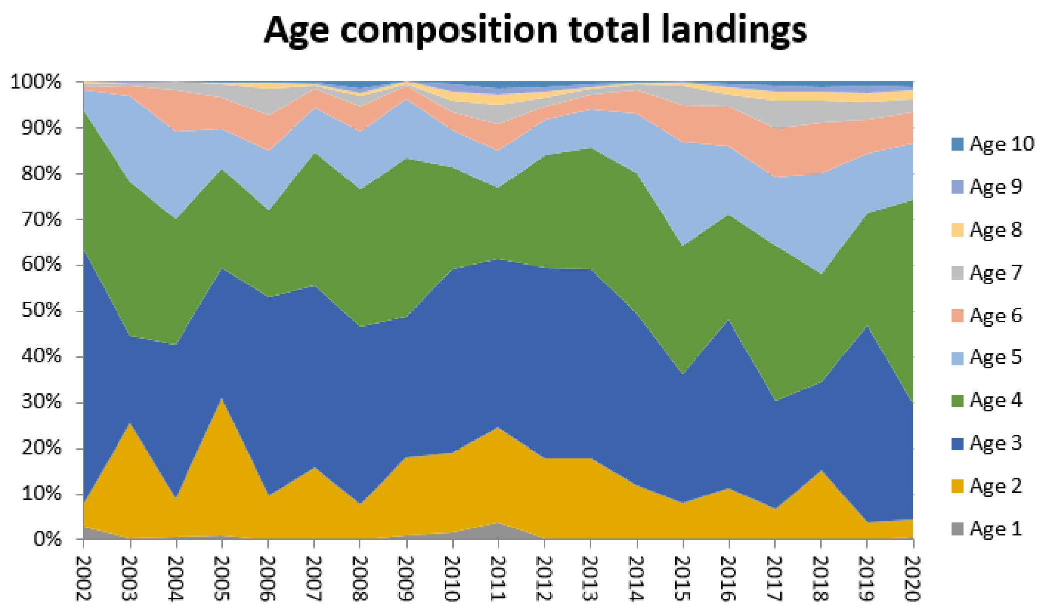


Figure 5.5a. Plaice in SD 27.21–23. Age composition for landings from 2002 to 2019.

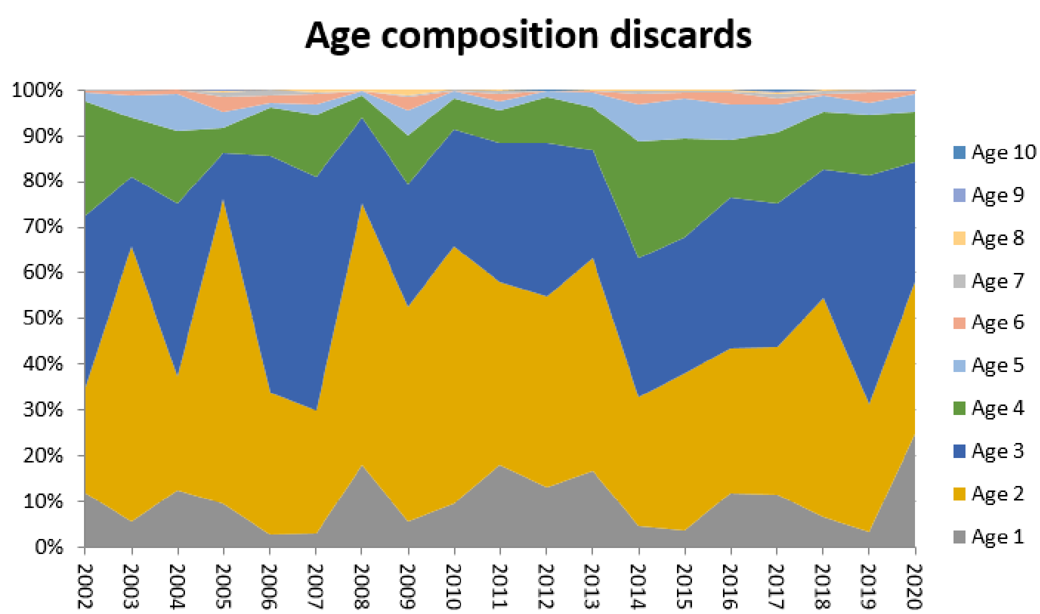


Figure 5.5b. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2019.

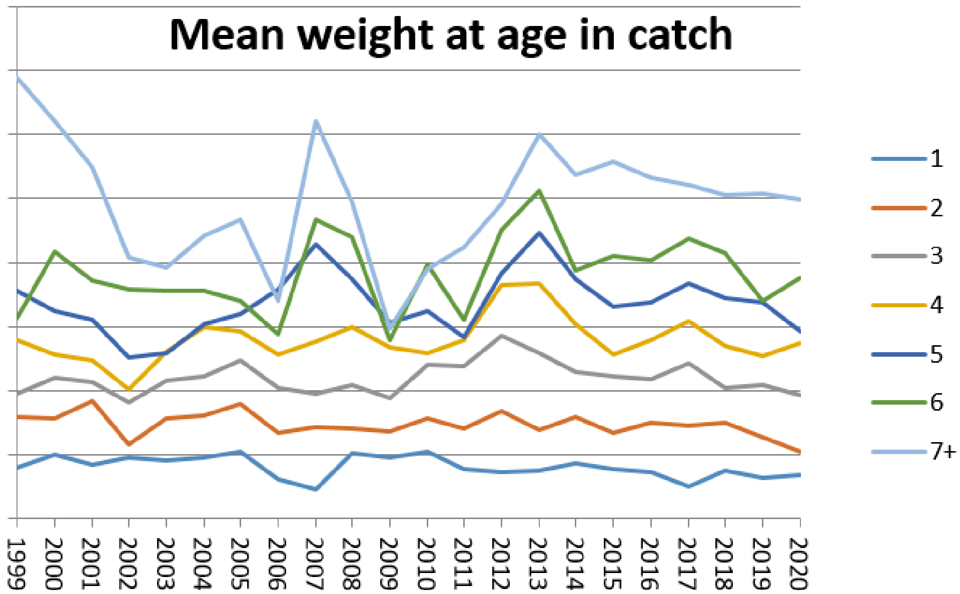


Figure 5.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

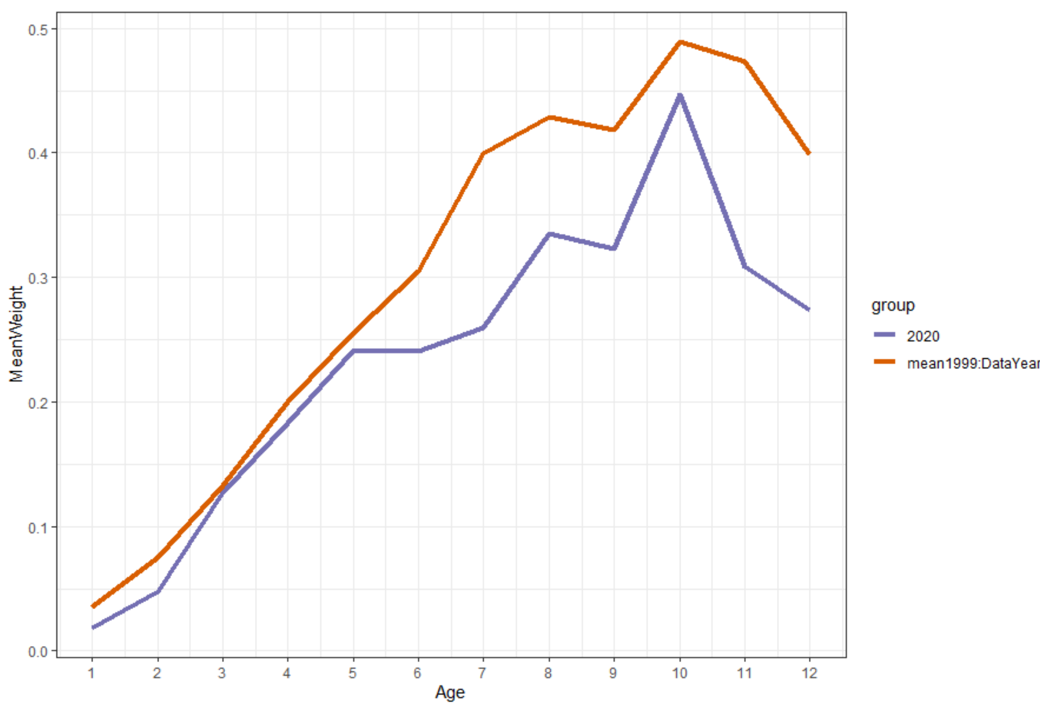


Figure 5.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock.

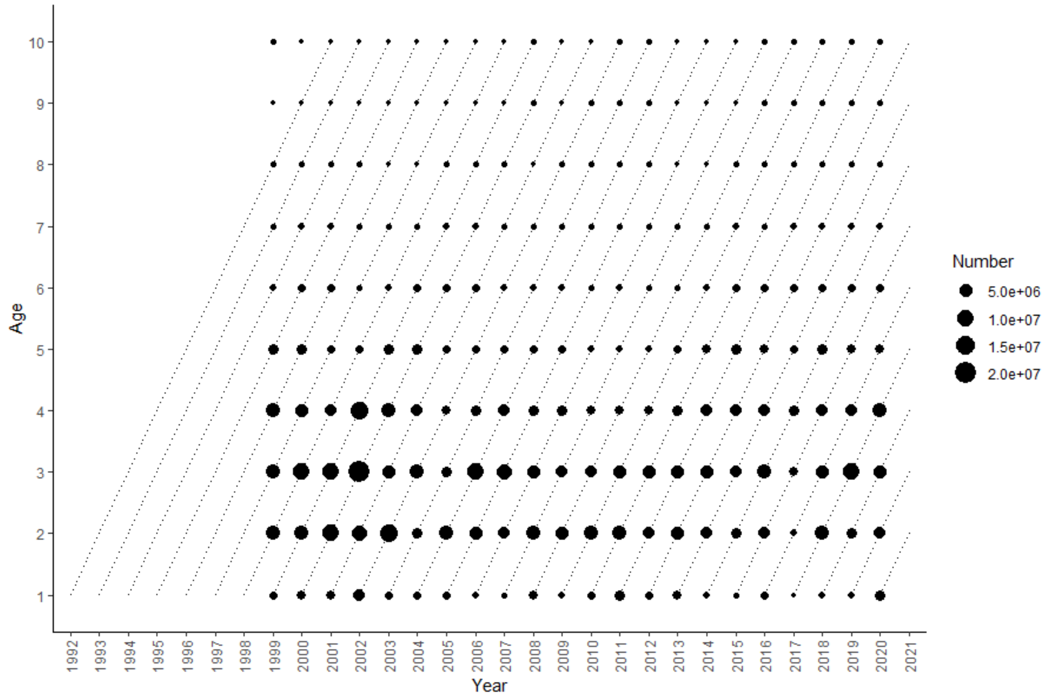


Figure 5.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix

Figure 5.9. Plaice in SD 27.21–23. Catch-at-age 1999-2019

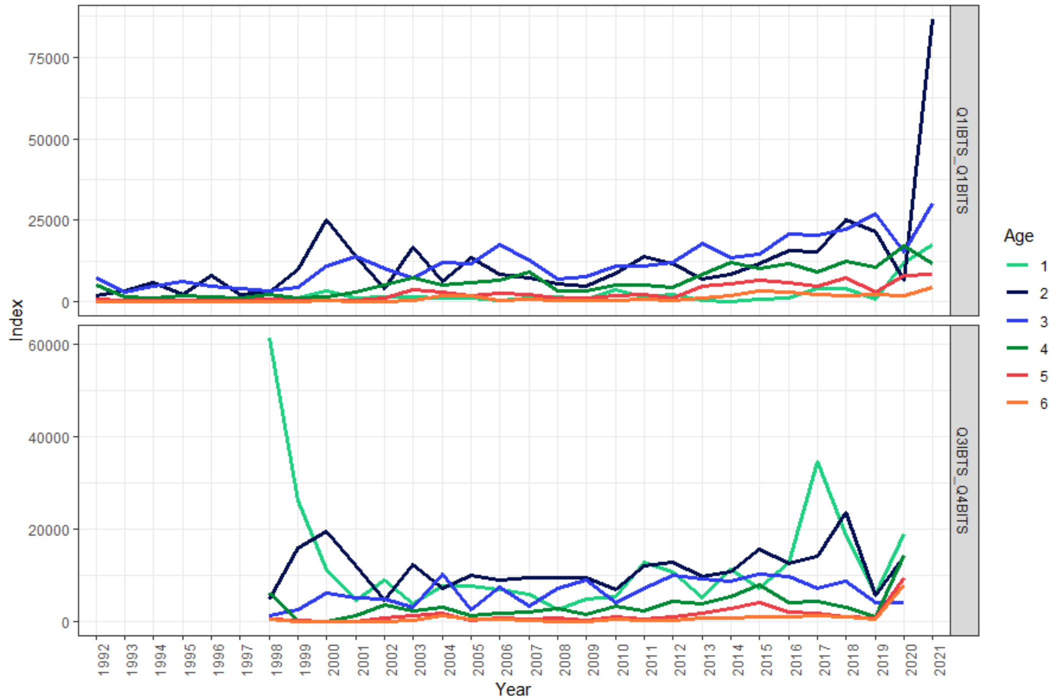


Figure 5.10. Plaice in SD 27.21-23. Survey indices over time (re-calculated within assessment year with all available data). Top: Q1 combined indices (note 2021 data not used in calculation of indices for the 2021 assessment. Bottom: Q3-4 combined indices (note 2019 data not used in calculation of indices for the 2021 assessment).

Figure 5.11. Plaice in SD 27.21-23. Cohort-tracking through survey indices by age. Bubble size relative to within year index by age recalculated from total dataseries available at time of assessment in 2021. Top: Combined Q1 survey indices (note 2021 data not used in assessment). Bottom: Combined Q3-4 survey indices (note 2019 excluded from calculation of all indices according to decision in 2019 assessment).

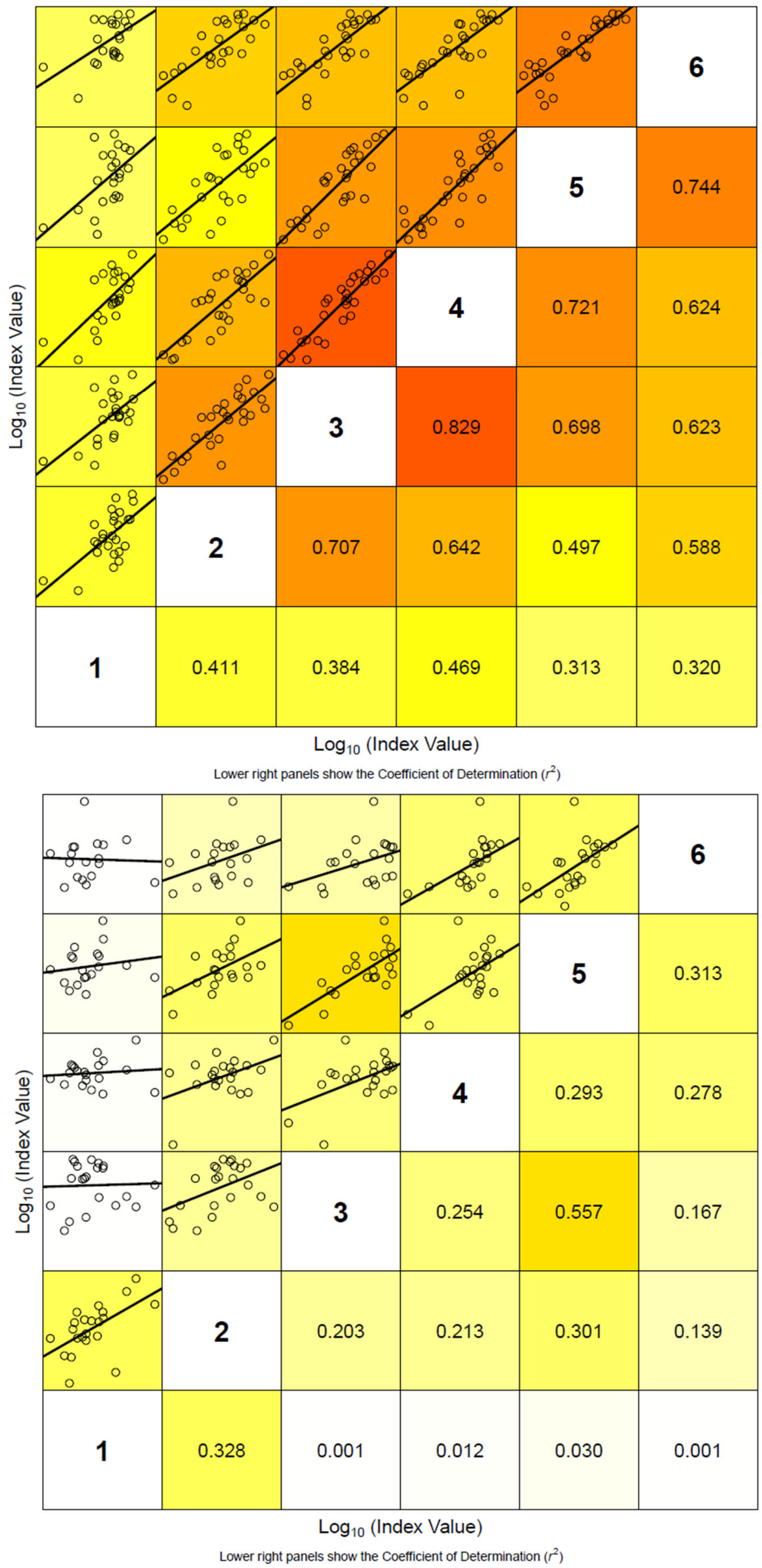


Figure 5.12. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

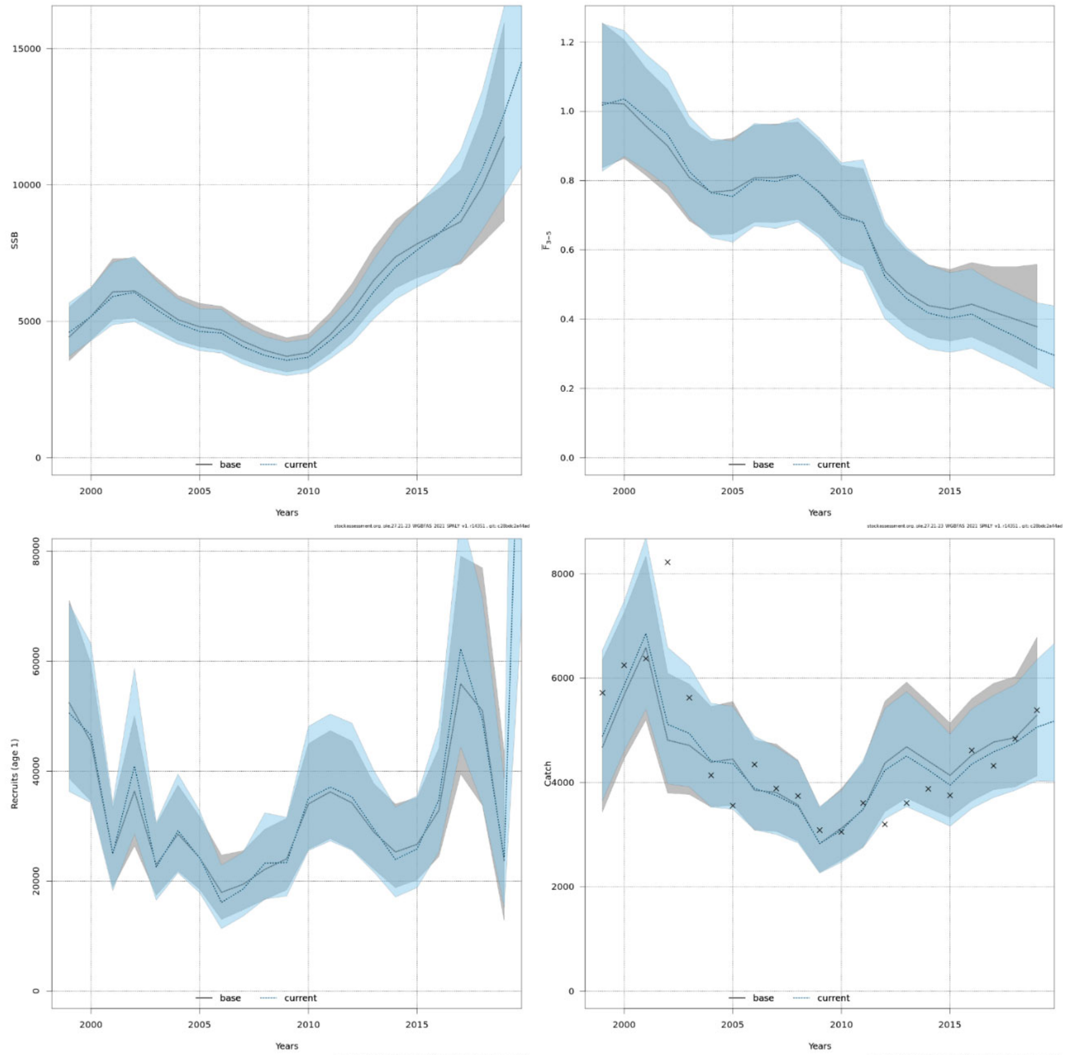


Figure 5.13. Plaice in SD 27.21–23. SPALY SAM run (in blue) in comparison with the 2019 assessment (in grey)

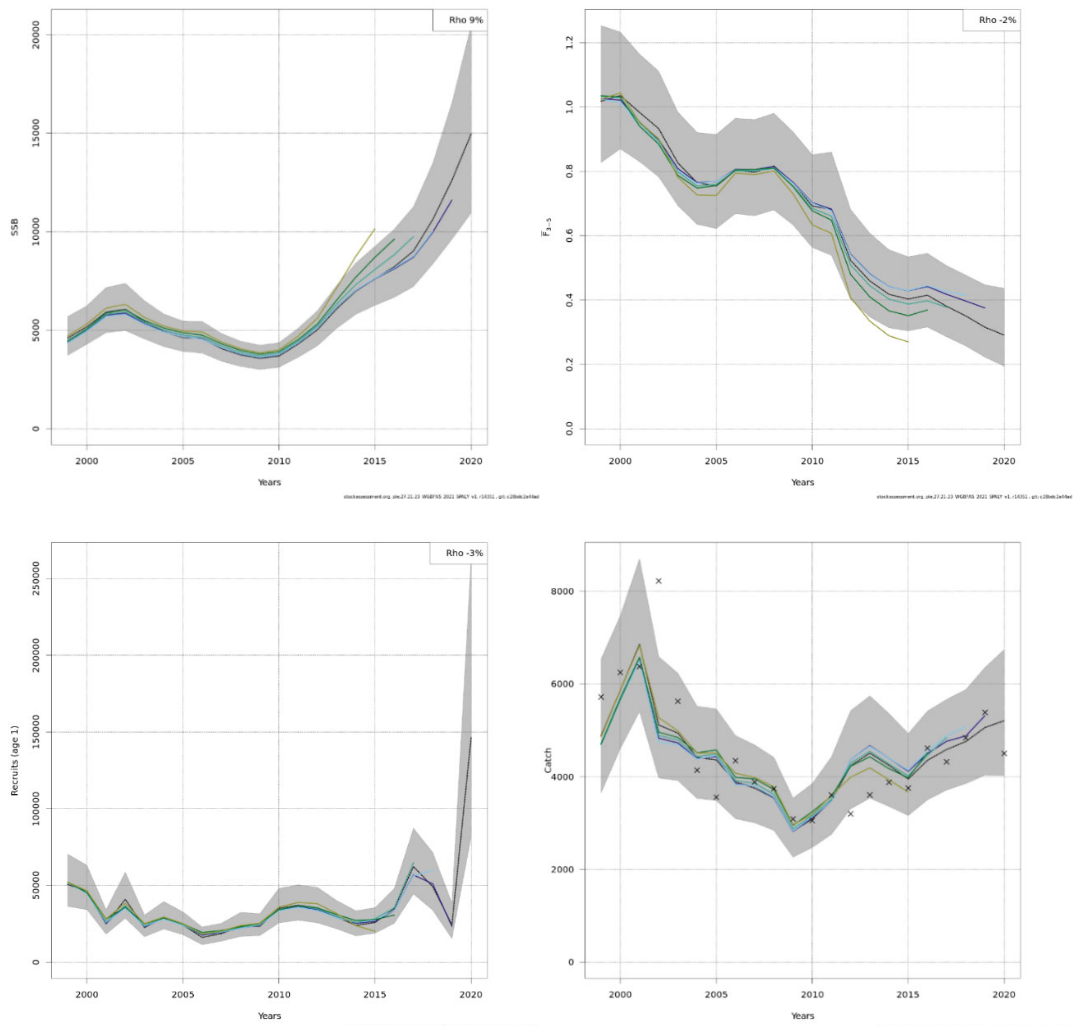


Figure 5.14. Plaice in SD 27.21–23. SPALY SAM run. Retrospective pattern

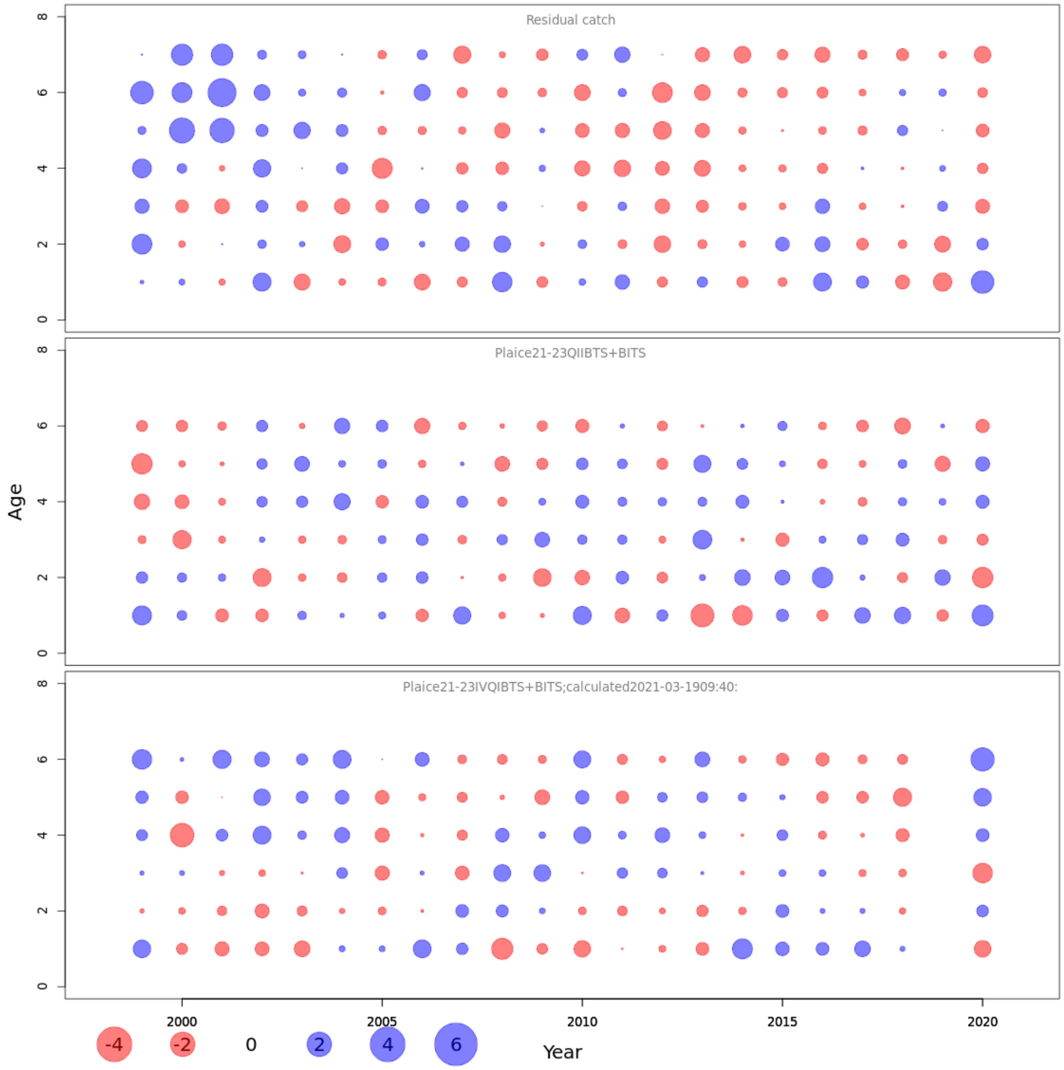


Figure 5.15. Plaice in SD 27.21–23. SPALY SAM Residuals by Fleet, Age and Year. The top panel represent catches, the middle the combined Q1 survey indices and the bottom the combined Q3-Q4 survey indices.

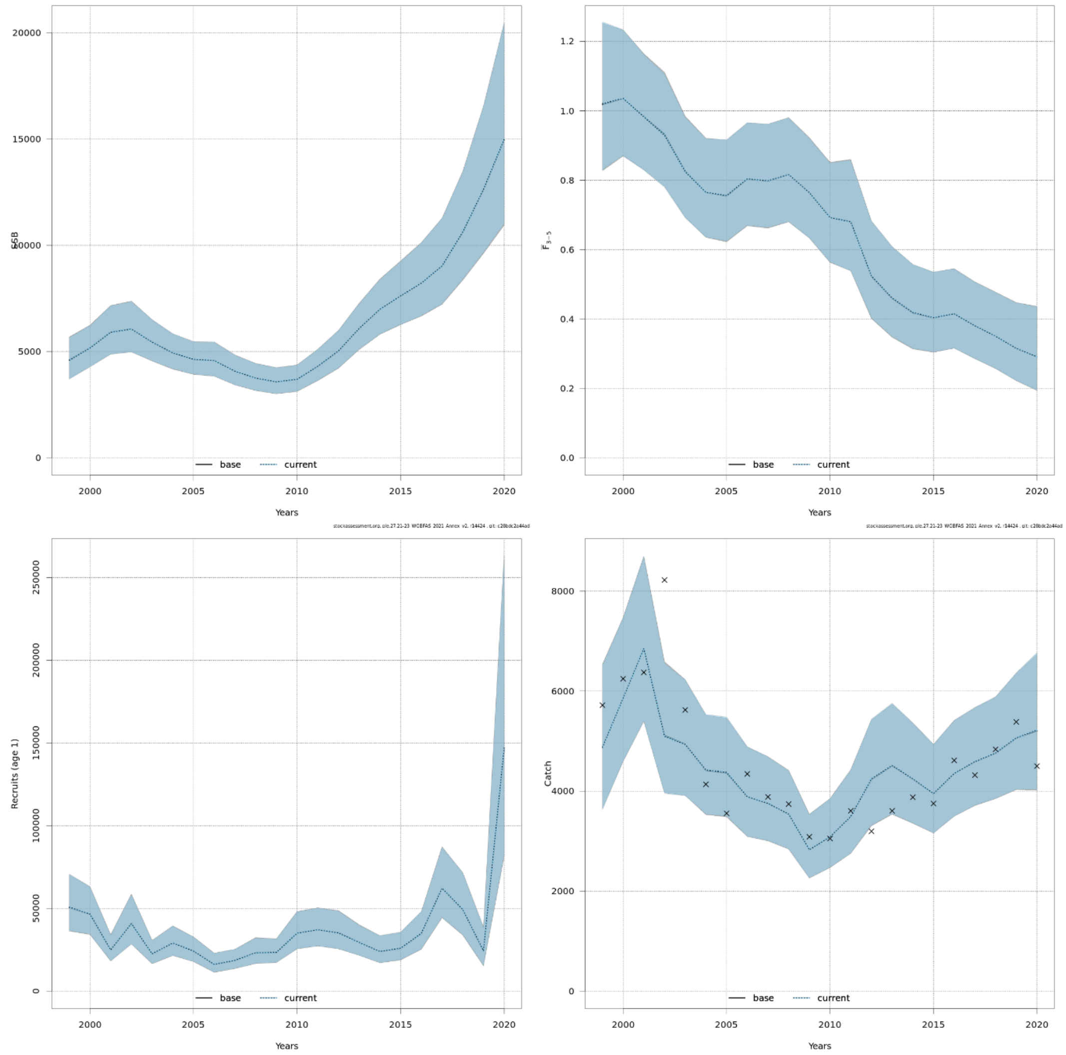


Figure 5.16. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey data in calculation of indices). Grey lines and ribbons are the 2021 SPALY assessment and the dashed lines and blue ribbons are the secondary SAM run from 2021 (which the advice is based on).

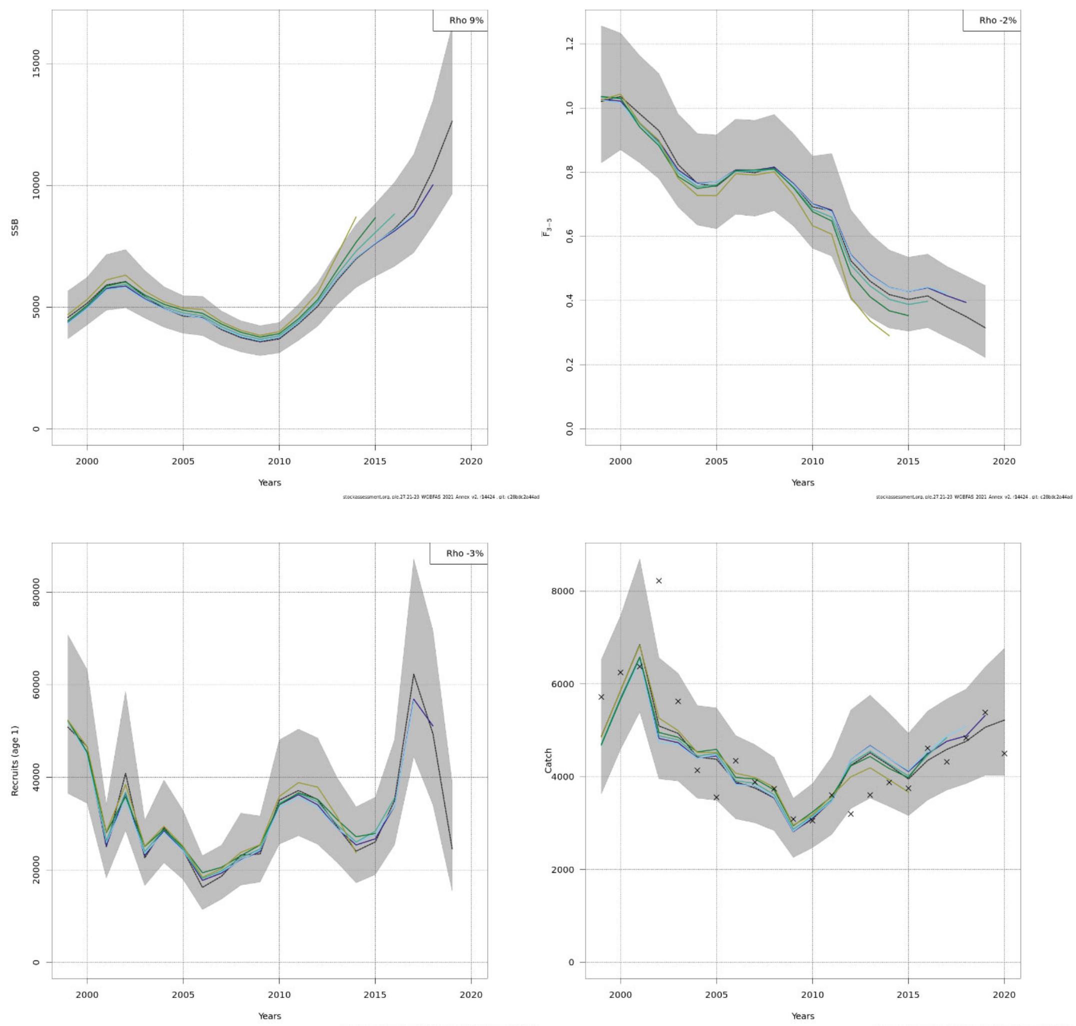


Figure 5.17. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey data in calculation of indices). Retrospective patterns.

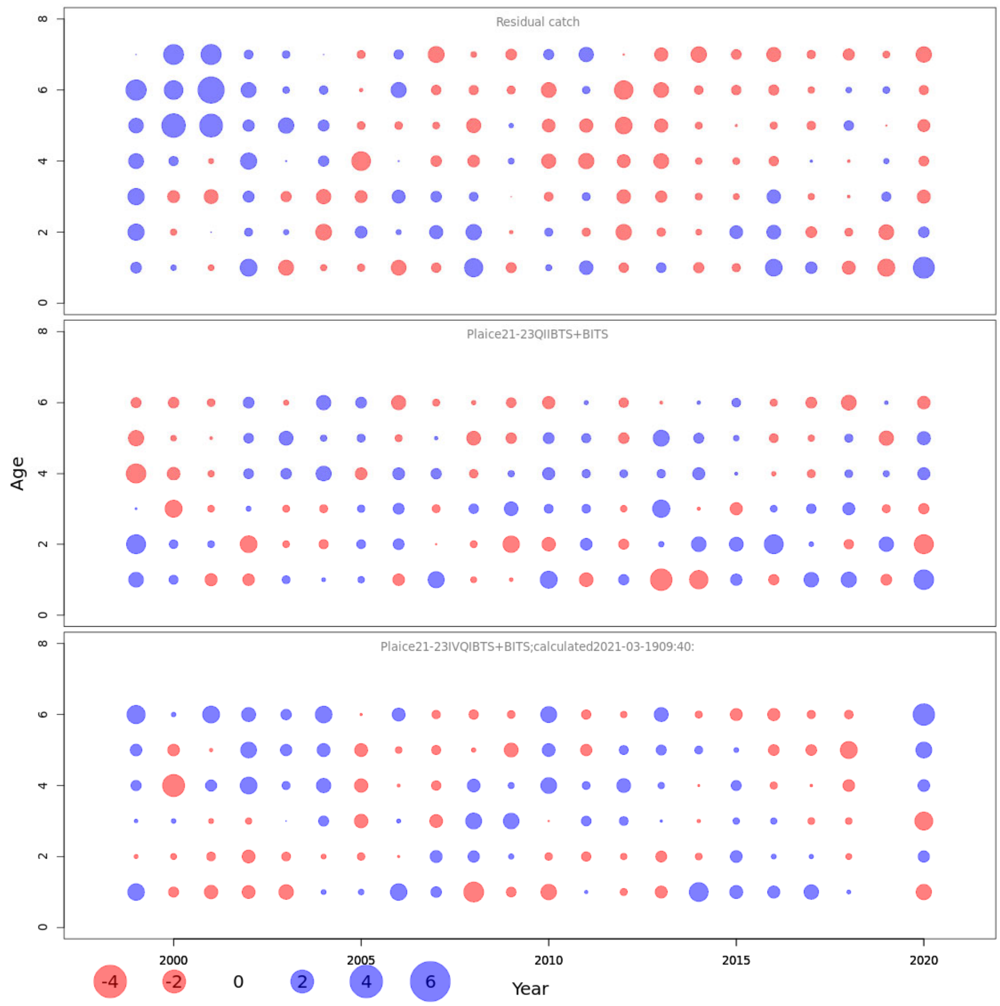


Figure 5.18. Plaice in SD 27.21-23. Secondary SAM run Residuals by Fleet, Age and Year. The top panel represent catches, the middle the combined Q1 survey indices and the bottom the combined Q3-Q4 survey indices.

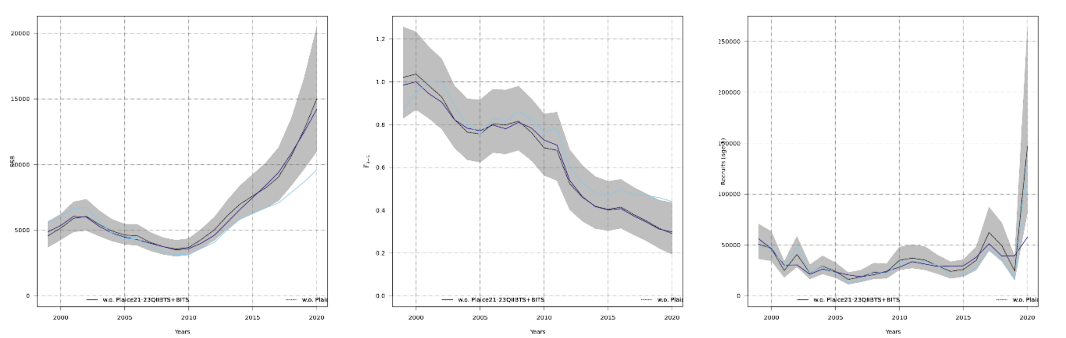


Figure 5.19. Plaice in SD 27.21-23. Secondary SAM run "leave-one-out" analysis where the black line and shaded confidence intervals are the model with both survey tuning indices, the purple line is the model estimation without the Q1 combined survey indices, and the light blue line is the model estimation without the Q3/4 survey indices.

5.3 Plaice in the 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 6894 tonnes for 2020 and increased to 7450 tonnes in 2021. The analytical assessment of ple.27.21-23 indicated an increase in recruitment which was considered when combining the results with ple.27.24-32, where a similar signal occurred.

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 ton/year.

Plaice are caught by trawlers and gillnetters mostly. The minimum landing size is 25 cm in 2020, 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 2020.

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 5.10 and 5.11. 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 5.20.

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 2018 and 2019 were about 160 tonnes and almost three times higher than in previous years. Recent landings in 2020 decreased to about 1024 tonnes. Since 2017, a landing obligation is in place, resulting in an additional 7.9 tonnes of "BMS landings" (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2020, which accounted for 0.63% 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 is 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, especially in the passive-gear segment is low, especially on discard in SD 25 and SD 26, where often only Danish data were available. The discards in 2016 were exceptional high and estimated to be around 1050 tonnes, which would result in a discard ratio of 67% of the total catch. Discards in the most recent year (2020) were around 223 tonnes (i.e. 17.9% of the total catch), about 40% less than in previous years.

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 (2019, 2020) 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 5.21).

5.3.2.2 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.22). Age classes above 7 are usually not very well sampled, causing some fluctuations in the average weight. Passive gears often catch larger fish and have a lower discard-rate.

5.3.2.3 Natural mortality

No further information or studies on natural mortality are available. The average natural mortality for age classes 1 and 2 is set at 0.2, age classes 3+ are set at 0.1 as a default.

5.3.2.4 Maturity-at-age

The maturity ogive was taken from the BITS from SD22 and SD24 (since they are more reliable and consistent than SD24+, see WKPLE 2015 report). Both quarters from the period 2002 to 2018 were combined and an average maturity-at-age was calculated:

Age	1	*2*	3	4	5	6	7	8	9	10
Maturity	0.18	0.51	0.70	0.85	0.94	0.97	0.97	0.99	0.98	0.99

5.3.3 Fishery independent information

The "Baltic International Trawl Survey (BITS)" is covering the area of the plaice stock in SD24–32. The survey is conducted twice a year (1st and 4th quarter) by the member-states having a fishery in this area. Survey-design and gear is standardized. Due to a change in trawling gear in 2000, only first and fourth quarter BITS since 2001 are considered. The CPUE is calculated from the catches. The BITS-Index is calculated as:

Average number of plaice ≥20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. (Figure 5.23). Note that after the Advice Drafting Group there was an update of the 2020 Q4 BITS index estimates by age in the DATRAS database. A new assessment run was carried out using the most up-to-date survey data. Results from this new assessment were agreed by ACOM and are presented here. Estimated SSB, F and R were extremely similar to the ones obtained during WGBFAS.

The internal consistency plots of the surveys (Figure 5.24a and 5.24b) indicate an overestimation of younger age classes, especially between age 1-2 and age 2-3. The effect is more prominent in

BITS Q-1 than in BITS Q-4. 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 2021 Q1 survey shows a highly increased number of smaller plaice (age 1). As the index only takes into account plaice >20 cm, the effect of the large amount of small plaice is not fully covered by the survey index. A Length-based or biomass index (as used for the SPiCT) shows the effect more prominently.

The internal consistency in the commercial catches is quite good (Figure 5.25). 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_2021_SAM_final_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 2021, advice will be given by the results of the 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_2021_spict

5.3.4.1 Exploration of SAM

The stock is in a very good condition. The result shows (Figures 5.27a-c and Table 5.12) an increase in SSB from <3000 tonnes in 2010 to >5600 tonnes in 2015 and estimated to 24 301 tonnes in the intermediate year 2021. 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 incoming high amount of small plaice is likely to influence the recruitment but not yet the SB. The F in 2020 decreased significantly compared to the previous two years (0.156 in 2020, 0.226 in 2019, 0.312 in 2018) and has been constantly decreasing in the whole period. This is the case for all age groups except the older age groups (7, 8, 9+), which seem to have a slight increase (Figure. 5.28). The decreasing F is most likely a result of more reduced fishing effort and hence less landings due to the COVID-19 pandemic and restrictions in fishing time of the cod fisheries (e.g. closures for directed cod trawling). Previous years showed an increasing plaice-targeted fisheries due to the bad condition and reduced availability of the eastern cod stock. It is to be expected that F will increase once fishery can resume their regular fishing pattern. The recruitment is regarded as constantly increasing but with significant variation. The recruitment in 2020 is exceptionally high at estimated 51.1 mill. which is the highest value since 2002 and a doubling compared to the previous year.

The normalized residuals show some year effects for the commercial catches in the last two years (Figure. 5.29). 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. 5.30).

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 (2021–2020) divided with the relative SSB average of the preceding three years (2017–2019) - this estimate gives an increase of 67%. An uncertainty cap is applied as the calculated trend exceeds 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 1.27.

After a period of decreasing total landings (and catch) until 2017, the years 2018 and 2019 showed a very strong increase in total catch and decreased strongly in the most recent year (2020). Advice will be given based on the advised catch of the last year (2020). Following that approach, the advised total catch for 2022 is 3956 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 $F > F_{MSY}$).

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 5.23. See section 5.3.1 under "Description of the fishery" for historical trend details.

5.3.5 Recruitment estimates

The recruitment in 2020 is estimated to around 51.1 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 5.26 and Table 5.12.

5.3.6 Short-term forecast and management options

No short term forecast is given for the stock.

5.3.7 Reference points

5.3.7.1 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 2020 and the BITS biomass index Q1 and Q4. No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios $F/F_{MSY\ proxy}$ and $B/B_{MSY\ proxy}$ are used to estimate stock status relative to the MSY reference points and are used in the catch advice as an additional indicator of the stock status.

The results of the assessment are stating a good status of the stock, below or above the respective reference points and thus confirming the results of the SAM assessment and the stock trend of the BITS index. The results are however uncertain with considerable confidence intervals (Figure 5.30, Table 5.14). 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 17 years. From 2018, SPiCT results are used to give information on proxy reference points. The recent time-series of 17 years combined with continuously increasing data quality (in terms of spatiotemporal sampling coverage, amount of samples and error/consistency checks) and the comparison with the other stock trends (SAM, BITS) justifies the use of this model for the proxy reference points.

Despite the high variance, the model states a good stock condition in recent years and well within F_{MSY} and B_{MSY}. Following the ICES approach, a proxy for MSY $B_{trigger}$ can be calculated as 0.5 x B_{MSY}.

5.3.7.1.1 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 dataset and results of the SpiCT were tested for all the above criteria. All technical criteria were fulfilled. The current B_{MSY} / K is at 55% (2019 estimates). Several different runs with manually changed priors were conducted to test the variance parameters and determined if the calculated default values are reliable.

This is just an exemplary calculation to test the method and compare the results with the SAM assessement (which is used for the advice).

The final run in SPiCT is named: ple.27.2432_ 2020_spict

5.3.8 Quality of assessment

The stock is categorized as a Category 3.2 Data Limited Stock (DLS). Stock Trend analysis was made based on the results of the SAM assessment run. The relative SSB was used as index for estimating the stock trend. The calculated trend was used for calculating the catch in 2022 by applying the "2 over 3 rule" in the same way as the previous year. Even though the SAM assessment is "indicative of trends only", the assessment shows surprisingly robustness despite the relatively short time series available. This is expressed in the retrospective analysis which looks acceptable (Figure 5.29), although the rel. SSB shows a consistent overestimation. The F looks good, while the recruitment is poorly estimated, however improving in confidence intervals and estimates. The F by-age group is shown in Figure 5.27. The final summary plots (F_{bar}, Spawning-Stock Biomass (SSB) and recruitment) for the SAM run are shown in Figure 5.26a-c. The summary output from the SAM is shown in Table 5.13, the final numbers used for the advice are given in Table 5.13. 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.

5.3.9 Comparison with previous assessment

Compared to the first year of giving a catch advice in 2015 (before that, landings advice was given based on survey trends), no major changes were found. Both, the trend of the stock and the respective catch advice are similar to 2018 and 2019. The estimated relative F for 2020 (0.156) decreased compared to 2019 (0.226), which resulted out of a more plaice-targeted fisheries since 2018 but also low catches due to fishing restrictions inflicted by COVID-19 measures and strongly reduced fishing opportunities for cod; the relative recruitment estimates (3.5) increased strongly compared to the previous assessment (1.71). The relative SSB increased at the same level (2.4 to 3.5 in the last three years). Data quality is improving annually and with increased sampling by the member states.

5.3.10 Management considerations

To improve the exploratory assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

The sampling of biological data needs further enhancement, especially 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 5.10. ple.27.24–32. Plaice in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
Area	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
1970	494				16				149								
1971	314				2				107								
1972	290				2				78								
1973	203			44	1		174	30	75								
1974	126			10	2		114	86	60								
1975	184			67	1		158	142	45								
1976	178			82	3		164	76	44								
1977	221			36	2		265	26	41								
1978	681			1198	3		633	290	32								
1979	2027			1604	7		555	224	113								
1980	1652			303	5		383	53	113								
1981	937			52	31		239	27	118								
1982	393			25	6		43	64	40	6		7	1				
1983	297			12	14		64	12	133	20		24	2				

1984	166	2	8	106		23	3		4	1
1985	771	593	40	119	49	25	4		5	1
1986	1019	372	7	171	59	48	7		9	1
1987	794	142	16	188	5	68	10		12	1
1988	323	16	1	9	1	49	7		9	1
1989	149	5		10		34	5		6	1
1990	100	1	1	6		50				
1991	112		9	2	1	5	2		2	
1992	74		4	6		3	1		1	
1993	66		6	4		4				
1994	159			43	4	4	7			
1995	343		91	233	2	13	10	1		
1996	263		77	183	5	28	23	10	1	
1997	201		56	308	3	7	8		1	
1998	278		41	101	14	6	17		1	
1999	183		46	145	1	5	10			
2000	161		37	408	3	9	12			
2001	173		43	549	3	9	13			

2002***	153	159	0		137	7	429	3	10	15							
2003	326	299	2		68	25	480	10	16	51		0	0				
2004	167	239			50	13	292	8	6	37							
2005	164	241			90	17	511	11	16	28		0	0				
2006	82	632			173	11	52	3	17	41			0				
2007	408	490	0		151	12			41	61		0	0				
2008	450	339			150	10	29	0	45	69			0				
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			

2020	462	11	232	2	311	3	1	4	0	<1	0	0	0	0	0

***From October to December 1990 landings from Fed. Rep. of Germany are included.**

****For the years 1970–1981 and 1990 the Swedish landings of subdivisions 25–28 are included in Subdivision 24.**

*****From 2002 and onwards Danish and German, FRG landings in SW Baltic were separated into subdivisions 24 and 25.**

Table 5.11. 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	691.59	186.12	1213.08	2267.30	4358.09
		Discards	169.90	13.32	115.03	48.42	346.67
		BMS landing	0.98	0.00	1.34	13.73	16.04
	Germany	Landings	132.39	226.61	1062.84	765.38	2187.21
		Discards	33.15	18.07	82.06	201.61	334.88
		BMS landing	5.00	0.00	5.00	6.00	16.00
	Poland	Landings	955.61	175.27	499.95	385.98	2016.81
		Discards	101.92	2.46	14.55	83.78	202.72
		BMS landing	0.50	0.00	0.00	0.15	0.65
	Sweden	Landings	5.52	2.52	0.39	1.19	9.62
		Discards	1.29	0.11	0.01	0.45	1.86
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.25	Denmark	Landings	48.04	0.26	0.22	17.79	66.31
		Discards	18.25	0.01	0.02	2.03	20.31
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Germany	Landings	9.59	4.75	3.75	0.00	18.10
		Discards	2.45	0.38	0.36	0.00	3.19
		BMS landing	3.99	0.06	0.00	0.23	4.28
	Lithuania	Landings	5.00				5.00
	Poland	Landings	206.64	90.77	283.36	451.90	1032.67
		Discards	54.52	1.55	24.15	87.21	167.43
		BMS landing	0.96	0.00	0.05	0.00	1.01
	Sweden	Landings	29.38	2.08	2.12	4.49	38.07
		Discards	7.49	0.06	0.05	0.51	8.11
		BMS landing	0.00	0.00	0.00	0.00	0.00
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	Landings			0.00	0.00	0.00

Area	Country	Catch Category	1	2	3	4	Total*
		Discards			0.63	0.31	0.95
		Logbook Registered Discard			0.00	0.00	0.00
	Lithuania	Landings	0.00	0.00	0.00	0.00	0.00
		Discards			0.00	0.00	0.00
	Poland	Landings	0.00	0.63	0.38	26.36	27.37
		Discards	0.00	0.01	0.01	7.71	7.73
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	0.00	0.00	0.01	0.00	0.01
		Discards			0.00		0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.28	Lithuania	Landings	0.00	0.00	0.00	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.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		0.01	0.04	0.01	0.06
		Discards		0.00	0.00	0.00	0.00
		BMS landing		0.00	0.00	0.00	0.00
27.3.d.31	Sweden	Landings		0.00	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 5.12. ple.27.24-32. Estimated recruitment (thousands), total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 2 to 5 (F25).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F25	Low	High
2002	4560	3154	6592	2268	1583	3250	1086	721	1636	0.907	0.613	1.343
2003	6083	4430	8352	2601	1982	3412	1195	880	1624	1.156	0.834	1.603
2004	7465	5342	10432	3037	2348	3929	1320	1022	1706	0.633	0.448	0.894
2005	6459	4611	9048	3645	2821	4709	1815	1409	2339	0.339	0.226	0.508
2006	5954	4243	8355	4293	3335	5527	2451	1893	3173	0.409	0.284	0.589
2007	4615	3250	6552	4389	3420	5634	2774	2137	3601	0.56	0.391	0.803
2008	4582	3201	6560	3994	3132	5093	2561	1986	3302	0.551	0.39	0.78
2009	7276	5142	10297	4146	3274	5251	2418	1897	3082	0.587	0.419	0.822
2010	12154	8346	17698	5170	4025	6641	2575	2040	3251	0.644	0.463	0.895
2011	13134	9013	19138	6333	4814	8332	3100	2406	3994	0.649	0.464	0.906
2012	8593	6290	11738	6439	4941	8392	3542	2697	4652	0.648	0.462	0.91
2013	13014	9654	17544	6818	5402	8606	3634	2829	4669	0.687	0.475	0.992
2014	14639	10748	19940	7445	6000	9238	3819	3083	4731	0.291	0.178	0.476
2015	19125	13909	26296	10067	8119	12482	5361	4340	6622	0.242	0.154	0.381
2016	26513	18760	37470	13887	11114	17352	7535	6079	9340	0.262	0.167	0.411
2017	27688	19224	39878	17527	13909	22086	10079	8056	12609	0.201	0.119	0.338
2018	27477	18085	41747	21380	16699	27374	13280	10426	16915	0.312	0.182	0.535
2019	28012	16762	46812	23371	17545	31132	15050	11377	19909	0.226	0.124	0.411
2020	51063	27055	96375	30101	21086	42969	18372	13156	25657	0.156	0.078	0.31
2021	59294	25414	138342	39410	25224	61573	24301	16442	35916	0.158	0.053	0.475

Table 5.13. 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	0.30	0.172	915	353	1.82
2003	0.40	0.189	1281	271	2.3
2004	0.49	0.21	1081	214	1.27
2005	0.43	0.29	1081	166	0.68
2006	0.39	0.39	1012	818	0.82
2007	0.30	0.44	1167	491	1.12
2008	0.30	0.41	1102	294	1.11
2009	0.48	0.38	1226	418	1.18
2010	0.80	0.41	903	998	1.29
2011	0.87	0.49	748	1377	1.30
2012	0.57	0.56	848	917	1.30
2013	0.86	0.58	738	781	1.38
2014	0.96	0.61	534	481	0.58
2015	1.26	0.85	427	220	0.49
2016	1.75	1.19	521	1058	0.53
2017	1.82	1.60	650	408	0.40
2018	1.81	2.10	1644	711	0.63
2019	1.85	2.38	1741	617	0.45
2020	3.36	2.91	1024	223	0.31
2021		3.85			

Table 5.14. ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002–2020.

Deterministic reference points (Drp)					
		estimate	cilow	ciupp	log.est
	Bmsyd	1442.0626	588.1020	3536.0270	7.2738
	Fmsyd	1.2757	0.5468	2.9765	0.2435
	MSYd	1839.6987	1608.5633	2104.0460	7.5174
Stochastic reference points (Srp)					
		estimate	cilow	ciupp	log.est
	Bmsys	1441.8227	608.2437	3417.7955	7.2737
	Fmsys	1.2673	0.5719	2.8087	0.2369
	MSYs	1827.2877	1594.8468	2093.6056	7.5106
States	**w**	**0.95**	**CI**	**(inp$msytype:**	**s)**
		estimate	cilow	ciupp	log.est
	B_2020.88	2823.3469	1186.9043	6716.0327	7.9457
	F_2020.88	0.4196	0.1616	1.0897	-0.8684
	B_2020.88/Bmsy	1.9582	1.3730	2.7927	0.6720
	F_2020.88/Fmsy	0.3311	0.1699	0.6454	-1.1054
Predictions	**w**	**0.950**	**CI**	**(inp$msytype:**	**s)**
		prediction	cilow	ciupp	log.est
	B_2021.00	2866.7630	1211.3613	6784.3756	7.9609
	F_2021.00	0.4181	0.1520	1.1496	-0.8721
	B_2021.00/Bmsy	1.9883	1.3936	2.8368	0.6873
	F_2021.00/Fmsy	0.3299	0.1564	0.6959	-1.1090
	Catch_2021.00	1251.4325	587.1859	2667.0999	7.1320
	E(B_inf)	3316.3930			8.1066

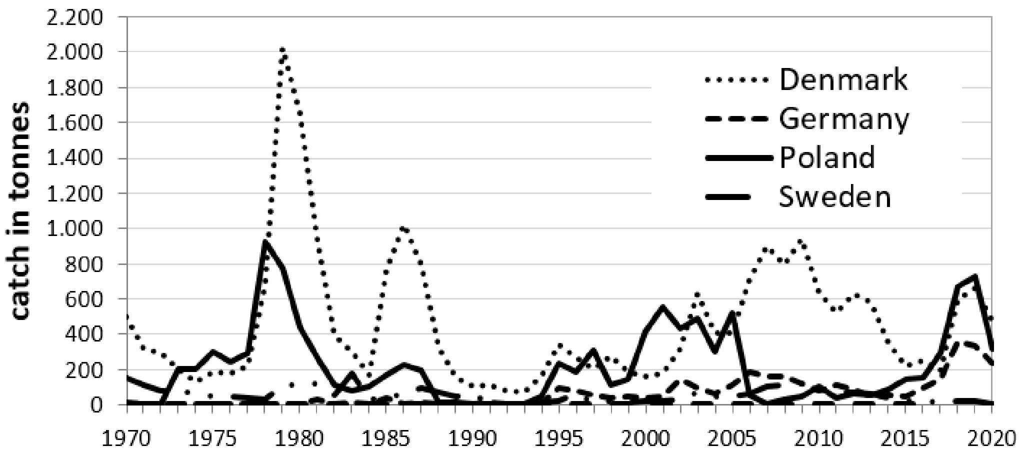


Figure 5.20. ple.27.24-32. Historical landings per country (in tonnes).

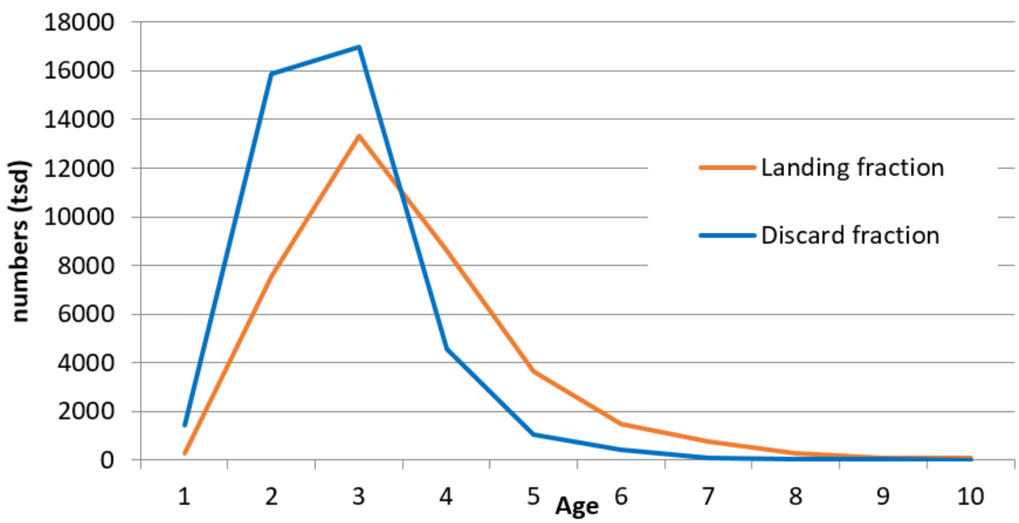


Figure 5.21. ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

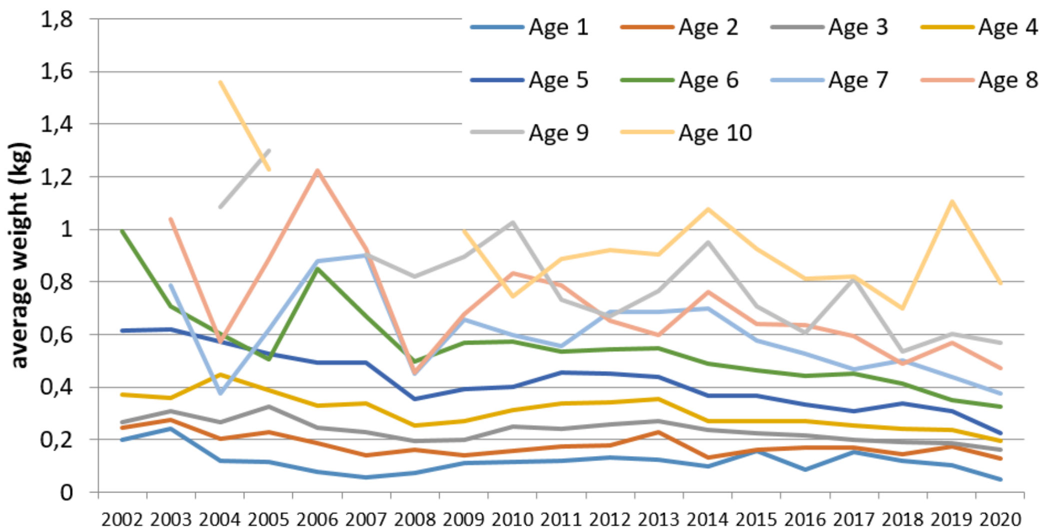


Figure 5.22. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined.

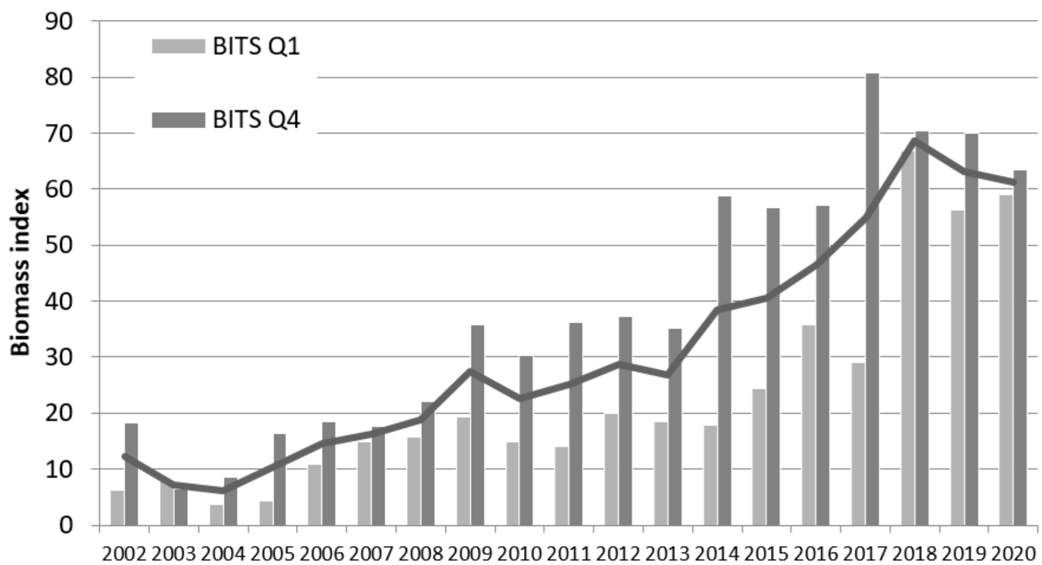


Figure 5.23. ple.27.24-32. Average biomass index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2020 data (Q4) are preliminary.

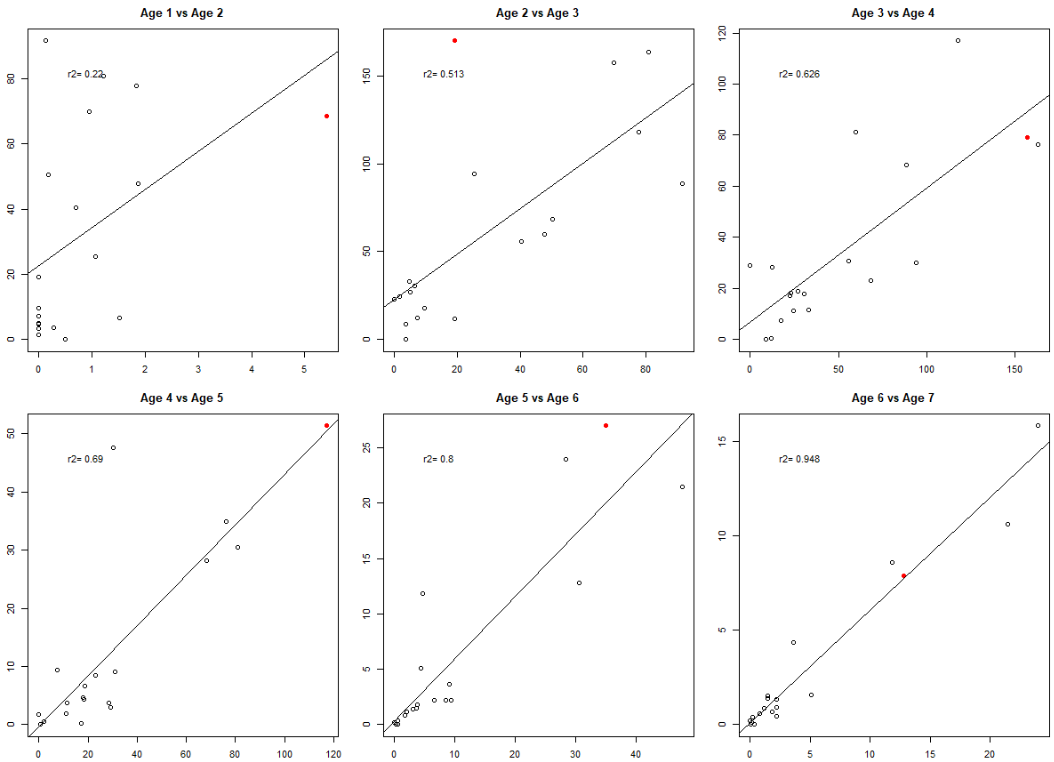


Figure 5.24a. ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

Figure 5.24b. ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.

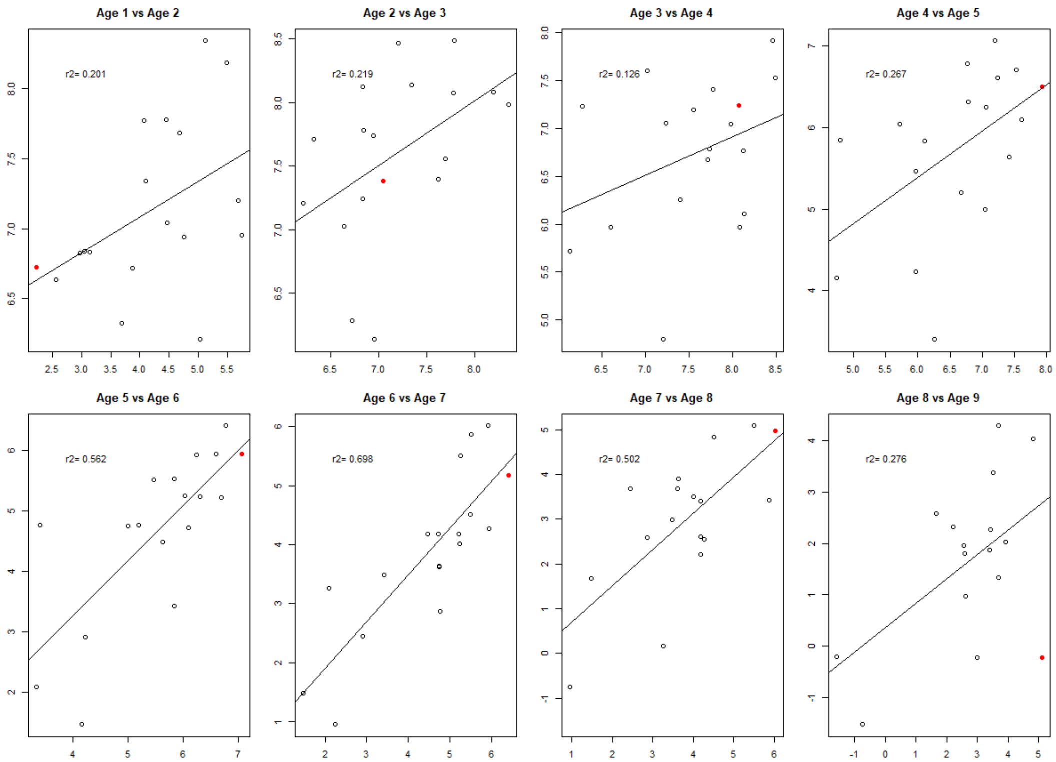


Figure 5.25. ple.27.24-32. Internal consistency of age classes 1–7 from commercial catches. All fleets and countries were combined.

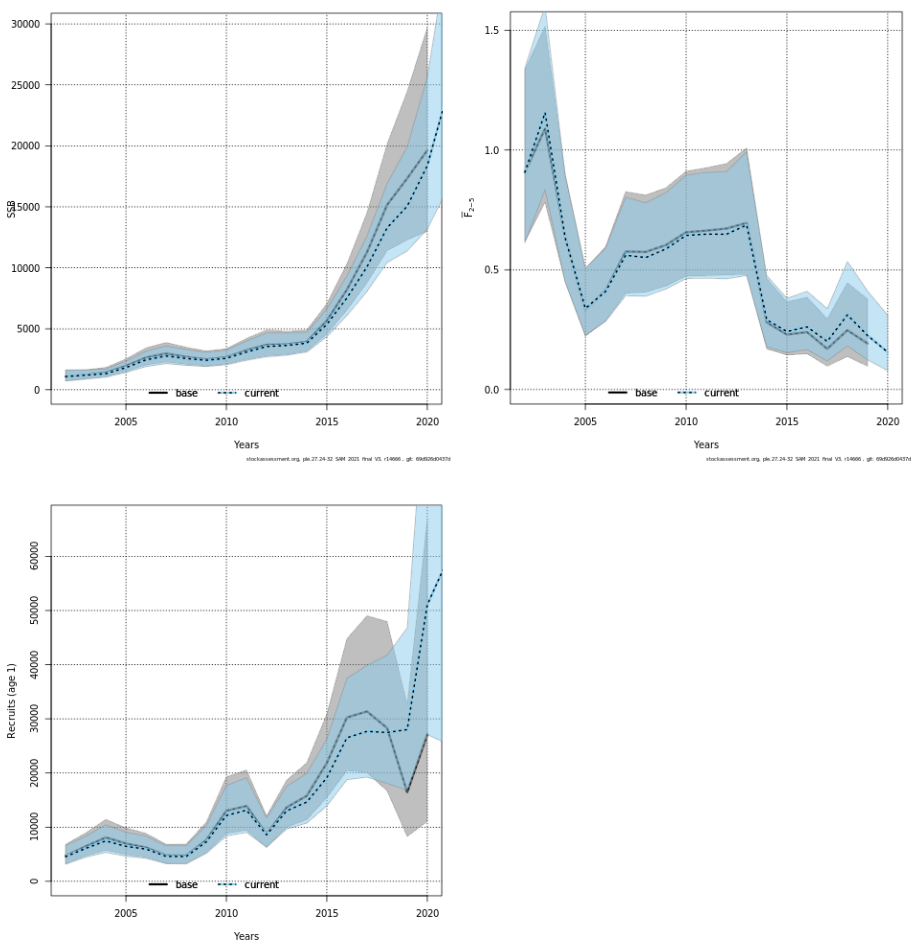


Figure 5.26. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment.

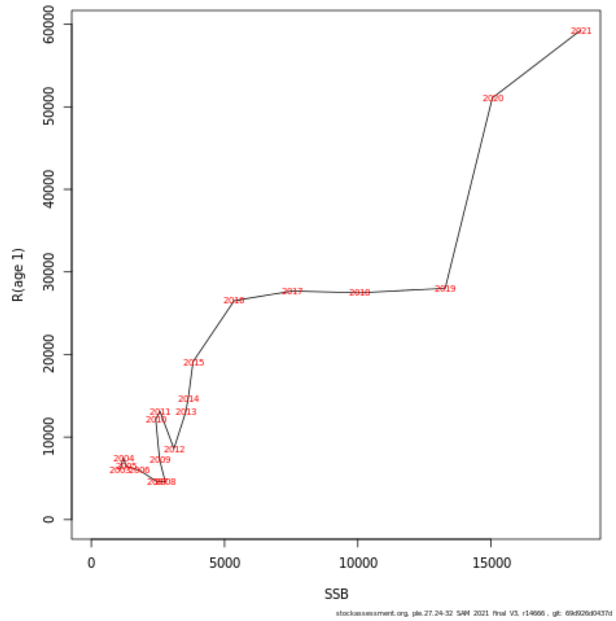


Figure 5.27. ple.27.24-32. Estimated recruitment as a function of spawning stock biomass.

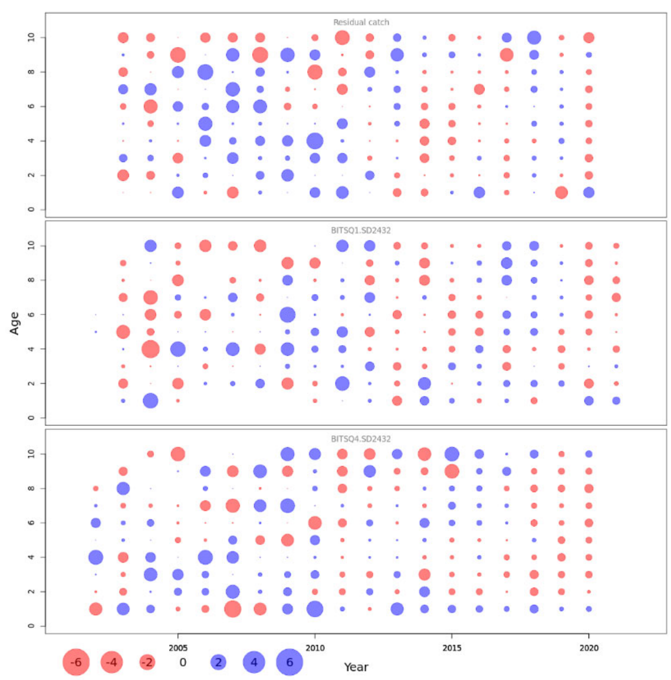


Figure 5.28. ple.27.24-32. Normalized residuals for the current run. Blue circles indicate positive residuals (observations larger than predicted) and filled circles indicate negative residuals.

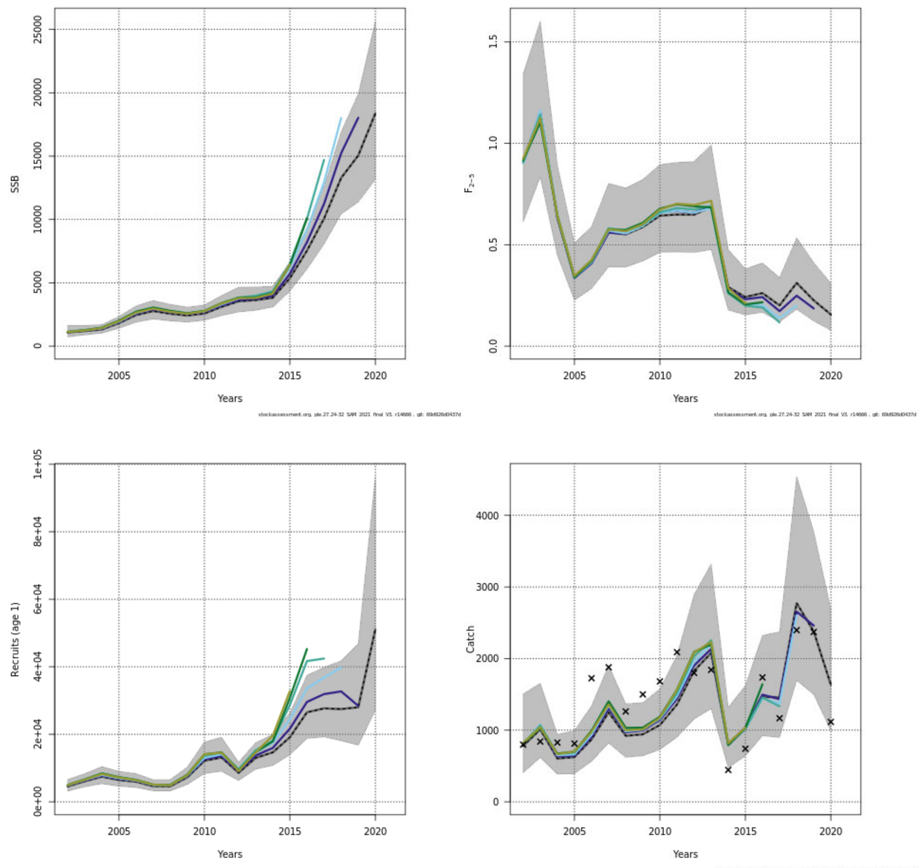


Figure 5.29. ple.27.24-32. The results of the retrospective analysis showing SSB, total catch, F (3–5) and recruitment.

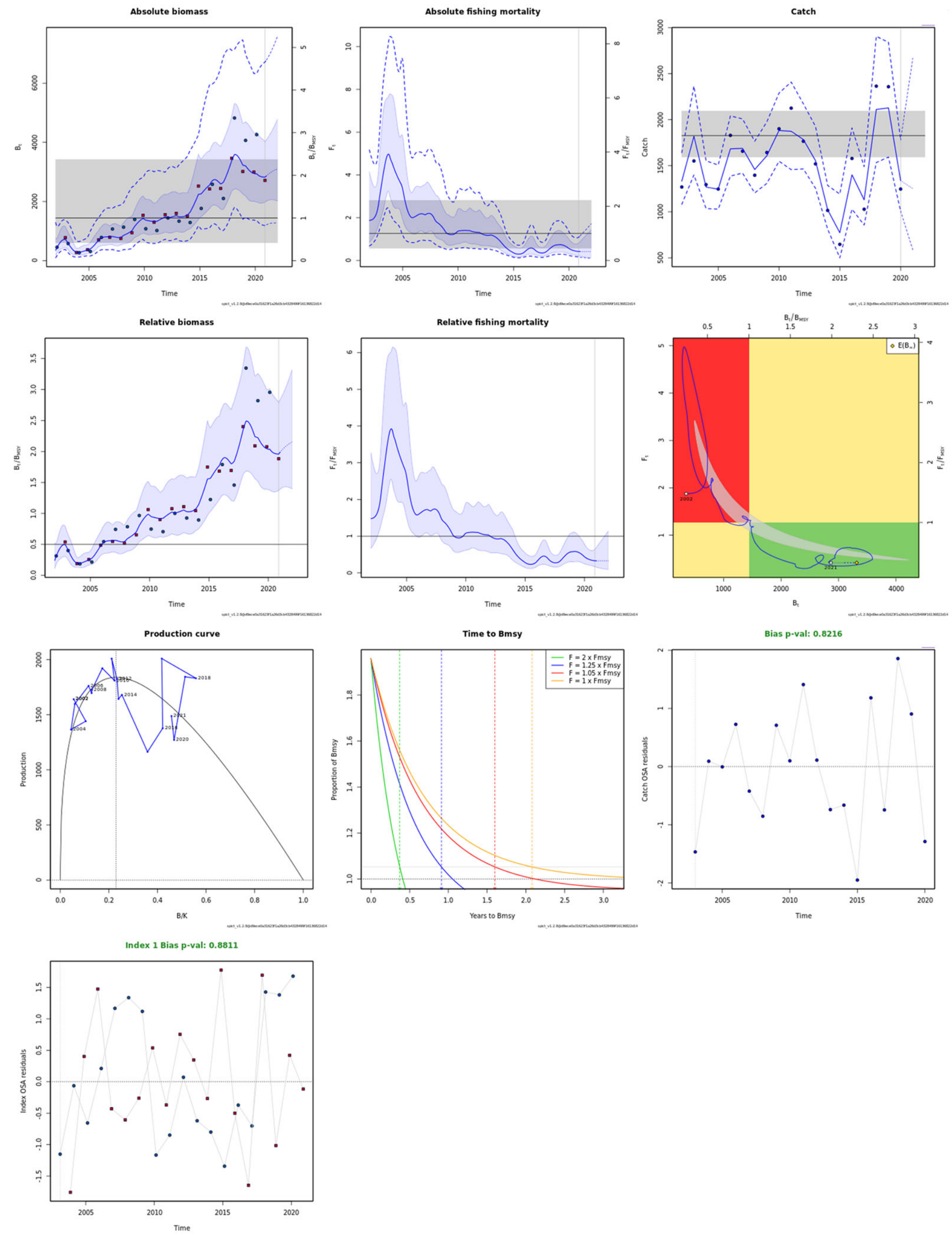


Figure 5.30. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2020.

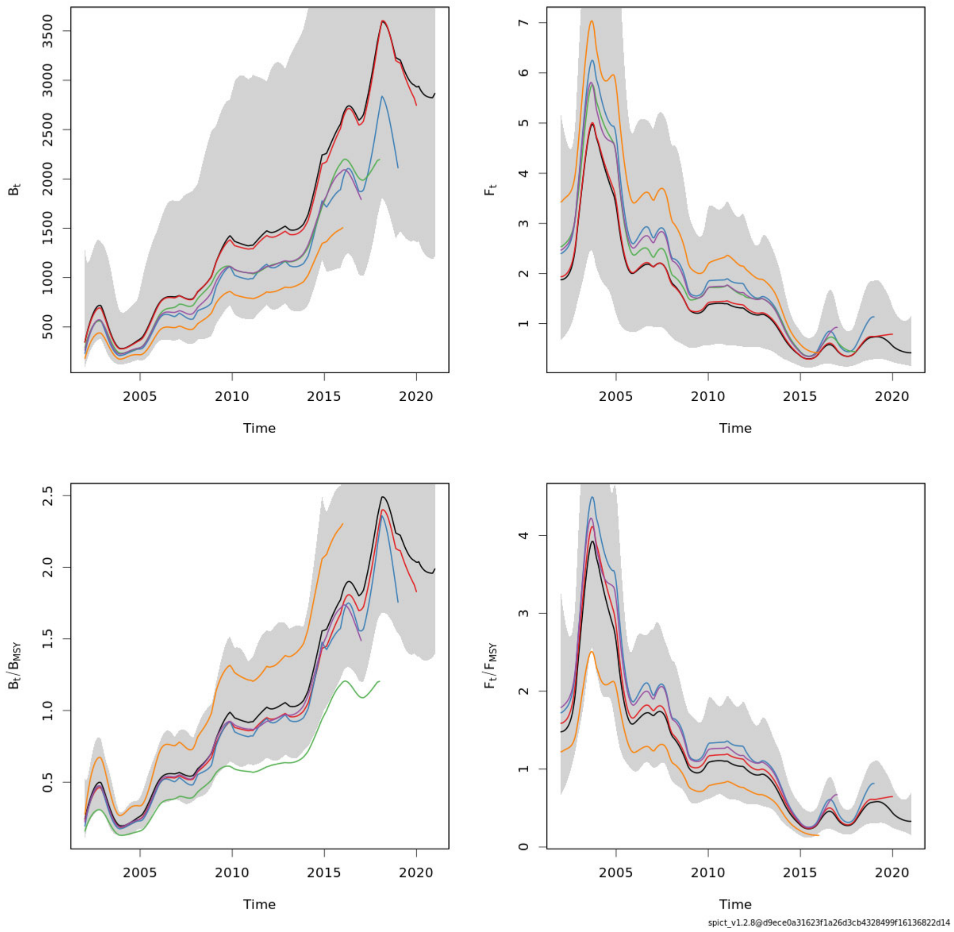


Figure 5.31. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2020

6 Sole in subdivisions 20–24 (Skagerrak, Kattegat, the Belts, and Western Baltic)

6.1 The Fishery

Sole is economically an important species in in the Danish fisheries. For both Kattegat and Skagerrak the major part of the sole catches is taken in the mixed species trawl fishery, using mesh sizes 90–105 mm and with gillnets using mesh sizes of 90–120 mm. The landings share of active and passive gears is approx. 55/45 variable between years. 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 2020 are given in Table 6.1. Denmark took 78% of the total catch in 2020. 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 provide the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2021, 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 2020 amounts to 3% of the catches by weight based on sampling from trawlers (Table 6.3) and the average of the recent 5 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 from 1994–2007 (Table 6.5).

6.2 Biological composition of the catch

6.2.1 Catch in numbers

Sampling of age structure of the catch was available only for the Danish fishery (Table 6.4). Overall the sampling has improved from the past (approx. 500 specimens from the catches). In 2020, landings from the Belts and the Skagerrak were not successfully sampled. 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 two decades, 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. The trend for 2020 vs. 2019 mean weights are that younger (2-7) age groups tend to decrease in weight while the oldest age groups increased.

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). The Belts and the Skagerrak was not sampled in 2020. The small and scattered catches in the fishery for sole mainly caught as by-catch requires a huge effort in port sampling and many port trips for samplings are therefore in vein. The improved sampling effort in recent three years seem to have a positive effect on the assessment quality in reducing retrospective patterns in stock and fishery development. Presently the retrospective pattern is non-existent.

6.3 Fishery independent information

Since 2004 a survey conducted cooperatively by DTU Aqua and with Danish fishers was designed with fixed haul positions chosen by both scientific and fishers. The survey takes place in November-December and covers the central part of the stock (Figure 6.4). The survey ceased in 2012–13 but resumed in 2014. Since 2016 the survey was redesigned to cover more areas in Skagerrak and also in the Belts. Figure 6.5 show the progressive expansion of the survey. The extended area has not been utilized in the survey index calculation, but awaits a longer time-series for further evaluation. Catch rates from the additional areas in Skagerrak was lower than for the core survey area in Kattegat. Based on 90 successful hauls out of 90 planned hauls in 2019, age disaggregated indices from the survey are used for the analytical assessment (Table 6.5). The index is estimated by a GAM model that takes into account spatial diversity of growth and that the survey coverage have been reduced over time (see stock annex). The aggregated index show an increasing trend in catch rates in 2020 and also confirmed 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_2021' and is visible at stockassessment.org.

6.4.1 Model residuals

Model residuals for the survey and catches are provided in Figure 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 6.10. The SSB has increased since 2015 and is in 2020 estimated to be at 2939 t. Fishing mortality has decreased since 2017 and has been below F_{MSY} since then. Recruitment calculated as age 1 has since 2010 been low but has increased since 2015 (Figure 6.10, Table 6.10). The good 2017 year class is confirmed in the survey and in the fisheries.

6.4.4 Retrospective analysis

Retrospective pattern (Figure 6.11) of the SSB and F estimates a nearly non-existent for the past 3 years. Mohns rho are in the range 0.02 to -0.04 for SSB, F and recruitment. 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 6.8 and 6.9, and the stock summary is given in Table 6.10 and Figure 6.10. SSB was estimated at 2939 t in 2020. Fishing mortality has decreased continuously since 2005 with a sudden increase in 2017 but has decreased again to 0.196 in 2020.

Recent recruitment, the 2017, 2018, and 2019 year classes, are estimated higher than previous year classes and expected to contribute to a more robust SSB in the coming years (tables 6.9 –6.10 and Figure 6.13).

6.5 Short-term forecast and management options

Input data to short-term prediction are provided in tables 6.11- 6.12.

Discards are not included in the assessment but comprise 3% in weight in 2020 (Table 6.3). The average of the discard in the recent 5 years (3%) is added to landings to derive advised catches for 2022.

Assumed recruitment ages 1 averaged for 2004-2020 led to an assumed recruitment 2021-2022 of 2848 thousands and 2669 thousands respectively.

TAC has not been utilized in 2020 and preliminary information on Danish catches in the first quarter of 2020 are lowest in the time-series. In addition, the Corona virus situation in 2020-2021 might likely cause some limitations for the fishery. Therefore, the TAC of 596 t for 2021 is assumed unlikely to be caught and status quo F is continued as catch option for the intermediate year (2021). An Fsq ($F = F_{2020}$) assumption leads to a catch of 521 t in 2021. The basis for Fsq (F_{2021}) is an average of recent Fs (e.g. 3 yrs) scaled to the final year (= 0.196). Catch options are provided in Table 6.12.

Given the Fsq scenario, SSB in the beginning of 2022 is estimated to 3756 t (Table 6.13). With this assumption, the forecast predicts that fishing at F_{MSY} in 2022 will lead to a total yield of 723 t. At this level of exploitation, spawning stock biomass is estimated at 3590 t in 2023. Catch in 2021/2022 and stock composition in 2022/2023, is estimated to be dominated by age 4 to 6 as indicated in Figure 6.13 under the assumed conditions in 2021.

EC has since 2018 requested advice for the sole stock in SD 20–24 based on F_{MSY} ranges. Catches in 2022 corresponding to F_{MSY} upper and lower range (F = 0.19–0.26) are 544–723 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 0.83 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. In 2021 the basis for F_{pa} have been decided to be based on F_{p05} (estimated to 0.26 in 2015 benchmark). This has caused F_{pa} to change from 0.23 (capped previously by F_{pa}) to the F_{MSY} estimate derived from stochastic equilibrium scenarios at 0.26. F_{MSY} lower is not recalculated since the F_{MSY} remain the uncapped value estimated in 2015.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Bt_{rigger}	2600 t	B_{pa}	ICES (2015)
	F_{MSY}	0.26	Equilibrium scenarios stochastic recruitment, short time-series 1992–2014,.	ICES (2015)
	F_{MSY} lower	0.19	F_{MSY} lower without AR from equilibrium scenarios	ICES (2015)
	F_{MSY} upper	0.26	F_{MSY} upper capped by Fp05 with AR from equilibrium scenarios	ICES (2015)
Precautionary approach	B_{lim}	1850 t	B_{loss} from 1992 (low productivity regime)	ICES (2015)
	B_{pa}	2600 t	B_{lim} × e 1.645σ, σ = 0.20	ICES (2015)
	F_{lim}	0.315	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic recruitment	ICES (2015)
	F_{pa}	0.26	Fp05 from equilibrium scenarios w. stochastic recruitment, short time-series 1992–2014	ICES (2021)
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 been a challenge for a long time 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 Danish 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 have all improved significantly and are all 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 the sole 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 and will be dealt with at a forthcoming benchmark.

6.8 Comparison with previous assessment

This year's assessment is 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 un-coupling 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 Div 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 Div 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.

The project is expected to provide results in early 2022.

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.
- Potential inclusion of expanded survey area since 2016 (Skagerrak, the Belts and the western Baltic).

Table 6.1. Sole 20-24. Landings (t) of sole in 2020 by area, nation, quarter and gear.

Skagerrak (SD20)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	16	63	5	26	71	70	109
Germany	0	4	0	0	0	4	4
Sweden	0	0	0	0	1	0	1
Netherlands	10	1	12	37	46	0	60
Norway	0	1	0	0		1	
Total	26	68	17	63	118	74	174

Kattegat (SD21)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
DK	26	22	15	73	106	30	136
Germany	0	6	8	3	0	17	17
Sweden	1	1	3	3	3	4	7
Total	27	29	26	78	109	52	161

Belts and Baltic (SD22-24)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
DK	7	23	14	42	27	58	85
Germany	0	1	0	1	1	2	5
Sweden	0	1	0	0	0	1	1
Total	0	0	1	0	28	61	91

Table 6.2. Sole 20--24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2020. 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	20-24	20-24	Skagerrak	Skagerrak	Corrections	
1952	156			51	59				266
1953	159			48	42				249
1954	177			43	34				254
1955	152			36	35				223
1956	168			30	57				255
1957	265			29	53				347
1958	226			35	56				317
1959	222			30	44				296
1960	294			24	83				401
1961	339			30	61				430
1962	356				58				414
1963	338				27				365
1964	376				45				421
1965	324				50				374
1966	312				20				332
1967	429				26				455
1968	290				16				306
1969	261				7				268
1970	158	25							183
1971	242	32			9				283
1972	327	31			12				370
1973	260	52			13				325
1974	388	39			9				436
1975	381	55		16	16		9	-9	468
1976	367	34		11	21	2	155	-155	435
1977	400	91		13	8	1	276	-276	513
1978	336	141		9	9		141	-141	495
1979	301	57		8	6	1	84	-84	373
1980	228	73		9	12	2	5	-5	324
1981	199	59		7	16	1			282
1982	147	52		4	8	1	1	-1	212
1983	180	70		11	15		31	-31	276
1984	235	76		13	13		54	-54	337
1985	275	102		19	1	+	132	-132	397
1986	456	158		26	1	2	109	-109	643
1987	564	137		19		2	70	-70	722
1988	540	138		24		4			706
1989	578	217		21	7	1			824
1990	464	128		29		2		427	1050
1991 [1]	746	216		38	+			11	1011
1992	856	372		54				12	1294
1993	1016	355		68	9			-9	1439
1994	890	296		12	4			-4	1198
1995	850	382		65	6			-6	1297
1996	784	203		57	612			-597	1059
1997	560	200		52	2				814
1998	367	145		90	3				605
1999	431	158		45	3				637
2000	399	320	13	34	11			-132 [2]	645
2001 [1]	249	286	21	25				-103 [2]	478
2002 [3]	360	177	18	15	11			281	862
2003 [3]	195	77	17	11	17			301	618
2004 [3]	249	109	40	16	18			392	824
2005 [3]	531	132	118	30	34	Norway		145	990
2006	521	114	107	38	43	9	4		836
2007	366	81	93	45	39	9	0		633
2008	361	102	113	34	35	7	3		655
2009	325	103	145	37	27	4			641
2010	273	61	125	46	26	3	3		538
2011	271	127	65	53	33	3			552
2012	154	140	28	30	0	6	0		358
2013	153	78	33	54	9	6	0		332
2014	141	104	48	36	2	3	0		335
2015	95	66	36	9	7	5	6		224
2016	164	78	56	14	17	2	16		348
2017	215	166	46	19	21	2	31		501
2018	158	140	57	16	15	0	47		434
2019	150	88	82	13	15	2	69		417
2020	136	109	85	9	24	1	60		424

Considerable non-reporting assumed for the period 1991–1993. [2]Catches from Skagerrak were reduced by these amounts because of misreporting from the North Sea. The subtracted amount has been added to the North Sea sole catches. Total landings for these years in IIIA has been reduced by the amount of misreporting. [3]Assuming misreporting rates at 50, 100, 100 and 20% in 2002-2005, respectively.

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

Discard in weight (kg)																			
Age	Year																		
	1999	2000	2001	2002	2003	2004	2005	2006-2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	-	7,992	-	-	-	-	-	-	616	140	128	490	3,128	1,156	5,913	254	230	219	348
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	1,236
3	-	119,198	-	-	7,040	-	-	-	2,646	1,105	1,782	1,872	19,126	-	1,800	9,733	2,457	1,281	3,686
4	-	4,592	-	4,171	10,366	-	-	-	2,175	972	4,032	954	1,316	1,076	3,408	1,117	568	2,465	474
5	-	-	-	1,962	-	-	-	-	2,499	888	680	510	1,785	981	14	1,404	1,379	1,306	973
6	-	-	-	-	588	-	-	-	166	480	928	1,232	972	264	315	692	588	518	703
7	-	-	-	-	158	-	-	-	1,080	714	570	1,030	1,800	-	702	315	716	155	1,093
8	-	-	-	-	123	-	-	-	291	545	248	416	1,220	296	-	603	30	441	1,105
9	-	-	-	-	-	-	-	-	1,197	306	572	708	232	-	172	345	143	103	2,319
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	12
Landings(	637	645	478	862	618	826	994	706	538	552	359	332	335	224	348	520	348	417	424
Catches	637	814	478	872	661	826	994	706	552	560	370	342	367	230	365	537	355	425	436
Discard %	0%	21%	0%	1%	6%	0%	0%	0%	3%	1%	3%	3%	9%	2%	5%	3%	2%	2%	3%

Table 6.4. Sole 20-24. Sampling and ageing in 2020 from landings.

	Belts and Baltic			Skagerrak			Kattegat			Total		
Quarter	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged
1	7,099	-	-	22,806	-	-	26,726	24,463	110	56,631	24,463	110
2	24,326	19,873	84	46,841	-	-	29,227	5,369	43	100,394	25,242	127
3	14,025	7,219	25	26,412	-	-	26,210	6,098	132	66,648	13,317	157
4	43,266	-	-	63,871	-	-	78,477	69,980	128	185,614	69,980	128
Total	88,716	27,092	109	159,930	-	-	160,641	105,910	413	409,287	133,002	522

Table 6.5. Sole 20-24. Tuning fleets.

103									
Fisherman-DTU Aqua survey meth 6									
2004	2020								
1	1	0.8	1						
1	9								
1	16.81675	55.63244	49.86173	31.46729	21.69616	9.002508	7.380025	4.444972	6.001396
1	12.93771	38.61357	67.95328	36.36597	18.02666	8.16397	2.848377	1.775283	1.420126
1	34.49954	38.78635	28.75918	51.29957	25.71245	13.9948	4.849805	1.591302	5.076621
1	32.0475	33.68539	24.55375	29.82973	31.05507	20.81031	11.94609	7.20201	12.66451
1	10.06202	46.30325	27.801	15.74882	13.38554	17.46229	7.388407	6.721877	7.692608
1	15.82009	13.8231	30.47798	12.87098	16.29397	15.52828	18.99879	7.125988	8.194522
1	13.92305	16.65361	19.71129	18.01859	7.321337	10.3888	8.675918	12.76415	14.76453
1	15.05429	30.23019	18.14685	17.38298	16.10598	10.18371	9.1238	4.181539	19.67623
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	22.3673	17.57118	19.50865	14.7055	12.53922	9.709523	4.090422	8.794353	12.48183
1	34.29962	29.30396	17.14458	15.57881	9.772076	17.79977	6.588998	4.828371	31.37076
1	18.24567	38.89483	27.62885	14.87994	14.22831	4.173854	7.880067	4.589344	27.06012
1	10.79649	50.54734	37.52496	24.32936	7.883941	12.43821	2.319349	2.338682	22.41587
1	41.78173	17.7488	39.93127	35.85389	15.6868	6.174575	7.157482	3.119242	21.6421
1	26.39153	69.97627	14.57185	31.64473	18.97451	15.03203	4.046981	3.637353	18.04592
1	30.60060	39.04576	50.90428	7.96066	19.942845	19.282380	10.310789	1.558742	21.663393

Private logbooks Gillnet KC + KS combined

1994	2007							
1	1	0.25	0.87					
2	9							
7246	1071	8794	7892	2547	1254	268	187	60
5900	682	3284	6795	4942	1673	936	203	153
24238	4914	19748	8589	10880	6350	2872	1578	948
19939	1303	5568	8787	7036	9251	6658	4775	3280
18984	2685	3309	3816	4869	2632	3033	3443	2270
19917	10704	33215	3187	3507	2700	2176	1978	1633
23645	2336	12192	11953	1815	2285	2461	2222	2315
17755	5721	11108	9181	3953	1463	2717	812	1260
19930	17094	20860	6010	6043	6757	2384	2155	2801
13812	2029	17166	16000	4387	7051	2468	395	691
5518	547	3854	4483	2289	1391	864	523	226
9067	2827	11590	13754	5559	1832	485	455	170
9742	1495	5999	10446	8760	5434	1443	991	287
7026	1374	2638	2360	3039	1856	920	394	319

Private logbook TR KC+KS combined

1987	2008		
1	1	0.75	1
2	6		

712	2756	5140	5562	2667	954
876	5667	7735	5361	3432	1025
933	5097	2253	3761	2825	2126
1174	16408	10277	2753	3874	1545
1809	16085	35139	14745	4452	3878
3136	56849	46507	16304	7177	1545
4035	41739	44475	19945	11105	6685
5276	9498	55455	64125	19324	12725
4969	42026	35885	41231	29359	14705
4294	24861	38831	23489	26033	16360
4027	3927	13138	14220	10668	13279
2464	12543	3357	1117	1041	1736
2142	13031	24798	3690	4268	3927
3342	9566	16153	20370	3215	2692
2268	6292	11562	6052	6953	635
1498	29987	20538	4835	5483	3963
2093	7473	21584	14949	7199	3760
3999	20124	39887	47640	18374	8401
2463	7956	34026	29590	16011	6975
3132	11878	14708	24084	19146	12809
2730	14422	11847	4636	8756	515
1281	4393	2674	2438	2735	2130

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

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,
AGE							
2,	64,	786,	258,	391,	516,	863,	1209,
3,	638,	594,	1255,	857,	1035,	613,	1300,
4,	240,	190,	671,	1018,	897,	847,	651,
5,	117,	55,	210,	434,	484,	592,	564,
6,	31,	60,	33,	174,	129,	404,	310,
7,	33,	16,	36,	64,	37,	83,	167,
8,	40,	8,	33,	31,	23,	30,	27,
+gp,	175,	69,	63,	87,	60,	52,	31,
0 TOTALNUM,	1338,	1778,	2559,	3056,	3181,	3484,	4259,
TONSLAND,	337,	397,	643,	722,	706,	824,	1050,
SOPCOF %,	99,	100,	100,	100,	100,	100,	100,

YEAR,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000,
AGE										
2,	530,	506,	523,	127,	272,	316,	54,	303,	249,	142,
3,	1301,	1178,	1804,	1037,	622,	1015,	251,	146,	826,	483,
4,	928,	939,	1251,	1451,	1359,	537,	440,	212,	150,	771,
5,	334,	493,	826,	752,	1226,	691,	365,	299,	228,	114,
6,	345,	320,	418,	444,	600,	440,	505,	267,	177,	130,
7,	302,	178,	117,	152,	385,	232,	360,	250,	165,	123,
8,	180,	166,	137,	45,	142,	148,	262,	218,	167,	135,
+gp,	76,	239,	157,	59,	104,	203,	263,	292,	233,	306,
TOTALNUM,	3996,	4019,	5233,	4067,	4710,	3582,	2500,	1987,	2195,	2204,
TONSLAND,	1011,	1294,	1439,	1198,	1297,	1059,	814,	605,	638,	646,
SOPCOF %,	95,	93,	100,	99,	98,	98,	100,	100,	100,	100,

1

YEAR,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010,
AGE										
2,	170,	655,	48,	195,	231,	122,	293,	313,	554,	230,
3,	369,	758,	431,	602,	1015,	400,	420,	330,	683,	591,
4,	360,	285,	480,	814,	1083,	857,	384,	354,	445,	458,
5,	354,	423,	280,	475,	583,	734,	583,	297,	285,	211,
6,	68,	472,	344,	257,	276,	505,	299,	489,	139,	132,
7,	84,	94,	197,	187,	117,	169,	135,	240,	92,	67,
8,	36,	85,	25,	86,	102,	67,	81,	179,	29,	83,
+gp,	205,	464,	210,	171,	91,	116,	108,	202,	88,	103,
0 TOTALNUM,	1646,	3236,	2015,	2787,	3498,	2970,	2303,	2404,	2315,	1875,
TONSLAND,	476,	862,	619,	824,	990,	836,	633,	656,	640,	541,
SOPCOF %,	99,	100,	100,	99,	98,	98,	97,	102,	98,	101,

YEAR,	2011,	2012,	2013,	2014,	2015,	2016,	2017,	2018,	2019,	2020,
AGE										
2,	138,	26,	48,	13,	37,	110,	137,	32,	163,	45,
3,	558,	157,	226,	66,	81,	273,	181,	131,	59,	325,
4,	613,	284,	286,	178,	95,	190,	347,	268,	309,	96,
5,	246,	160,	194,	109,	109,	175,	195,	201,	268,	228,
6,	65,	111,	137,	199,	89,	82,	186,	97,	93,	243,
7,	28,	36,	62,	105,	81,	38,	163,	144,	54,	120,
8,	14,	54,	23,	68,	18,	50,	120,	104,	83,	34,
+gp,	106,	192,	96,	69,	93,	181,	301,	157,	235,	214,
0 TOTALNUM,	1768,	1020,	1072,	807,	603,	1099,	1630,	1134,	1264,	1305,
TONSLAND,	507,	358,	332,	331,	215,	348,	520,	434,	417,	424,
SOPCOF %,	100,	100,	109,	100,	100,	101,	100,	100,	99,	100,

Table 6.7. Sole 20-24. Weight at age (kg) in the catch and in the stock.

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,
AGE							
2,	.1830,	.1740,	.1650,	.1600,	.1590,	.1760,	.1800,
3,	.2130,	.2340,	.2310,	.1940,	.1970,	.2210,	.2280,
4,	.2570,	.2830,	.2870,	.2450,	.2350,	.2550,	.2510,
5,	.2940,	.2910,	.2970,	.2740,	.2510,	.2660,	.3080,
6,	.2970,	.3350,	.4090,	.3190,	.3350,	.2710,	.3330,
7,	.2800,	.2920,	.2670,	.3600,	.3480,	.3520,	.4000,
8,	.3210,	.2790,	.2620,	.4170,	.3630,	.3000,	.5470,
+gp,	.3680,	.3640,	.3830,	.3610,	.3520,	.3550,	.5550,
0 SOPCOFAC,	.9930,	.9984,	.9995,	1.0027,	1.0032,	.9964,	.9970,

YEAR,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000,
AGE										
2,	.1740,	.2130,	.1780,	.1740,	.1870,	.1760,	.1980,	.1610,	.1620,	.1690,
3,	.2290,	.2520,	.2240,	.2290,	.2000,	.2180,	.2720,	.2190,	.2320,	.2360,
4,	.2750,	.3360,	.2740,	.2800,	.2480,	.2670,	.2960,	.3160,	.3040,	.3040,
5,	.2920,	.4120,	.3280,	.3420,	.2910,	.3070,	.3080,	.3220,	.3680,	.3440,
6,	.3460,	.4300,	.3740,	.3880,	.3510,	.3390,	.3450,	.3500,	.3600,	.3190,
7,	.3090,	.4910,	.4030,	.4450,	.3820,	.4040,	.3590,	.3580,	.3780,	.3640,
8,	.3860,	.5660,	.3880,	.4480,	.4320,	.4570,	.3640,	.3770,	.3970,	.3520,
+gp,	.5030,	.6220,	.4740,	.3940,	.3830,	.6640,	.3610,	.3270,	.3500,	.3280,
0 SOPCOFAC,	.9508,	.9304,	.9980,	.9931,	.9767,	.9826,	.9983,	1.0006,	1.0041,	1.0004,

YEAR,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010,
AGE										
2,	.1840,	.1720,	.1740,	.2030,	.1920,	.2010,	.2110,	.2150,	.2110,	.2580,
3,	.2420,	.2050,	.2100,	.2370,	.2230,	.2150,	.2280,	.2460,	.2590,	.2700,
4,	.2900,	.2940,	.2460,	.2910,	.3000,	.2630,	.2950,	.2670,	.3010,	.2830,
5,	.3780,	.3730,	.3600,	.3280,	.3240,	.3170,	.3020,	.2800,	.3190,	.3240,
6,	.3460,	.3860,	.3820,	.3710,	.3670,	.3390,	.3540,	.2900,	.4030,	.3110,
7,	.3080,	.2140,	.4310,	.4010,	.3710,	.3210,	.3390,	.2960,	.4390,	.3690,
8,	.3620,	.2920,	.2610,	.3700,	.4210,	.2930,	.3800,	.3010,	.4390,	.3100,
+gp,	.2810,	.2760,	.3820,	.3150,	.3720,	.3440,	.2440,	.2460,	.2630,	.2630,
0 SOPCOFAC,	.9941,	.9967,	.9971,	.9916,	.9841,	.9794,	.9654,	1.0209,	.9832,	1.0103,

YEAR,	2011,	2012,	2013,	2014,	2015,	2016,	2017,	2018,	2019,	2020,
AGE										
2,	.2610,	.2850,	.2390,	.2270,	.2210,	.2340,	.2160,	.2100,	.2000,	.1820,
3,	.2710,	.2790,	.2250,	.2830,	.2390,	.2670,	.2650,	.2280,	.2880,	.2400,
4,	.2920,	.3170,	.2760,	.3720,	.2860,	.2680,	.2920,	.3130,	.2900,	.2650,
5,	.2770,	.3750,	.3040,	.4210,	.3910,	.2830,	.2990,	.3680,	.3840,	.3470,
6,	.3580,	.4060,	.3730,	.4430,	.4040,	.3410,	.3260,	.3570,	.4230,	.3570,
7,	.4760,	.4060,	.3050,	.4860,	.3880,	.3300,	.3770,	.4630,	.4590,	.3000,
8,	.2850,	.3500,	.3060,	.4540,	.5010,	.5440,	.3340,	.4750,	.3860,	.4790,

```
      +gp,        .3010,   .4060,   .2870,   .4060,   .4340,   .4390,   .3950,   .5640,   .3440,   .4360,
0    SOPCOFAC,    1.0003,  1.0006,  1.0891,   .9976,  1.0043,  1.0051,  1.0034,  1.0007,   .9949,  1.0022,
```

Table 6.8. Sole 20-24. Fishing mortality at age (age 6-9 assumed constant).

Year Age	2	3	4	5	6	7	8	9
1984	0.081	0.393	0.483	0.400	0.378	0.378	0.378	0.378
1985	0.074	0.304	0.371	0.335	0.286	0.286	0.286	0.286
1986	0.084	0.314	0.414	0.394	0.345	0.345	0.345	0.345
1987	0.100	0.330	0.445	0.458	0.455	0.455	0.455	0.455
1988	0.099	0.310	0.413	0.410	0.403	0.403	0.403	0.403
1989	0.104	0.317	0.425	0.429	0.414	0.414	0.414	0.414
1990	0.098	0.302	0.413	0.417	0.371	0.371	0.371	0.371
1991	0.098	0.303	0.423	0.441	0.484	0.484	0.484	0.484
1992	0.096	0.300	0.419	0.461	0.588	0.588	0.588	0.588
1993	0.094	0.301	0.421	0.474	0.592	0.592	0.592	0.592
1994	0.080	0.259	0.360	0.411	0.444	0.444	0.444	0.444
1995	0.087	0.286	0.382	0.439	0.481	0.481	0.481	0.481
1996	0.084	0.287	0.354	0.401	0.425	0.425	0.425	0.425
1997	0.078	0.257	0.336	0.382	0.424	0.424	0.424	0.424
1998	0.073	0.237	0.311	0.373	0.402	0.402	0.402	0.402
1999	0.068	0.225	0.294	0.343	0.365	0.365	0.365	0.365
2000	0.064	0.214	0.291	0.327	0.358	0.358	0.358	0.358
2001	0.055	0.183	0.238	0.284	0.301	0.301	0.301	0.301
2002	0.061	0.197	0.260	0.322	0.423	0.423	0.423	0.423
2003	0.053	0.166	0.243	0.299	0.391	0.391	0.391	0.391
2004	0.063	0.191	0.288	0.346	0.443	0.443	0.443	0.443
2005	0.072	0.219	0.320	0.371	0.440	0.440	0.440	0.440
2006	0.074	0.225	0.316	0.373	0.368	0.368	0.368	0.368
2007	0.077	0.234	0.314	0.346	0.298	0.298	0.298	0.298
2008	0.086	0.266	0.361	0.364	0.312	0.312	0.312	0.312
2009	0.077	0.256	0.355	0.319	0.181	0.181	0.181	0.181
2010	0.069	0.256	0.354	0.310	0.160	0.160	0.160	0.160
2011	0.052	0.207	0.313	0.251	0.119	0.119	0.119	0.119
2012	0.041	0.155	0.260	0.218	0.136	0.136	0.136	0.136
2013	0.035	0.132	0.233	0.203	0.139	0.139	0.139	0.139
2014	0.028	0.096	0.189	0.177	0.144	0.144	0.144	0.144
2015	0.025	0.081	0.152	0.167	0.122	0.122	0.122	0.122
2016	0.030	0.093	0.184	0.204	0.164	0.164	0.164	0.164
2017	0.036	0.098	0.214	0.257	0.269	0.269	0.269	0.269
2018	0.031	0.079	0.176	0.215	0.242	0.242	0.242	0.242
2019	0.028	0.074	0.164	0.195	0.213	0.213	0.213	0.213
2020	0.027	0.077	0.159	0.189	0.211	0.211	0.211	0.211

Table 6.9. Sole 20-24. Stock number at age from assessment.

Year Age	1	2	3	4	5	6	7	8	9
1984	6425	2588	1616	510	367	134	80	127	480
1985	5245	5993	2320	922	265	222	89	46	351
1986	4833	4660	4974	1653	596	173	145	71	265
1987	4338	4391	3889	3264	990	363	124	92	222
1988	5928	3685	3796	2709	1869	492	176	71	181
1989	7658	5409	2672	2577	1685	1163	266	101	150
1990	7574	7213	4443	1754	1583	1016	700	143	141
1991	8587	6714	5672	2875	1037	942	668	468	187
1992	6549	8246	5453	3537	1582	588	509	370	395
1993	3578	6230	6963	3659	2126	885	286	263	368
1994	3536	2962	5277	4865	2213	1219	414	140	293
1995	2291	3409	2613	3965	3150	1448	767	266	280
1996	1538	2062	2939	1862	2426	1741	856	431	375
1997	3658	1151	1447	1737	1247	1518	1122	626	547
1998	3705	3763	871	946	989	777	854	690	746
1999	3114	3447	3699	636	728	614	523	523	888
2000	4452	2601	2689	2548	432	504	373	366	962
2001	5981	4066	2184	1962	1596	297	376	212	903
2002	4487	5907	3795	1554	1502	1155	226	275	843
2003	4594	3875	4440	2742	1143	1050	633	120	641
2004	2970	4453	3784	3303	1759	756	584	343	439
2005	2527	2794	4590	3390	2210	989	374	292	346
2006	3292	2400	2292	3489	2190	1429	562	230	417
2007	3515	2737	1978	1636	2216	1109	797	361	488
2008	2130	3228	1957	1433	1101	1425	683	547	595
2009	2200	2042	2658	1288	1011	714	924	393	689
2010	2046	2032	1953	1782	769	677	465	702	828
2011	1823	1905	1890	1489	1165	504	475	285	1154
2012	1581	1593	1548	1429	952	833	349	383	1131

Year Age	1	2	3	4	5	6	7	8	9
2013	1607	1397	1412	1235	1052	690	649	249	1022
2014	2669	1350	1188	1047	872	808	473	544	908
2015	3450	2400	1181	1036	723	687	574	316	1258
2016	2848	3028	2205	995	940	511	468	413	1380
2017	1745	2808	2547	1752	706	774	407	344	1434
2018	4445	1343	2389	2102	1199	453	553	308	1241
2019	3609	4408	1011	2020	1606	850	288	382	1204
2020	3996	3115	3948	760	1501	1257	651	186	1229

Table 6.10. Sole 20-24. Stock summary from SAM.

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 8 (F48). "Low" and "high" are lower and upper boundary of 95% confidence limits as indicated on plots.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
1984	6425	3925	10516	863	697	1068	0.403	0.304	0.535	1722	1405	2110
1985	5245	3398	8097	1122	898	1400	0.313	0.238	0.412	2479	1980	3104
1986	4833	3189	7325	2030	1620	2543	0.368	0.290	0.468	3088	2541	3754
1987	4338	2811	6693	2104	1746	2536	0.454	0.357	0.577	3067	2596	3624
1988	5928	3909	8990	2169	1827	2576	0.406	0.319	0.517	3111	2660	3638
1989	7658	5038	11642	2188	1862	2571	0.420	0.331	0.531	3600	3067	4225
1990	7574	5009	11454	2716	2309	3195	0.389	0.309	0.489	4469	3789	5270
1991	8587	5589	13191	3199	2701	3790	0.463	0.374	0.574	4883	4160	5732
1992	6549	4314	9941	4172	3546	4908	0.529	0.425	0.658	6322	5371	7440
1993	3578	2373	5397	3982	3362	4715	0.534	0.426	0.670	5305	4532	6210
1994	3536	2356	5307	4163	3559	4869	0.421	0.335	0.528	4890	4224	5661
1995	2291	1509	3481	3446	2983	3981	0.453	0.364	0.564	4221	3681	4840
1996	1538	957	2474	3264	2839	3752	0.406	0.329	0.502	3719	3255	4250
1997	3658	2390	5600	2644	2298	3042	0.398	0.322	0.493	3091	2709	3527
1998	3705	2469	5560	1890	1628	2195	0.378	0.303	0.473	2718	2350	3144
1999	3114	2052	4726	2257	1920	2654	0.347	0.278	0.432	3002	2574	3502
2000	4452	2969	6675	2299	1962	2693	0.338	0.271	0.422	3005	2593	3484
2001	5981	3937	9084	2250	1931	2621	0.285	0.225	0.361	3357	2886	3904
2002	4487	2991	6732	2602	2218	3053	0.370	0.294	0.465	3887	3301	4578
2003	4594	3061	6893	2969	2532	3481	0.343	0.268	0.440	3919	3393	4525
2004	2970	2095	4211	3215	2776	3723	0.392	0.311	0.495	4297	3731	4949
2005	2527	1768	3612	3510	3011	4092	0.402	0.320	0.506	4198	3632	4852
2006	3292	2273	4769	2981	2542	3495	0.359	0.287	0.449	3660	3149	4255
2007	3515	2455	5034	2522	2160	2944	0.311	0.244	0.396	3310	2855	3838
2008	2130	1446	3139	2099	1778	2479	0.332	0.257	0.429	2921	2491	3425

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
2009	2200	1541	3142	2445	2032	2943	0.243	0.186	0.318	3008	2536	3568
2010	2046	1430	2927	2098	1737	2535	0.229	0.174	0.301	2745	2302	3273
2011	1823	1247	2666	2105	1724	2570	0.184	0.140	0.244	2711	2246	3273
2012	1581	1020	2451	2315	1874	2859	0.177	0.133	0.236	2864	2346	3495
2013	1607	1047	2466	1803	1460	2227	0.171	0.129	0.226	2234	1830	2727
2014	2669	1852	3847	2296	1877	2809	0.160	0.121	0.211	2763	2285	3341
2015	3450	2348	5070	2065	1686	2530	0.137	0.103	0.184	2803	2320	3386
2016	2848	1983	4089	2281	1873	2778	0.176	0.135	0.229	3502	2904	4223
2017	1745	1142	2667	2485	2052	3010	0.255	0.194	0.337	3406	2827	4103
2018	4445	2940	6720	2908	2381	3553	0.223	0.170	0.293	3991	3284	4849
2019	3609	2379	5475	2547	2062	3146	0.200	0.150	0.266	3894	3171	4783
2020	3996	2332	6847	2939	2306	3745	0.196	0.143	0.271	4305	3395	5458

Table 6.11. Sole 20-24. Input to short term prediction.

2021								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2848	0.1	0	0	0	0.132	0.000	0.132
2	3652	0.1	0	0	0	0.222	0.030	0.222
3	2720	0.1	1	0	0	0.256	0.070	0.256
4	3319	0.1	1	0	0	0.306	0.160	0.306
5	585	0.1	1	0	0	0.352	0.180	0.352
6	1151	0.1	1	0	0	0.374	0.200	0.374
7	927	0.1	1	0	0	0.409	0.200	0.409
8	470	0.1	1	0	0	0.462	0.200	0.462
9	1046	0.1	1	0	0	0.448	0.200	0.448

2022								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2669	0.1	0	0	0	0.132	0.000	0.132
2	2462	0.1	0	0	0	0.222	0.100	0.222
3	3251	0.1	1	0	0	0.256	0.280	0.256
4	2286	0.1	1	0	0	0.306	0.600	0.306
5	2552	0.1	1	0	0	0.352	0.710	0.352
6	434	0.1	1	0	0	0.374	0.780	0.374
7	836	0.1	1	0	0	0.409	0.780	0.409
8	693	0.1	1	0	0	0.462	0.780	0.462
9	1132	0.1	1	0	0	0.448	0.780	0.448

2023								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2669	0.1	0	0	0	0.132	0.000	0.132
2	2332	0.1	0	0	0	0.222	0.030	0.222
3	1966	0.1	1	0	0	0.256	0.090	0.256
4	2161	0.1	1	0	0	0.306	0.190	0.306

5	1169	0.1	1	0	0	0.352	0.230	0.352
6	1098	0.1	1	0	0	0.374	0.250	0.374
7	180	0.1	1	0	0	0.409	0.250	0.409
8	339	0.1	1	0	0	0.462	0.250	0.462
9	747	0.1	1	0	0	0.448	0.250	0.448
Input units are thousands and kg								

Table 6.12. Sole 20-24. Basis for forecasts and management options table for short term predictions.

Variable	Value	Notes
F ages 4–8 (2021)	0.196	Fsq (=F2020)
SSB (2022)	3756 tonnes	When fishing at F=0.196
Rage1 (2021)	2848 thousands	Resampled from recruitment (2004-2019)
Rage1 (2022)	2669 thousands	Resampled from recruitment (2004-2019)
Wanted catch (2021)	503 tonnes	Based on fishing at Fsq and mean discard rate
Unwanted catch (2021)	18 tonnes	Mean discard rate in weight (2016-2020) of 3%.
Total catch (2021)	521 tonnes	Fishing at Fsq in 2021

Basis	Total catch (2022) *	Pro-jected land-ings (2022) **	Pro-jected dis-card (2021) **	F pro-jected landings (4–8) (2022)	SSB (2023)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis								
EU MAP#: F_{MSY}	715	695	20	0.257	3598	-4.21%	20.0%	20.0%
EU MAP#: F_{lower}	544	529	15	0.190	3773	0.45%	-8.71%	8.39%
EU MAP#: F_{upper}	723	703	20	0.260	3590	-4.42%	21.32%	8.73%
Other options								
F = 0	0	0	0	0	4323	15.1%	-100%	-100%
$F_{pa, Fmsy}$	723	703	20	0.26	3590	-4.42%	21.3%	21.3%
F_{lim}	856	832	24	0.315	3454	-8.04%	44%	44%
SSB (2023) = Blim	2153	2347	67	1.320	1859	-51%	261%	261%
SSB (2023) = Bpa	1680	1633	47	0.74	2617	-30%	182%	182%
SSB (2023) = MSY Btrigger	1680	1633	47	0.74	2617	-30%	182%	182%
F = F_{2021}	561	545	16	0.196	3756	0.00%	-5.95%	-5.95%

Total catch is calculated based on wanted catch (fish that would be landed in the absence of the EU landing obligation) and recent discard rate (in weight).

"Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rate estimates for 2016–2020.

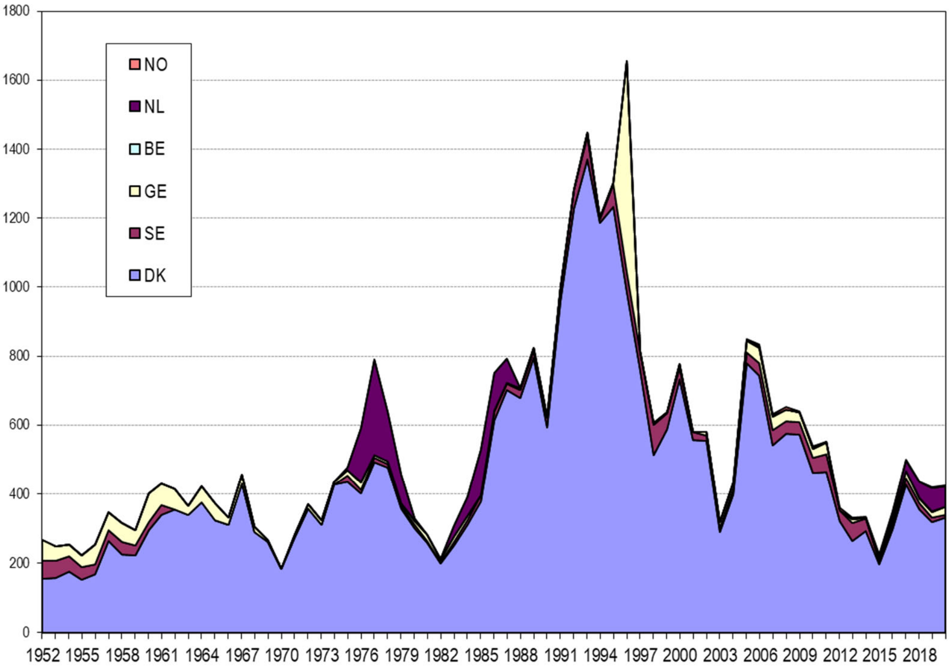
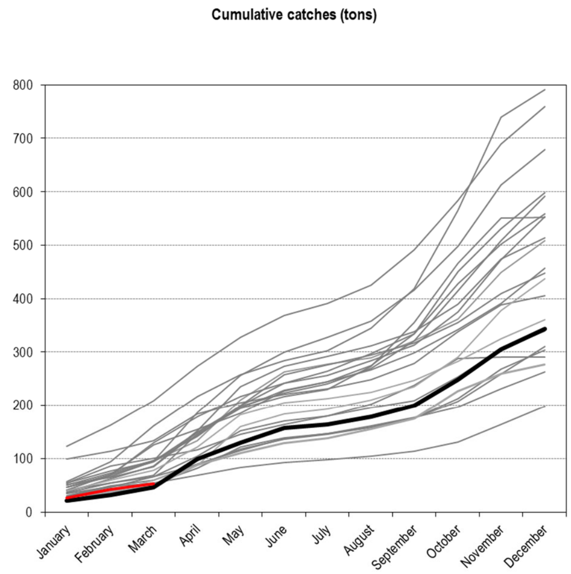


Figure 6.1. Sole 20-24. Landings of sole in divisions 20-24 by nation since 1952.



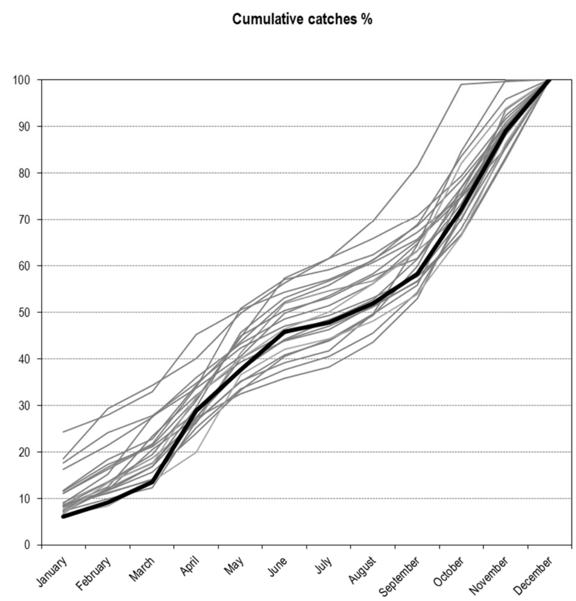


Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curves are 2020 and red bold curve is 2021 including March.

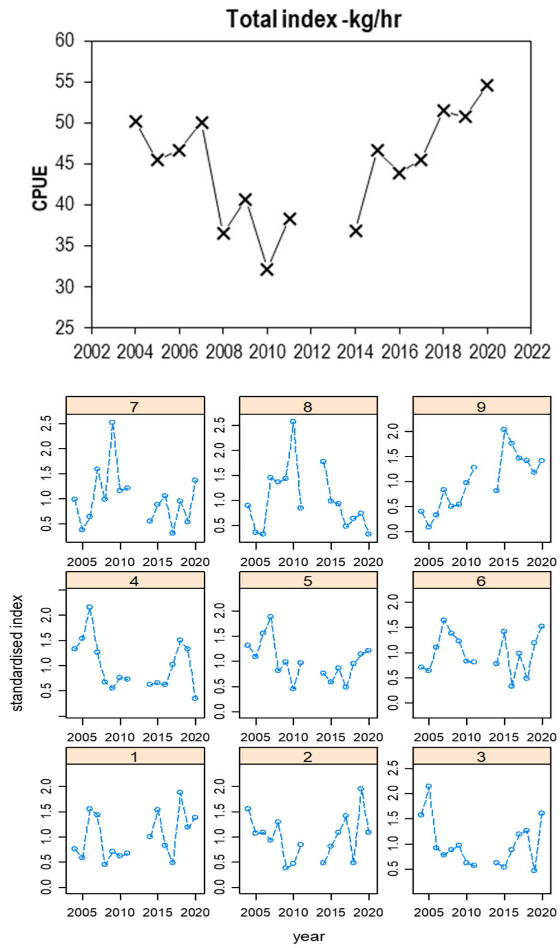


Figure 6.3. Sole 20-24. Left: Age aggregated catch rates from Fisherman/DTU Aqua survey. Right: age dis-aggregated catch rates from the survey.

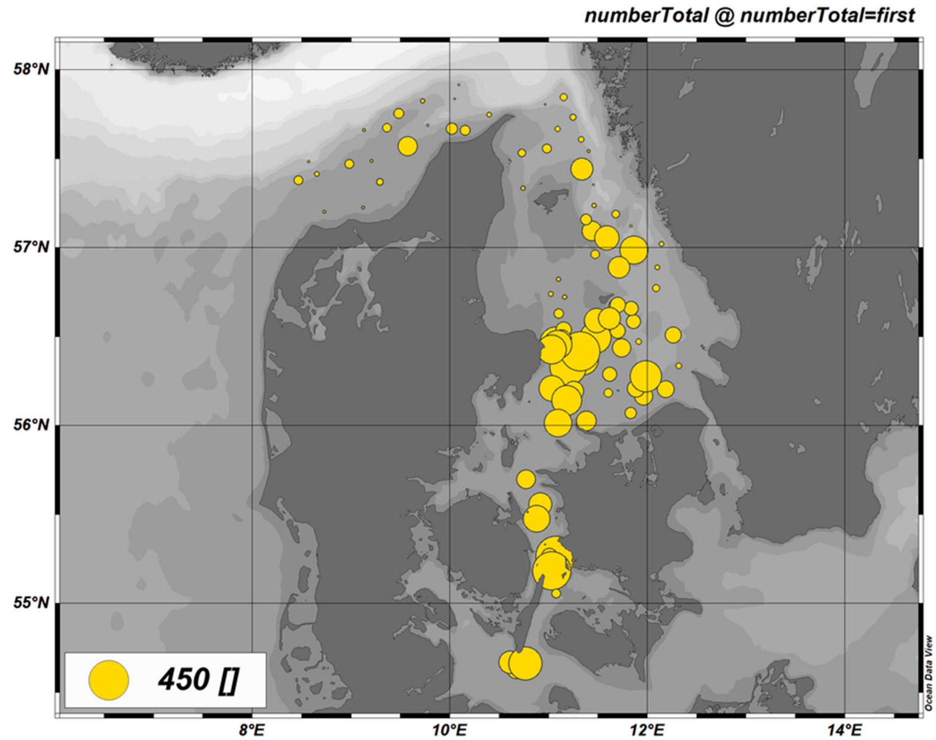


Figure 6.4. 20-24. Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2019.

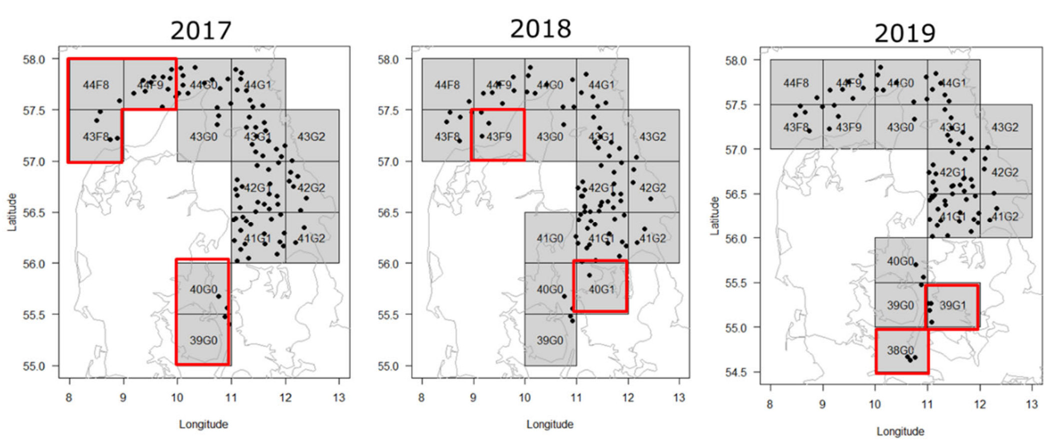


Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2017 - 2019, red boxes illustrating the successively extended survey area (subdivisions 20 and 22).

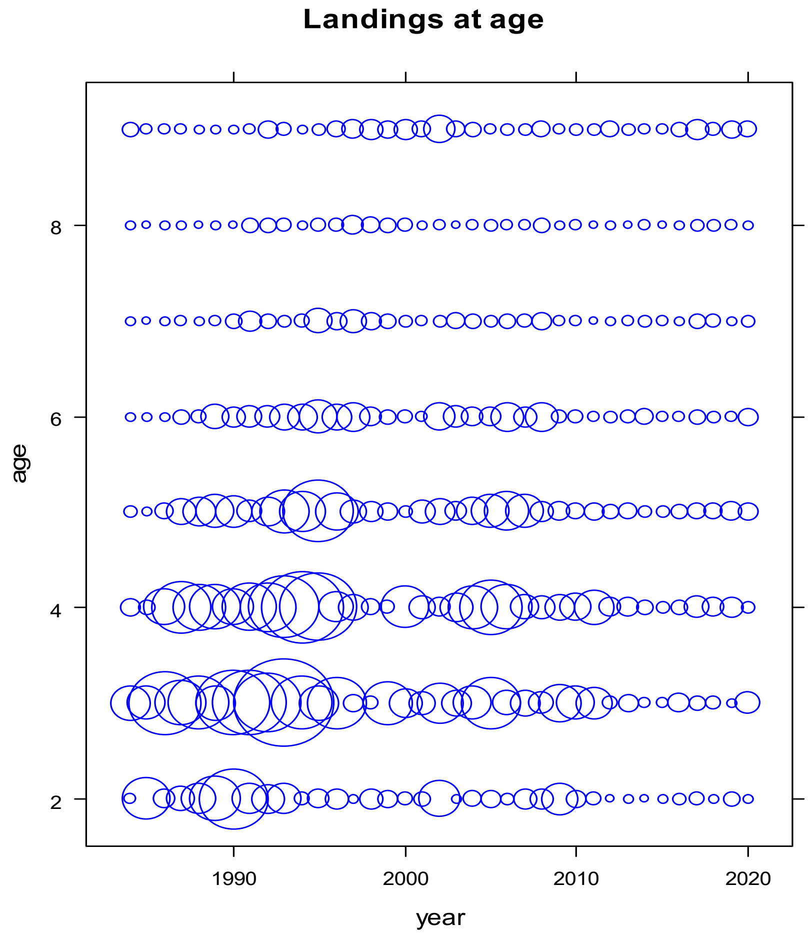


Figure 6.6. Sole 20-24. Landing numbers at age.

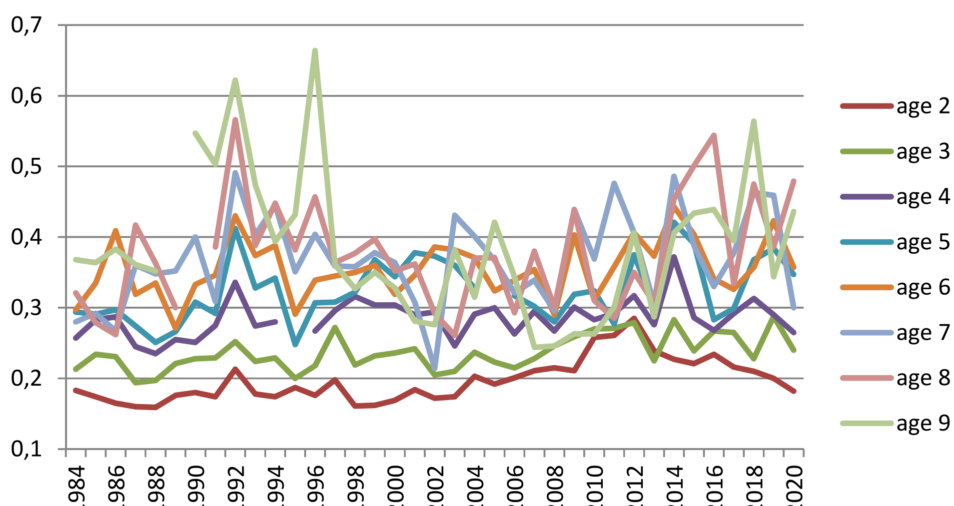


Figure 6.7. Sole in 20-24. Landings weight-at-age.

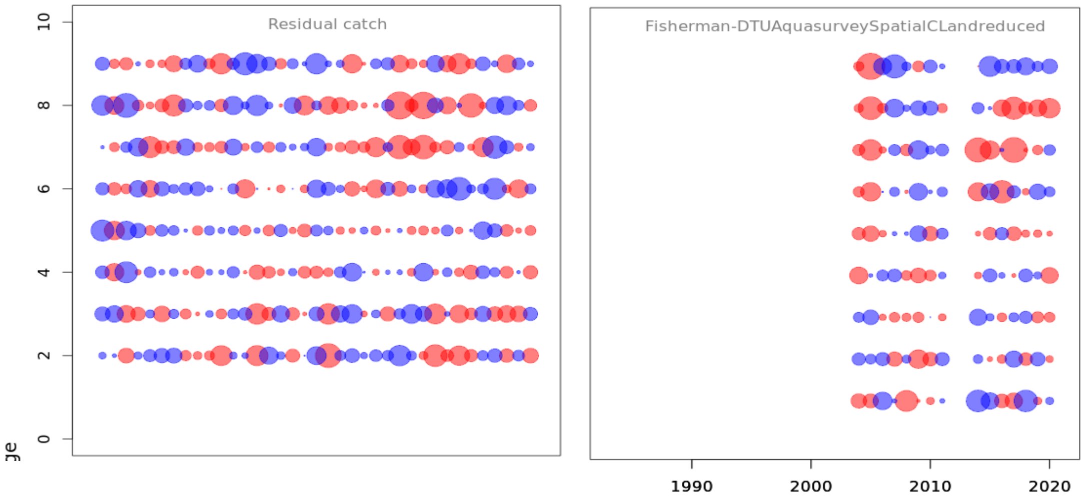
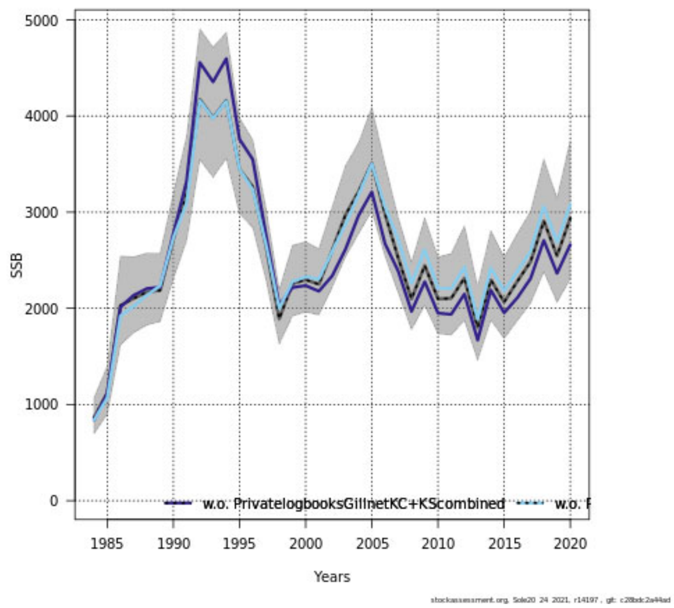


Figure 6.8. Sole 20-24. Model residuals for landings and survey.



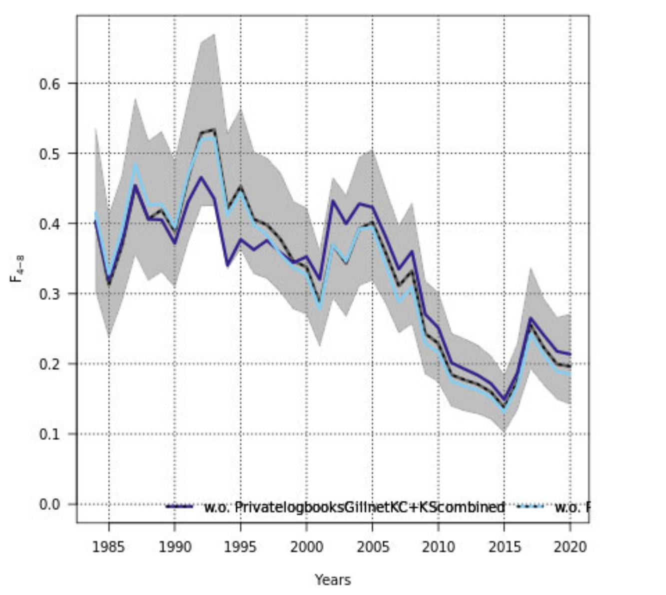


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

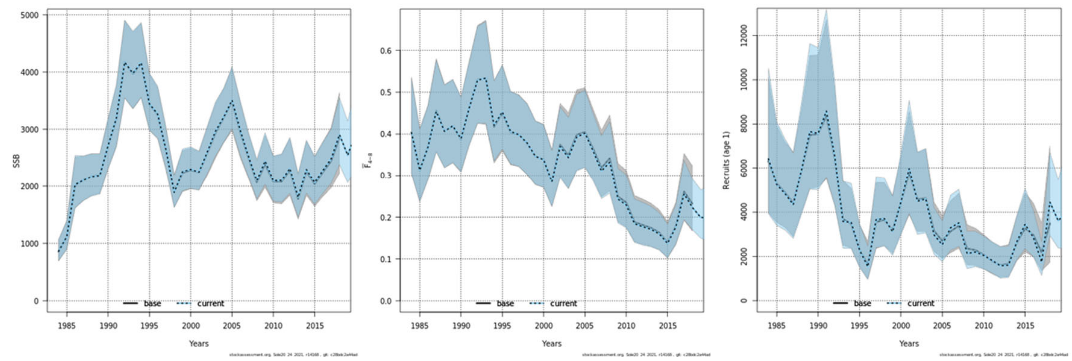


Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year's assessment.

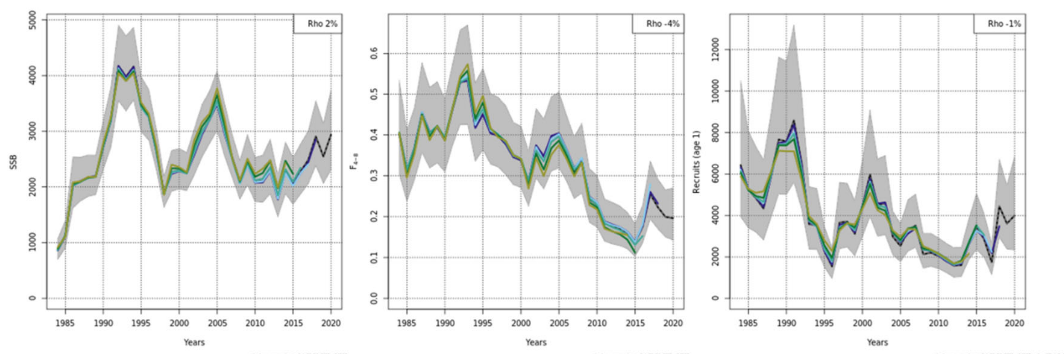


Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F, and recruitment. Confidence limits are provided for the 2020 scenario.

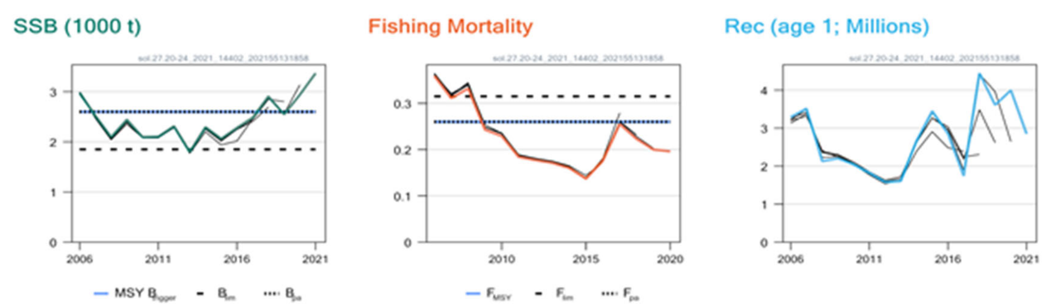


Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

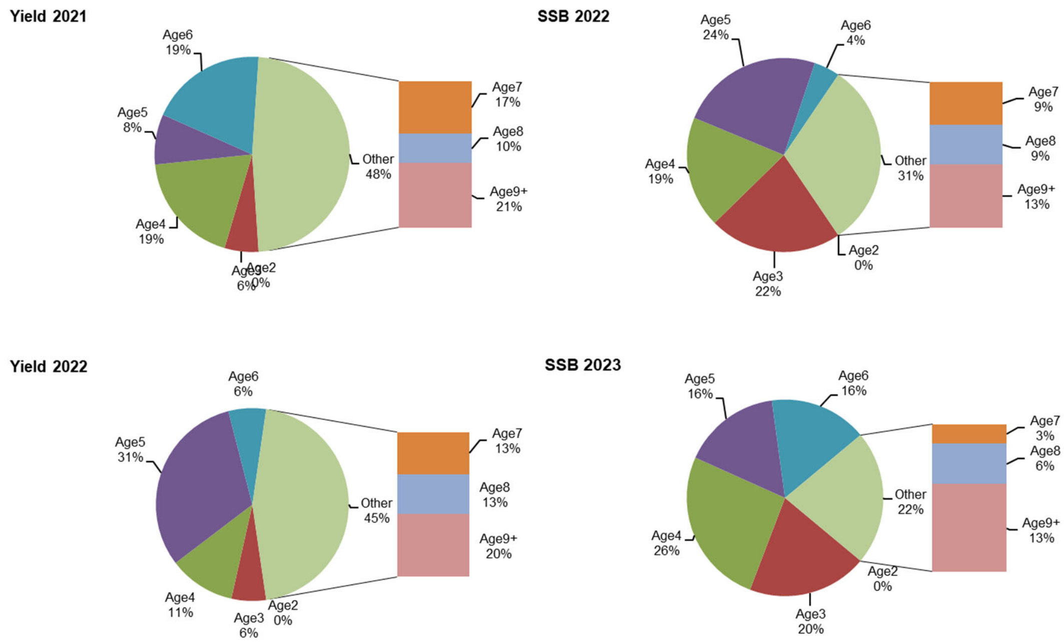


Figure 6.13. Sole 20-24. Short-term forecast for 2021-2023. Yield and SBB at age 2-9+ assuming fishery at Fsq in 2020.

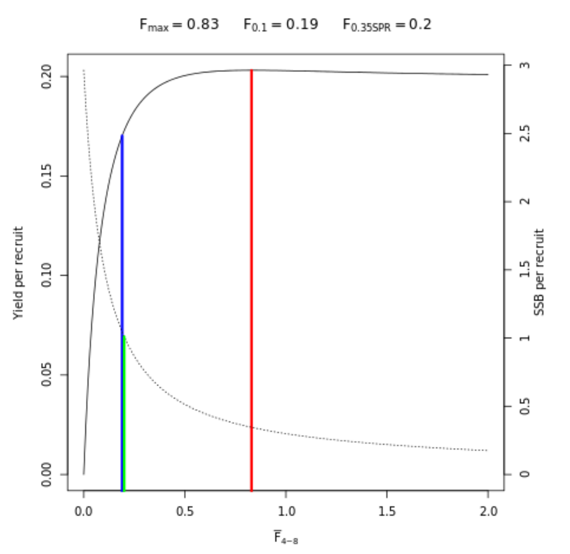


Figure 6.14 Sole 20-24 Yield per recruit curve and reference point estimates (red=Fmax, green=F35%SPR and blue=F0.1)

7 Sprat in subdivisions 22-32

As in previous years, sprat in the Baltic subdivisions 22–32 was assessed as a single unit. The note on assessments by „assessment units" used up to the 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 the 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 the SMS model.

In addition, at benchmark the tuning fleet from Age 0 index, in previous assessment constrained to subdivisions 26+28, was extended to cover subdivisions 22–29. In some years minor revisions were made in other tuning fleets data (May and October acoustic surveys).

Following extensive analysis of the XSA options, no reason was found to change previous settings (age 1 with catchability, q, dependent on stock size, q plateau at age 5, shrinkage SE of 0.75).

The SAM model was attempted at benchmark as an alternative assessment model; it produced slightly lower SSB and higher Fs than the XSA. However, the XSA has been still considered as the main assessment model for sprat stock.

Maturity estimates were obtained from several countries but only simplified approach for their analysis was applied due to time constraints. 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 in the assessment. In previous assessments, they were available from multispecies model SMS up to 2011, and from regression between cod biomass and predation mortality in the 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 were 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 2020 were 271 532 t, which is 14% less than in 2019 and 49% less than the record high value of 529 400 t in 1997. In 2020 total TAC set by the EU plus the Russian autonomous quota was 256 647 (210 147 + 46 500) t, which was utilized in 105.8%. The largest decrease in catches was observed for Germany (39%). At the same time, the Russian catches increased by 12% compared to 2019.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 33% share in the sprat catch. Other important areas are subdivisions 25 and 28 (27 and 21%, 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 2001–2020. 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 the 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 (logbook registered) discard data for Baltic sprat in 2016, 2017, 2018, and 2020 into the InterCatch – 563, 482, 335, and 135 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 1995–2020 (Table 7.4). These data indicate an 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 2018-2020 the Russian effort was much higher compared to the previous years. At the same time, the CPUE has decreased 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 10% of the total. Most of the German catches (87%) were landed in foreign ports and were not very well sampled, in a result only 55% of German total landings were sampled. It is not clear whether the willingness of the fishermen to collect samples was reduced due to the COVID-19 situation or the reduced quota in 2020 lead to this reduction in sampling intensity. 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 7.4a). In 1999–2020 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. The mean weight of the year class 2014 is also very low; it could be a result of density dependent effects as both year classes were 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 a similar quality as the consistency of catch-at-age data (the correlation between mean weight at a given age and the mean weight of the same generation 1 year later is high and exceeds 0.9 in most cases).

7.2.3 Natural mortality

As in previous years, the natural mortalities used varied between years and ages as an effect of cod predation.

In 2019 new estimates of predation mortality (M2) covering 1974-2018 were available from updated SMS (WGSAM 2019), using analytical estimates of cod stock as an external variable. The M2 for 2019 was assumed equal to the 2018 values. At WGBFAS in 2021 the average M2 for 2020 was estimated from regression of average M2 in 1974-2018 against biomass of cod at length ≥20 cm (R = 0.95, Figure 7.4b). Next, the average value was distributed into ages following the distribution of M2 by ages in recent 10 years. M was obtained by adding 0.2 to M2. 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 WG was provided with rather extensive maturity data by the Study Group on Herring and Sprat Maturity. These data were analysed using the 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 a more extensive analysis of the data. Thus the maturities were averaged over years in the 2002 assessment. These maturities were kept the same in the assessments up to 2012.

At the benchmark workshop (ICES, 2013a) maturity estimates were obtained from several countries but only a simplified approach for their analysis was applied due to time constraints. The results did not suggest the need to change the maturity parameters used so far. Thus, maturities estimated in 2002 are still kept in the 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 log-book data. In some countries, such as Denmark and Poland, these data are supplemented by data collected in regional Marine Offices. In Denmark, Sweden, Finland, and to a lesser degree in Poland, much of the sprat catch is taken in industrial fisheries where large by-catches of other fish species (mostly herring) may occur. The species composition of these catches is not accurately known, and can create errors in annual sprat catch statistics.

The landings and sampling activity for 2020 by quarter, ICES subdivision, and country are presented in Table 7.5. These data show that generally in 2020 the sampling activity by ICES subdivision exceeded much the levels indicated in the EC regulation No. 1639/2001, i.e. at least 1 sample per 2000 t. of catch, 100 length measurements and 50 age readings per sample. On average number of samples, a number of length measurements, and a number of age readings was 4-5 times higher than indicated in the directive.

7.3 Fishery independent information

Two tuning datasets covering subdivisions 22–29 were available: from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2020 and one dataset covering subdivisions 24–26 and 28 from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2020 (tables 7.12–7.14). The survey data were corrected for area coverage (WGBIFS, ICES, 2021). However, in 2016 the May survey (BASS) only covered ca. 50% of planed areas, **so the 2016 survey estimates from BASS we not used in the assessment**. Such was also recommendation from WGBIFS (ICES, 2017). Due to the low area coverage also the 1993, 1995, and 1997 BIAS survey estimates we not used in the assessment as recommended by the WGBIFS (ICES, 2021).

The internal consistency of the survey at age estimates and consistency between surveys was checked on graphs (figures 7.5a-c). The correlation between CPUE at a 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 weighting;
2. catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions were significantly different from 1);
3. catchability independent of age for ages 5 and older;
4. the SE of the F shrinkage mean equal 0.75.

Table 7.15 contains the diagnostic of the run. The log q residuals are presented in Figure 7.6. The residuals are moderately noisy and slightly lower for the October fleet (SE of log q = 0.3-0.40) than for the May survey (SE's range of 0.3–0.5, except age 7 (0.66)). The residuals from the 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 a level of 0.6–0.8).

October survey gets higher weight in survivors estimates (mostly 35–60%) than the May survey (weight of 20–40%). The weight of estimates resulting from the F shrinkage is low (up to 7%) 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 3, where estimate based on Age0 survey is much higher than the 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 7.8) shows quite scattered estimates for Fbar defined as average F at ages 3-5 (five years Mohn's rho of -0.24, three years Mohn's rho of -0.16). The F(3–5) estimates may be noisy as they are based on Fs from 3 ages only. In addition, recruitment of sprat is very variable which easily can lead to overestimation of F for weak year classes when they neighbour strong year classes, due to possible misspecification of age readings from these strong generations.

The retrospective estimates of SSB (five years Mohn's rho of 0.14) and recruitment (five years Mohn's rho = 0.12) 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 7.10).

7.4.2 Exploration of SAM

The SAM model was attempted at the benchmark workshop as the second assessment model for sprat. This year SAM estimates have been updated. Results of SAM parameterised in a 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 mostly contained within SAM confidence intervals. The distributions of residuals for the SAM model show similar patterns as in the case of XSA (Figure 7.12a). The retrospective analysis shows more consistent estimates for SAM than for XSA, especially for fishing mortality (Figure 7.12b). The assessment with SAM is available at 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 a range of 0.7–0.8. Estimates are mainly determined by survey (weight of 60–70%). The 2020 year class was estimated at 112 billion individuals, 29% above the average from the 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 a marked increase of stock biomass in 2016-2018. The estimate of SSB for 2021 (assuming TAC constraint) is 977 000 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, 2021).

7.5 Short-term forecast and management options

The RCT3 program estimate of the 2020 year class at age 1 was used in the predictions. The 2021 and 2022 year classes were assumed as the geometric mean of the recruitment at age 1 in 1991–2020 (period of recruitment fluctuations without a clear trend, the 2020 value is well estimated in the assessment). The natural mortalities, mean weights, and fishing pattern were assumed as averages of 2018–2020 values. Fishing mortality in the intermediate year was estimated consistent with TAC in 2021 (TAC defined as EU quota of 223 kt plus Russian quota of 45.5 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, a prediction option with F_{sq} in 2021 was performed (unscaled F, Table 7.22b); that produced catches in 2021 at 315 kt, 17% higher than the TAC. The differences between the two predictions are small, e.g. the difference between total biomass in 2023 is about 2%. The group considers TAC constraint prediction as the basis for the advice.

In Figure 7.13 the sensitivity of the projection to the assumed strength (GM) of the 2021 and 2022 year classes and the estimate of the 2020 year class is presented. The assumed level of the 2021 year class contributes 11% to the predicted catch in 2022 and with an assumed level of the 2022 year class contributes 39% to SSB in 2023. The level of these sensitivities is slightly lower than in previous years.

7.6 Reference points

Below recent history of estimates of BRPs is presented and at the end of the 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 an average of outcomes from different recruitment models) and $B_{MSYtrigger} = B_{pa}$ at 574 000 t ($B_{pa} = B_{lim}$ *1.4).

The method of equilibrium yield and biomass (Horbowy and Luzenczyk, 2012) was used to estimate the F_{MSY} reference points. The uncertainty included in the estimating procedure was from assessment errors in SSB and R, which are then used to estimate the S-R relationship. In addition, uncertainty was imposed on weight, natural mortality, selection and maturity-at-age. The CV was assumed at 0.2 for SSB, R and maturity, and it was estimated using data from the 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 FMSY ranges for all stocks (WKMSYREF3; ICES, 2014)) the F_{MSY} reference points were revised and ranges for them estimated. The new estimate of F_{MSY} was 0.26, while ranges are provided in the text table below.

Stock	MSY Flower	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 a 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). In addition, F_{pa} estimated in 2020 at 0.45 was replaced by $F_{p.05}$ estimated at IBPBASH at 0.41.

New estimates and their basis is given below.

Reference Point	Value	Rationale
B_{lim}	410 000t	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 000t).
B_{pa}	570 000t	1.4* B_{lim}
MSY $B_{trigger}$	570 000t	B_{pa}
F_{MSY}	0.31	Estimated by EqSim
$F_{MSYUpper}$	0.41	Estimated by EqSim as the F producing 95% of the landings at F_{MSY}
$F_{MSYLower}$	0.22	Estimated by EqSim as the F producing 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}	0.41	$F_{p.05}$, F with 95% probability of being above B_{lim}

The biomass reference points are the same as the 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 the 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 sensitive to the assumed (GM) year class strength. The assumed year classes contribute usually 40–55% to the predicted SSB. If a strong year class goes through the stock (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 the 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. Surveys are also consistent between themselves.

7.8 Comparison with previous assessment

A comparison between the results of 2020 and 2021 assessments is presented in the text table below. The XSA settings were the same in both years.

Category	Parameter	Assessment 2020	Assessment 2021	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 2019 (million t)	0.93	0.86	-8%
	TSB 2019 (million t)	1.45	1.33	-8%
	F(3-5) 2019	0.38	0.39	3%
	Recruitment (age 1) in 2019 (billions)	56.5	49.8	-12%

7.9 Management considerations

There is an EU multiannual plan for sprat in the Baltic Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1139&from=EN). In the plan, F_{MSY} ranges are defined as 0.19 – 0.26 and 0.26–0.27. 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 the 1980s. At the beginning of the 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 a 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 2012–15. Very strong year class of 2014 has led to a 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 the 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
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
2020	26.4	24.3	12.5	8.9	28.9	11.2	72.5	45.7	41.1	271.5

* Sum of landings by Estonia, Latvia, Lithuania, and Russia.

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 1/4

Year 2001

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	39.7	-	-	39.7	-	-	-	-	-	-	-
Estonia	37.5	-	-	-	-	-	6.3	16.1	-	-	15.1
Finland	15.4	-	-	-	-	-	-	4.5	3.2	0.001	7.6
Germany	0.8	0.02	0.8	-	-	-	-	-	-	-	-
Latvia	42.8	-	-	1.1	7	-	34.7	-	-	-	-
Lithuania	3	-	-	-	3	-	-	-	-	-	-
Poland	85.8	-	0.4	46.3	39.1	-	-	-	-	-	-
Russia	32	-	-	-	29.6	-	2.3	-	-	-	-
Sweden	85.4	-	1	2.9	4.8	27.8	30.2	18.1	-	-	0.5
Total	**342.2**	**0.02**	**2.1**	**90**	**83.5**	**27.8**	**73.5**	**38.7**	**3.2**	**0.001**	**23.2**

Year 2002

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	42.0	4.7	1.0	22.5	7.7	0.7	4.6	0.9	-	-	-
Estonia	41.3	-	-	-	-	-	7.7	17.0	-	-	16.6
Finland	17.2	-	0.8	2.3	0.004	0.1	0.001	3.7	4.8	-	5.5
Germany	1.0	0.03	-	0.1	0.4	0.1	0.1	0.2	-	-	-
Latvia	47.5	-	-	1.4	4.5	-	41.7	0.0	-	-	-
Lithuania	2.8	-	-	0.0	2.8	-	-	-	-	-	-
Poland	81.2	-	0.04	39.7	41.5	-	-	-	-	-	-
Russia	32.9	-	-	-	29.9	-	2.9	-	-	-	-
Sweden	77.3	-	3.0	13.3	5.6	27.2	19.9	8.3	-	-	-
Total	**343.2**	**4.8**	**4.8**	**79.3**	**92.4**	**28.1**	**76.8**	**30.1**	**4.8**	**0.0**	**22.1**

Year 2003

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	32.0	8.2	0.7	10.4	8.9	1.8	1.7	0.3	-	-	-
Estonia	29.2	-	-	-	-	-	11.1	11.6	-	-	6.5
Finland	9.0	-	0.03	0.4	0.04	0.2	0.1	4.6	1.5	0.001	2.0
Germany	18.0	0.2	0.5	0.8	3.0	9.5	2.8	1.1	-	-	-
Latvia	41.7	-	-	0.8	7.8	-	33.2	-	-	-	-
Lithuania	2.2	-	-	-	2.2	-	-	-	-	-	-
Poland	84.1	-	0.03	26.7	57.4	-	-	-	-	-	-
Russia	28.7	-	-	0.0	27.2	-	1.4	-	-	-	-
Sweden	63.4	-	2.1	5.5	8.6	24.1	19.3	3.8	-	-	-
Total	**308.3**	**8.3**	**3.5**	**44.6**	**115.1**	**35.6**	**69.6**	**21.5**	**1.5**	**0.001**	**8.5**

Year 2004

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	44.3	16.0	5.5	16.8	0.5	0.5	3.9	1.1	-	-	-
Estonia	30.2	-	-	-	-	-	8.9	10.1	-	-	11.1
Finland	16.6	-	0.5	2.5	0.003	0.1	0.03	9.3	3.0	0.003	1.1
Germany	28.5	0.8	0.9	1.4	6.0	8.2	6.8	4.4	-	-	-
Latvia	52.4	-	-	2.3	7.5	0.2	42.4	0.0	-	-	-
Lithuania	1.6	-	-	-	1.6	-	-	-	-	-	-
Poland	96.7	-	1.4	33.6	61.6	0.04	0.02	-	-	-	-
Russia	25.1	-	-	-	23.9	-	1.2	-	-	-	-
Sweden	78.3	-	1.4	9.2	7.6	25.8	22.3	12.0	-	-	-
Total	**373.7**	**16.8**	**9.7**	**65.8**	**108.8**	**34.8**	**85.6**	**36.9**	**3.0**	**0.003**	**12.2**

Year 2005

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	46.5	17.6	2.1	11.1	5.4	0.3	10.0	-	-	-	-
Estonia	49.8	-	-	-	-	-	7.1	16.6	-	-	26.0
Finland	17.9	-	0.1	0.6	0.6	0.1	0.3	9.0	3.2	0.005	4.0
Germany	29.0	1.2	0.1	0.4	4.3	10.2	6.8	6.1	-	-	-
Latvia	64.7	-	-	1.2	7.3	0.4	55.8	-	-	-	-
Lithuania	8.6	-	-	-	8.6	-	-	-	-	-	-
Poland	71.4	-	2.0	23.5	45.6	0.2	0.1	-	-	-	-
Russia	29.7	-	-	-	29.7	-	-	-	-	-	0.1
Sweden	87.8	-	0.7	11.1	10.3	25.1	24.5	16.2	-	-	-
Total	**405.2**	**18.8**	**5.0**	**47.9**	**111.7**	**36.2**	**104.5**	**47.9**	**3.2**	**0.005**	**30.2**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 2/4

Year 2006

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**42.1**	19.4	1.7	6.9	9.9	0.3	2.6	1.2	-	-	-
Estonia	**46.8**	-	-	0.1	-	0.3	5.5	19.2	-	-	21.6
Finland	**19.0**	-	0.2	0.5	1.1	1.9	2.0	6.8	3.5	0.007	3.0
Germany	**30.8**	1.2	0.01	1.3	8.2	12.0	4.6	3.4	-	-	-
Latvia	**54.6**	-	-	1.1	6.0	-	47.5	-	-	-	-
Lithuania	**7.5**	-	-	-	7.5	-	-	-	-	-	-
Poland	**54.3**	-	0.8	16.7	36.8	-	-	-	-	-	-
Russia	**28.2**	-	-	-	27.9	-	-	-	-	-	0.3
Sweden	**68.7**	0.0	0.7	4.6	25.3	13.7	16.6	7.6	0.0	0.0	0.2
Total	**352.1**	**20.5**	**3.4**	**31.3**	**122.8**	**28.3**	**78.9**	**38.3**	**3.5**	**0.007**	**25.1**

Year 2007

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**37.6**	9.6	0.7	6.4	17.0	-	3.0	0.8	-	-	-
Estonia	**51.0**	-	-	2.2	0.8	0.1	4.3	15.3	-	-	28.3
Finland	**24.6**	0.0	0.0	1.9	4.2	0.3	2.6	4.5	7.2	0.002	3.8
Germany	**30.8**	0.8	0.46	1.8	12.2	5.8	4.8	4.9	-	-	-
Latvia	**60.5**	-	-	5.1	7.4	1.4	46.5	-	-	-	-
Lithuania	**20.3**	-	-	1.7	11.8	-	3.6	3.2	-	-	-
Poland	**58.7**	-	0.8	21.4	36.4	0.04	0.06	-	-	-	-
Russia	**24.8**	-	-	-	24.8	-	-	-	-	-	-
Sweden	**80.7**	-	1.8	10.0	30.8	11.0	14.9	11.9	0.1	-	0.2
Total	**388.9**	**10.4**	**3.8**	**50.5**	**145.4**	**18.7**	**79.8**	**40.6**	**7.3**	**0.002**	**32.4**

Year 2008

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**45.9**	5.6	1.0	5.6	4.0	7.1	13.2	0.3	-	-	9.2
Estonia	**48.6**	-	-	0.3	0.0	-	5.3	15.6	-	-	27.3
Finland	**24.3**	-	-	2.1	2.1	0.2	2.3	8.6	5.2	0.0002	3.8
Germany	**30.4**	1.3	0.07	1.8	6.0	4.0	13.7	3.6	-	-	-
Latvia	**57.2**	-	-	2.1	6.3	0.2	48.6	0.005	-	-	-
Lithuania	**18.7**	-	0.01	5.5	6.0	0.7	4.6	1.8	-	-	-
Poland	**53.3**	-	3.9	25.4	23.8	0.02	0.15	-	-	-	-
Russia	**21.0**	-	-	-	21.0	-	-	-	-	-	-
Sweden	**81.1**	-	2.0	13.3	13.2	9.1	27.4	15.4	0.00005	-	0.7
Total	**380.5**	**6.9**	**7.1**	**56.0**	**82.4**	**21.4**	**115.2**	**45.3**	**5.2**	**0.0002**	**41.0**

Year 2009

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**59.7**	3.8	0.5	0.7	9.7	14.3	0.3	22.1	8.3	-	-	-
Estonia	**47.3**	-	-	-	0.6	-	-	2.5	13.7	-	-	30.5
Finland	**23.1**	-	-	-	0.0	2.7	0.3	2.9	7.7	4.4	0.0001	5.2
Germany	**26.3**	1.4	-	0.24	1.9	3.7	6.2	9.0	4.0	-	-	-
Latvia	**49.5**	-	-	0.0	6.0	5.0	0.5	38.0	0.008	-	-	-
Lithuania	**18.8**	-	-	0.45	3.3	6.4	0.5	7.2	0.9	-	-	-
Poland	**81.9**	-	0.3	2.1	25.4	33.9	6.60	8.40	5.2	-	-	-
Russia	**25.2**	-	-	-	-	25.2	-	-	-	-	-	-
Sweden	**75.3**	-	-	2.4	7.9	13.5	10.5	28.2	12.6	0.0014	-	0.2
Total	**407.1**	**5.2**	**0.9**	**5.9**	**54.8**	**104.6**	**24.9**	**118.3**	**52.3**	**4.4**	**0.0001**	**35.9**

Year 2010

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**43.6**	8.0	-	0.7	5.2	12.3	2.4	9.6	5.3	-	-	-
Estonia	**47.9**	-	-	-	-	-	-	2.6	16.9	-	-	28.3
Finland	**24.4**	-	-	-	-	1.9	0.3	5.3	6.8	3.3	0.002	6.9
Germany	**17.8**	1.8	-	0.05	1.3	4.7	2.8	4.5	2.7	-	-	-
Latvia	**45.9**	-	-	-	5.2	5.0	-	35.7	-	-	-	-
Lithuania	**9.2**	-	-	-	0.03	4.6	-	4.6	-	-	-	-
Poland	**56.7**	-	0.02	0.1	14.3	32.8	6.1	2.9	0.6	-	-	-
Russia	**25.6**	-	-	-	-	25.6	-	-	-	-	-	-
Sweden	**70.4**	-	-	1.6	5.3	8.8	22.5	19.9	12.2	0.003	-	-
Total	**341.5**	**9.8**	**0.02**	**2.5**	**31.2**	**95.7**	**34.1**	**85.0**	**44.5**	**3.3**	**0.002**	**35.2**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 3/4

Year 2011

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**31.4**	7.1		0.426	2.4	4.0	0.13	8.9	8.1			0.3
Estonia	**35.0**				0.2	0.2	0.04	2.5	11.9			20.2
Finland	**15.8**					0.6	0.27	1.2	4.5	3.49		5.7
Germany	**11.4**	1.2		0.061	0.4	2.8	0.01	3.8	3.3			
Latvia	**33.4**			0.003	2.5	4.2	0.12	26.6				
Lithuania	**9.9**			0.021	1.8	5.8	0.05	1.7	0.6			
Poland	**55.3**			0.689	9.5	38.0	0.16	6.0	1.0			
Russia	**19.5**					19.5						
Sweden	**56.2**			1.190	5.9	8.9	11.02	15.4	11.9	0.08		1.8
Total	**267.9**	**8.3**	**0.00**	**2.4**	**22.7**	**83.8**	**11.8**	**66.1**	**41.2**	**3.6**	**0.000**	**28.0**

Year 2012

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**11.4**	4.73	0.00	0.23	2.5	1.4	0.13	-	2.45	-	-	-
Estonia	**27.7**	-	-	-	-	-	-	2.19	10.16	-	-	15.3
Finland	**9.0**	-	-	-	-	-	-	-	2.34	2.45	0.02	4.1
Germany	**11.3**	0.92		0.06	2.0	2.2	0.09	4.10	1.93	-	-	-
Latvia	**30.7**	-	-	-	0.1	4.7	-	25.85	0.01	-	-	-
Lithuania	**11.3**	-	-	-	2.8	6.6	-	2.00	-	-	-	-
Poland	**62.1**	-	-	3.56	24.3	30.5	0.08	2.55	1.16	-	-	-
Russia	**25.0**	-	-	-	-	25.0	-	-	-	-	-	-
Sweden	**46.5**	-	-	0.59	7.7	2.7	5.30	19.31	10.62	0.04	-	0.3
Total	**235.0**	**5.7**	**0.00**	**4.4**	**39.3**	**73.0**	**5.6**	**56.0**	**28.7**	**2.5**	**0.022**	**19.8**

Year 2013

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**25.6**	7.10		0.36	3.31	2.2	0.7	3.4	8.4			
Estonia	**29.8**							1.8	11.7			16.2
Finland	**11.1**				0.08		0.1	0.2	4.1	2.86		3.7
Germany	**10.3**	0.59		0.17	1.30	2.6	0.9	1.4	3.4			
Latvia	**33.3**				0.12	4.2		28.6	0.4			
Lithuania	**10.4**				1.35	4.6		3.1	1.3			
Poland	**79.7**			0.96	19.13	53.4	1.6	2.6	2.1			
Russia	**22.6**					22.6						
Sweden	**49.7**			0.12	8.25	4.4	10.9	8.8	16.5	0.12		0.5
Total	**272.4**	**7.7**	**0.00**	**1.6**	**33.5**	**94.0**	**14.2**	**50.0**	**47.9**	**3.0**	**0.000**	**20.5**

Year 2014

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**26.6**	1.07		1.50	6.52	4.8	0.2	5.7	6.8			0.1
Estonia	**28.5**				0.00	0.0		1.1	9.9			17.5
Finland	**11.7**						0.2	0.1	2.8	2.80	0.001	5.8
Germany	**10.2**	0.60		0.04	2.62	2.2	0.6	1.5	2.6			
Latvia	**30.8**				0.27	2.9		27.6				
Lithuania	**9.6**				0.65	3.5	0.0	4.5	0.9			
Poland	**56.9**			1.49	21.83	31.2	0.2	2.1	0.1			
Russia	**23.4**					23.4						
Sweden	**46.0**			0.04	8.27	6.4	6.3	11.0	12.8	0.25		0.9
Total	**243.8**	**1.7**	**0.00**	**3.1**	**40.2**	**74.5**	**7.5**	**53.6**	**35.9**	**3.0**	**0.001**	**24.3**

Year 2015

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**22.5**	4.239		0.265	0.077	2.918	2.038	9.562	3.133	0.222		
Estonia	**24.0**				0.490		0.205	1.378	6.807			15.073
Finland	**12.0**				0.354		0.482	0.082	4.396	2.027	0.0003	4.619
Germany	**10.3**	0.657		0.071	2.680	0.851	0.294	4.671	1.068			
Latvia	**30.5**				0.527	2.716		27.067	0.182			
Lithuania	**11.0**				4.355	0.782		5.117	0.749			
Poland	**62.2**			2.715	26.122	33.004	0.001	0.387				
Russia	**30.7**					30.694						
Sweden	**44.1**			0.059	5.857	0.957	13.320	11.212	12.544	0.181		
Total	**247.2**	**4.9**	**0.00**	**3.1**	**40.5**	**71.9**	**16.3**	**59.5**	**28.9**	**2.4**	**0.0003**	**19.7**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 4/4

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**

Year 2020

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**26.4**	0.000		0.004	16.387	1.216	0.727	4.051	4.063			
Estonia	**24.3**							3.751	6.605			13.915
Finland	**12.5**				0.184	0.048	0.050	0.686	6.440	0.743	0.019	4.328
Germany	**8.9**	0.001		0.018	5.049	0.373		2.225	1.264			
Latvia	**28.9**				0.423	2.950		25.521				
Lithuania	**11.2**				3.303	4.197		3.665				
Poland	**72.5**			2.434	35.046	33.364	0.067	1.629				
Russia	**45.7**					44.884						0.832
Sweden	**41.1**		0.004	0.005	14.035	2.129	6.451	14.582	3.858	0.008		
Total	**271.5**	**0.0**	**0.0**	**2.5**	**74.4**	**89.2**	**7.3**	**56.1**	**22.2**	**0.8**	**0.019**	**19.1**

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Sub-division in 2020. 1/4

Sub-division 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0			0.0				
1	0.0	0.0			0.0	5.0	9.4		
2	0.0	0.0			0.0	10.2	10.4		
3	0.0	0.0			0.0	10.5	13.5		
4	0.0	0.0			0.0	11.8	16.4		
5	0.0	0.0			0.0	11.7	15.5		
6	0.0	0.0			0.0	12.7	14.9		
7	0.0	0.0			0.0	13.9	17.8		
8	0.0	0.0			0.0				
9	0.0	0.0			0.0				
10	0.0	0.0			0.0		16.4		
Sum	0.0	0.1	0.0	0.0	0.1				
SOP	0.1	1.0	0.0	0.0	1.0				
Catch	0.1	1.0	0.0	0.0	1.0				

Sub-division 23

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0				0.0	0.0			
1	0.0				0.0	5.0			
2	0.0				0.0	10.2			
3	0.1				0.0	10.5			
4	0.1				0.0	11.8			
5	0.1				0.0	11.7			
6	0.1				0.0	12.7			
7	0.0				0.0	13.9			
8	0.0				0.0	0.0			
9	0.0				0.0	0.0			
10	0.0				0.0	0.0			
Sum	0.3	0.0	0.0	0.0	0.0				
SOP	3.5	0.0	0.0	0.0	3.5				
Catch	3.5	0.0	0.0	0.0	3.5				

Sub-division 24

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	5.3	10.1	15.5			5.7	5.7
1	2.6	0.7	15.0	28.4	46.7	5.1	9.4	12.1	12.1
2	8.2	4.7	6.3	12.0	31.2	10.2	10.4	12.5	12.5
3	11.6	14.9	5.4	10.2	42.1	10.4	13.5	12.7	12.7
4	13.1	12.2	0.4	0.7	26.3	11.8	16.4	17.0	17.0
5	13.6	9.0	0.0	0.0	22.5	11.7	15.5		
6	11.7	5.2	0.0	0.0	16.8	12.7	14.9		
7	1.3	1.6	0.0	0.0	2.8	13.9	17.8		
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	0.2	0.0	0.0	0.2		16.4		
Sum	62.1	48.4	32.4	61.5	204.3				
SOP	697.3	703.4	365.4	693.8	2459.8				
Catch	697.2	702.8	365.8	694.5	2460.3				

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2020. 2/4

Sub-division 25

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	2.6	2.6				3.8
1	106.1	60.3	0.0	47.7	214.1	3.9	4.4		11.1
2	656.0	376.6	6.5	70.0	1109.1	9.0	8.7	12.8	12.2
3	901.0	606.9	14.5	89.0	1611.4	9.5	9.9	13.5	12.7
4	952.8	475.2	20.5	60.1	1508.6	10.4	11.0	14.9	13.3
5	710.3	495.3	13.6	36.2	1255.4	11.1	11.6	14.4	13.7
6	545.0	581.2	16.7	46.3	1189.3	11.5	12.3	14.3	13.8
7	55.1	65.6	1.3	4.9	126.9	12.8	14.0	14.8	14.0
8	10.4	17.2	1.3	1.3	30.2	13.0	14.7	15.6	14.6
9	4.3	6.6	0.0	0.0	10.9	12.5	13.4		
10	0.6	1.8	0.0	0.3	2.7	12.8	9.9		11.4
Sum	3941.4	2686.8	74.6	358.4	7061.3				
SOP	39838.3	28950.4	1061.1	4549.6	74399.4				
Catch	39846.5	28968.9	1061.3	4549.1	74425.8				

Sub-division 26

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	481.7	481.7				4.4
1	805.3	704.0	19.9	334.0	1863.3	4.1	5.5	7.1	9.3
2	1415.2	978.0	49.8	428.6	2871.5	8.9	9.1	9.3	10.6
3	1302.2	542.1	32.2	245.1	2121.6	9.7	10.6	10.7	11.5
4	913.3	257.5	13.4	111.7	1295.9	10.6	11.6	11.9	12.5
5	545.3	129.5	4.1	61.9	740.7	10.8	11.8	13.1	13.3
6	312.0	88.1	4.5	59.0	463.6	11.0	12.7	12.6	13.6
7	26.9	6.5	0.1	5.4	39.0	13.8	11.0	15.9	16.5
8	10.4	2.2	0.0	0.9	13.5	12.3	15.9		17.2
9	0.0	0.0	0.0	1.6	1.6				14.3
10	0.0	0.0	0.0	0.0	0.0				
Sum	5330.5	2707.8	124.1	1730.0	9892.4				
SOP	48028.5	24257.7	1221.9	15738.1	89246.1				
Catch	48015.8	24274.3	1221.0	15649.8	89161.0				

Sub-division 27

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	2.2	2.2				3.5
1	199.9	1.4	0.2	31.2	232.7	3.1	3.9	9.0	8.9
2	75.1	17.7	1.0	25.1	118.9	8.9	9.0	9.9	10.1
3	101.4	19.0	2.1	28.4	150.9	9.4	9.4	11.1	10.9
4	68.1	16.6	0.7	18.9	104.4	10.0	10.1	11.0	11.4
5	59.8	9.7	1.4	15.6	86.5	10.3	10.4	10.6	11.8
6	74.3	29.4	2.2	31.8	137.6	10.7	10.3	11.2	11.8
7	10.2	4.9	0.3	2.2	17.6	10.9	11.1	12.6	10.4
8	2.8	1.4	0.2	1.7	6.0	9.5	11.6	12.7	10.9
9	1.9	1.0	0.0	1.7	4.6	12.1	10.0		14.1
10	0.9	0.3	0.0	0.6	1.8	9.9	11.9		16.8
Sum	594.4	101.5	8.0	159.4	863.2				
SOP	4502.3	999.8	87.2	1697.6	7286.9				
Catch	4507.2	1000.4	87.2	1700.4	7295.1				

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2020. 3/4

Sub-division 28

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	1.2	105.6	106.7			3.3	3.6
1	483.3	71.6	266.9	770.8	1592.6	2.9	3.3	7.9	8.5
2	403.1	153.5	90.4	305.4	952.3	8.6	8.9	9.5	10.1
3	577.4	224.6	86.6	483.8	1372.3	9.3	9.8	10.0	10.7
4	284.0	74.4	31.9	181.5	571.8	10.0	10.3	10.7	11.1
5	215.0	54.7	27.1	127.3	424.1	10.2	11.0	10.7	11.3
6	310.0	150.6	88.1	422.7	971.4	10.2	10.9	10.3	11.5
7	18.6	13.5	4.4	48.3	84.9	10.7	11.5	10.9	11.4
8	18.1	17.8	3.5	39.3	78.8	11.8	12.8	12.0	13.0
9	0.9	0.6	0.0	0.0	1.5	13.3	12.4		
10	0.0	0.6	0.0	0.0	0.6		12.5		
Sum	2310.5	761.8	600.1	2484.7	6157.1				
SOP	18858.8	7210.6	5466.2	24569.1	56104.7				
Catch	18831.1	7218.0	5459.2	24600.7	56109.0				

Sub-division 29

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.4	192.0	192.5			1.7	2.7
1	1010.0	22.3	121.1	439.4	1592.9	2.7	2.9	7.9	7.4
2	170.0	7.5	26.7	106.4	310.6	8.2	8.6	9.4	9.1
3	240.2	12.0	47.3	197.0	496.5	9.1	9.3	9.8	9.6
4	112.0	6.6	6.6	53.8	179.1	9.9	10.1	10.8	10.2
5	102.4	10.3	7.2	55.3	175.1	10.3	10.9	12.0	10.8
6	144.2	17.5	31.7	116.4	309.7	10.0	10.0	10.2	10.2
7	18.6	0.9	3.9	3.9	27.3	10.7	11.3	10.0	12.2
8	7.7	6.5	1.5	10.0	25.8	11.6	11.6	11.0	11.2
9	0.0	0.0	0.0	0.0	0.0				
10	3.4	0.0	0.0	0.0	3.4	11.5			
Sum	1808.5	83.6	246.5	1174.2	3312.9				
SOP	10239.8	680.8	2208.6	9122.3	22251.6				
Catch	10218.9	682.6	2209.1	9119.0	22229.6				

Sub-division 30

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	4.9	4.9			1.7	2.7
1	5.8	1.0	0.0	3.1	9.9	2.7	2.9	7.9	7.5
2	1.1	0.3	0.0	3.4	4.9	8.7	8.6	9.4	9.1
3	3.1	0.8	0.0	8.2	12.1	9.3	9.3	9.8	9.6
4	2.7	0.6	0.0	2.8	6.1	10.1	10.1	10.8	10.2
5	5.3	2.1	0.0	4.1	11.5	10.8	10.9	12.0	10.8
6	9.4	2.4	0.0	9.3	21.1	10.1	10.0	10.2	10.2
7	3.3	0.2	0.0	1.0	4.6	11.3	11.3	10.0	12.2
8	3.2	2.1	0.0	2.1	7.4	11.6	11.6	11.0	11.0
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	34.0	9.7	0.1	38.8	82.5				
SOP	308.4	94.1	1.3	347.9	751.6				
Catch	307.8	94.2	1.3	348.0	751.2				

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2020. 4/4

Sub-division 31

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0		0.0	0.0		0.0			1.7	
1		0.2	0.0		0.2		2.9	7.9	
2		0.1	0.0		0.1		8.6	9.4	
3		0.1	0.1		0.2		9.3	9.8	
4		0.1	0.0		0.1		10.1	10.8	
5		0.4	0.0		0.4		10.9	12.0	
6		0.4	0.1		0.5		10.0	10.2	
7		0.0	0.0		0.1		11.3	10.0	
8		0.4	0.0		0.4		11.6	11.0	
9		0.0	0.0		0.0				
10		0.0	0.0		0.0				
Sum	0.0	1.7	0.3	0.0	2.0				
SOP	0.0	17.0	2.3	0.0	19.3				
Catch	0.0	17.0	2.3	0.0	19.3				

Sub-division 32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	1.3	57.0	58.3				2.6
1	193.4	67.4	73.0	553.6	887.4	2.6	3.1	7.6	7.8
2	65.5	11.3	38.7	141.6	257.1	8.9	8.0	9.5	9.6
3	115.6	19.6	44.4	232.7	412.3	9.2	9.2	9.8	9.8
4	31.3	9.0	18.2	58.5	117.1	9.8	10.0	10.7	10.2
5	35.2	10.2	11.5	44.3	101.2	10.7	10.6	10.9	11.0
6	120.0	38.7	45.5	178.1	382.3	9.8	10.0	10.4	10.1
7	10.0	3.2	5.6	18.5	37.3	10.9	10.9	11.0	11.3
8	18.0	6.5	5.5	14.8	44.8	11.2	10.8	11.0	11.4
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	589.1	166.0	243.9	1298.9	2297.8				
SOP	4319.8	1170.3	2274.4	11364.6	19129.1				
Catch	4318.6	1167.4	2272.0	11317.8	19075.7				

Sub-divisions 22-32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	8.4	856.1	864.4			4.2	3.8
1	2806.5	928.9	496.2	2208.3	6439.8	3.2	5.0	8.0	8.3
2	2794.3	1549.5	219.5	1092.5	5655.7	8.8	9.0	9.6	10.3
3	3252.6	1440.2	232.5	1294.3	6219.6	9.5	10.2	10.3	10.7
4	2377.3	852.3	91.8	488.1	3809.5	10.4	11.2	11.8	11.5
5	1686.9	721.2	64.9	344.5	2817.5	10.8	11.6	11.8	11.8
6	1526.6	913.5	188.8	863.6	3492.5	10.8	11.9	10.7	11.3
7	144.0	96.5	15.6	84.3	340.4	12.2	13.2	11.1	11.9
8	70.6	54.1	12.1	70.1	206.9	11.8	13.1	11.8	12.4
9	7.1	8.2	0.0	3.3	18.6	12.5	12.9		14.2
10	4.9	3.0	0.0	0.9	8.8	11.3	11.1		14.7
Sum	14670.7	6567.4	1329.9	7305.8	29873.9				
SOP	126796.8	64085.1	12688.3	68082.9	271653.1				
Catch	126746.6	64126.5	12679.3	67979.3	271531.7				

Table 7.4. Sprat in SD 22–32. Fishing effort and CPUE data.

Year	Russia - Sub-division 26			
	Type of vessels			
	*) SRTM (51 m length, 1100 hp)		MRTK (27 m length, 300 hp)	
	Effort [h]	CPUE, [kg/h]	Effort [h]	CPUE, [kg/h]
1995	8907	647	8760	601
1996	12129	620	7810	953
1997	17140	470	10691	746
1998	13469	646	9986	782
1999	13898	869	15967	965
2000	14417	766	13501	1031
2001	12837	937	12912	1282
2002	11789	884	18979	1012
2003	5869	958	14128	1285
2004	2973	895	14751	1394
2005	1696	1323	21908	1115
2006	877	1362	16592	1406
2007			16032	1303
2008			14428	1306
2009			17966	1258
2010			14179	1276
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
2020			45572	1015

*) - vessels withdrawn from exploitation in 2007

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 1/8

Sub-division 22	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2	0.0	0	0	0
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	0.1	0	0	0
		2	1.0	0	0	0
		3				
		4				
		Total	1.0	0	0	0
	Total	1	0.1	0	0	0
		2	1.0	0	0	0
		3	0.0	0	0	0
		4	-	0	0	0
		Total	1.0	0	0	0

Sub-division 23+24	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2	2.9	0	0	0
		3	0.0	0	0	0
		4	0.9	0	0	0
		Total	3.8	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	5.3	2	117	89
		2	11.1	0	0	0
		3				
		4	2.0	2	85	56
		Total	18.5	4	202	145
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Poland	1	691.9	2	398	148
		2	688.3	4	870	306
		3	365.7	0	0	0
		4	687.6	0	0	0
		Total	2 433.5	6	1268	454
	Sweden	1	3.5	0	0	0
		2	0.5	0	0	0
		3	0.0	0	0	0
		4	4.0	0	0	0
		Total	8.1	0	0	0
	Total	1	700.7	4	515	237
		2	702.8	4	870	306
		3	365.8	0	0	0
		4	694.5	2	85	56
		Total	2 463.8	10	1470	599

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 2/8

Sub-division 25	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	11 844.7	12	1515	637
		2	3 391.1	6	965	329
		3	234.3	0	0	0
		4	916.7	5	206	206
		Total	16 386.8	23	2686	1172
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1	20.4	0	0	0
		2	159.2	0	0	0
		3				
		4	3.9	0	0	0
		Total	183.5	0	0	0
	Germany	1	2 449.6	0	0	0
		2	2 535.2	1	226	42
		3				
		4	64.2	0	0	0
		Total	5 049.0	1	226	42
	Latvia	1				
		2	422.5	0	0	0
		3				
		4				
		Total	422.5	0	0	0
	Lithuania	1	553.2	0	0	0
		2	2 749.6	0	0	0
		3				
		4				
		Total	3 302.8	0	0	0
	Poland	1	18 789.3	3	715	205
		2	12 798.8	7	1328	398
		3	779.5	0	0	0
		4	2 678.3	3	371	123
		Total	35 045.9	13	2414	726
	Sweden	1	6 189.3	25	1190	1144
		2	6 912.5	9	450	430
		3	47.5	4	212	174
		4	885.9	12	383	380
		Total	14 035.2	50	2235	2128
	Total	1	39 846.5	40	3420	1986
		2	28 968.9	23	2969	1199
		3	1 061.3	4	212	174
		4	4 549.1	20	960	709
		Total	74 425.8	87	7561	4068

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 3/8

Sub-division 26	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	1 202.6	3	303	132
		2				
		3				
		4	13.3	0	0	0
		Total	1 215.8	3	303	132
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4	48.1	0	0	0
		Total	48.1	0	0	0
	Germany	1	373.0	1	287	53
		2				
		3				
		4				
		Total	373.0	1	287	53
	Latvia	1	2 233.1	3	630	287
		2	392.4	0	0	0
		3	45.6	0	0	0
		4	279.0	0	0	0
		Total	2 950.1	3	630	287
	Lithuania	1	3 479.8	2	624	161
		2	349.5	2	397	218
		3	34.7	0	0	0
		4	332.7	4	570	319
		Total	4 196.7	8	1591	698
	Poland	1	20 613.8	8	1737	479
		2	5 416.2	4	994	278
		3	739.6	0	0	0
		4	6 594.4	0	0	0
		Total	33 364.0	12	2731	757
	Russia	1	19 757.5	12	2202	649
		2	18 116.3	18	3761	791
		3	401.1	8	1331	230
		4	6 609.1	24	3781	677
		Total	44 884.0	62	11075	2347
	Sweden	1	356.0	3	150	150
		2				
		3				
		4	1 773.2	8	367	367
		Total	2 129.2	11	517	517
	Total	1	48 015.8	32	5933	1911
		2	24 274.3	24	5152	1287
		3	1 221.0	8	1331	230
		4	15 649.8	36	4718	1363
		Total	89 161.0	100	17134	4791

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 4/8

Sub-division 27	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	675.5	1	69	45
		2				
		3				
		4	51.3	0	0	0
		Total	726.8	1	69	45
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4	50.3	0	0	0
		Total	50.3	0	0	0
	Germany	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1				
		2	66.6	0	0	0
		3				
		4				
		Total	66.6	0	0	0
	Sweden	1	3 831.7	15	587	547
		2	933.8	6	293	293
		3	87.2	2	100	100
		4	1 598.8	6	295	286
		Total	6 451.4	29	1275	1226
	Total	1	4 507.2	16	656	592
		2	1 000.4	6	293	293
		3	87.2	2	100	100
		4	1 700.4	6	295	286
		Total	7 295.1	30	1344	1271

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 5/8

Sub-division 28	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	3 608.8	12	1558	636
		2				
		3	239.5	0	0	0
		4	202.7	0	0	0
		Total	4 050.9	12	1558	636
	Estonia	1	1 286.9	13	1689	1090
		2	682.1	7	917	700
		3	366.5	4	400	400
		4	1 415.0	9	1415	812
		Total	3 750.5	33	4421	3002
	Finland	1	109.6	0	0	0
		2	9.2	0	0	0
		3	13.9	0	0	0
		4	552.9	0	0	0
		Total	685.6	0	0	0
	Germany	1	1 409.5	1	346	54
		2				
		3				
		4	815.0	0	0	0
		Total	2224.5	1	346	54
	Latvia	1	7 629.7	7	1467	662
		2	4 863.7	5	1055	472
		3	3 814.0	7	1481	680
		4	9 213.8	7	1198	656
		Total	25 521.2	26	5201	2470
	Lithuania	1	774.9	0	0	0
		2	290.0	0	0	0
		3	216.0	0	0	0
		4	2 384.3	0	0	0
		Total	3 665.2	0	0	0
	Poland	1	416.3	0	0	0
		2	285.7	0	0	0
		3	103.2	0	0	0
		4	824.1	0	0	0
		Total	1 629.3	0	0	0
	Russia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	3 595.3	14	512	491
		2	1 087.3	8	400	399
		3	706.2	7	338	337
		4	9 192.9	10	289	271
		Total	14 581.7	39	1539	1498
	Total	1	18 831.1	47	5572	2933
		2	7 218.0	20	2372	1571
		3	5 459.2	18	2219	1417
		4	24 600.7	26	2902	1739
		Total	56 109.0	111	13065	7660

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 6/8

Sub-division 29	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	3590.7	14	1423	681
		2				
		3				
		4	472.8	0	0	0
		Total	4063.4	14	1423	681
	Estonia	1	2282.3	11	2134	1054
		2	383.4	3	501	300
		3	1144.6	1	302	100
		4	2794.4	7	1331	700
		Total	6604.7	22	4268	2154
	Finland	1	1546.6	6	795	0
		2	299.2	4	73	0
		3	1064.6	4	674	0
		4	3529.6	16	2488	0
		Total	6440.0	30	4030	0
	Germany	1	543.3	1	375	53
		2				
		3				
		4	720.2	0	0	0
		Total	1263.5	1	375	53
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Poland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	2256.0	3	150	150
		2				
		3				
		4	1602.0	0	0	0
		Total	3858.0	3	150	150
	Total	1	10218.9	35	4877	1938
		2	682.6	7	574	300
		3	2209.1	5	976	100
		4	9119.0	23	3819	700
		Total	22229.6	70	10246	3038

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 7/8

Sub-division 30	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1	303.2	24	879	0
		2	91.5	16	545	0
		3	0.4	0	0	480
		4	348.0	26	420	72
		Total	743.1	66	1844	552
	Sweden	1	4.6	0	0	0
		2	2.7	0	0	0
		3	0.9	0	0	0
		4				
		Total	8.2	0	0	0
	Total	1	307.8	24	879	0
		2	94.2	16	545	0
		3	1.3	0	0	480
		4	348.0	26	420	72
		Total	751.2	66	1844	552

Sub-division 31	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Finland	1				
		2	17.0	0	0	0
		3	2.3	0	0	0
		4				
		Total	19.3	0	0	0
	Sweden	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Total	1	0.0	0	0	0
		2	17.0	0	0	0
		3	2.3	0	0	0
		4	0.0	0	0	0
		Total	19.3	0	0	0

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2020 available to the Working Group. 8/8

Sub-division 32	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Estonia	1	3 150.0	15	3070	1249
		2	1 081.8	10	2643	984
		3	1 390.9	4	1039	400
		4	8 292.7	11	2150	1035
		Total	13 915.4	40	8902	3668
	Finland	1	903.6	3	966	0
		2	13.8	3	383	0
		3	880.4	6	1814	0
		4	2 530.5	6	1932	0
		Total	4 328.3	18	5095	0
	Russia	1	265.0	0	0	0
		2	71.8	0	0	0
		3	0.7	0	0	0
		4	494.6	5	1055	200
		Total	832.0	5	1055	200
	Total	1	4 318.6	18	4036	1249
		2	1 167.4	13	3026	984
		3	2 272.0	10	2853	400
		4	11 317.8	22	5137	1235
		Total	19 075.7	63	15052	3868
Sub-divisions 22-32	**Total**	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish measured**	**Number of fish aged**
		1	**126 746.6**	**216**	**25888**	**10846**
		2	**64 126.5**	**113**	**15801**	**5940**
		3	**12 679.3**	**47**	**7691**	**2901**
		4	**67 979.3**	**161**	**18336**	**6160**
		Total	**271 531.7**	**537**	**67716**	**25847**

Table 7.6. Sprat in SD 22–32. Catch-in-numbers (Thousands) CANUM.

CANUM: Catch in numbers (Total International Catch) (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	2615000	6172000	3618000	1940000	1929000	933000	1213000	278000
1975	628000	2032000	5678000	2387000	790000	878000	247000	546000
1976	4682000	818000	2106000	3510000	1040000	350000	548000	422000
1977	2371000	8399000	997000	1907000	1739000	364000	140000	399000
1978	500000	3325000	4936000	480000	817000	683000	73000	189000
1979	1340000	597000	1037000	2291000	188000	150000	335000	125000
1980	369000	1476000	378000	500000	1357000	72000	67000	235000
1981	2303000	920000	405000	94000	88000	527000	13000	99000
1982	363000	2460000	425000	225000	64000	57000	231000	51000
1983	1852000	297000	531000	107000	47000	12000	18000	148000
1984	1005000	2393000	388000	447000	77000	38000	9000	83000
1985	566000	1703000	2521000	447000	271000	30000	19000	65000
1986	495000	1142000	1425000	2099000	340000	188000	16000	50000
1987	779000	394000	1320000	1833000	1805000	227000	149000	73000
1988	78000	2696000	730000	1149000	762000	760000	65000	141000
1989	2102000	290000	1772000	404000	739000	390000	398000	137000
1990	1049000	3171000	346000	952000	188000	316000	112000	200000
1991	1044000	2649000	2439000	407000	569000	106000	160000	152000
1992	1782000	2939000	3040000	1643000	444000	311000	121000	163000
1993	1832000	5685000	3244000	1898000	884000	267000	244000	257000
1994	1079000	8169000	8176000	3525000	2201000	779000	193000	208000
1995	6373000	2341000	6643000	6636000	3366000	1902000	627000	409000
1996	8389000	27675000	4704000	6517000	3323000	1499000	690000	403000
1997	1718000	23182000	23395000	6343000	4108000	1651000	683000	279000
1998	11018000	3803000	17688000	19618000	2659000	1778000	1468000	489000
1999	2082000	19901000	5832000	9972000	8836000	1180000	687000	515000
2000	10535000	2948000	14716000	2870000	4284000	4077000	707000	761000
2001	2776000	11557000	2670000	9252000	1999000	2651000	2264000	523000
2002	6648000	5429000	10781000	3835000	4308000	998000	880000	1340000
2003	9366000	7109000	4805000	5067000	2396000	1903000	833000	1383000
2004	23264000	13094000	5448000	3086000	3246000	1334000	1143000	1364000
2005	2843000	30968000	11254000	2934000	1868000	843000	659000	615000
2006	10851000	3266000	21097000	6832000	1380000	614000	405000	530000
2007	13796000	11968000	3706000	13723000	3855000	623000	301000	539000
2008	6391000	15479000	6684000	2937000	5719000	2255000	299000	362000
2009	21145000	8891000	10181000	3905000	1795000	2837000	1008000	353000
2010	4584000	21493000	5363000	4234000	1239000	881000	994000	511000
2011	8799000	4361000	12720000	2749000	1471000	549000	379000	568000
2012	5218000	5712000	2727000	7041000	1246000	736000	298000	437000
2013	6266000	9569000	4486000	2391000	3849000	682000	310000	317000
2014	4911208	7619008	6498613	2373559	1458602	1402152	352393	371808
2015	17057263	4720316	5121411	3272068	1244627	659072	584565	292838
2016	2973969	18520734	3801288	2547751	1226450	508161	406247	450644
2017	3579884	6141001	16543725	3195711	1563614	675502	241309	398356
2018	6278336	6497104	6473215	12795134	1871268	610191	255558	207540
2019	5962092	10263401	5560056	5543538	7445687	777196	290655	235195
2020	6439838	5655737	6219636	3809510	2817502	3492510	340448	234291

Table 7.7. Sprat in SD 22–32. Mean weight in the catch and in the stock (kg).

WECA (=WEST): Mean weight in Catch (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.0066	0.0105	0.0122	0.0134	0.0139	0.0154	0.0141	0.0143
1975	0.0068	0.0112	0.0124	0.0134	0.0147	0.0143	0.0157	0.0135
1976	0.0069	0.0107	0.0127	0.0135	0.0145	0.0161	0.0147	0.0143
1977	0.0054	0.0110	0.0134	0.0140	0.0144	0.0159	0.0159	0.0158
1978	0.0051	0.0109	0.0125	0.0131	0.0141	0.0152	0.0158	0.0151
1979	0.0055	0.0127	0.0130	0.0137	0.0151	0.0158	0.0156	0.0162
1980	0.0078	0.0113	0.0143	0.0141	0.0143	0.0167	0.0158	0.0160
1981	0.0063	0.0141	0.0161	0.0180	0.0165	0.0159	0.0168	0.0161
1982	0.0088	0.0117	0.0160	0.0162	0.0167	0.0164	0.0163	0.0173
1983	0.0092	0.0145	0.0162	0.0171	0.0169	0.0170	0.0169	0.0168
1984	0.0097	0.0111	0.0146	0.0153	0.0158	0.0163	0.0169	0.0172
1985	0.0091	0.0113	0.0127	0.0140	0.0160	0.0171	0.0171	0.0158
1986	0.0079	0.0121	0.0129	0.0140	0.0148	0.0161	0.0170	0.0167
1987	0.0085	0.0117	0.0133	0.0145	0.0152	0.0164	0.0170	0.0176
1988	0.0056	0.0103	0.0122	0.0142	0.0152	0.0153	0.0166	0.0170
1989	0.0097	0.0136	0.0145	0.0158	0.0169	0.0173	0.0175	0.0181
1990	0.0104	0.0126	0.0149	0.0160	0.0175	0.0177	0.0184	0.0181
1991	0.0090	0.0129	0.0143	0.0158	0.0166	0.0175	0.0169	0.0169
1992	0.0087	0.0121	0.0147	0.0154	0.0173	0.0172	0.0181	0.0184
1993	0.0066	0.0111	0.0138	0.0146	0.0150	0.0162	0.0166	0.0166
1994	0.0080	0.0098	0.0121	0.0140	0.0145	0.0152	0.0155	0.0159
1995	0.0065	0.0106	0.0110	0.0126	0.0137	0.0141	0.0143	0.0145
1996	0.0043	0.0075	0.0103	0.0111	0.0124	0.0128	0.0127	0.0129
1997	0.0067	0.0074	0.0085	0.0101	0.0117	0.0124	0.0125	0.0127
1998	0.0046	0.0076	0.0083	0.0089	0.0104	0.0106	0.0108	0.0118
1999	0.0040	0.0078	0.0092	0.0091	0.0092	0.0106	0.0112	0.0110
2000	0.0062	0.0102	0.0100	0.0108	0.0113	0.0117	0.0128	0.0134
2001	0.0063	0.0093	0.0114	0.0108	0.0116	0.0113	0.0110	0.0118
2002	0.0069	0.0097	0.0102	0.0109	0.0111	0.0111	0.0115	0.0117
2003	0.0050	0.0099	0.0108	0.0109	0.0114	0.0111	0.0107	0.0108
2004	0.0044	0.0076	0.0105	0.0112	0.0111	0.0114	0.0111	0.0113
2005	0.0047	0.0069	0.0081	0.0107	0.0112	0.0116	0.0110	0.0113
2006	0.0049	0.0078	0.0082	0.0089	0.0108	0.0112	0.0111	0.0114
2007	0.0056	0.0077	0.0091	0.0092	0.0094	0.0109	0.0113	0.0110
2008	0.0068	0.0092	0.0098	0.0105	0.0103	0.0102	0.0112	0.0122
2009	0.0050	0.0092	0.0105	0.0109	0.0114	0.0108	0.0110	0.0120
2010	0.0052	0.0080	0.0099	0.0107	0.0110	0.0112	0.0108	0.0114
2011	0.0040	0.0091	0.0096	0.0107	0.0114	0.0114	0.0114	0.0124
2012	0.0059	0.0094	0.0111	0.0112	0.0120	0.0123	0.0123	0.0121
2013	0.0051	0.0096	0.0115	0.0125	0.0126	0.0129	0.0130	0.0125
2014	0.0052	0.0092	0.0107	0.0120	0.0127	0.0127	0.0123	0.0123
2015	0.0042	0.0095	0.0110	0.0117	0.0126	0.0132	0.0125	0.0122
2016	0.0047	0.0071	0.0099	0.0113	0.0118	0.0126	0.0123	0.0122
2017	0.0054	0.0080	0.0088	0.0108	0.0118	0.0118	0.0115	0.0109
2018	0.0047	0.0086	0.0096	0.0098	0.0110	0.0117	0.0117	0.0111
2019	0.0049	0.0078	0.0094	0.0102	0.0103	0.0121	0.0122	0.0119
2020	0.0056	0.0092	0.0099	0.0108	0.0111	0.0112	0.0123	0.0124

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
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
2020	0.31	0.27	0.27	0.26	0.26	0.26	0.26	0.26

Table 7.9. Sprat in SD 22–32. Proportion mature at spawning time.

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2020	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+
1974-2020	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+
1974-2020	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 7.12. Sprat in SD 22–32. Tuning Fleet/Acoustic Survey in SD 22–29 age 0 shifted to represent age 1.

Year	Fish. Effort	Age 1
1992	1	59473
1993	1	48035
1994	1	-11
1995	1	64092
1996	1	-11
1997	1	3842
1998	1	-11
1999	1	1279
2000	1	33320
2001	1	4601
2002	1	12001
2003	1	79551
2004	1	146335
2005	1	3562
2006	1	41863
2007	1	66125
2008	1	17821
2009	1	115698
2010	1	12798
2011	1	41916
2012	1	45186
2013	1	33653
2014	1	24921
2015	1	168125
2016	1	42251
2017	1	30848
2018	1	78167
2019	1	18542
2020	1	95603

Table 7.13. Sprat in SD 22–32. Tuning Fleet/ International Acoustic Survey in October (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
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
2020	1	38625	14226	15142	7984	6799	11730	1037	861	96403

Table 7.14. Sprat in SD 22–32. Tuning Fleet/ International Acoustic 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
2020	1	38096	26252	29054	19630	18377	11756	473	376

Table 7.15. Sprat in SD 22–32. Output from XSA. 1/7

Lowestoft VPA Version 3.1

2/04/2021 14:54

Extended Survivors Analysis

Sprat 22 32

CPUE data from file z:\SprDat20\Fleet3xsa.txt

Catch data for 47 years. 1974 to 2020. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT01: Internatic	1991	2020	1	7	0.75	0.85
FLT02: Internatic	2001	2020	1	7	0.35	0.42
FLT03: Latvian/R	1992	2020	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 70 iterations

Total absolute residual between iterations
69 and 70 = .00033

Table 7.15. Sprat in SD 22–32. Output from XSA. 2/7

Final year F values

Age	1	2	3	4	5	6	7
Iteration 69	0.076	0.2345	0.3053	0.3888	0.41	0.4424	0.4389
Iteration 70	0.076	0.2345	0.3053	0.3887	0.4099	0.4425	0.4388

1

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.206	0.095	0.132	0.118	0.101	0.047	0.073	0.106	0.152	0.076
2	0.194	0.254	0.317	0.297	0.194	0.179	0.15	0.209	0.285	0.234
3	0.364	0.214	0.387	0.444	0.39	0.268	0.273	0.259	0.306	0.305
4	0.411	0.428	0.347	0.428	0.489	0.386	0.428	0.393	0.409	0.389
5	0.415	0.396	0.524	0.43	0.482	0.382	0.488	0.534	0.46	0.41
6	0.418	0.453	0.462	0.426	0.4	0.414	0.419	0.391	0.485	0.442
7	0.493	0.509	0.408	0.545	0.359	0.519	0.391	0.301	0.355	0.439

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7
2011	59500	29900	50300	9810	5180	1930	1160
2012	72400	30500	16800	24000	4500	2380	882
2013	63800	42100	16500	9620	11100	2170	1090
2014	55400	35500	21500	8020	4900	4750	987
2015	215000	31300	18400	9830	3770	2310	2250
2016	77900	133000	18800	9210	4470	1730	1160
2017	60800	51500	80400	10600	4670	2270	858
2018	73400	39900	32600	45300	5190	2160	1130
2019	49700	47800	24300	19000	23100	2320	1120
2020	102000	31000	27000	13500	9530	11100	1090

Estimated population abundance at 1st Jan 2021

0	70000	18700	15300	7040	4890	5520

Taper weighted geometric mean of the VPA populations:

79000	46500	27000	14000	6660	2990	1270

Standard error of the weighted Log(VPA populations) :

0.4551	0.4865	0.502	0.5435	0.5797	0.5861	0.4174

1

Log catchability residuals.

Table 7.15 Sprat in SD 22–32. Output from XSA. 3/7

Fleet : FLT01: International

Age		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	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		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	1	-0.2	0.41	0.38	-0.11	-0.64	0.18	0.17	0.18	-0.03	-0.18
	2	0.14	-0.13	0.66	0.06	0.52	-0.44	0.04	0.52	0.32	0.14
	3	-1.08	0.49	0.61	-0.1	0.31	0.61	-0.64	0.33	0.19	-0.21
	4	0.29	-0.82	0.61	0.06	0.34	0.43	-0.12	-0.56	-0.06	-0.23
	5	-0.86	0.39	0.02	-0.24	0.34	0.7	-0.2	0.2	-0.11	-0.78
	6	0.33	-0.7	0.75	-0.42	0.01	1.07	-0.53	0.14	0.1	-0.14
	7	-0.12	0.37	0.59	-0.18	0.35	0.34	-0.32	0.42	0.08	-0.07

Age		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	1	0.17	0.39	0.02	-0.29	-0.06	-0.25	0.28	0.02	-0.07	-0.08
	2	-0.22	0.13	0.07	-0.63	0.08	0.17	0.21	-0.08	-0.23	-0.12
	3	0.3	-0.45	0.05	-0.31	0.49	0.56	0.29	-0.5	-0.29	-0.27
	4	0.33	0.04	-0.23	-0.19	0.45	0.25	0.52	-0.2	-0.29	-0.31
	5	0.39	-0.16	0.16	-0.77	0.04	-0.12	0.44	0.72	-0.05	-0.29
	6	0.44	-0.18	0	-0.12	0.5	-0.08	0.24	0.41	-0.17	0.12
	7	0.62	-0.19	-0.25	-0.16	0.25	0.19	0.01	0.01	0.01	0.02

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	-0.2572	0.1442	0.3075	0.4901	0.4901	0.4901
S.E(Log q)	0.2867	0.3992	0.3308	0.4401	0.3318	0.2542

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	0.73	1.795	3.55	0.81	20	0.23	-0.65

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	1.509	2.38	0.85	20	0.22	-0.26
3	0.84	0.802	1.54	0.71	20	0.34	0.14
4	1.19	-0.858	-2.17	0.67	20	0.4	0.31
5	1.01	-0.036	-0.57	0.63	20	0.47	0.49
6	1.05	-0.28	-1.01	0.76	20	0.35	0.59
7	0.89	0.713	0.34	0.79	20	0.22	0.55
1							

Table 7.15. Sprat in SD 22–32. Output from XSA. 4/7

Fleet : FLT02: International

Age		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	1	-0.52	0.45	-0.43	0.41	-1.15	-0.55	0.4	-0.72	-0.34	-0.4
	2	-0.12	-0.1	-0.28	0.16	-0.11	-1.05	0	0.08	0.07	-0.04
	3	-0.79	0.02	-0.86	-0.23	-0.84	-0.13	-1.29	-0.15	0.22	-0.32
	4	-0.1	-0.18	-0.38	-0.2	-0.59	-0.58	-0.43	-1.09	-0.26	-0.02
	5	-0.96	-0.32	-0.77	0.18	-0.58	-0.1	-0.93	-0.17	-0.29	-0.16
	6	-0.88	-1.14	-0.3	-0.59	-0.5	-0.26	-0.83	-0.69	0.27	-0.81
	7	-0.91	-0.37	-0.92	0.53	-0.4	-0.42	-0.72	-0.56	0.49	0.21

Age		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	1	0.11	0.07	0.3	-0.37	-0.02	99.99	0.53	0.18	0.11	0.14
	2	-1.03	0.15	0.32	0.21	0.19	99.99	0.06	-0.02	-0.05	0.26
	3	0.26	-0.48	0.08	-0.08	0.44	99.99	0.42	0.08	0.22	-0.01
	4	0.23	0.09	-0.17	-0.38	0.36	99.99	0.34	0.09	0.63	0.03
	5	0.37	0.15	-0.02	-0.13	0.42	99.99	0.03	0.01	-0.09	0.27
	6	0.41	0.41	0.11	-0.57	0.19	99.99	-0.38	-0.42	0.03	-0.31
	7	0.41	0.12	0.33	-0.09	-0.25	99.99	-0.44	-0.51	-1.23	-1.21

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	-0.2345	0.3006	0.5971	0.64	0.64	0.64
S.E(Log q)	0.3694	0.399	0.4109	0.3011	0.4617	0.6602

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	0.9	0.394	2.08	0.62	19	0.4	-1.02

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	0.94	0.212	0.9	0.55	19	0.36	-0.23
	3	0.8	1.001	1.77	0.74	19	0.32	0.3
	4	0.94	0.239	-0.03	0.67	19	0.41	0.6
	5	1.19	-1.023	-2.49	0.75	19	0.36	0.64
	6	1.19	-0.693	-2.09	0.59	19	0.51	0.46
	7	0.69	1.061	1.96	0.57	19	0.4	0.34
	1							

Table 7.15. Sprat in SD 22–32. Output from XSA. 5/7

Fleet : FLT03: Latvian/Russi

Age		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	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		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	1	-1.05	-0.55	-0.09	-0.32	-1.29	-0.08	-0.03	-0.46	-0.16	-0.4
	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		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	1	0.28	0.13	0.06	-0.01	-0.1	-0.08	0.05	0.49	-0.09	0.29
	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	0.67	1.593	4.13	0.7	20	0.31	-0.62
1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2019

Fleet	E: Sı	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	64470	0.3	0	0	1	0.348	0.082
FLT02: Internatic	80178	0.421	0	0	1	0.177	0.067
FLT03: Latvian/R	93321	0.339	0	0	1	0.272	0.058
P shrinkage mea	46479	0.49				0.143	0.112
F shrinkage mea	54801	0.75				0.06	0.096

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
70027	0.18	0.13	5	0.71	0.076

1

Age 2 Catchability constant w.r.t. time and dependent on age

Table 7.15. Sprat in SD 22–32. Output from XSA. 6/7

Year class = 2018

Fleet	E: S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	17000	0.213	0.024	0.11	2	0.492	0.255
FLT02: Internatic	22808	0.285	0.076	0.27	2	0.277	0.196
FLT03: Latvian/R	17085	0.34	0	0	1	0.177	0.254
F shrinkage mea	21766	0.75				0.054	0.205

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
18702	0.15	0.06	6	0.422	0.234

Age 3 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:	13066	0.191	0.089	0.46	3	0.482	0.349
FLT02: Internatic	15711	0.237	0.068	0.29	3	0.329	0.298
FLT03: Latvian/R	24832	0.334	0	0	1	0.135	0.199
F shrinkage mea	15472	0.75				0.054	0.302

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
15279	0.14	0.09	8	0.653	0.305

1

Age 4 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:	6343	0.171	0.137	0.8	4	0.509	0.424
FLT02: Internatic	8274	0.212	0.115	0.55	4	0.337	0.34
FLT03: Latvian/R	7387	0.33	0	0	1	0.102	0.374
F shrinkage mea	6317	0.75				0.052	0.425

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7044	0.12	0.08	10	0.645	0.389

Table 7.15. Sprat in SD 22–32. Output from XSA. 7/7

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2015

Fleet	E: S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	3988	0.165	0.113	0.68	5	0.465	0.483
FLT02: Internatic	6447	0.2	0.109	0.55	4	0.401	0.325
FLT03: Latvian/R	4522	0.33	0	0	1	0.079	0.437
F shrinkage mea	4084	0.75				0.055	0.474

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4889	0.12	0.1	11	0.785	0.41

1

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

Year class = 2014

Fleet	E: S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	5780	0.166	0.065	0.39	6	0.522	0.426
FLT02: Internatic	5188	0.2	0.11	0.55	5	0.372	0.465
FLT03: Latvian/R	4997	0.37	0	0	1	0.042	0.479
F shrinkage mea	5790	0.75				0.065	0.426

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5519	0.13	0.05	13	0.412	0.442

Age 7 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:	587	0.167	0.114	0.68	7	0.613	0.411
FLT02: Internatic	452	0.21	0.229	1.09	6	0.288	0.508
FLT03: Latvian/R	540	0.346	0	0	1	0.028	0.441
F shrinkage mea	577	0.75				0.071	0.418

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
543	0.13	0.1	15	0.759	0.439

1

1

Table 7.16. Sprat in SD 22–32. Output from XSA. Fishing mortality (F) at age.

Run title : Sprat 22 32
At 9/04/2021 22:24

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	0.2115
4	0.3357	0.2027	0.2706	0.1856	0.1547	0.1985	0.1839	0.3643	0.2101	0.1826
5	0.2496	0.1489	0.3365	0.1292	0.2928	0.179	0.301	0.3104	0.3249	0.2525
6	0.4305	0.2528	0.2214	0.1464	0.2115	0.2362	0.2343	0.4395	0.2631	0.3402
7	0.3507	0.2061	0.2846	0.1567	0.2234	0.2074	0.243	0.3773	0.2696	0.2613
+gp	0.3507	0.2061	0.2846	0.1567	0.2234	0.2074	0.243	0.3773	0.2696	0.2613
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	0.0194	0.03	0.0633	0.0347	0.0882	0.0457
2	0.1636	0.0918	0.0864	0.0992	0.1672	0.0613	0.198	0.2756	0.1104	0.2558
3	0.0774	0.2008	0.1562	0.1441	0.2317	0.2259	0.1854	0.2808	0.3849	0.2727
4	0.1946	0.134	0.2179	0.1519	0.2609	0.3372	0.4013	0.4459	0.4421	0.4338
5	0.1387	0.1853	0.2272	0.1916	0.2987	0.4824	0.3087	0.5213	0.3674	0.4037
6	0.186	0.1166	0.1556	0.227	0.2901	0.5169	0.4532	0.2667	0.4866	0.3006
7	0.1743	0.1461	0.2015	0.1916	0.2859	0.4505	0.3915	0.4152	0.4364	0.3832
+gp	0.1743	0.1461	0.2015	0.1916	0.2859	0.4505	0.3915	0.4152	0.4364	0.3832
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	0.1303	0.0677	0.1476	0.0879	0.1171	0.0655	0.1701	0.167	0.1196	0.1557
2	0.0958	0.2421	0.2171	0.275	0.1968	0.2657	0.1199	0.3569	0.3573	0.3052
3	0.3468	0.1326	0.4369	0.3492	0.397	0.2995	0.3503	0.2308	0.4204	0.5179
4	0.2335	0.4404	0.3282	0.4357	0.4474	0.4412	0.3554	0.4908	0.3445	0.57
5	0.3776	0.2867	0.4371	0.4024	0.6354	0.6201	0.4487	0.4163	0.4695	0.4395
6	0.3691	0.4879	0.2576	0.402	0.4619	0.3738	0.4941	0.4411	0.5597	0.5486
7	0.33	0.411	0.3374	0.4083	0.5099	0.4986	0.3571	0.5699	0.4667	0.6464
+gp	0.33	0.411	0.3374	0.4083	0.5099	0.4986	0.3571	0.5699	0.4667	0.6464
FBAR 3- 5	**0.32**	**0.29**	**0.40**	**0.40**	**0.49**	**0.45**	**0.38**	**0.38**	**0.41**	**0.51**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	FBAR **-**
AGE												
1	0.1151	0.2062	0.0945	0.1316	0.1179	0.1006	0.0469	0.0727	0.1059	0.1516	0.076	0.1112
2	0.2999	0.1944	0.2538	0.3169	0.2967	0.1943	0.1787	0.1496	0.2084	0.2847	0.2345	0.2425
3	0.3735	0.3642	0.2143	0.3871	0.4436	0.3903	0.2683	0.2731	0.2592	0.3062	0.3054	0.2903
4	0.5185	0.4108	0.4281	0.3466	0.4285	0.4889	0.3861	0.4275	0.3925	0.409	0.3887	0.3967
5	0.4288	0.4154	0.3961	0.5238	0.4302	0.4823	0.3822	0.4878	0.5333	0.4601	0.4099	0.4678
6	0.4887	0.4182	0.4529	0.4618	0.4261	0.3999	0.4135	0.419	0.3906	0.4843	0.4426	0.4391
7	0.4555	0.4929	0.509	0.4081	0.5448	0.3594	0.5191	0.3911	0.3011	0.3549	0.4388	0.3649
+gp	0.4555	0.4929	0.509	0.4081	0.5448	0.3594	0.5191	0.3911	0.3011	0.3549	0.4388	
FBAR 3- 5	**0.44**	**0.40**	**0.35**	**0.42**	**0.43**	**0.45**	**0.35**	**0.40**	**0.40**	**0.39**	0.368	

Table 7.17. Sprat in SD 22–32. Output from XSA. Stock number at age (Numbers*10^-6).

Run title : Sprat 22 32
At 9/04/2021 22:24
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	182883	45092	16404	32558
2	69816	24625	8891	98291	19006	5350
3	16150	37260	12949	4952	50651	6803
4	6764	7303	18465	6733	2251	22100
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	97322	230169	167159	96605	71152

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	20055	64217	34161	124735	49917	42732	18171	40822	15300	42790
2	9615	5994	20871	11586	53275	24375	22963	9307	21259	8389
3	2028	3185	2297	8159	5757	28154	13486	13311	5494	11217
4	2530	699	1327	851	4038	3127	15587	7413	7513	2914
5	8913	869	306	518	389	2065	1617	8336	3377	3965
6	292	3300	401	117	255	176	1107	783	4023	1614
7	325	94	1310	165	57	126	91	578	335	2063
+gp	1092	701	279	1326	519	425	280	278	716	701
TOTAL	44849	79059	60952	147457	114208	101180	73302	80828	58018	73654

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	50566	57667	101926	92592	67380	254132	158819	58455	152073	55170
2	24442	34612	40820	70973	62497	45691	177839	110550	41911	102530
3	5392	15328	24057	28296	46252	38087	31900	109494	63619	28280
4	6233	3700	9591	15709	17879	26800	22600	20130	62999	32786
5	1675	3828	2488	5906	9918	10153	14313	11515	9888	30754
6	2149	1095	2457	1528	3595	5434	4704	8033	5271	5238
7	806	1339	754	1623	901	1992	2437	2287	4744	2484
+gp	1429	1265	1009	1695	961	1282	1407	923	1560	1839
TOTAL	92693	118835	183102	218323	209383	383571	414017	321387	342066	259081

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	103360	51093	58743	132654	248860	54357	84925	110176	70326	181708
2	37666	63177	32848	34488	85528	158343	34642	47781	61812	40550
3	58693	25128	35905	18969	19251	51573	85291	21395	23283	30049
4	16079	30371	16109	16693	9881	9656	27182	42087	11993	10701
5	15866	9356	14297	8399	7975	4736	4506	13452	18210	6000
6	15369	8017	5162	6685	4165	3164	1856	2064	6283	8000
7	2919	7848	3610	2891	3307	1968	1589	816	951	2517
+gp	3105	1787	5424	4734	3885	1805	2050	1432	1131	861
TOTAL	253057	196776	172098	225514	382852	285603	242040	239203	193988	280388

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
AGE										
1	53004	59520	72387	63778	55386	215431	77947	60854	73394	49775
2	101258	29914	30481	42077	35473	31294	133219	51527	39878	47844
3	20766	50338	16776	16533	21491	18449	18806	80423	32639	24273
4	12578	9814	23963	9618	8022	9826	9214	10611	45339	18997
5	4269	5183	4500	11116	4899	3769	4469	4667	5189	23143
6	2735	1926	2385	2171	4747	2311	1734	2275	2159	2317
7	3261	1165	882	1089	987	2247	1160	858	1128	1115
+gp	1644	1711	1270	1096	1024	1111	1268	1399	907	891
TOTAL	199516	159572	152643	147478	132029	284439	247817	212616	200632	168356

YEAR	2020	2021	GMST 74-**	AMST 74-**
AGE				
1	102470	0	64939	81734
2	30997	70008	36025	49276
3	26985	18680	19562	27963
4	13480	15257	9871	14617
5	9538	7041	4656	6856
6	11118	4887	2193	3302
7	1090	5513	1070	1668
+gp	741	911		
TOTAL	196418	122296		

Table 7.18. Sprat in SD 22–32. Output from XSA. Stock summary.

At 9/04/2021 22:24

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 5
1974	52788	1594	940	242	0.257	0.370
1975	18704	1099	726	201	0.278	0.396
1976	182883	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	32558	706	377	77	0.204	0.263
1980	20055	485	227	58	0.256	0.301
1981	64217	633	199	49	0.248	0.183
1982	34161	641	254	49	0.191	0.303
1983	124735	1498	394	37	0.095	0.136
1984	49917	1242	616	53	0.085	0.180
1985	42732	1111	605	70	0.115	0.166
1986	18171	862	570	76	0.133	0.209
1987	40822	895	461	88	0.191	0.269
1988	15300	609	403	80	0.199	0.239
1989	42790	882	423	86	0.203	0.216
1990	50566	1122	556	86	0.154	0.137
1991	57667	1370	775	103	0.133	0.173
1992	101926	2000	1045	142	0.136	0.200
1993	92592	2187	1360	178	0.131	0.163
1994	67380	2189	1375	289	0.210	0.264
1995	254132	3156	1429	313	0.219	0.349
1996	158819	2883	1811	441	0.244	0.298
1997	58455	2618	1777	529	0.298	0.416
1998	152073	2335	1354	471	0.348	0.398
1999	55170	1965	1353	421	0.311	0.370
2000	103360	2224	1319	389	0.295	0.319
2001	51093	1830	1196	342	0.286	0.287
2002	58743	1587	942	343	0.365	0.401
2003	132654	1644	829	308	0.372	0.396
2004	248860	2274	1040	374	0.359	0.493
2005	54357	2001	1324	405	0.306	0.454
2006	84925	1738	1055	352	0.334	0.385
2007	110176	1741	898	388	0.432	0.379
2008	70326	1677	921	381	0.413	0.412
2009	181708	1907	827	407	0.492	0.509
2010	53004	1557	948	342	0.360	0.440
2011	59520	1214	752	268	0.356	0.397
2012	72387	1278	694	231	0.333	0.346
2013	63778	1235	706	272	0.386	0.419
2014	55386	1088	620	244	0.393	0.434
2015	215431	1640	680	247	0.364	0.454
2016	77947	1707	1077	247	0.229	0.346
2017	60854	1670	1095	286	0.261	0.396
2018	73394	1551	982	309	0.315	0.395
2019	49775	1330	855	314	0.367	0.392
2020	102470	1525	817	272	0.3323	0.368
Mean	81495	1556	872	242	0.27	0.33
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 7.19. Sprat in SD 22–32. Input for RCT3 analysis.

Sprat 22-32: Acoustic on age 0 in subdiv. 22-29, shifted to represent age1

Year	VPA, age 1	Acoustic, Age 0
1991	101926	59473
1992	92592	48035
1993	67380	-11
1994	254132	64092
1995	158819	-11
1996	58455	3842
1997	152073	-11
1998	55170	1279
1999	103360	33320
2000	51093	4601
2001	58743	12001
2002	132654	79551
2003	248860	146335
2004	54357	3562
2005	84925	41863
2006	110176	66125
2007	70326	17821
2008	181708	115698
2009	53004	12798
2010	59520	41158
2011	72387	45186
2012	63778	33653
2013	55386	24921
2014	215431	168125
2015	77947	42251
2016	60854	30848
2017	73394	78167
2018	49775	18542
2019	102470	95603
2020	-11	102931.2

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. 1/3

Analysis by RCT3 ver3.1 of data from file z:\recsprl1.txt
Sprat 22-32: YFS data from international acoustic survey on age 0

Data for 1 surveys over 30 years: 1991-2020
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 = 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	0.684	17	10.72	11.65	0.44	0.594
				VPA	Mean	=	11.39	0.532	0.406

Yearclass = 2012

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.49	6.35	0.39	0.648	18	10.42	11.46	0.451	0.562
				VPA	Mean	=	11.37	0.51	0.438

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	5.99	0.4	0.618	19	10.12	11.26	0.461	0.532
				VPA	Mean	=	11.34	0.492	0.468

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. 2/3

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	5.51	0.41	0.6	20	12.03	12.27	0.515	0.465
				VPA	Mean	=	11.3	0.48	0.535

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	5.27	0.38	0.681	21	10.65	11.48	0.439	0.599
				VPA	Mean	=	11.37	0.536	0.401

Yearclass = 2016

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.61	4.98	0.36	0.688	22	10.34	11.25	0.415	0.606
				VPA	Mean	=	11.36	0.515	0.394

Yearclass = 2017

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.64	4.58	0.35	0.696	23	11.27	11.79	0.405	0.605
				VPA	Mean	=	11.33	0.501	0.395

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. 3/3

Yearclass = 2018

I-----------Regression----------I						I-----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.67	4.15	0.37	0.647	24	9.83	10.78	0.435	0.546
				VPA	Mean	=	11.31	0.478	0.454

Yearclass = 2019

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	0.68	4.06	0.34	0.686	25	11.47	11.87	0.401	0.583
				VPA	Mean	=	11.27	0.474	0.417

Yearclass = 2020

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	0.66	4.19	0.31	0.706	26	11.54	11.86	0.367	0.606
				VPA	Mean	=	11.28	0.455	0.394

Year class	Weighted Average Prediction (Age 1)	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2006	129713	11.77	0.34	0.25	0.51	110176	11.61
2007	89868	11.41	0.32	0.04	0.02	70326	11.16
2008	142211	11.87	0.32	0.33	1.07	181708	12.11
2009	79999	11.29	0.29	0.13	0.19	53004	10.88
2010	108100	11.59	0.3	0.1	0.12	59520	10.99
2011	103666	11.55	0.34	0.13	0.14	72387	11.19
2012	91394	11.42	0.34	0.05	0.02	63778	11.06
2013	80528	11.3	0.34	0.04	0.02	55386	10.92
2014	127045	11.75	0.35	0.48	1.91	215431	12.28
2015	92459	11.43	0.34	0.05	0.02	77947	11.26
2016	80229	11.29	0.32	0.06	0.03	60855	11.02
2017	110314	11.61	0.31	0.23	0.52	73395	11.2
2018	61105	11.02	0.32	0.27	0.69	49776	10.82
2019	111046	11.62	0.31	0.3	0.95	102471	11.54
2020	**112431**	11.63	0.29	0.28	0.99		

Table 7.21. Sprat in SD 22–32. Input data for short-term prediction

MFDP version 1a
Run: run1
Time and date: 00:27 2021-04-10
Fbar age range: 3-5

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	112431	0.305	0.17	0.4	0.4	0.0051	0.1112	0.0051
2	70008	0.272	0.93	0.4	0.4	0.0085	0.2425	0.0085
3	18680	0.265	1	0.4	0.4	0.0096	0.2903	0.0096
4	15257	0.261	1	0.4	0.4	0.0103	0.3967	0.0103
5	7041	0.259	1	0.4	0.4	0.0108	0.4678	0.0108
6	4887	0.259	1	0.4	0.4	0.0117	0.4392	0.0117
7	5513	0.259	1	0.4	0.4	0.0121	0.3649	0.0121
8	911	0.259	1	0.4	0.4	0.0118	0.3649	0.0118

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	86919	0.305	0.17	0.4	0.4	0.0051	0.1112	0.0051
2	.	0.272	0.93	0.4	0.4	0.0085	0.2425	0.0085
3	.	0.265	1	0.4	0.4	0.0096	0.2903	0.0096
4	.	0.261	1	0.4	0.4	0.0103	0.3967	0.0103
5	.	0.259	1	0.4	0.4	0.0108	0.4678	0.0108
6	.	0.259	1	0.4	0.4	0.0117	0.4392	0.0117
7	.	0.259	1	0.4	0.4	0.0121	0.3649	0.0121
8	.	0.259	1	0.4	0.4	0.0118	0.3649	0.0118

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	86919	0.305	0.17	0.4	0.4	0.0051	0.1112	0.0051
2	.	0.272	0.93	0.4	0.4	0.0085	0.2425	0.0085
3	.	0.265	1	0.4	0.4	0.0096	0.2903	0.0096
4	.	0.261	1	0.4	0.4	0.0103	0.3967	0.0103
5	.	0.259	1	0.4	0.4	0.0108	0.4678	0.0108
6	.	0.259	1	0.4	0.4	0.0117	0.4392	0.0117
7	.	0.259	1	0.4	0.4	0.0121	0.3649	0.0121
8	.	0.259	1	0.4	0.4	0.0118	0.3649	0.0118

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_{2020} Age 1:	RCT3 estimate (Table 7.20)
N_{2020} Age 2-8+:	Survivors estimates from XSA (Table 7.16)
$N_{2021-2022}$ Age 1:	Geometric mean from XSA-estimates at age 1 for the years 1991-2020
Natural Mortality (M):	average 2018-2020
Weight in the Catch/Stock (CWt/SWt):	average 2018-2020
Expoitation pattern (Sel):	average 2018-2020

Table 7.22a. Sprat in SD 22–32. Output from short-term prediction with management option table for TAC constrained fishery in 2021.

MFDP version 1a
Run: runTAC
Sprat
Time and date: 01:03 2021-04-10
Fbar age range: 3-5

2021				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1714	977	0.8343	0.3211	269

2022					2023	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1829	1274	0	0	0	2146	1565
.	1259	0.1	0.0385	40	2106	1511
.	1245	0.2	0.077	79	2067	1459
.	1230	0.3	0.1155	116	2030	1409
.	1216	0.4	0.154	153	1993	1361
.	1202	0.5	0.1925	189	1957	1315
.	1188	0.6	0.231	224	1923	1271
.	1175	0.7	0.2694	257	1889	1228
.	1161	0.8	0.3079	290	1856	1188
.	1148	0.9	0.3464	322	1825	1148
.	1135	1	0.3849	353	1794	1111
.	1122	1.1	0.4234	384	1763	1074
.	1109	1.2	0.4619	413	1734	1039
.	1097	1.3	0.5004	442	1705	1006
.	1084	1.4	0.5389	470	1678	974
.	1072	1.5	0.5774	497	1651	943
.	1060	1.6	0.6159	524	1624	913
.	1048	1.7	0.6544	550	1598	884
.	1036	1.8	0.6929	575	1573	856
.	1024	1.9	0.7314	599	1549	830
.	1013	2	0.7698	623	1525	804

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 2021

MFDP version 1a
Run: run1

Time and date: 00:27 2021-04-10
Fbar age range: 3-5

2021				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1714	959	1.0000	0.3849	315

2022					2023	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1781	1232	0	0	0	2107	1530
.	1218	0.1	0.0385	39	2068	1478
.	1204	0.2	0.077	76	2031	1427
.	1190	0.3	0.1155	113	1994	1379
.	1176	0.4	0.154	148	1959	1332
.	1163	0.5	0.1925	183	1924	1287
.	1150	0.6	0.231	216	1891	1244
.	1137	0.7	0.2694	249	1858	1203
.	1124	0.8	0.3079	281	1826	1163
.	1111	0.9	0.3464	312	1795	1125
.	1098	1	0.3849	342	1765	1089
.	1086	1.1	0.4234	371	1736	1053
.	1073	1.2	0.4619	400	1708	1019
.	1061	1.3	0.5004	428	1680	987
.	1049	1.4	0.5389	455	1653	955
.	1037	1.5	0.5774	481	1627	925
.	1026	1.6	0.6159	507	1601	896
.	1014	1.7	0.6544	532	1576	868
.	1003	1.8	0.6929	556	1552	841
.	991	1.9	0.7314	580	1528	815
.	980	2	0.7698	603	1505	790

Input units are millions and kg - output in kilotonnes

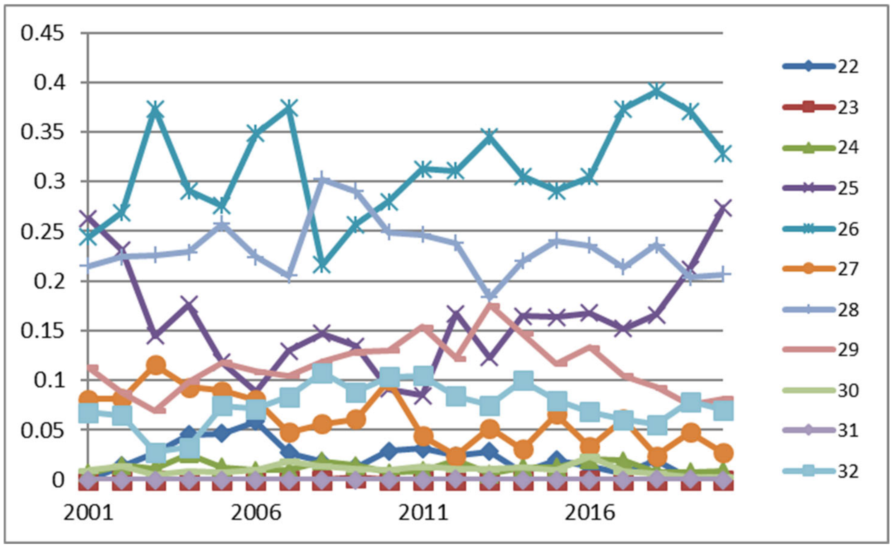


Figure 7.1 Sprat in Subdivisions 22-32. Share of catches by subdivision in 2001-2020

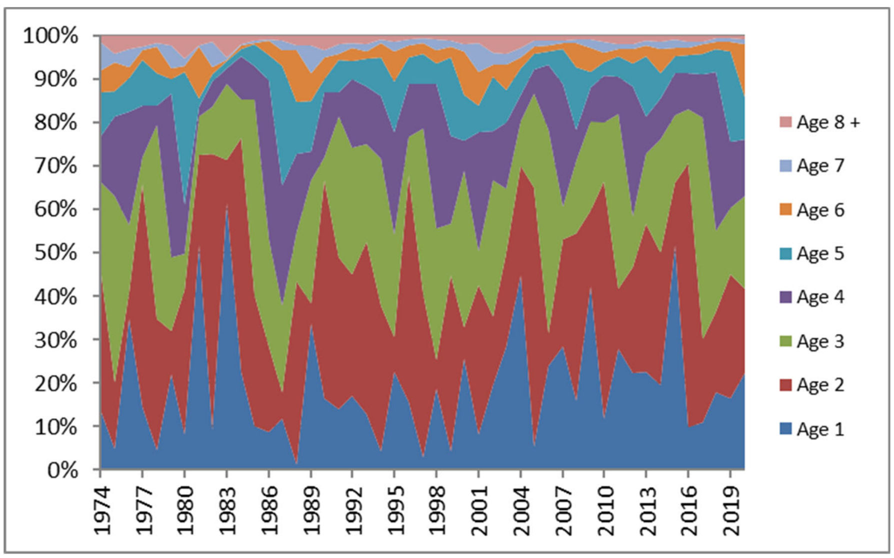


Figure 7.2. Sprat in SD 22-32. Relative catch-at-age in numbers.

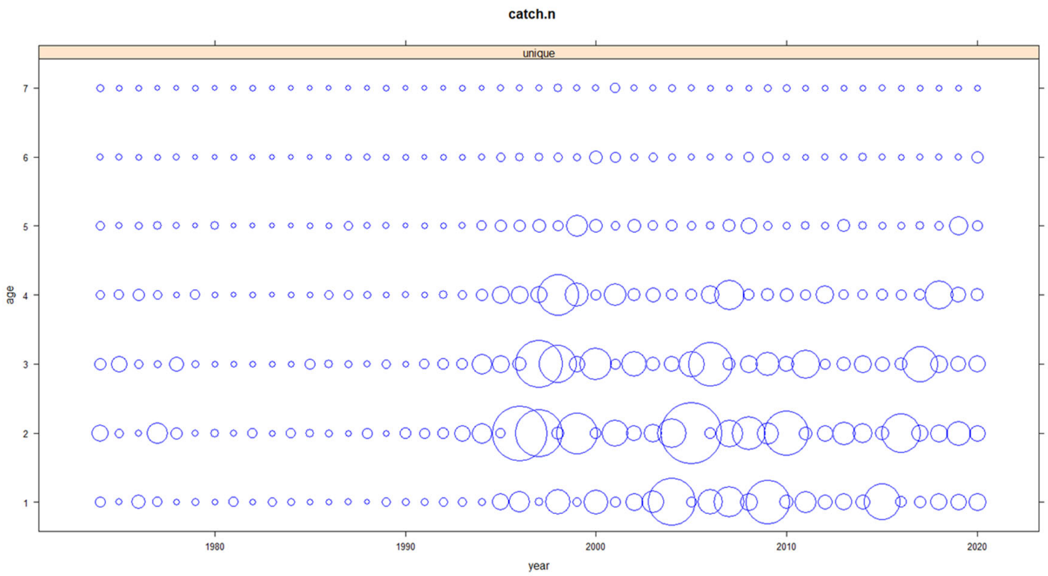
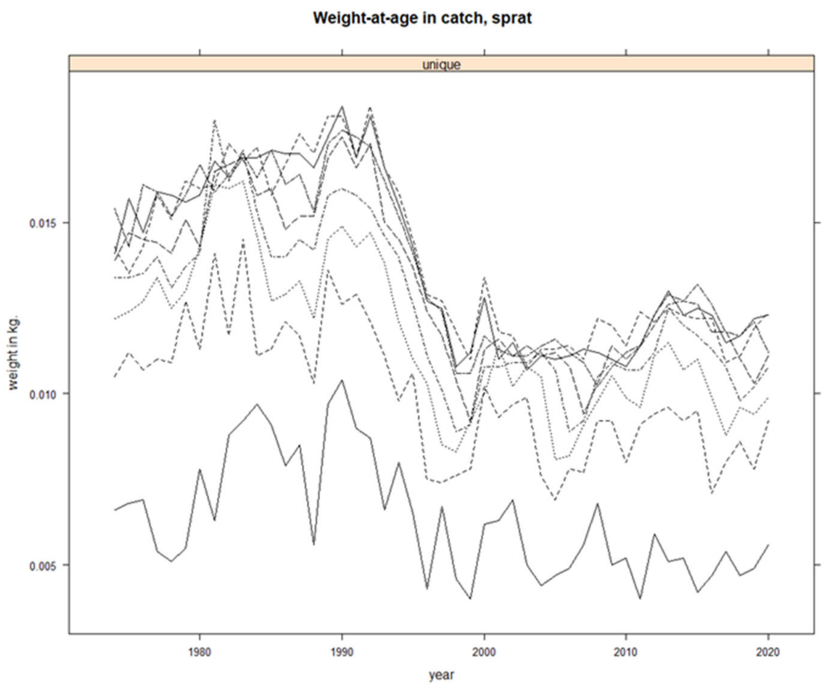


Figure 7.3. Sprat in SD 22-32. CANUM consistency check.

a.



b.

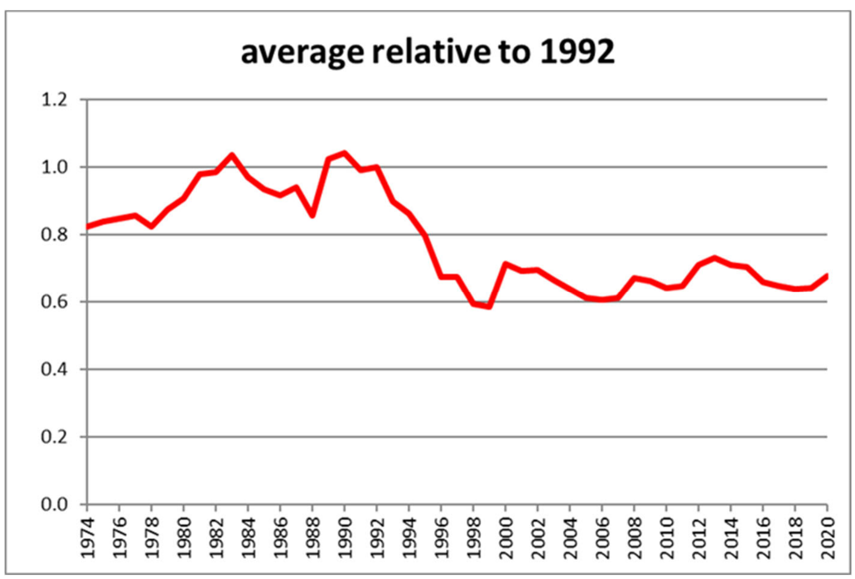


Figure 7.4. Sprat in SD 22-32: mean weight-at-age in the catches by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

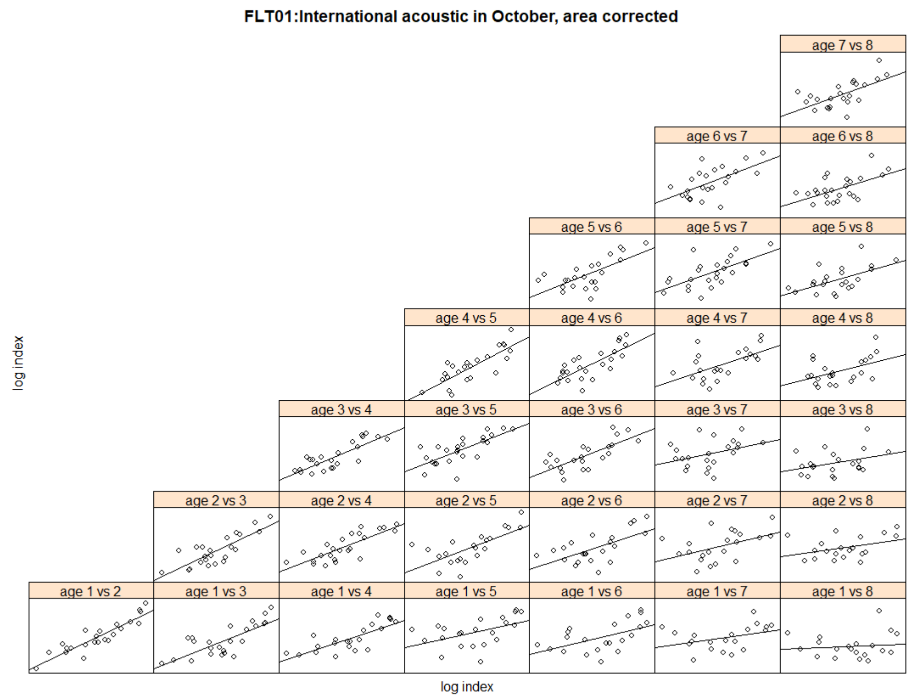


Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey estimates.

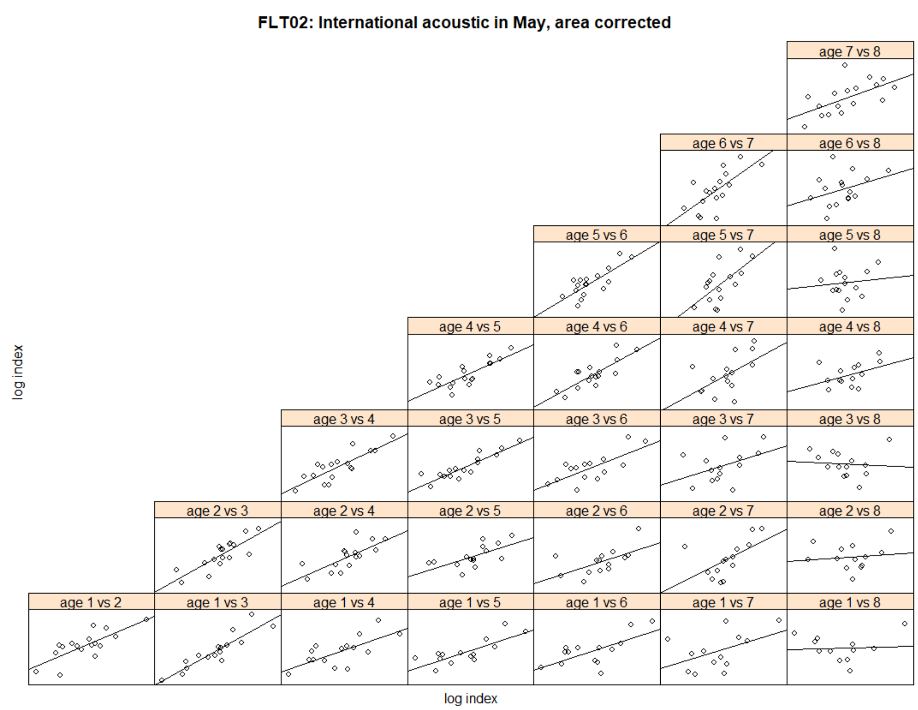


Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey estimates.

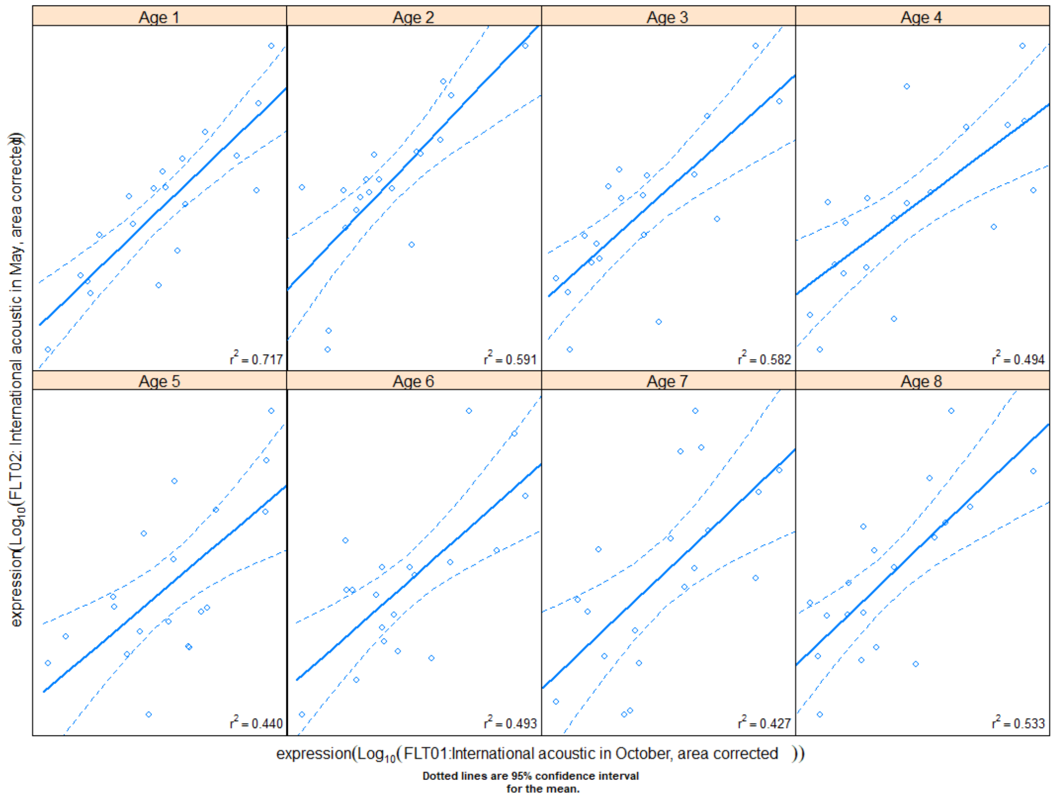


Figure 7.5c. Sprat in SD 22-32. Check for consistency between May and October surveys.

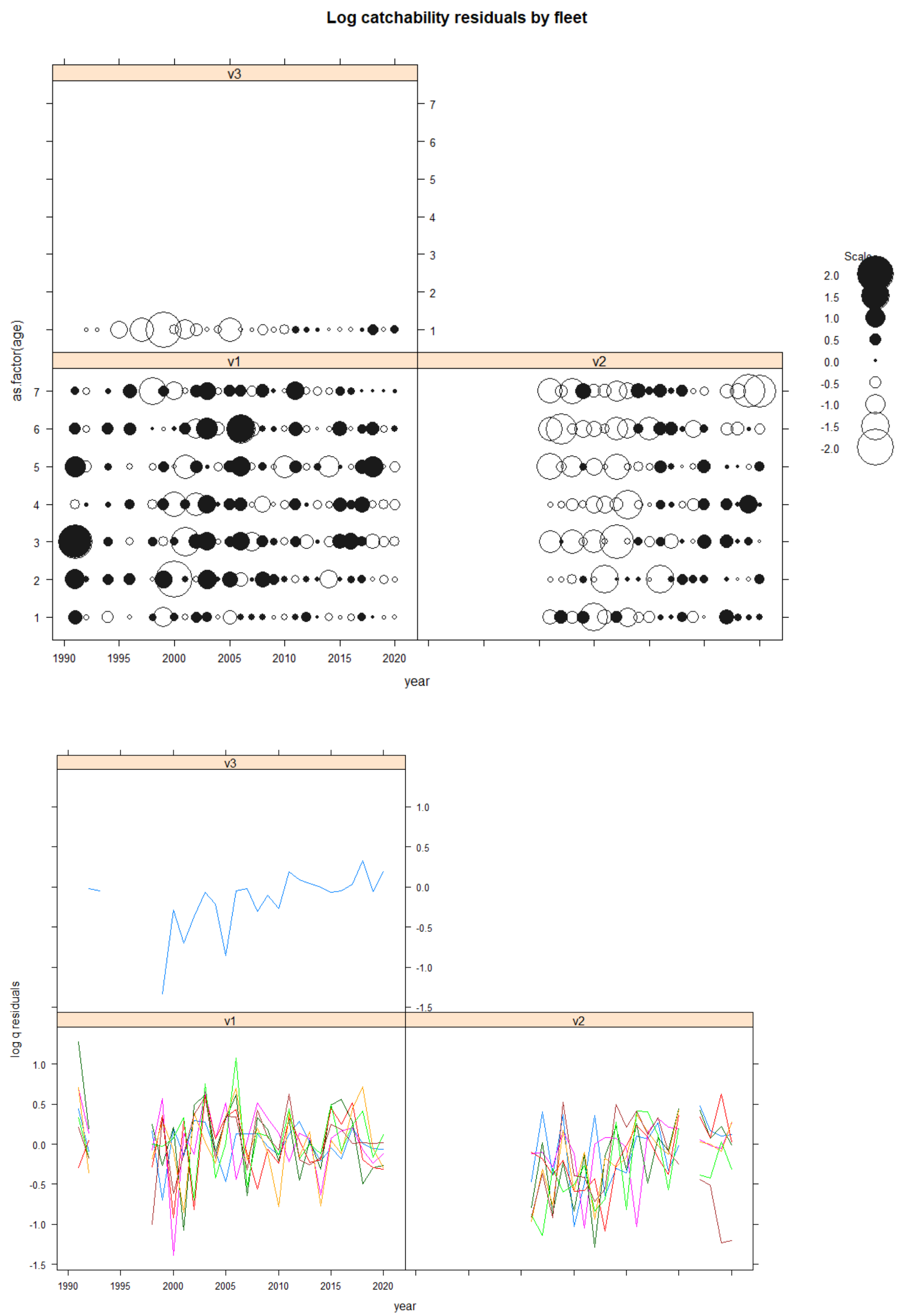


Figure 7.6. Sprat in SD 22-32. Log catchability residuals by fleet presented in two ways.

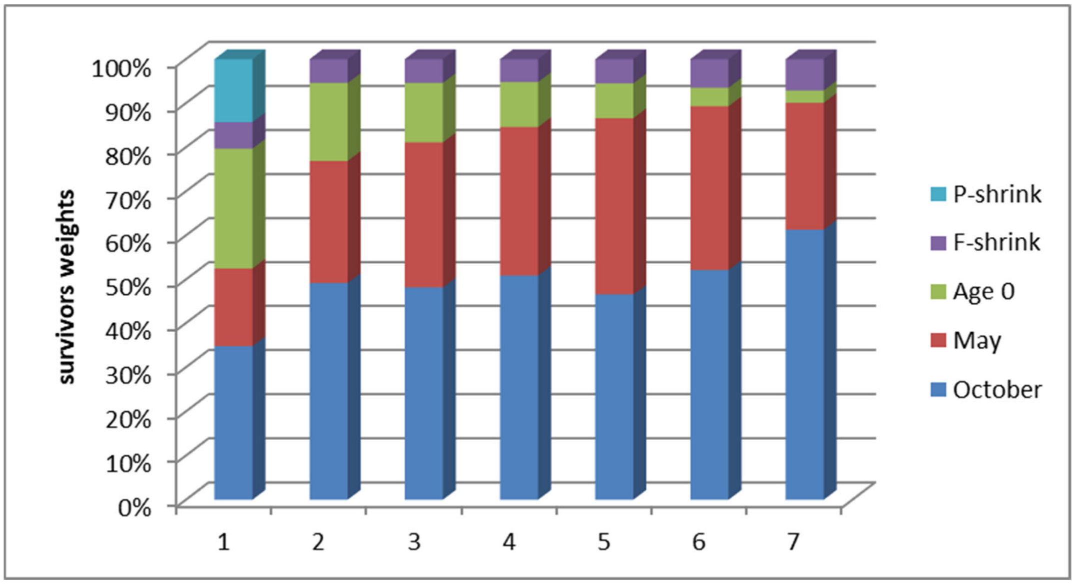


Figure 7.7a. Sprat In SD 22-32. Weights of survivors' estimates by fleet used to provide final survivors estimates.

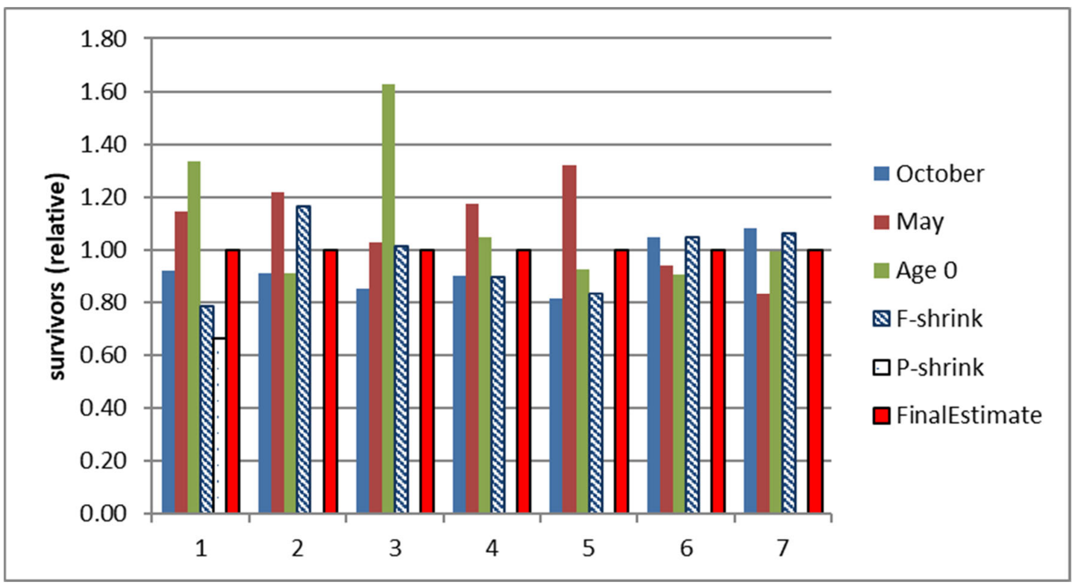


Figure 7.7b. Sprat in SD 22-32. Survivors estimates by fleet and age relative to final estimate.

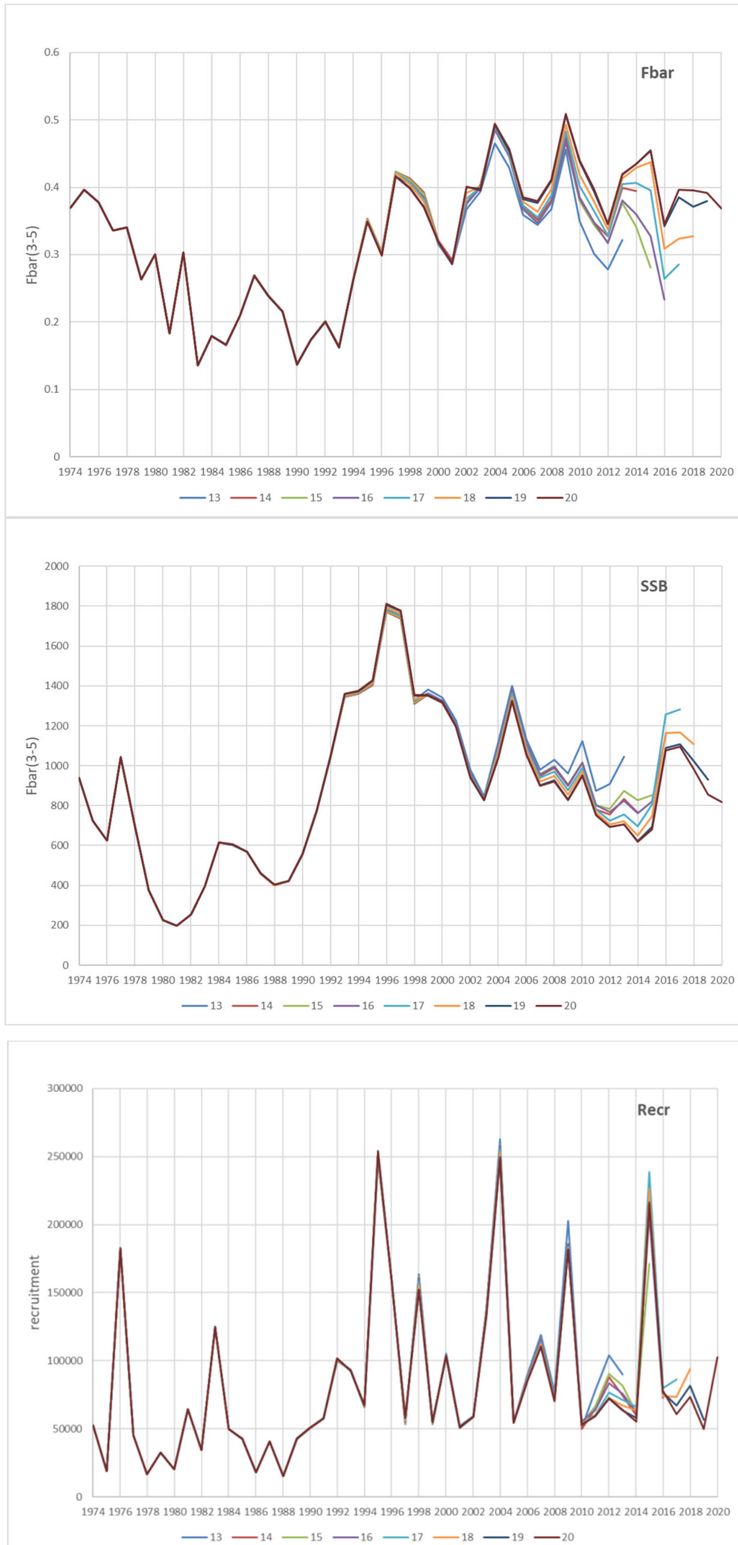


Figure 7.8. Sprat in SD 22-32. Retrospective analysis from XSA.

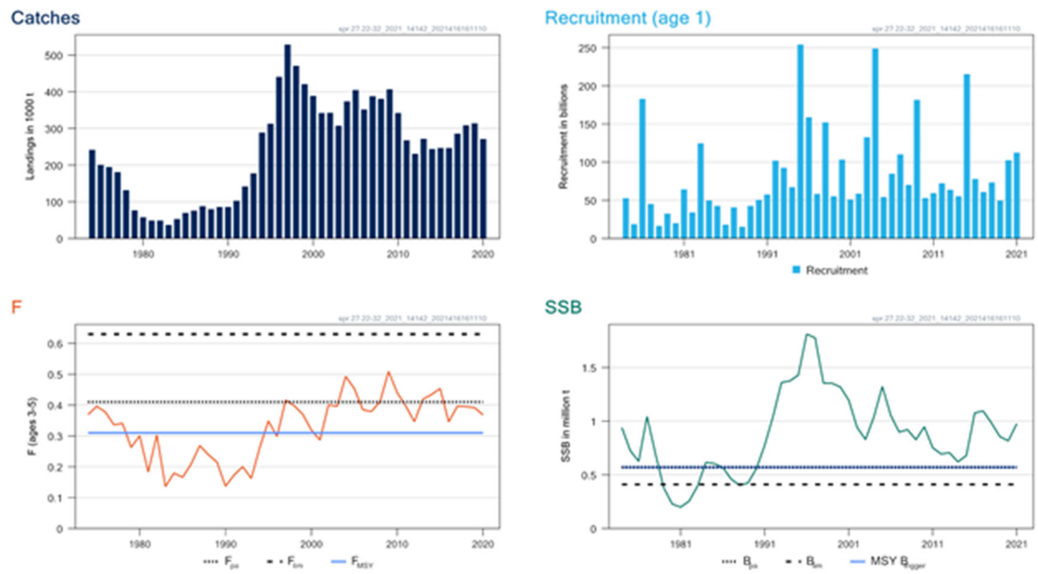


Figure 7.9. Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning stock biomass.

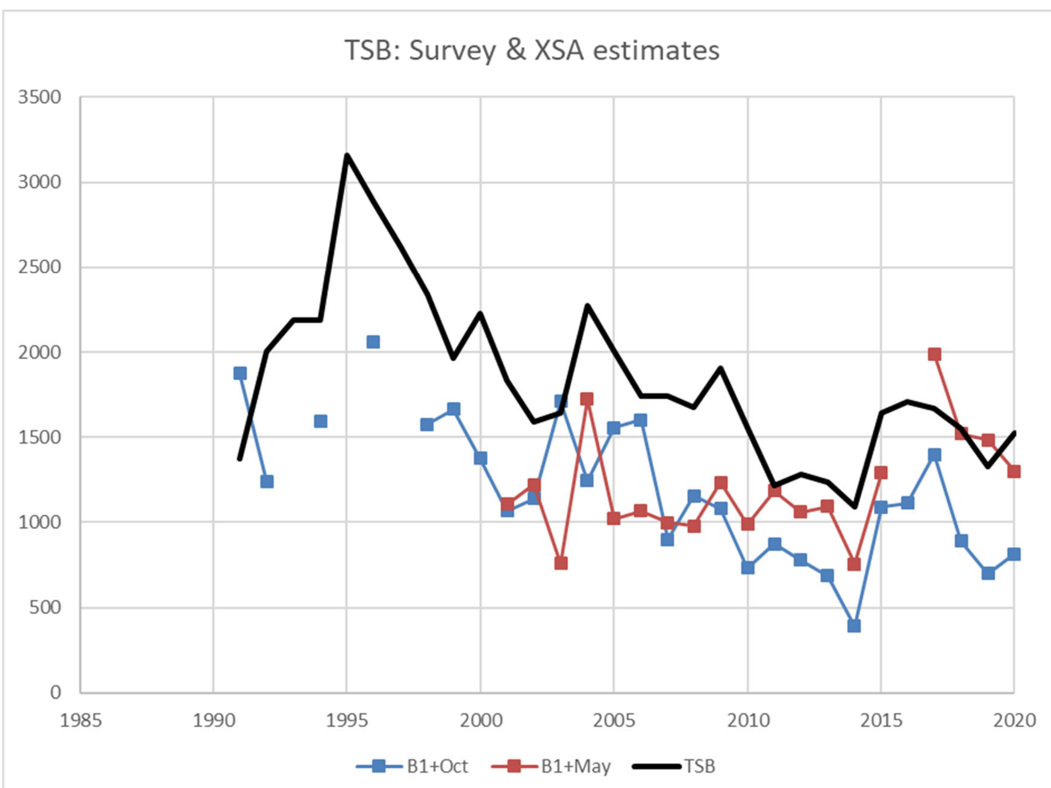


Figure 7.10. Sprat in SD 22-32. Comparison of survey (age 1+) stock size estimates with TSB.

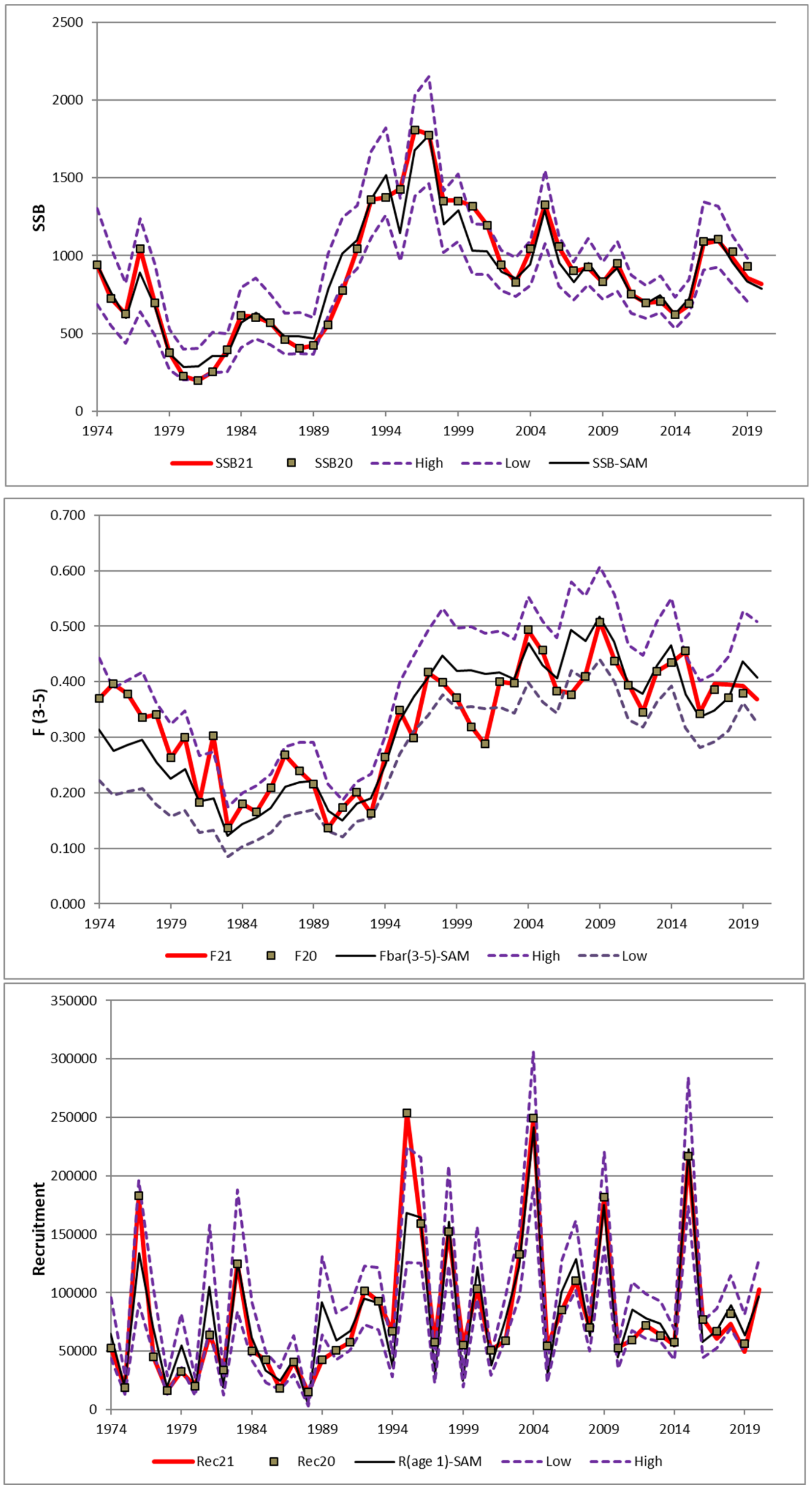


Figure 7.11. Sprat in SD 22-32. Comparison of spawning stock biomass, fishing mortality, and recruitment (age 1) from XSA 2021, SA 2020, and SAM. Uncertainties of SAM estimates are shown (thin, broken lines).

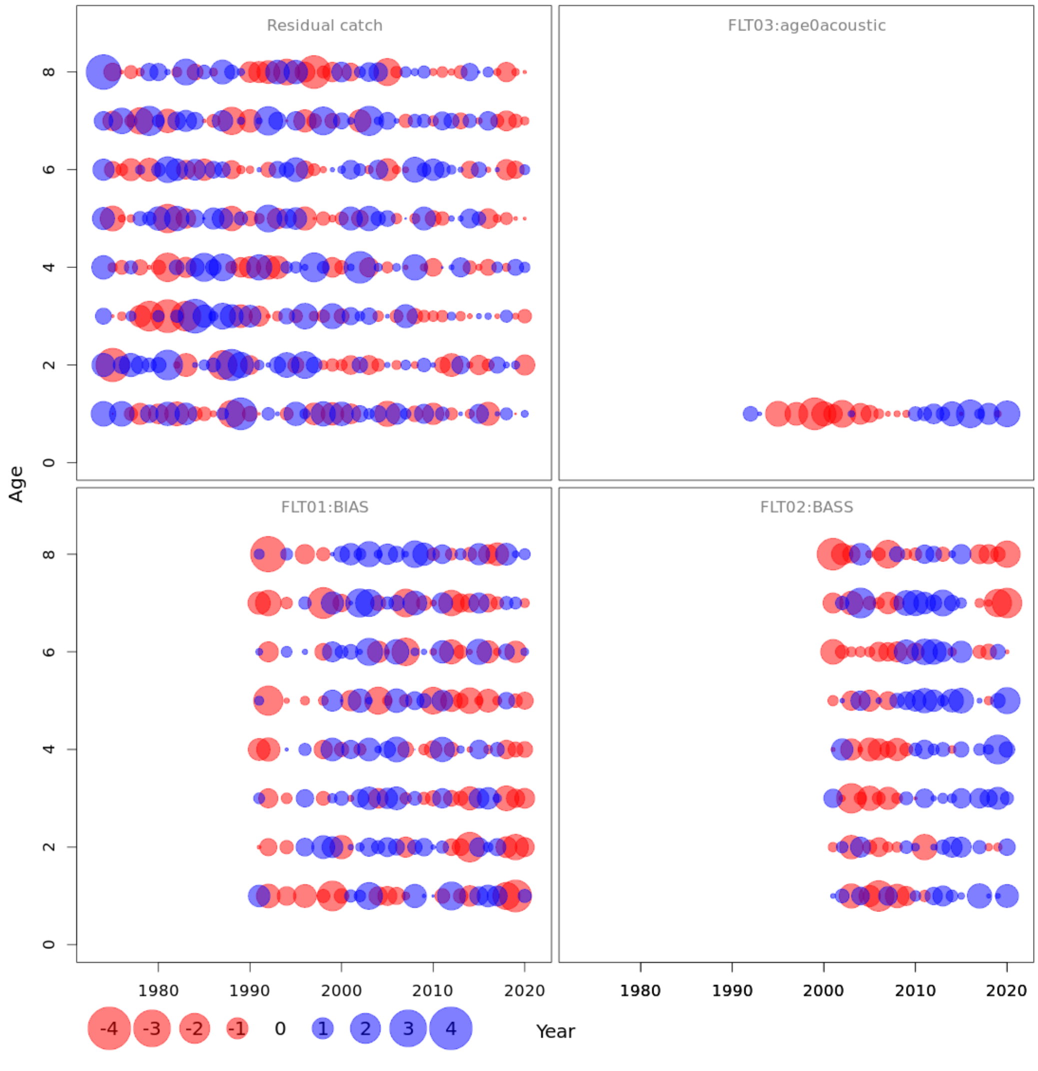


Figure 7.12a. Sprat in SD 22-32. Log catchability residuals by fleet from SAM.

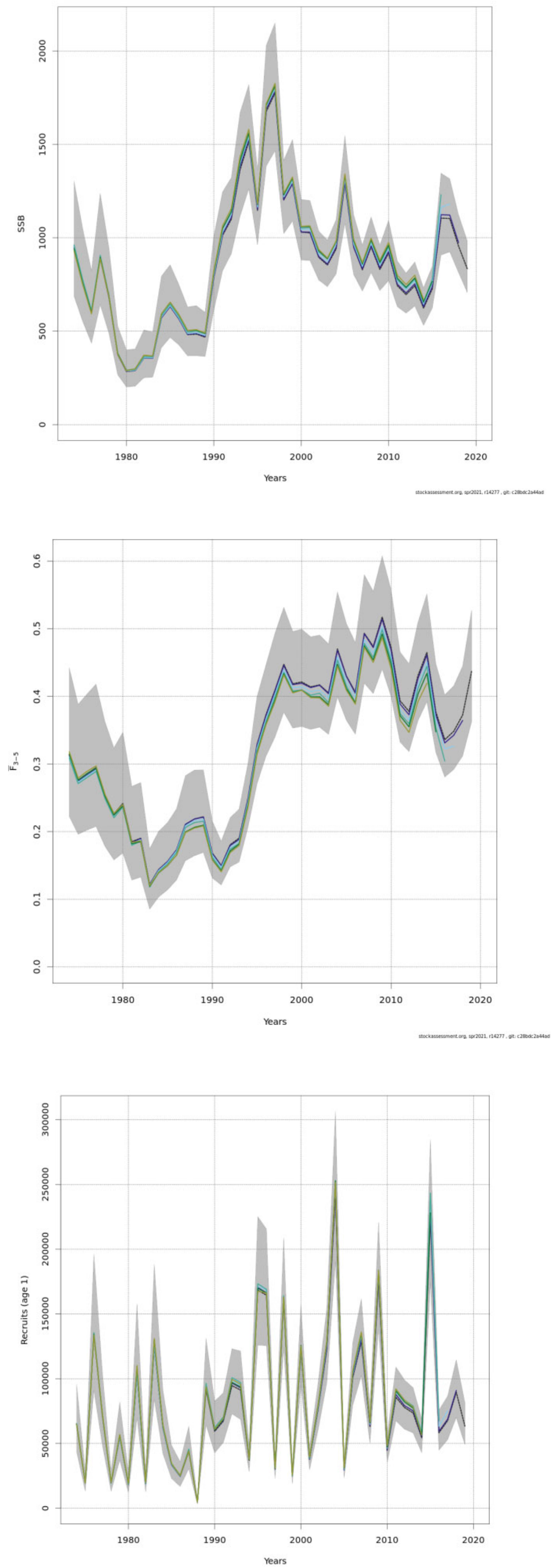


Figure 7.12b. Sprat in SD 22-32. Retrospective analysis from SAM.

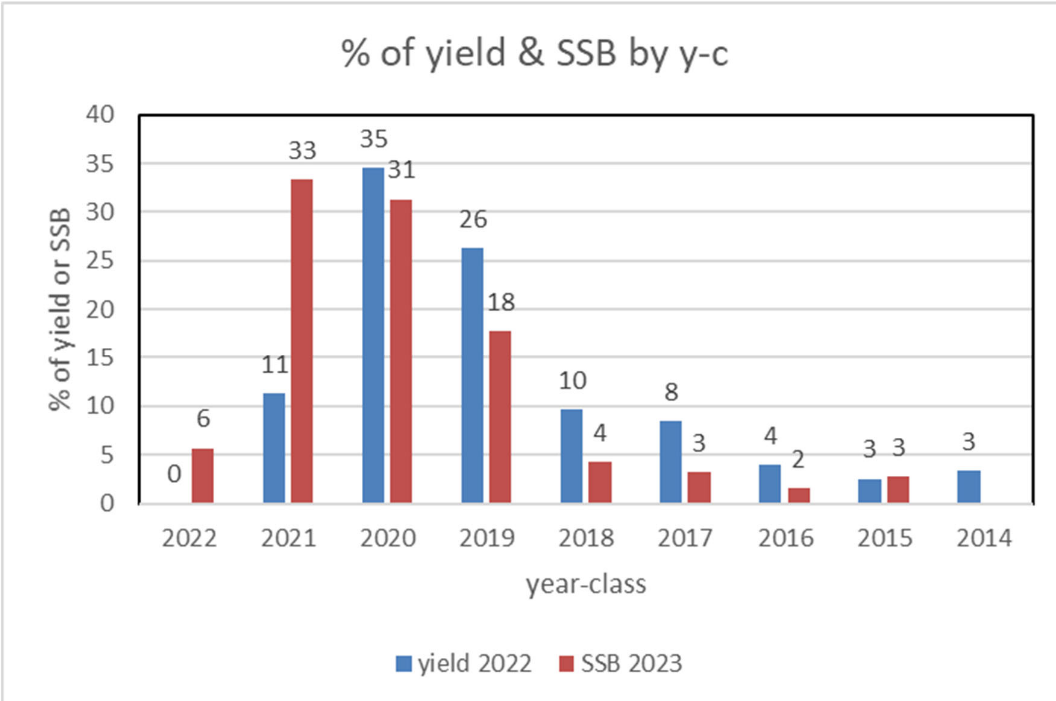


Figure 7.13. Sprat in SD 22-32. Sensitivity of short-term forecast to year-class assumptions or predictions. Yield in 2022 and SSB in 2023 by year-classes under the TAC constraint in 2021.

8 Turbot, dab, and brill in the Baltic Sea

8.1 Turbot

8.1.1 The 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 decline until the minimum of 305 t in 2006 and varied between 221 t in 2012 and 394 t in 2009 with a slightly negative trend between 2007 and 2016 (Table 8.1, Figure 8.1). 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 fishes 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. Presently, 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 2020 were about 197 tonnes.

Due to the low stock level, the 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 to 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 28% for the years 2012 to 2020. Due to the low sampling coverage of the discarded catch fraction in the past, the estimates are considered too imprecise to be used for catch advice. The advice is given for landings only.

Discard estimates have increased in the last five years, as more countries are reporting data and the number of length measures is increasing. Discards in 2020 were exceptionally high, about three times higher than the average discard since the beginning of the time series. An increasing amount of smaller turbot was caught, especially in trawl fisheries. Similar, a signal of above-average recruitment is apparent in the most recent survey index.

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
2020	197	374

8.1.2 Biological composition of the catch

Available age data were compared during the 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 (i.e. slicing), the fishing mortality estimate declined by a factor of about two. WKFLABA did not make suggestions on age reading 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 BITS trawl (TVS) were multiplied with a conversion factor of 1.4 (Figure 8.2). Stable indices with low fluctuations were observed between 2007 and 2015. The index of 2020 remained stable compared to the previous year, but is still on a low level (~3.43 turbot/hour) compared to earlier years. The length distribution indicates a higher number of turbot (around 20% larger than in previous years) entering the index in 2021, as it only considers turbot larger 20 cm TL. A similar signal of incoming smaller turbot was also seen in the commercial fisheries data.

8.1.3.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.3. Almost no turbot above 35 cm are caught. High numbers of smaller turbot <25 cm were caught.

8.1.4 Assessment

An update advice was given in 2021. However, only landings and trends in the survey were used to estimate stock status for the advice. 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. Exploitation is below with F_{MSY} proxy ($L_{F=M}$) and optimal yield in 2020 due to the high amount of small turbot in the commercial CANUM and WECA data. MSY $B_{trigger}$ is unknown. The length-based indicator are stating an unsustainable stock status (Figure 8.4).

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 8.2). CANUM and WECA of commercial catches from 2014–2020 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarters, only females → L_{inf} = 54.7 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 20.5 cm

The results of LBI (Figure 8.4) show that the stock status of tur.27.22–32 is below possible reference points (Table 8.3). 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 relatively 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 ($L_{F=M}$), but underperfomed in 2020. This might be an artifact of the high amount of small turbot, as the amount of larger individuals did not decrease significantly.

Table 8.1. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark					Germ. Dem. Rep.[1]		Germany, FRG				Poland		Sweden[2]							Latvia		Lithuania	Russia	Finland						Estonia	
	22	23	24(+25)	25	26+27	22	24	22	24	25	27	25(+24)	26	22	23	24	25	26	27	28(+29)	26	28	26	26	24	25	29	30	31	32	29	32
1965						3	39																									
1966	16		21			5	53																									
1967	14		20			7	10																									
1968	14		18			3	67																									
1969	13		13			4	57																									
1970	11		13			5	40									2																
1971	11		26			4	86									2																
1972	10		26			3	100									3																
1973	11		30			3	33					58	13			5																
1974	14		40			2	23					34	36			6																
1975	27		48			3	38	15				23	6			7																
1976	29		24				52	11				14	12			7																
1977	32		37				55	9				12	55			8																
1978	33		37			2	27	9				7	3			10																
1979	23		38			3	39	6				29	34			12																
1980	28		38				30	9				12	20			15																
1981	28		62			1	46	8				10	19			7																
1982	31		51			1	27	7				2	17			3	4		4	3												
1983	33		40			3	9	8				5	4			31	41		35	24												
1984	41		45			4	8	12				13	2			3	4		3	2												
1985	56		34			5	22	15				67	15			4	5		4	3												
1986	99		81			6	32	25				32	37			6	8		7	5												
1987	134		93			4	34	30				155	21			8	11		9	6												
1988	117		117			3	28	34				7	10			12	16		14	9												
1989	135		109			7	22	20					11			11	15		13	9												
1990	178		181			4	2	26				24	25			14																
1991	228		137					44	39			73	20			2	12		16													
1992	267		127					55	68			80	55			12	12		21	36				30								
1993	159	29	152					74	56			520	72		2	4	14		13	38				34								
1994	211	18	166					52	57	10		380	30		2	3	18	1	17	44				15								
1995	257	11	94					65	53	4		30	15		2	3	54	9	31	83	34	27	15	20								
1996	207	12	95					36	47	4	1	288	92	1	3	15	100	5	54	104	42	3	72	25								
1997	151		68					60	52	3		290	70		2	6	70	1	53	86	33	14	59	25								
1998	138		80					44	55	1		66	68		2	4	58	1	18	69	12	24	62	96								
1999	106		59					23	48			18	15		2	4	41	3	17	60	20	34	58	48								
2000	97		58					23	54			90	12		2	3	39		16	39	7	9	23	53								
2001	76		53					19	31			121	10		2	5	16		9	29	5	1	18	69								
2002	73		22	4	0			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	0			10	39	1		184	178		1	2	18		3	14	7	2	13	28								
2004	61		27	7				12	27	1		225	96		1	1	8		3	14	3	8	7	15								
2005	57	5	36	12				14	35	1		123	57		1	3	6		5	21	1	6	18	19								
2006	30	5	16	33				19	45	1		87	11		1	2	5	0	4	19	3	3	9	12								
2007	60	5	26	5	0			22	34	0		83	8		0	5	5		2	15	0	1	12	24								
2008	79	5	33	6				24	30	0		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	0			33	50	1		92	11		1	6	10	0	5	6	0	0	11	8								
2010	102	6	31	4	0			24	35	0		38	1		1	4	16	0	4	8	3	7	9	2								
2011	84	3	24	3	0			26	31	0		66	11	0	0	0	0	0	0	0	3	6	0	5	0	0	0	0	0	0	0	0
2012	43	3	16	1	0			16	27	0	0	55	11	0	0	0	0	0	0	0	5	5	14	15	0	0	0	0	0	0	0	0
2013	66	5	21	1	0			23	40	0	0	61	12	0	1	6	16	0	1	3	5	4	13	20	16	0	0	0	0	0	0	0
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	0	2	4	2	5	7	6	0		0				0	
2015	84	5	22	1	0			27	19	0	0	41	8	0	0	4	9	0	1	1	0	4	4	3	0	0	0	0	0	0	0	0
2016	68	4	37	3	0			25	23	1		43	13	0	2	5	9	0	1	1	1	5	7	6	0	0	0	0	0	0	0	0
2017	76	5	18	3	0			41	33	0		55	8	0	1	2	4	0	1	1	0	1	7	7	0	0	0	0	0	0	0	0
2018	103	9	41	3	0.00			37	55	0.02		72	4	0.01	1.08	14	11	0.00	1	2	1	5	0.42	6.96	0.00	0.00	0.01	0.00	0.00	0.00	0.45	0.20
2019	**53**	2	25	1	0.00			20	26	0.00		50	5	0.00	0.67	3	2	0.00	1	2	0.64	4	5	1			0.00			0.01	0.00	0.00
2020	57	3	26	0.21				28	19	0.05		42	3	0.00	0.68	3	5	0.00	2	2	0.13	2	2	0.36			0.00				0.22	0.16

Year/SD	Denmark					Germ. Dem. Rep.[1]		Germany, FRG				Poland		Sweden[2]							Latvia		Lithuania	Russia	Finland						Estonia	
	22	23	24(+25)	25	26+27	22	24	22	24	25	27	25(+24)	26	22	23	24	25	26	27	28(+29)	26	28	26	26	24	25	29	30	31	32	29	32
1965						3	39																									
1966	16		21			5	53																									
1967	14		20			7	10																									
1968	14		18			3	67																									
1969	13		13			4	57																									
1970	11		13			5	40									2																
1971	11		26			4	86									2																
1972	10		26			3	100									3																
1973	11		30			3	33					58	13			5																
1974	14		40			2	23					34	36			6																
1975	27		48			3	38	15				23	6			7																
1976	29		24				52	11				14	12			7																
1977	32		37				55	9				12	55			8																
1978	33		37			2	27	9				7	3			10																
1979	23		38			3	39	6				29	34			12																
1980	28		38				30	9				12	20			15																
1981	28		62			1	46	8				10	19			7																
1982	31		51			1	27	7				2	17			3	4		4	3												
1983	33		40			3	9	8				5	4			31	41		35	24												
1984	41		45			4	8	12				13	2			3	4		3	2												
1985	56		34			5	22	15				67	15			4	5		4	3												
1986	99		81			6	32	25				32	37			6	8		7	5												
1987	134		93			4	34	30				155	21			8	11		9	6												
1988	117		117			3	28	34				7	10			12	16		14	9												
1989	135		109			7	22	20					11			11	15		13	9												
1990	178		181			4	2	26				24	25			14																
1991	228		137					44	39			73	20			2	12		16													
1992	267		127					55	68			80	55			12	12		21	36				30								
1993	159	29	152					74	56			520	72		2	4	14		13	38				34								
1994	211	18	166					52	57	10		380	30		2	3	18	1	17	44				15								
1995	257	11	94					65	53	4		30	15		2	3	54	9	31	83	34	27	15	20								
1996	207	12	95					36	47	4	1	288	92	1	3	15	100	5	54	104	42	3	72	25								
1997	151		68					60	52	3		290	70		2	6	70	1	53	86	33	14	59	25								
1998	138		80					44	55	1		66	68		2	4	58	1	18	69	12	24	62	96								
1999	106		59					23	48			18	15		2	4	41	3	17	60	20	34	58	48								
2000	97		58					23	54			90	12		2	3	39		16	39	7	9	23	53								
2001	76		53					19	31			121	10		2	5	16		9	29	5	1	18	69								
2002	73		22	4	0			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	0			10	39	1		184	178		1	2	18		3	14	7	2	13	28								
2004	61		27	7				12	27	1		225	96		1	1	8		3	14	3	8	7	15								
2005	57	5	36	12				14	35	1		123	57		1	3	6		5	21	1	6	18	19								
2006	30	5	16	33				19	45	1		87	11		1	2	5	0	4	19	3	3	9	12								
2007	60	5	26	5	0			22	34	0		83	8		0	5	5		2	15	0	1	12	24								
2008	79	5	33	6				24	30	0		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	0			33	50	1		92	11		1	6	10	0	5	6	0	0	11	8								
2010	102	6	31	4	0			24	35	0		38	1		1	4	16	0	4	8	3	7	9	2								
2011	84	3	24	3	0			26	31	0		66	11	0	0	0	0	0	0	0	3	6	0	5	0	0	0	0	0	0	0	0
2012	43	3	16	1	0			16	27	0	0	55	11	0	0	0	0	0	0	0	5	5	14	15	0	0	0	0	0	0	0	0
2013	66	5	21	1	0			23	40	0	0	61	12	0	1	6	16	0	1	3	5	4	13	20	16	0	0	0	0	0	0	0
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	0	2	4	2	5	7	6	0		0				0	
2015	84	5	22	1	0			27	19	0	0	41	8	0	0	4	9	0	1	1	0	4	4	3	0	0	0	0	0	0	0	0
2016	68	4	37	3	0			25	23	1		43	13	0	2	5	9	0	1	1	1	5	7	6	0	0	0	0	0	0	0	0
2017	76	5	18	3	0			41	33	0		55	8	0	1	2	4	0	1	1	0	1	7	7	0	0	0	0	0	0	0	0
2018	103	9	41	3	0			37	55	0.02		72	4	0.01	1.08	14	11	0	1	2	1	5	0.42	6.96	0	0	0.01	0	0	0	0.45	0.20
2019	**53**	2	25	1	0			20	26	0.00		50	5	0	0.67	3	2	0	1	2	0.64	4	5	1			0			0.01	0	0
2020	57	3	26	0.21				28	19	0.05		42	3	0	0.68	3	5	0	2	2	0.13	2	2	0.36			0.00				0.22	0.16

Continued Table 8.1. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year	Total by SD								Total
	22	23	24[3]	25	26	27	28(+29)	30-32	SD 22-32
1965	3	0	39	0	0	0	0		42
1966	21	0	74	0	0	0	0		95
1967	21	0	30	0	0	0	0		51
1968	17	0	85	0	0	0	0		102
1969	17	0	70	0	0	0	0		87
1970	16	0	55	0	0	0	0		71
1971	15	0	114	0	0	0	0		129
1972	13	0	129	0	0	0	0		142
1973	14	0	68	58	13	0	0		153
1974	16	0	69	34	36	0	0		155
1975	45	0	93	23	6	0	0		167
1976	40	0	83	14	12	0	0		149
1977	41	0	100	12	55	0	0		208
1978	44	0	74	7	3	0	0		128
1979	32	0	89	29	34	0	0		184
1980	37	0	83	12	20	0	0		152
1981	37	0	115	10	19	0	0		181
1982	39	0	81	6	17	4	3		150
1983	44	0	80	46	4	35	24		233
1984	57	0	56	17	2	3	2		137
1985	76	0	60	72	15	4	3		230
1986	130	0	119	40	37	7	5		338
1987	168	0	135	166	21	9	6		505
1988	154	0	157	23	10	14	9		367
1989	162	0	142	15	11	13	9		352
1990	208	0	197	24	25	0	0		454
1991	272	0	178	85	20	16	0		571
1992	322	0	207	92	85	21	36		763
1993	233	31	212	534	106	13	38		1167
1994	263	20	226	408	46	17	44		1024
1995	322	13	150	88	93	31	110		807
1996	244	15	157	392	236	55	107		1206
1997	211	2	126	363	188	53	100		1043
1998	182	2	139	125	239	18	93		798
1999	129	2	111	59	144	17	94		556
2000	120	2	115	129	95	16	48		525
2001	95	2	89	137	102	9	30		464
2002	93	5	56	266	135	7	29		591
2003	58	1	69	208	225	3	16		579
2004	73	1	55	241	121	3	22		516
2005	72	5	74	143	94	5	27	0	420
2006	49	6	63	126	35	4	22	0	305
2007	83	5	65	94	44	2	16	0	309
2008	103	6	70	113	39	8	17	0	356
2009	144	7	91	110	31	5	6	0	394
2010	126	7	70	58	15	4	15	0	295
2011	110	3	56	70	19	0	6	0	263
2012	59	3	44	57	44	0	5	0	221
2013	88	5	83	77	50	1	7	0	313
2014	119	5	60	39	19	2	9	0	253
2015	111	5	45	51	15	1	5	0	233
2016	94	6	64	56	28	1	7	0	255
2017	117	5	53	63	23	1	2	0	265
2018	141	10	111	87	13	1	7	0	370
2019	73	3	69	38	11	1	6	0	201
2020	86	4	62	34	5	2	5	0	197

1 From October-December 1990 landings of Germany, Fed. Rep. are included

2 For the years 1970-1981 and 1990 catches of Subdivisions 25–28 are included in Subdivision 24

3 For the years 1970-1981 and 1990 Swedish catches of Subdivisions 25–28 are included in Subdivision 24

4 Preliminary data

Danish catches in 2002-2004 in SW Baltic were separated according to Subdivisions 24 and 25

In 2005 Lithuanian landings are reported for 1995 onwards

Table 8.2. Turbot in the Baltic Sea. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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

Table 8.3. Turbot in the Baltic Sea Indicator status for the most recent three years 2015-2017.

	Conservation				Optimizing Yield	MSY
Year	**L_c / L_{mat}**	**$L_{25\%}$ / L_{mat}**	**$L_{max 5}$ / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**L_{mean} / $L_{F=M}$**
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
2020	1.10	1.15	0.69	0.01	0.73	0.87

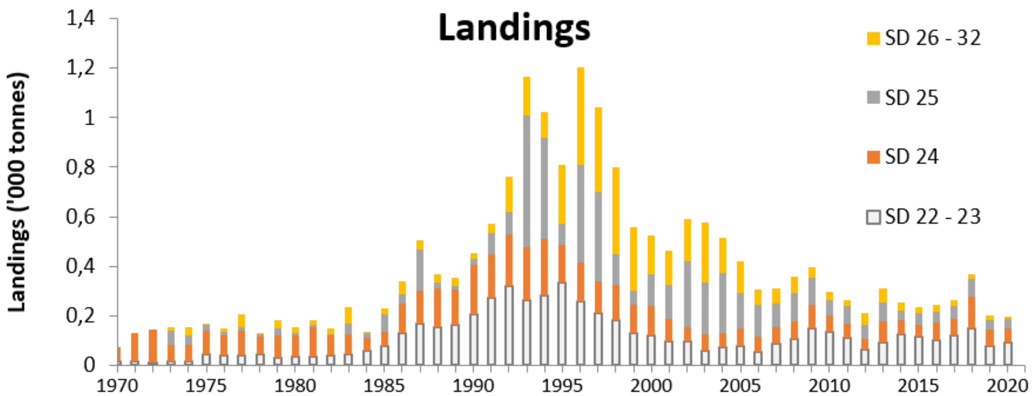


Figure 8.1. Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

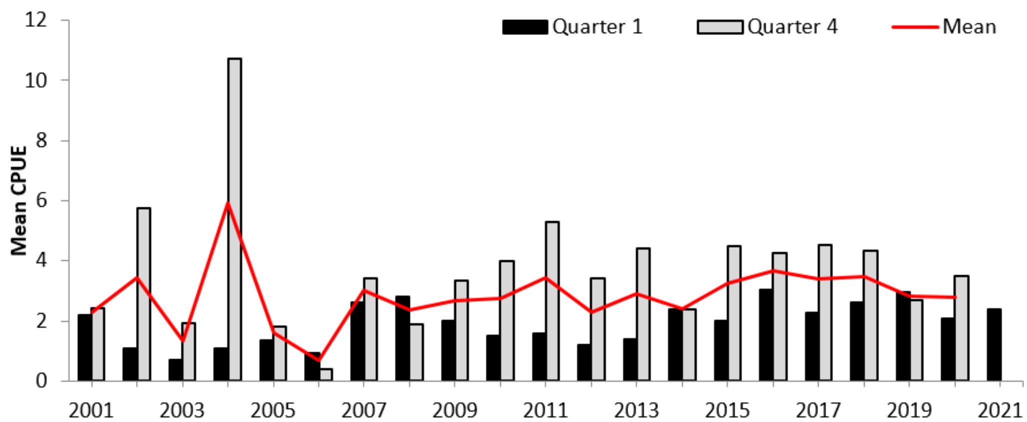


Figure 8.2. Turbot in the Baltic Sea. Mean CPUE (no. hr-1) of turbot with L ≥20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28.

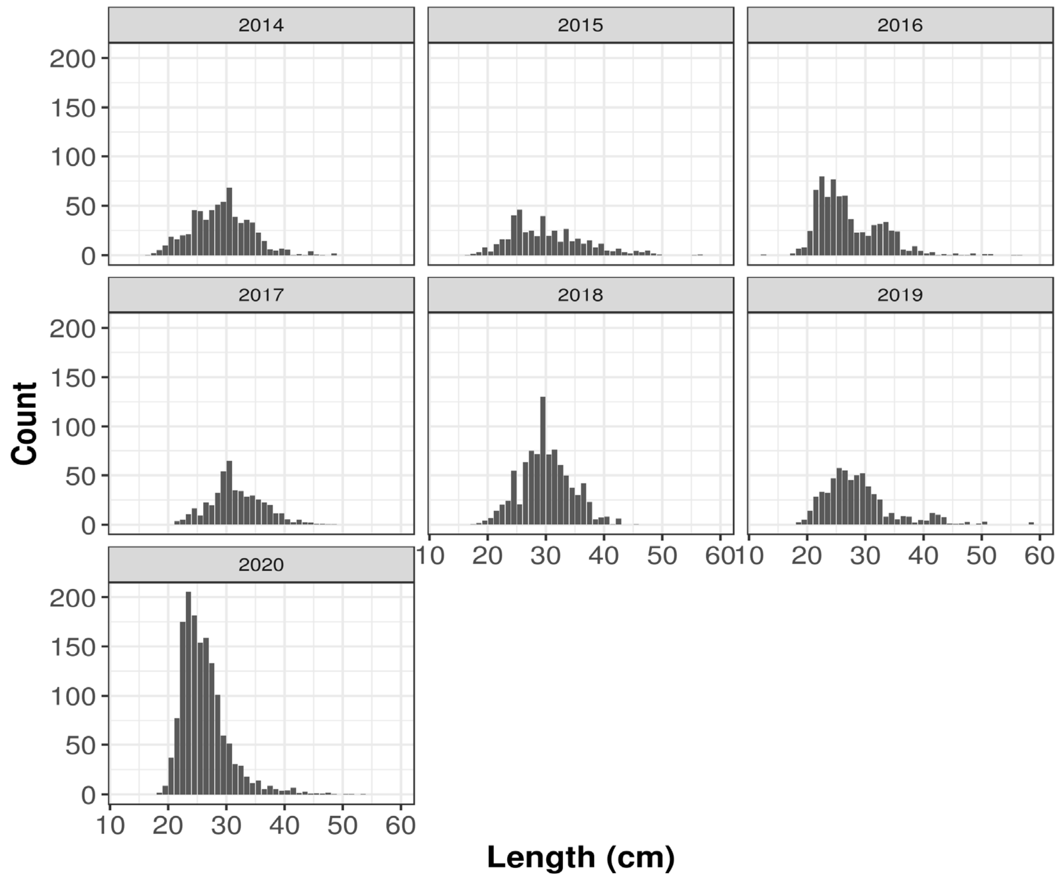

2014
2015
2016
2017
2018
2019
2020
Count
0
50
100
150
200
10
20
30
40
50
60
Length (cm)

Figure 8.3. Turbot in subdivisions 22 to 32. Binned length frequency distributions.

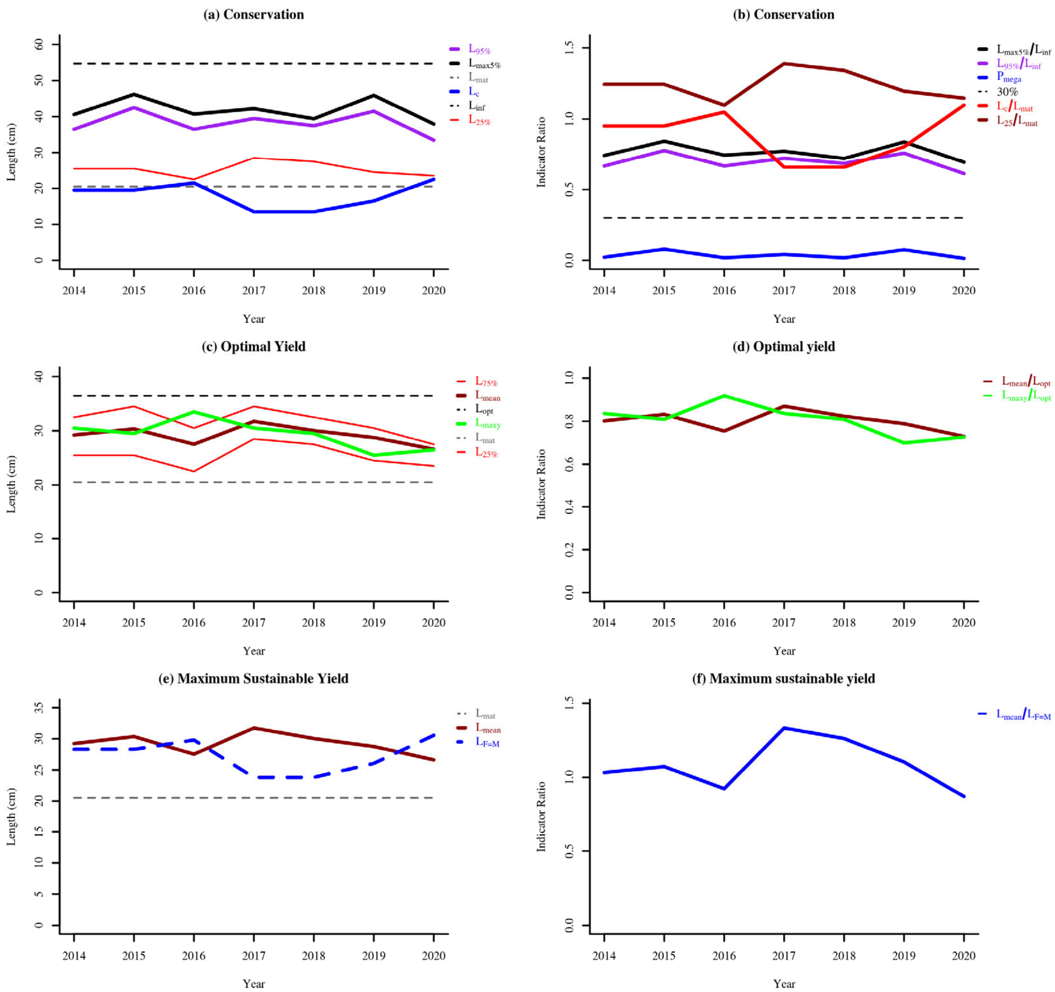


Figure 8.4. Turbot in subdivisions 22 to 32. Indicator trends

8.2 Dab

8.2.1 The 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 8.4). 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 2020.

The largest amount of dab landings are reported by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22, Figure 8.5). 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
2020	1026	573

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 8.6. Almost no dab above 35 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 8.7). 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 four years. A stock status update is given in 2021, 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 2020 is also a catch advice.

The mean biomass index of 2020 and 2019 was 20% lower than the mean of the mean biomass index from 2016–2018 (Figure 8.7). The length-based indicators (proxy reference points) are stating a good status of the stock. A precautionary buffer was applied the last time in 2013.

8.2.5 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015) (Table 8.5). CANUM and WECA of commercial catches from 2014–2020 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter and sexes → L_{inf} = 35.61 cm
- L_{mat}: average of 2002–2018, quarter 1 only, females only → L_{mat} = 18 cm

The results of LBI (Figure 8.8) show that stock status of dab.27.22-32 is slightly above possible reference points (Table 8.6). 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 8.4. Dab in the Baltic Sea: total landings (tonnes) of by Subdivision and country.

Year/SD	Denmark				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
1970	845		20		11		74												930	0	20	0	0	0	0	0	0	950
1971	911		26		10		64												985	0	26	0	0	0	0	0	0	1011
1972	1110		30		9		63						23						1182	0	53	0	0	0	0	0	0	1235
1973	1087		58		18		118						30						1223	0	88	0	0	0	0	0	0	1311
1974	1178		51		18		118						34						1314	0	85	0	0	0	0	0	0	1399
1975	1273		74		20		131						32						1424	0	106	0	0	0	0	0	0	1530
1976	1238		60		17		114						27						1369	0	87	0	0	0	0	0	0	1456
1977	889		32		13		89						25						991	0	57	0	0	0	0	0	0	1048
1978	928		51		19	14	128	4											1075	0	69	0	0	0	0	0	0	1144
1979	1413		50		18	25	123	1					9						1554	0	85	0	0	0	0	0	0	1639
1980	1593		21		15	25	101						3						1709	0	49	0	0	0	0	0	0	1758
1981	1601		32		24	39	164						5						1789	0	76	0	0	0	0	0	0	1865
1982	1863		50		46	38	182	4					6	5	8	6		1	2091	0	98	5	0	8	6	0	1	2209
1983	1920		42		46	28	198						24	20	32	22		2	2164	0	94	20	0	32	22	0	2	2334
1984	1796		65		30	47	175	2					4	3	5	4		1	2001	0	118	3	0	5	4	0	1	2132

Year/SD	Denmark				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
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

Year/SD	Denmark				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
2001	586		72				191	5				4	1	2					777	4	78	2	0	0	0	0	0	861
2002	502		31				173	5				4							675	4	36	0	0	0	0	0	0	715
2003	559		171				494	7	0			1	0						1053	1	179	0						1233
2004	953		185				745	10	0			1	1	0					1698	1	196	0						1894
2005	752	34	163	16			474	45	9			1	1	0					1226	35	209	25	0	0	0	0	0	1495
2006	400	23	112	161			494	24	11			1	2	0		0			894	24	138	172						1228
2007	860	40	108	7			472	18	0			0	0	0	0	0			1332	40	126	7						1504
2008	757	36	86	222			507	33	0			3	0	1	1	2			1264	39	119	223		1	2			1648
2009	521	25	97	0			587	32	0			2	0	0	1	3			1108	27	129	1		1	3			1268
2010	552	18	51	0			398	17	2			1	0	0					950	19	69	2						1041
2011	544	20	39	0			647	15	0			1	0	1	0	0			1192	21	53	1						1268
2012	481	22	69	0			692	20	0	0	0	1	0	0	0	1	0	0	1173	23	89	0						1285
2013	445	18	69	0			834	17	0	0		0	0	1	0	0	1		1279	18	86	1						1384
2014	373	11	57	0			801	25	2	0		0	0	0	0	0			1174	11	82	2						1269
2015	268	9	21	0	0	0	955	14	0	0	0	0	0	0	1	0	0	0	1223	9	35	0	0	1	0	0	0	1268
2016	268	14	21				1027	23	1	0	0	0	0	0	1	1	0	0	1295	38	23	1	0	1	1	0	0	1358

Year/SD	Denmark				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
2017	276	9	15				874	50			0.0	0.1	0	0.4	0	0.6	0.7	0	1150.7	59.3	15.1	0.4	0	0	0.6	0.7	0	1227
2018	273	18	20	0			560	66			0.0	1.3	0	0.1	0	0.0	0.0	0	833.2	86.1	19.9	0.2	0	0	0.0	0.0	0	940
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	0.0	0.0	0	1102
2020	398	13	95	0			469	49			0.0	1.3	0	0.1	1	0.0					95.0	0.1	0	1	0.0	0.0	0	96

[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 8.5. Dab in subdivisions 22 to 32. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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

Table 8.6. Dab in subdivisions 22 to 32. Indicator status for the most recent three years. Indicator values above the expected value (i.e. signalling a good stock status) are given in green; values below the expected value are given in red.

	Conservation				Optimizing Yield	MSY
Year	**L_c / L_{mat}**	**$L_{25\%}$ / L_{mat}**	**L_{max5} / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**L_{mean} / $L_{F=M}$**
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
2020	0.58	1.14	0.89	0.25	0.96	1.36

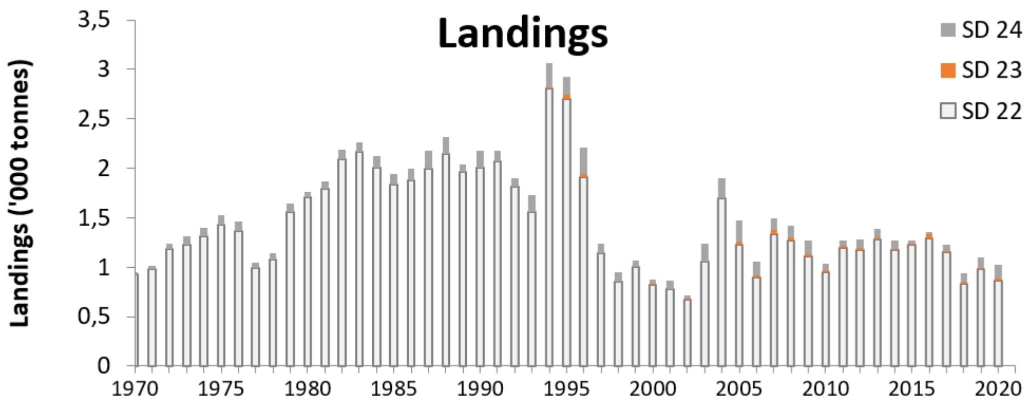


Figure 8.5. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

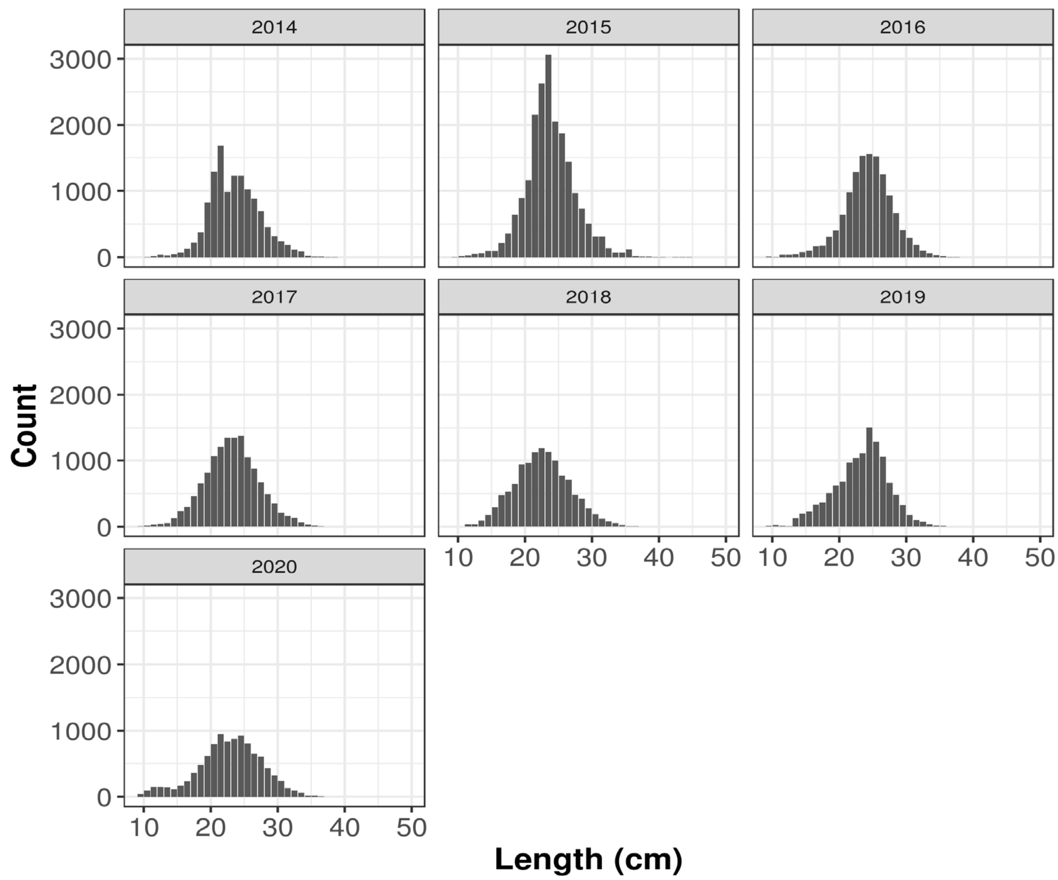


Figure 8.6. Dab in subdivisions 22 to 32. Catch in numbers per length for the three most recent years 2014–2020.

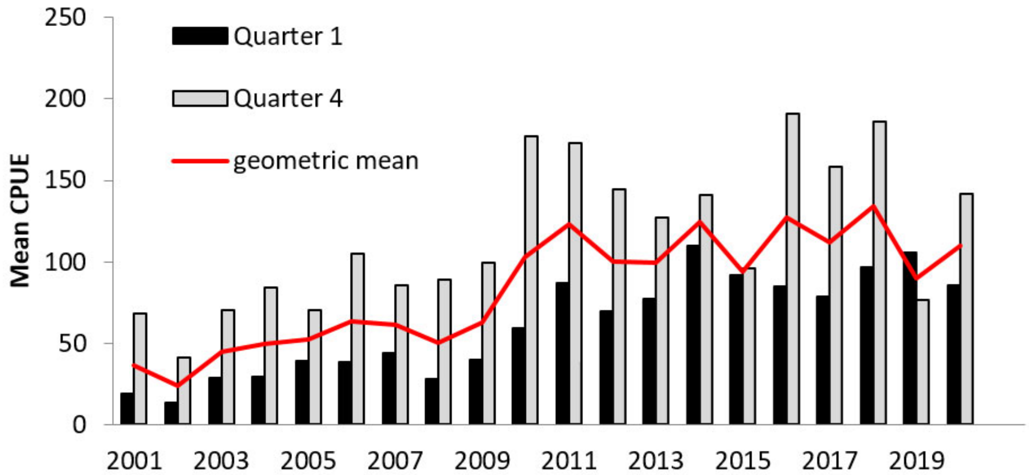


Figure 8.7. Dab in subdivisions 22 to 32. Mean biomass (kg hr-1) of dab with L ≥15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

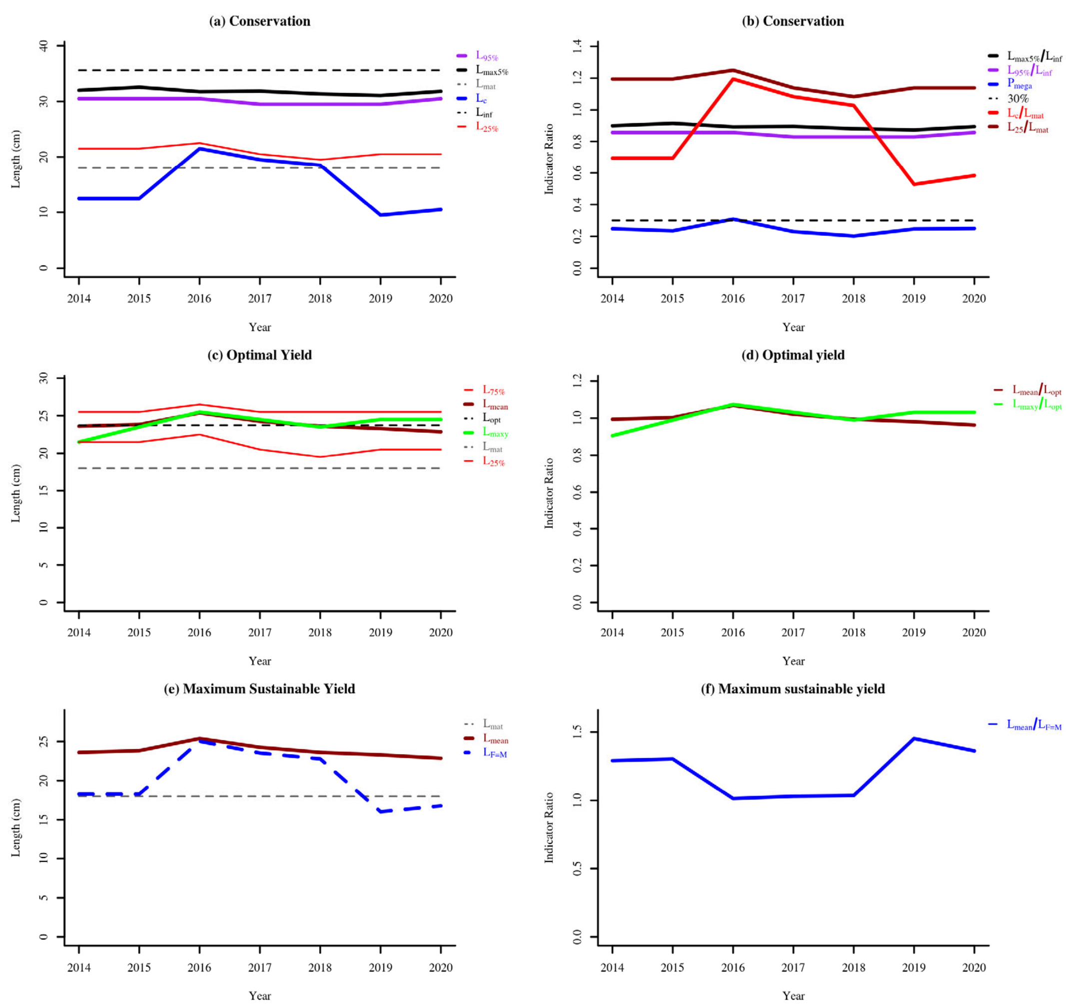


Figure 8.8. Dab in subdivisions 22 to 32. LBI F_{MSY} Proxy reference points

8.3 Brill

8.3.1 The Fishery

8.3.1.1 Landings

Total landings of brill varied from 1 t to 160 t between 1975 and 2004 (Table 8.7, Figure 8.9). 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, but increased again in 2020 to 65 t.

8.3.1.2 Discard

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. For 2020, 6.1 tonnes of discards have been reported. This corresponds to about 10% of the landings. Most of these discards have been generated in Subdivision 22, in proportion with the landings in Subdivision 22, which constantly contributes 60- 80% of the total.

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 sub-areas sampled in the ICES subdivisions. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 8.10).

The area data are available at http://www.ices.dk/marine-data/data-portals/Pages/DATRAS-Docs.aspx . The CPUE data were derived from DATRAS (CPUE per length per haul per hour). It was not possible to match exactly the same data as in the assessments used before 2018. This is probably due to some selective weightings of subareas done in former assessments, that has not been possible to reconstruct. However, the new and old calculation routine yield the same trends in CPUE and it is considered important from now on to derive the stock indices in a transparent and reproducible way.

Stable index with low fluctuations were observed between 2007 and 2017. Since 2018 the index increased, but decreased in 2020. 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 8.11). 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 Subdivision 22-32 with Brill in Subdivision 21.

Table 8.7. Brill in the Baltic Sea: total landings (tonnes) by Subdivision and country.

Year	Denmark			Germany, FRG		Sweden		Total			Total
	22	23	24-28	22	24	23	24-28	22	23	24-28	SD 22-28
1970	4							4	0	0	4
1971	3							3	0	0	3
1972	7							7	0	0	7
1973	11		2					11	0	2	13
1974	25		1					25	0	1	26
1975	38		1	1				39	0	1	40
1976	45		1	2				47	0	1	48
1977	60		2	5				65	0	2	67
1978	37			3				40	0	0	40
1979	30							30	0	0	30
1980	26							26	0	0	26
1981	22			1				23	0	0	23
1982	19						17	19	0	17	36
1983	13						42	13	0	42	55
1984	12						3	12	0	3	15
1985	16						1	16	0	1	17
1986	15						3	15	0	3	18
1987	12						3	12	0	3	15
1988	5						1	5	0	1	6
1989	9						1	9	0	1	10
1990							1	0	0	1	1
1991	15							15	0	0	15
1992	28							28	0	0	28
1993	29	5	1					29	5	1	35
1994	57	4	1				1	57	4	2	63
1995	134	12	1			5	8	134	17	9	160
1996	56	6						56	6	0	62
1997	25					1		25	1	0	26
1998	21					1		21	1	0	22
1999	24					1		24	1	0	25
2000	27					1		27	1	0	28
2001	19							19	0	0	19
2002	25		0			1		25	1	0	27
2003	35		1			0		35	0	1	36
2004	39		1			1	0	39	1	1	41
2005	50	9	3			0	0	50	9	3	62
2006	42	9	2	3		0	0	45	9	2	56
2007	50			5		0	0	55	0	0	56
2008	81	9	3	11		1	1	92	10	3	105
2009	70	7	2	11		1	0	82	8	3	92
2010	65	4	1	10		0	0	76	5	1	82
2011	46	5	1	4		1	0	50	6	1	57
2012	24	4	0	2		1	0	26	4	0	31
2013	24	6	0	1	0	1	0	25	7	0	31
2014	19	5	0	2	0	1	0	21	6	0	28
2015	29	7	0	3	0	1	0	32	8	0	40
2016	28	8	0	2	0	1	0	29	9	1	39
2017	29	6	0	4	0	0	0	33	6	0	39
2018	36	11	1	6	1	1	0	41	11	1	53
2019	35	6	1	5	0	1	0	40	7	1	48
2020	43	11	2	8	0	1	0	51	12	2	65

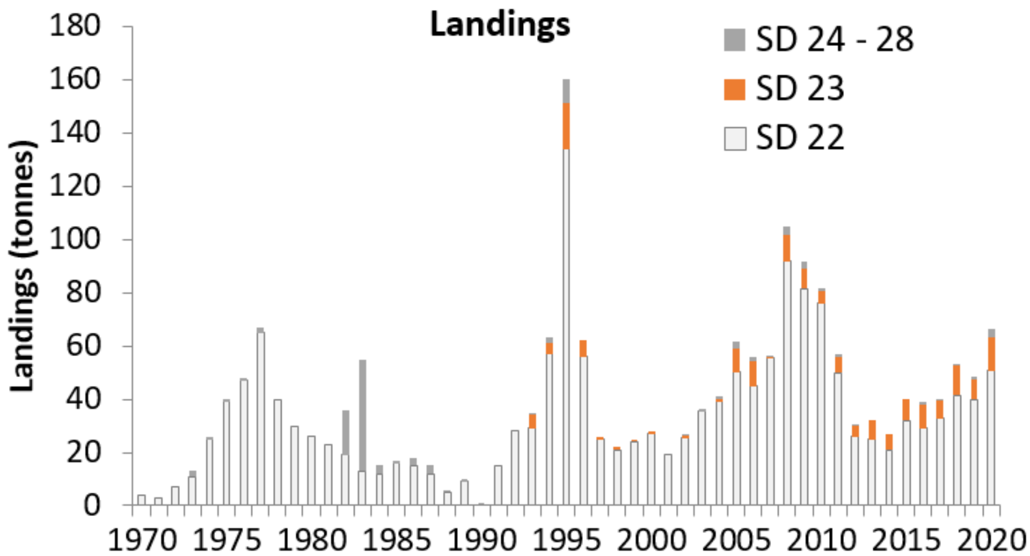


Figure 8.9. Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

Figure 8.10. Mean CPUE (no. hr^{-1}) of brill with L ≥ 20 cm.

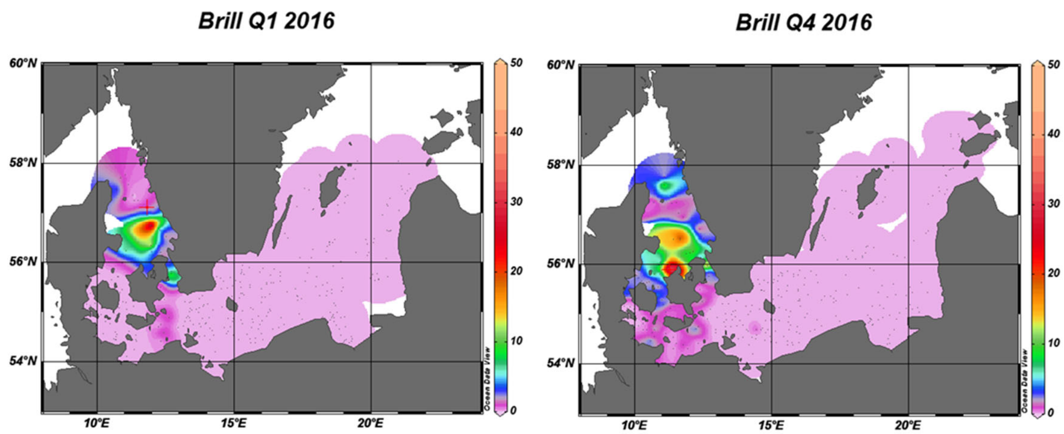


Figure 8.11. Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

9 References

Andersson, E., & Lövgren, J. (2018). Trål för fångst av rödspätta och stor torsk (rist/stormaskig trål). Ch. 5 (s. 52-65) i Nilsson m fl 2018. Sekretariatet för selektivt fiske- rapportering av 2016 och 2017 års verksamhet. Aqua Reports 2018:4. Sveriges lantbruksuniversitet, Institutionen för akvatiska resurser, Lysekil, 211 s. ISBN: 978-91-576-9557-4. Available at: https://www.slu.se/globalassets/ew/org/inst/aqua/externwebb/sidan-publikationer/aqua-reports-xxxx_xx/aqua-reports-2018_4.pdf

Amosova, V.M., Zezera A.S., Karpushevskaya, A.I., Karpushevskiy, I.V., Patokina, F.A., Dmitrieva, M.A., Vinokur, M.L. and Shumilova., K.Yu. (2017). Biological and hydrological components describing the long-term changes and the current state of cod *Gadus morhua callarias* in the Baltic Sea (Gdansk basin, subdivision ICES 26). Problems of Fisheries, 2017,18: 42–51.

Birjukov, N. P. 1970. Baltijskaja treska [Baltic cod]. AtlantNIRO, Kaliningrad. 165 pp. (in Russian)

Cardinale, M., and Arrhenius, F. 2000. Decreasing weight-at-age of Atlantic herring (*Clupea harengus*) from the Baltic Sea between 1986 and 1996: a statistical analysis. ICES Journal of Marine Science, 57: 1-12.

Casini M., Bartolino, V., Molinero, J.C. and Kornilovs, G. 2010. Linking fisheries, trophic interactions and climate: threshold dynamics drive herring (*Clupea harengus*) growth in the central Baltic Sea. Marine Ecology Progress Series, 413:241-252.

Casini, M., Cardinale, M., and Hjelm, J. 2006. Inter-annual variation in herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) condition in the central Baltic Sea: what gives the tune? Oikos, 112: 638-650.

Casini, M., Kornilovs, G., Cardinale, M., Möllmann, M., Grygiel, W., Jonsson, P., Raid, T., Flinkman, J. and Feldman, V. 2011. Spatial and temporal density-dependence regulates the condition of central Baltic Sea clupeids: compelling evidence using an extensive international acoustic survey. Population Ecology, 53: 511-523.

Cieglewicz W (1963). Flounder migration and mortality rates in the southern Baltic. ICES CM Baltic-Belt Seas Committee No. 78: 7.

Davies, J. C. 2021. 2020 Western Baltic Cod age reading exchange report (SmartDots ID 292 & 294), DTU Aqua. 65 p.

Darby, C.D. and Flatman, S., 1994. Virtual Population Analysis: Version 3.1 (Windows/DOS), User Guide. *Inf. Techn. Ser., MAFF Direct. Fish. Res., Lowestoft* (1): 85 p.

Dementjeva, T. F. 1959. Some data on the life history and fishery of cod in the central Baltic. Rapports et Procès-Verbaux des Réunions du Conseil Permanent International pour l'Exploration de la Mer, 147: 68–73.

EU. 2016. Regulation (EU) 2016/1139 of the European Parliament and of the Council of 6 July 2016 establishing a multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (EC) No 2187/2005 and repealing Council Regulation (EC) No 1098/2007.

Florin, AB., Höglund, J. Population structure of flounder (*Platichthys flesus*) in the Baltic Sea: differences among demersal and pelagic spawners. Heredity 101, 27–38 (2008). https://doi.org/10.1038/hdy.2008.22

Francis, R.I.C. 2011. Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124–1138.

Funk S, Krumme U, Temming, Möllmann C 2020. Gillnet fishers' knowledge reveals seasonality in depth and habitat use of cod (*Gadus morhua*) in the Western Baltic Sea. ICES J Mar Sci, doi:10.1093/icesjms/fsaa071

Gårdmark, A., Florin, A.-B., 2007. Flounder (*Platichtys flesus*) growth and length distributions — an input to length based assessments. Working Document, ICES Baltic Fisheries Assessment Working Group (WGBFAS), Copenhagen, Denmark.

Gröhsler, T., Oeberst, R., Schaber, M., Larson, N. and Kornilovs, G. Discrimination of western Baltic spring-spawning and central Baltic herring (*Clupea harengus* L.) based on growth vs. natural tag information. ICES Journal of Marine Science (2013) 70 (6): 1108-1117. doi:19.1093/icesjms/fst064.

Hemmer-Hansen, J., Nielsen, E. E., Grønkjaer, P., & Loeschcke, V. (2007). Evolutionary mechanisms shaping the genetic population structure of marine fishes; lessons from the European flounder (*Platichthys flesus* L.). Molecular Ecology, 16(15), 3104-3118.

Hemmer-Hansen, J., Nielsen, E. E., Frydenberg, J., & Loeschcke, V. (2007). Adaptive divergence in a high gene flow environment: Hsc70 variation in the European flounder (*Platichthys flesus* L.). Heredity, 99(6), 592-600.

Hentati-Sundberg, J., Hjelm, J., & Österblom, H. (2015). Does fisheries management incentivize non-compliance? Estimated misreporting in the Swedish Baltic Sea pelagic fishery based on commercial fishing effort. ICES Journal of Marine Science 71 (7): 1846-1853.

Holmgren, N.M.A., Norrström, N., Aps, R., & Kuikka, S. 2012. MSY-orientated management of Baltic Sea herring (*Clupea harengus*) during different ecosystem regimes. ICES Journal of Marine Science, 69: 257-266.

Horbowy, J., Luzeńczyk, A. 2012. The estimation and robustness of FMSY and alternative fishing mortality reference points associated with high long-term yield. Can. J. Fish. Aquat. Sci. 69: 1468–1480.

Hordyk, A., Ono, K., Valencia, S., Loneragan, N., Prince, J., 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES J Mar Sci 72, 217–231. doi:10.1093/icesjms/fsu004

Hovgård, H. 2006. A compilation of information relevant for evaluating misreporting of cod in Kattegat by use of modal separation techniques. ICES C.M. 1995 G:24

Hurtado-Ferro, F., Szuwalski, C.S., Valero, J.L., Anderson, S.C., Cunningham, C.J.,Johnson, K.F., Licandeo, R., McGilliard, C.R., Monnahan, C.C., Muradian, M.L.,Ono, K., Vert-Pre, K.A., Whitten, A.R. and Punt, A.E., 2014. Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES J. Mar. Sci. 72, 99–110.

ICES. 2001. Report of the Study Group on the herring assessment units in the Baltic Sea. ICES C.M. 2001/ACFM:10.

ICES. 2002. Report of the Study Group on Baltic Herring and Sprat Maturity. ICES CM 2002/ACFM:21

ICES. 2005. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 12-21 April 2005, Hamburg, Germany. 589 pp.

ICES. 2006. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 18 - 27 April 2006, Rostock, Germany. ICES CM 2006?ACFM:24. 640 pp.

ICES. 2007. Report of the Workshop on Age Reading of Flounder (WKARFLO), 20–23 March 2007, Öregrund, Sweden. ICES CM 2007/ACFM:10. 69 pp.

ICES. 2008. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 8–17 April 2008, ICES Headquarters, Copenhagen, Denmark. ICES CM 2008\ACOM:06. 692 pp.

ICES. 2008. Report of the Workshop on Age Reading of Flounder (WKARFLO), 26 – 29 May 2008, Rostock, Germany.

ICES. 2008. Report of the Workshop on Reference Points in the Baltic Sea (WKREFBAS), 12 - 14 February 2008, ICES Headquarters, Copenhagen. ICES CM 2008/ACOM:28. Ref: AMAWGC. 26 pp.

ICES. 2009. Report of the Workshop on Multi-annual Management of Pelagic Fish Stocks in the Baltic (WKMAMPEL), 23–27 February 2009, ICES Headquarters. ICES CM 2009/ACOM: 38.

ICES. 2010. Report of the ICES/HELCOM Workshop on Flatfish in the Baltic (WKFLABA), 8 – 11 November 2010, Öregrund, Sweden. (ICES CM 2010/ACOM:68).

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42pp.

ICES. 2012. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 12 - 19 April 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:10.

ICES. 2013. Report of the Baltic International Fish Survey Working Group (WGBIFS), 21-25 March 2013, Tartu, Estonia. ICES CM 2013/SSGESST:08. 505 pp.

ICES. 2013. Report of the Benchmark Workshop on Baltic Multispecies Assessments (WKBALT), 4-8, February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:43.

ICES. 2014. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 3-10 April 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:10. 919 pp.

ICES. 2014. Report of the Benchmark Workshop on Baltic Flatfish stocks (WKBALFLAT), 27– 31 January 2014. ICES CM 2014/ACOM:39.

ICES. 2014. Report of the Joint ICES–MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 147 pp.

ICES. 2015. EU request to ICES to provide FMSY ranges for selected North Sea and Baltic Sea stocks. In Report of the ICES Advisory Committee, 2015. ICES Advice 2015, Book 6, Section 6.2.3.1. 11 pp. http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/Special_Requests/EU_FMSY_ranges_for_selected_N S_and_BS_stocks.pdf

ICES. 2015. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 14–21 April 2015, ICES HQ, Copenhagen, Denmark. ICES CM 2015/ACOM:10. 826 pp.

ICES. 2015. Report of the Benchmark Workshop on Baltic Cod Stocks (WKBALTCOD), 2–6 March. ICES Document CM 2015/ACOM: 35. Rostock, Germany.

ICES. 2015. Report of the Fifth Workshop on the Development of Quantitative Assessment Methodologies based on Life-history Traits, Exploitation Characteristics and other Relevant Parameters for Data-limited Stocks (WKLIFE V), 5–9 October 2015, Lisbon, Portugal. ICES CM 2015/ACOM:56. 157 pp.

ICES. 2016. Report of the Baltic International Fish Survey Working Group (WGBIFS), 30 March -3 April 2016, Rostock, Germany. ICES CM 2016/ACOM:11.

ICES. 2016. Report of the Workshop on Guidance on Development of Operational Methods for the Evaluation of the MSFD Criterion D3.3 (WKIND3.3i), 14–17 March 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:44. 99 pp.

ICES. 2017. BALTIC FISHERIES ASSESSMENT WORKING GROUP, 2. Series title. Jan De Haes 108 pp.

ICES. 2017. Final Report of the Baltic International Fish Survey Working Group (WGBIFS), Report 2017 27-31 March 2017, Riga, Latvia. ICES CM 2017/SSGIEOM:07. 684 pp.

ICES. 2017. Report of the Benchmark Workshop on Baltic Stocks (WKBALT), 7–10 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:30. 108 pp.

ICES 2017. Report of the Workshop on Biological Input to Eastern Baltic Cod Assessment (WKBEBCA). ICES CM 2017/SSGEPD:19

ICES. 2018. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2018), 12–16 February 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:32. 313 pp.

ICES. 2018. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). 29-31 January 2018 and 12-20 March 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:07. 960 pp.

ICES 2018. Workshop on evaluation of Input Data to Eastern Baltic Cod stock Assessment (WKIDEBCA). 23-25 January 2018, Copenhagen, Denmark

ICES. 2019. Benchmark Workshop on Baltic Cod Stocks (WKBALTCOD2). ICES Scientific Reports. 1:9. 310 pp. http://doi.org/10.17895/ices.pub.4984

ICES. 2019. Working Group on Multispecies Assessment Methods (WGSAM). ICES Scientific Reports. 1:91. 320 pp. http://doi.org/10.17895/ices.pub.5758

ICES. 2020. Inter-Benchmark Process on BAltic Sprat (Sprattus sprattus) and Herring (Clupea harengus) (IBPBash). ICES Scientific Reports. 2:34. 44 pp. http://doi.org/10.17895/ices.pub.5971

ICES. 2021. ICES Working Group on Baltic International Fish Survey (WGBIFS; outputs from 2020 meeting). ICES Scientific Reports. 3:02. 539pp. http://doi.org/10.17895/ices.pub.7679

Kornilovs, G. 1994. Yearly length distribution of herring in the Gulf of Riga in relation to population structure of the stock. ICES C.M. 1994/J:9, Ref.H.

Köster, F.W., Huwer, B., Kraus, G., Diekmann, R., Eero, M., Makarchouk, A., Örey, S., Dierking, J., Margonski, P., Herrmann, J.P., Tomkiewicz, J., Oesterwind, D., Kotterba, P., Haslob. H., Voss, R., Reusch, T.B.H. 2020. Egg production methods applied to Eastern Baltic cod provide indices of spawning stock dynamics. Fisheries Research, 227, 105553

Lablaika, I., Hoziosky, S. and Jushkevitz, Z. 1991. The USSR Baltic cod catches and relevant fishing effort dynamics in the ICES Subdivisions 26 and 28. ICES C.M.1991/J:22

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology, 49: 627–642.

Methot, R.D. and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142 86–99.

Möllmann, C., Kornilovs, G., Fetter, M., Köster, F. W., and Hinrichsen, H-H. 2003. The marine copepod, *Pseudocalanus elongatus*, as a mediator between climate variability and fisheries in the Central Baltic Sea. Fisheries Oceanography, 12: 360-368.

Momigliano, P., Denys, G. P., Jokinen, H., & Merilä, J. (2018). *Platichthys solemdali* sp. nov. (*Actinopterygii, Pleuronectiformes*): a new flounder species from the Baltic Sea. Frontiers in Marine Science, 5, 225.

Mohrholz, V. 2018 Major Baltic Inflow Statistics. Revised. Front. Mar. Sci. 5:384. doi: 10.3389/fmars.2018.00384

Nielsen, A. 2008. State-space assessment model for cod in the Kattegat. Working Document 7, ICES WGBFAS 2008.

Nielsen, A. 2009. State-space fish stock assessment model as alternative to (semi-) deterministic approaches and stochastic models with a high number of parameters Working Document 14, ICES WKROUND 2009.

Nissling, A, Westin, L & Hjerne, O (2002). Reproduction success in relation to salinity for three flatfish species in the Baltic Sea. ICES Journal of Marine Science, vol. 59 no. 1, pp. 93–108.

Nissling, A., and Dahlman, G. (2010). Fecundity of flounder, *Pleuronectes flesus*, in the Baltic Sea—reproductive strategies in two sympatric populations. J. Sea Res. 64, 190–198. doi: 10.1016/j.seares.2010.02.001

Ojaveer, E., Jevtjukhova, B., Rechlin, O. and Strzyzewska, K. 1981. Results of investigations of population structure and otoliths of Baltic spring spawning herring. ICES C. M. 1981/J:19.

Ojaveer, H., Blenckner, T., Casini, M., Florin, A-B., Horbowy, J., Möllmann, C., Neuenfeldt, S., Orio, A., Polte, P., Raid, T., (2017) Integrating spatial processes into ecosystem models for sustainable utilization of fish resources (INSPIRE). Report on spatially explicit MSFD indicators. Work package number and leader: WP 5, LUKE. Deliverable No: 5.2. May, 2017

Orio, A., Florin, A.-B., Bergström, U., Sics, I., Baranova, T., and Casini, M. 2017. Modelling indices of abundance and size-based indicators of cod and flounder stocks in the Baltic Sea using newly standardized trawl survey data. – ICES Journal of Marine Science, doi:10.1093/icesjms/ fsx005.

Otterlind G (1967). Om rödspättans och flundrans vandringsvanor i södra Östersjön. *Ostkusten* **10**: 9–14.

Pedersen, M.W. and Berg, C.W. 2017. A stochastic surplus production model in continuous time. Fish and Fisheries, 18, 226–243.

Punt, A.E., 2017. Some insights into data weighting in integrated stock assessments. Fish. Res. 192, 52–65. http://dx.doi.org/10.1016/j.fishres.2015.12.006.

Putnis, I., Müller-Karulis, B., and Kornilovs, G. 2011. Changes in the reproductive success of the Gulf of Riga herring. ICES C.M./H:13.

Raid,T., Kornilovs, G., and Shpilev, H. 2005. Stock diversity of herring in the Northern Baltic: is the separate assessment of herring natural stock units possible? ICES CM 2005/K:22.

Rönkkönen, S., Ojaveer, E., Raid, T., and Viitasalo, M. 2004. Long-term changes in Baltic herring (*Clupea harengus membras*) growth in the Gulf of Finland. Canadian Journal of Fisheries and Aquatic Sciences, 61: 219-229.

Stepputtis, D., Santos, J., Mieske, B., Lichtenstein, U., Schütz, A., Stechert, R. 2020. Abschlussbericht an das Ministerium für Landwirtschaft und Umwelt Mecklenburg-Vorpommern für das Projekt CODEX (CodExcluder) - Netzmodifikation zur Reduktion des Dorschbeifanges. Rostock: Thünen-Institute of Baltic Sea Fisheries, 99 p

Then, A.Y., J.M. Hoenig, N.G. Hall and D.A. Hewitt. 2015. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science 72 (1): 82-92. doi: 10.1093/icesjms/fsu136.

Thurow, F., and Weber, W. 1992. Catch rates versus biomass in Baltic cod. ICES CM 1992/J:37.

Valentinsson, D & Ulmestrand, M. (2008). Species-selective *Nephrops* trawling: Swedish grid experiments. Fisheries Research. 90. 109-117. 10.1016/j.fishres.2007.10.011

Vitinsh, M. 1976. Some regularities of flounder (*Platichthys flesus* L.) distribution and migrations in the eastern and north-eastern Baltic. Fischerei-Forschung, 1: 39—48.

Walter, J., Winker, H., 2019. Projections to create Kobe 2 Strategy Matrices using the multivariate log-normal approximation for Atlantic yellowfin tuna. ICCAT-SCRS/2019/145 1–12.

Winker, H., Walter, J., Cardinale, M., Fu, D., 2019. A multivariate lognormal Monte-Carlo approach for estimating structural uncertainty about the stock status and future projections for Indian Ocean Yellowfin tuna. IOTC-2019-WPM10-XX.

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Annex 2: Resolution

Generic ToRs for Regional and Species Working Groups

2020/2/FRSG01 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

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

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

i) descriptions of ecosystem impacts on fisheries

ii) descriptions of developments and recent changes to the fisheries

iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock,providing summaries of the following where relevant:

i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.

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 2020.

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

v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue

through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

vi) The state of the stocks against relevant reference points; Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data 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 associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. 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.

i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention (restricted access) and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.

i) update the benchmark issues lists for the individual stocks;

ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;

iii) determine the prioritization score for benchmarks proposed for 2022–2023;

iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

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

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

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

Specific ToRs

2020/2/FRSG07 The **Baltic Fisheries Assessment Working Group** (WGBFAS) chaired by Mikaela Bergenius, Sweden, will meet

on-line 19 and 29 March 2021 to:

a) Evaluate the catch and survey data of Baltic Sea fish stocks, cod in Kattegat and sole in Skagerrak and Kattegat;

and at ICES HQ, Copenhagen, Denmark 13–20 April 2021.

b) Address generic ToRs for Regional and Species Working Groups;

c) Review the main result from WGMIXFISH, WGIAB, WGSAM, and WGBIFS with a focus on the biological processes and interactions of key species in the Baltic Sea;

d) Test the sensitivity to the exclusion of particular survey indices for the stock ple.27.21-23 through a "leave one out" analysis.

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 4th May 2021 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

Annex 3: Tentative Resolution for 2022 meeting

WGBFAS suggests the following tentative ToRs for 2022.

2022/X/ACOMXX The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Mikaela Bergenius Nord, and Kristiina Hommik, will meet online on 11 April 2022 to:

- Evaluate the catch and survey data of Baltic Sea fish stocks, cod in Kattegat and sole in Skagerrak and Kattegat;

and at ICES HQ, Denmark, on 20-27 April 2022 to:

a) Address generic ToRs for Regional and Species Working Groups
b) Review the main results from WGMIXFISH, WGIAB, WGSAM and WGBIFS. 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 2022 ICES data call.

WGBFAS will report by xx May 2022 for the attention of ACOM.

Annex 4: Working documents

- **WD01: Estimated mixing proportions. Eastern/Western Baltic Cod 2020 w. additional genetics, cut-off score 0.98**
  C. Moesgaard Albertsen, 103 pp.

- **WD02: German herring & sprat fisheries and assessment data in the Baltic Sea in 2020.**
  T. Gröhsler, 21 pp.

DTU Aqua
National Institute of Aquatic Resources

Estimated mixing proportions

Eastern/Western Baltic Cod 2020 w. additional genetics, cut-off score 0.98

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March 26, 2021

DTU Aqua

Executive summary - background

Otolith contour shapes are used to estimate the mixed stock fishery composition of commercial Danish catches of cod in ICES subdivision 24 (SD24). Catches in SD24 are assumed to be a combination of Eastern and Western Baltic cod. The stocks are biologically defined by the difference in spawning areas and seasons. Eastern Baltic cod spawn in the Bornholm Basin (SD25) from May to September, while the Western Baltic cod mainly spawn in the Kiel Bay and Danish straits from March to April. This information is used to construct genetic baselines.

The available data consists of a combination of otoliths with known stock origin from the period 2011 to 2015, but mainly from 2011 to 2012. Fish with known stock origin are a combination of spawning individuals and genetically assigned individuals, based on spawning individuals. Further, otoliths from fish of unknown stock origin are available from commercial Danish catches. Data are available for selected years from 1996 to 2020. To reduce computational complexity, samples with unknown stock origin before 2015 were not used.

Further, genetic information from the 2019 and 2020 commercial samples were included. Including information from a classifier with less than 100% accuracy will introduce bias if not accounted for. Therefore, only samples with classification score above 99.9% was included.

Every otolith has been manually screened by experts to ensure that they are not broken, crystalized, dirty, or otherwise unsuitable. For simplicity, only right otoliths are used.

DTU Aqua

Executive summary - method and results

The mixed stock fishery composition is estimated by maximum likelihood. Normalized elliptical Fourier descriptors (NEFDs), describing a simplified otolith contour, are assumed to follow a multivariate normal contaminated by a Student's t distribution. Parameters depend on the stock origin, fish length, time of year, and cohort. The cohort effect is modelled by an interaction between year and fish length. To be identifiable, the cohort effect is assumed to be the same for both stocks.

Fish with known stock origin directly informs parameters related to the relevant stock. Since fish with unknown stock origin must come from a mixture of the relevant stocks, they are modelled by a mixture of the stock-wise distributions. The mixture proportion can be estimated by maximum likelihood. In this setting, individual classification is not of interest.

For 2020, the estimated proportion of Eastern Baltic cod in SD24 Area 1 (Western part) commercial samples was 7% (2%; 18%) while it was 80% (51%; 94%) in SD24 Area 2 (Eastern part).

Note: The estimated 2019 mixing proportion for Area 1 is highly influenced by the number of years included. This is not the case for Area 2. When reducing the number of years, the estimated proportion of Eastern cod is estimated to be lower, but with high uncertainty. This is likely because the 10 genetic samples gets (relatively) higher weight in the model.

Residuals from the model indicate that the mean, variance, and heavy tails of the NEFDs are adequately modelled; however, some residual distributions show a slight skewness, which could influence the results. Under the true model, the method provides unbiased stock mixing proportions with correct confidence intervals.

DTU Aqua

Executive summary - Commercial / Survey (1/2)

In 2020, both commercial and survey samples were included from Area 1. Therefore, when additional genetic was included, the model was fitted with separate mixing composition estimates for commercial and survey samples.

Sample distribution (%) per month.

	1	2	3	4	5	6	7	8	9	10	11	12
Commercial Area1	0	29.7	0.0	0	0	0	0	0.0	0	0.0	26.9	43.3
Survey Area1	0	0.0	72.5	0	0	0	0	0.0	0	0.0	27.5	0.0
Commercial Area2	0	0.0	42.4	0	0	0	0	41.8	0	15.8	0.0	0.0

DTU

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Executive summary - Commercial / Survey (2/2)

Comparison of estimated proportion of Eastern Baltic cod inArea1 2020 from Danish commercial and survey catches from otolith shapes.

	Commercial	Survey
Estimate	0.065	0.835
Confidence interval lower bound	0.021	0.594
Confidence interval upper bound	0.184	0.946

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Limitations (1/3)

- Number of NEFDs

In theory, the method can estimate unbiased stock mixing proportions from any combination of NEFDs showing stock differences. Naturally, estimated mixing proportions are more reliable when stocks are easier to separate. While including more NEFDs should make it easier to separate stocks, it comes at a computational cost and a risk of overfitting the data. From a certain point, additional NEFDs no longer describe stock differences, but individual differences in otolith shape. As a compromise, the following NEFDs were used: B2, B3, B4, C2, C4, D1, D2, and D3. By construction, the NEFDs A1, B1, and C1 are 1, 0, and 0, respectively, and can not be included.

With n NEFDs and y years, the current model has $2 \cdot 9 \cdot n$ stock-wise mean parameters, $3 \cdot y \cdot n$ common mean parameters, $2 \cdot n$ variance parameters, $2\frac{(n \cdot n - n)}{2}$ correlation parameters, $4 \cdot n$ t contamination parameters, and $2 \cdot y + 2$ mixing proportion parameters. Therefore, the number of parameters grows quickly with the number of NEFDs, while the number of observations does not.

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Limitations (2/3)

- Data sampling

To interpret the estimated mixing proportions as estimated of the mixed fishery composition, it is assumed that the data sampling is representative of the fishery. If this is not the case, otolith shape analysis cannot account for this without additional information about the sampling procedure.

- Modelling framework

To estimate mixed fishery compositions, it is assumed that the present model adequately describes the distributional differences in NEFDs between stocks. Model residuals indicate that the mean, variance, and heavy tails are adequately modelled for each NEFD. Residual distributions for some NEFDs are slightly skewed which can influence the results.

- Distribution

In the present model, the t distribution contamination is the same for all NEFDs, but different between stocks. Preliminary tests have been run with different t contamination proportions per NEFD. This did not change the estimated mixing proportions very much. Further, it is currently assumed that the covariance matrix is the same for all fish in a stock. For some NEFDs, residuals indicate that small fish may have smaller variance; however, this may also be an artifact of the sample size.

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Limitations (3/3)

- Changes from earlier results

Previously, preliminary results have been presented with different estimated mixing proportions; however, investigation of model residuals have highlighted the need to account for the heavy tails of the NEFD distributions. This has changed the results compared to previously, where a multivariate normal was assumed.

Compared to the estimated mixing proportions from 2018, results for the period 2015 to 2018 are similar.

From 2020, a random effect was included on “trip” to account for overdispersion in the mixing proportions. Overdispersion is, for example, present when fish of the same stock are more likely to be caught together than the overall stock composition would suggest.

- Conclusion

Based on the residuals, combined with the fact that the estimated stock mixing proportions does not change by reducing the number of years or NEFDs, the model appears to adequately describe the available data. If the model is adequate, simulation studies have shown that the method provides unbiased stock mixing proportion estimates with correct confidence intervals.

DTU Aqua

Estimated mixing proportions 2020

Estimated proportion of Eastern Baltic cod in 2020 Danish commercial catches from otolith shapes.

	SD24 Area 1 Commercial	SD24 Area 1 Survey	SD24 Area 2 Commercial
Estimate	0.065	0.835	0.802
Confidence interval lower bound	0.021	0.594	0.512
Confidence interval upper bound	0.184	0.946	0.940

DTU Aqua

Estimated mixing proportions 2020 - only using baseline, 2018-2020

Estimated proportion of Eastern Baltic cod in 2020 Danish commercial catches from otolith shapes. Based on baseline data and commercial samples from 2018-2020

	SD24 Area 1 Commercial	SD24 Area 1 Survey	SD24 Area 2 Commercial
Estimate	0.059	0.745	0.836
Confidence interval lower bound	0.016	0.431	0.522
Confidence interval upper bound	0.195	0.919	0.960

DTU Aqua

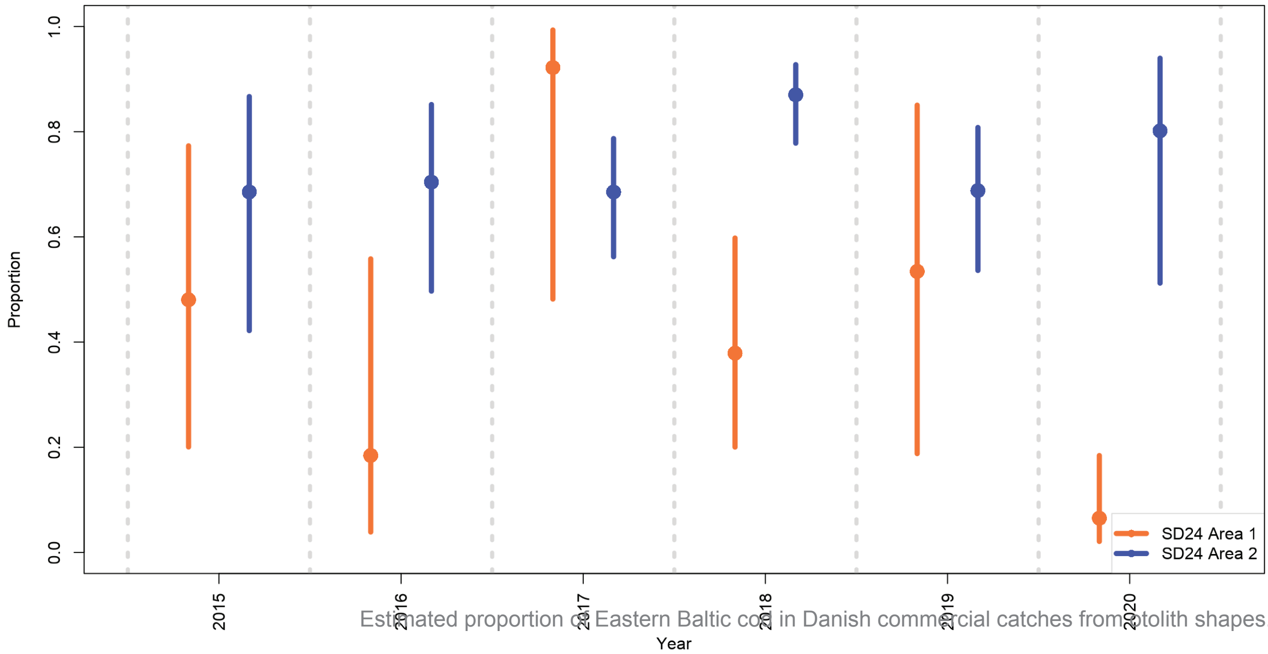
Estimated mixing proportions 2020 - only using baseline, 2020

Estimated proportion of Eastern Baltic cod in 2020 Danish commercial catches from otolith shapes. Based on baseline data and commercial samples from 2020

	SD24 Area 1 Commercial	SD24 Area 1 Survey	SD24 Area 2 Commercial
Estimate	0.050	0.639	0.896
Confidence interval lower bound	0.009	0.226	0.518
Confidence interval upper bound	0.243	0.914	0.986

DTU Aqua

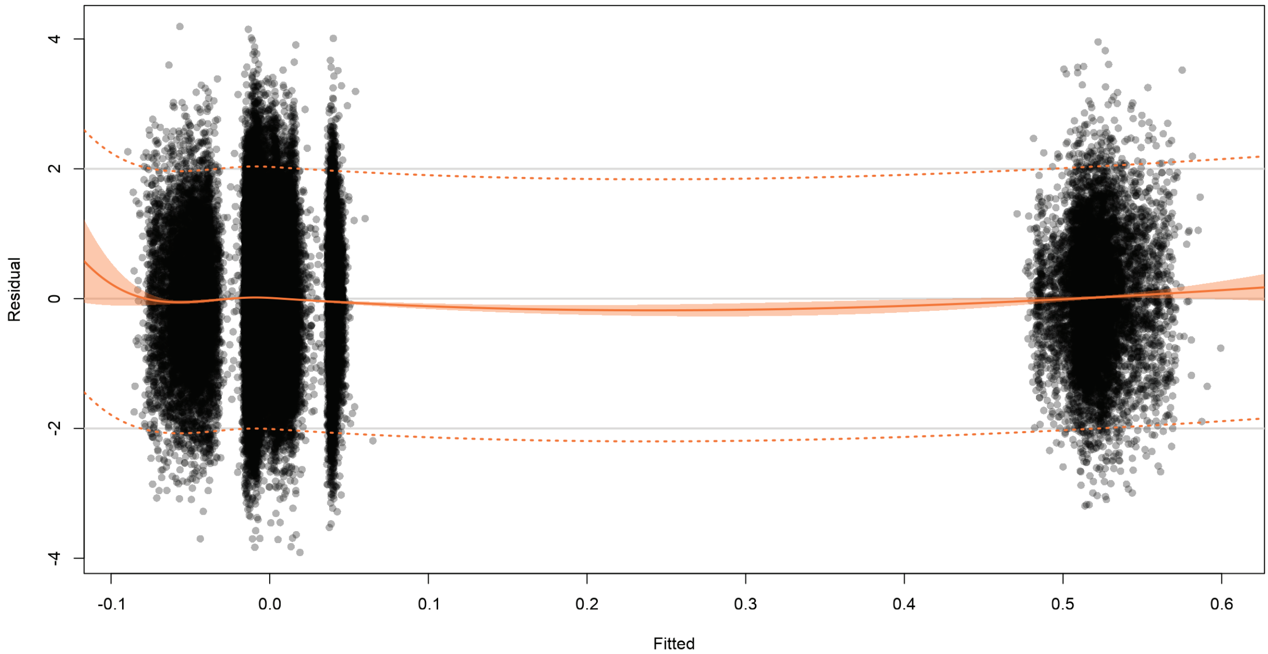
Estimated mixing proportions



Estimated proportion of Eastern Baltic cod in Danish commercial catches from otolith shapes.

DTU Aqua

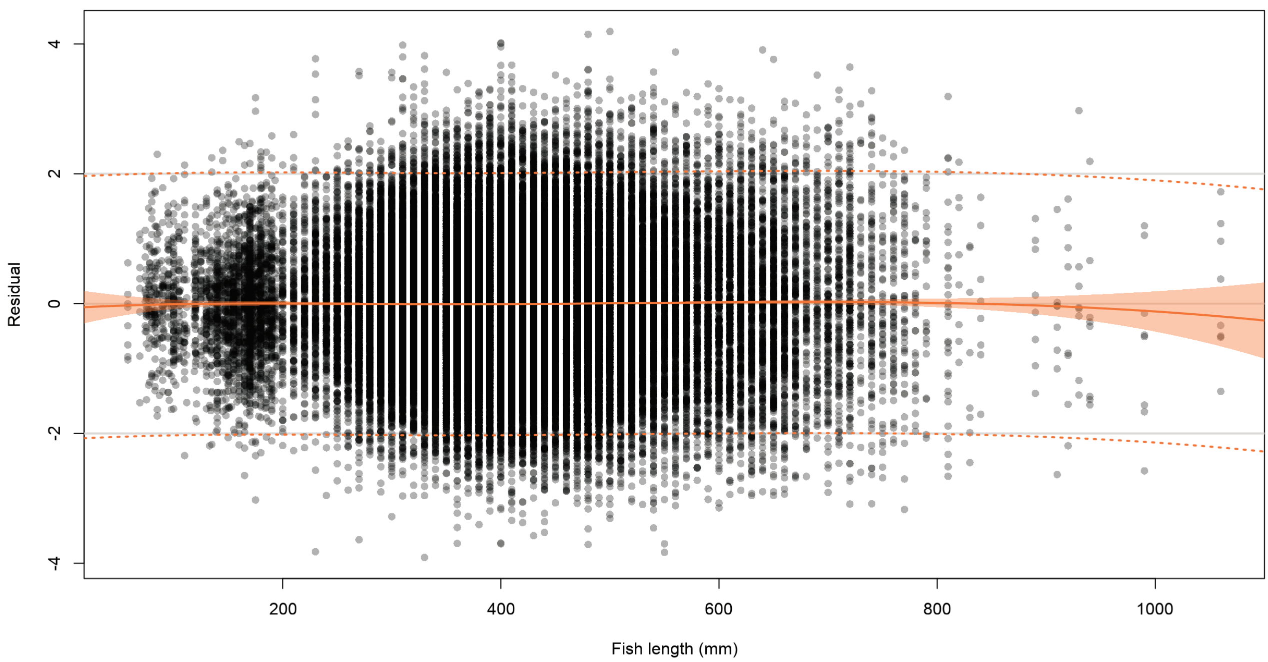
Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

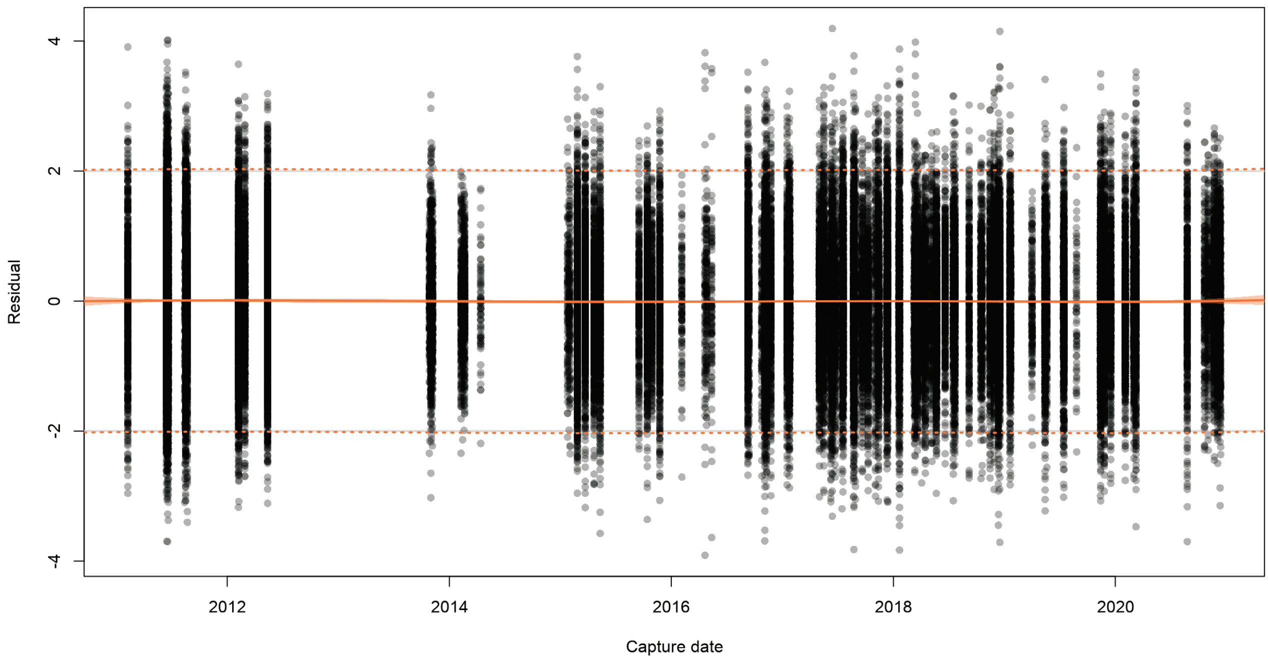
Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

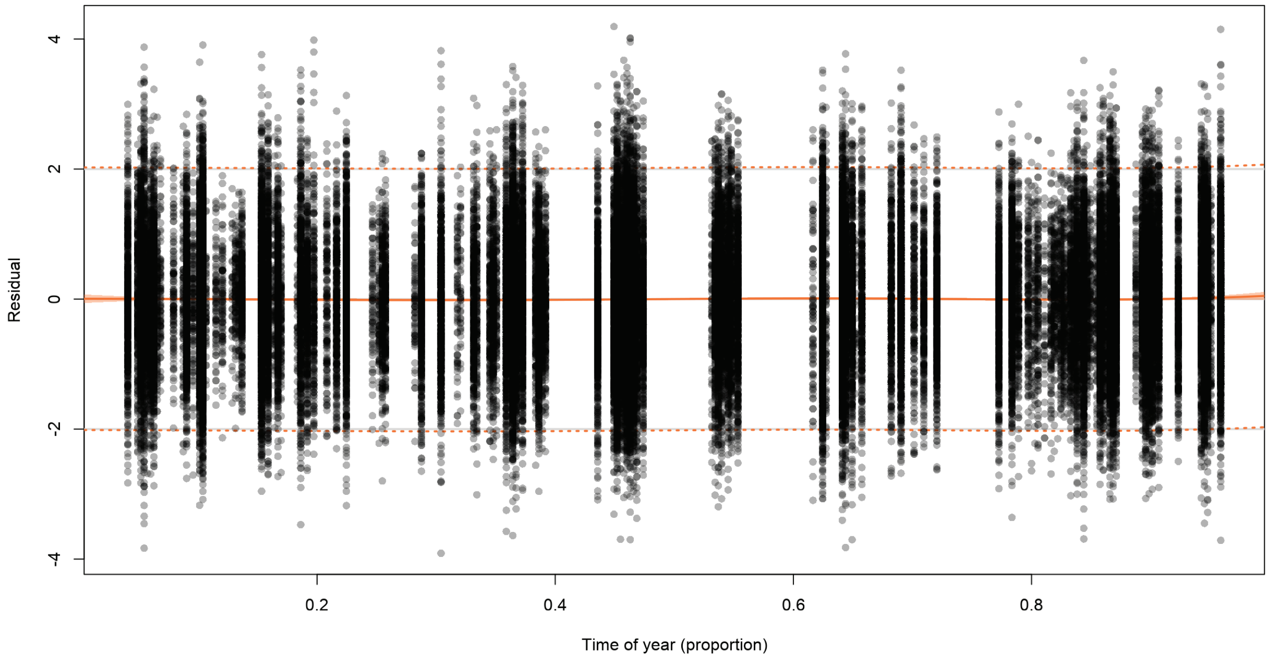
Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

Residuals to time of year

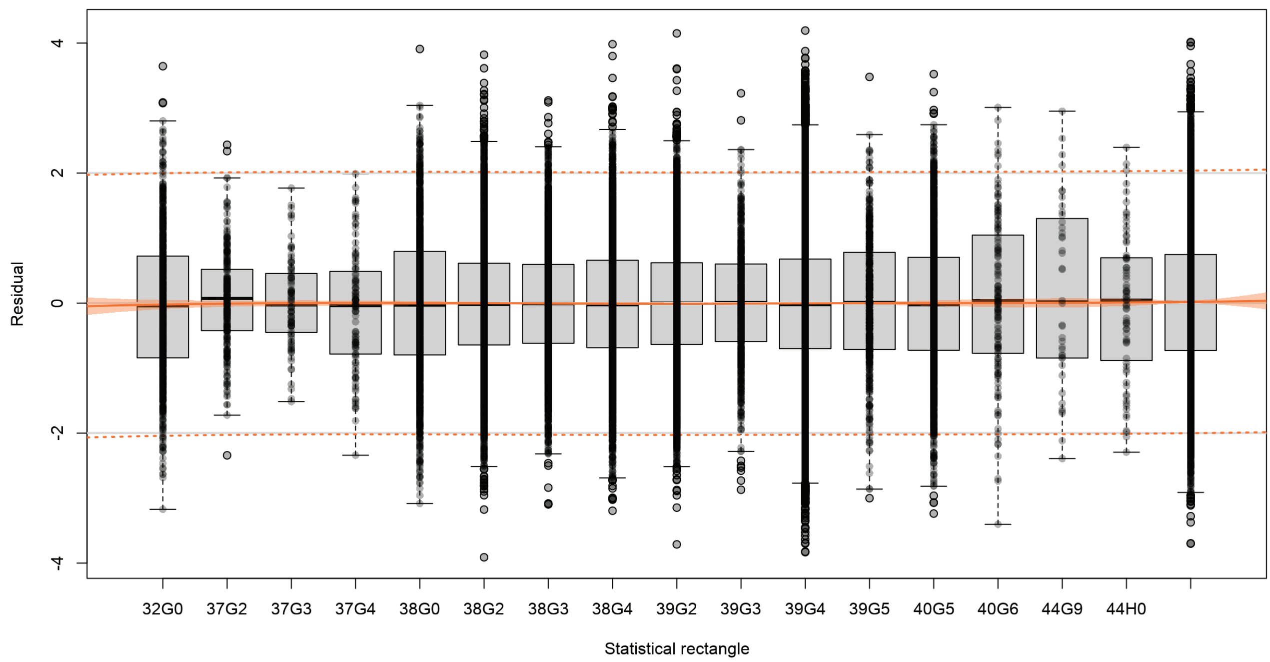


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

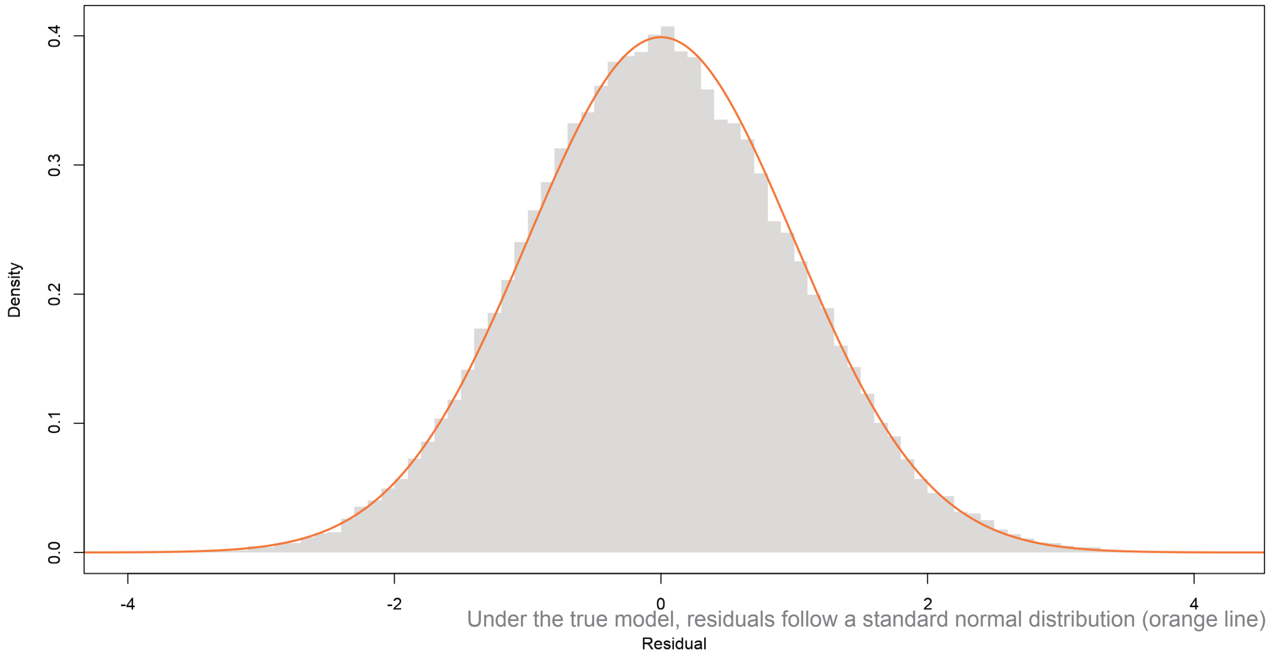
Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

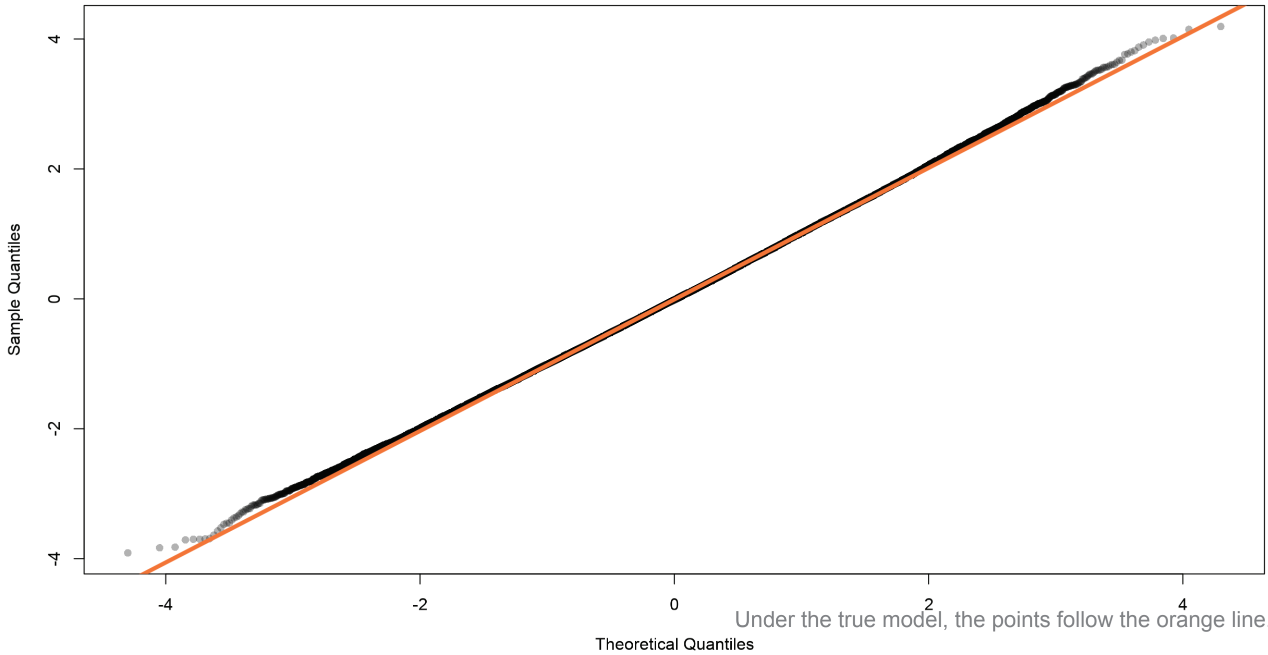
Residual histogram



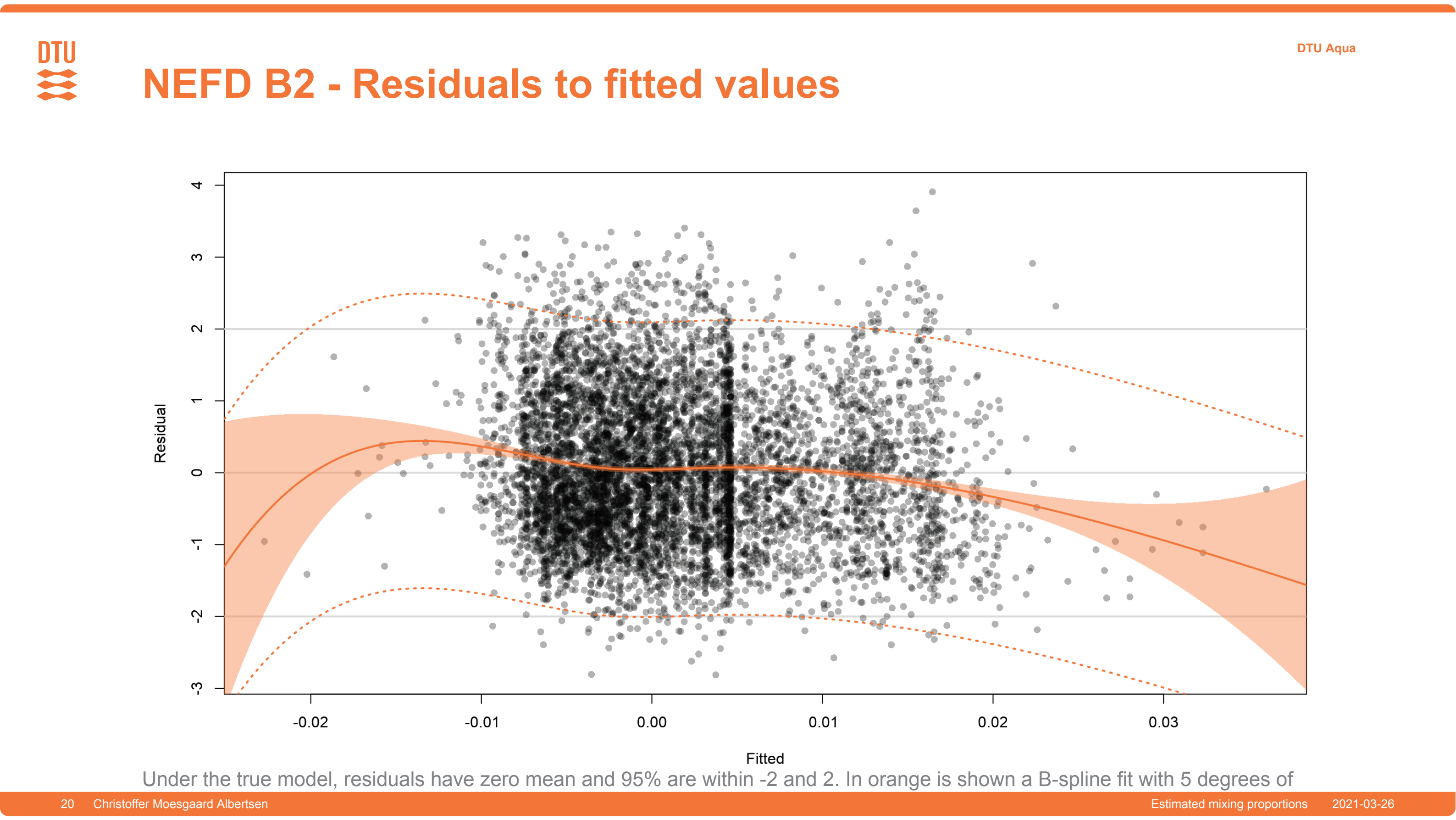
Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

Residual Quantile-Quantile plot

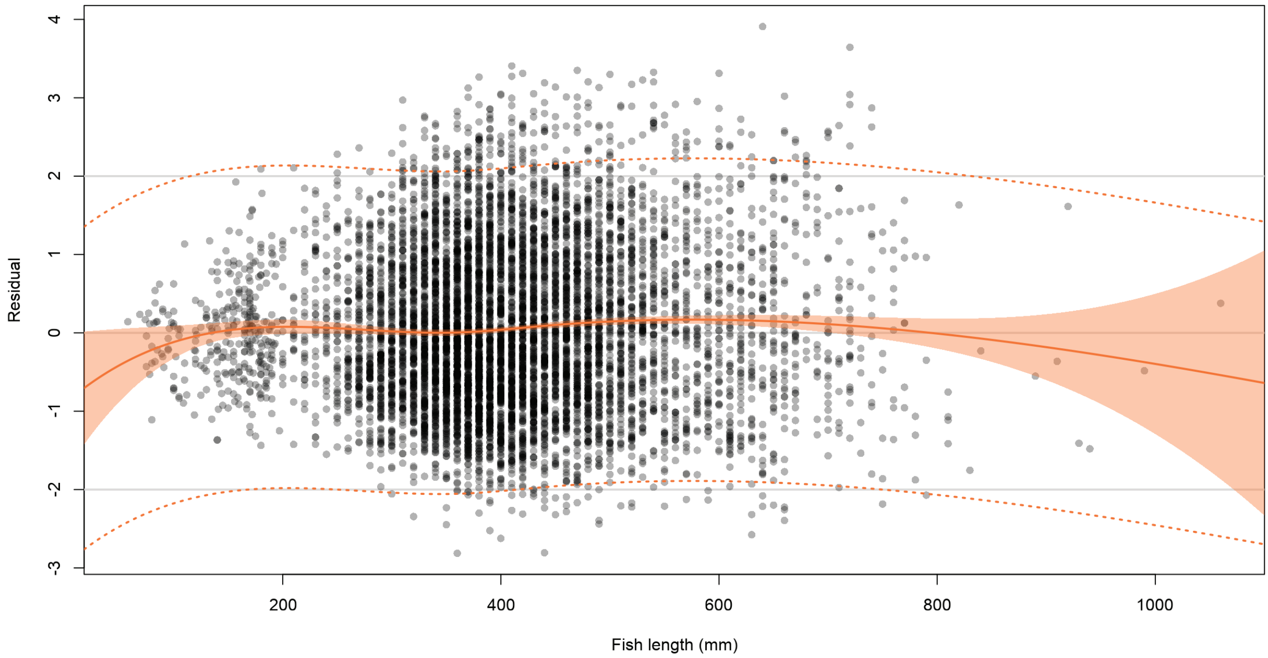


Under the true model, the points follow the orange line.


DTU
DTU Aqua
NEFD B2 - Residuals to fitted values
Residual
Fitted
-0.02
-0.01
0.00
0.01
0.02
0.03
-3
-2
-1
0
1
2
3
4
Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of
20 Christoffer Moesgaard Albertsen
Estimated mixing proportions 2021-03-26

DTU Aqua

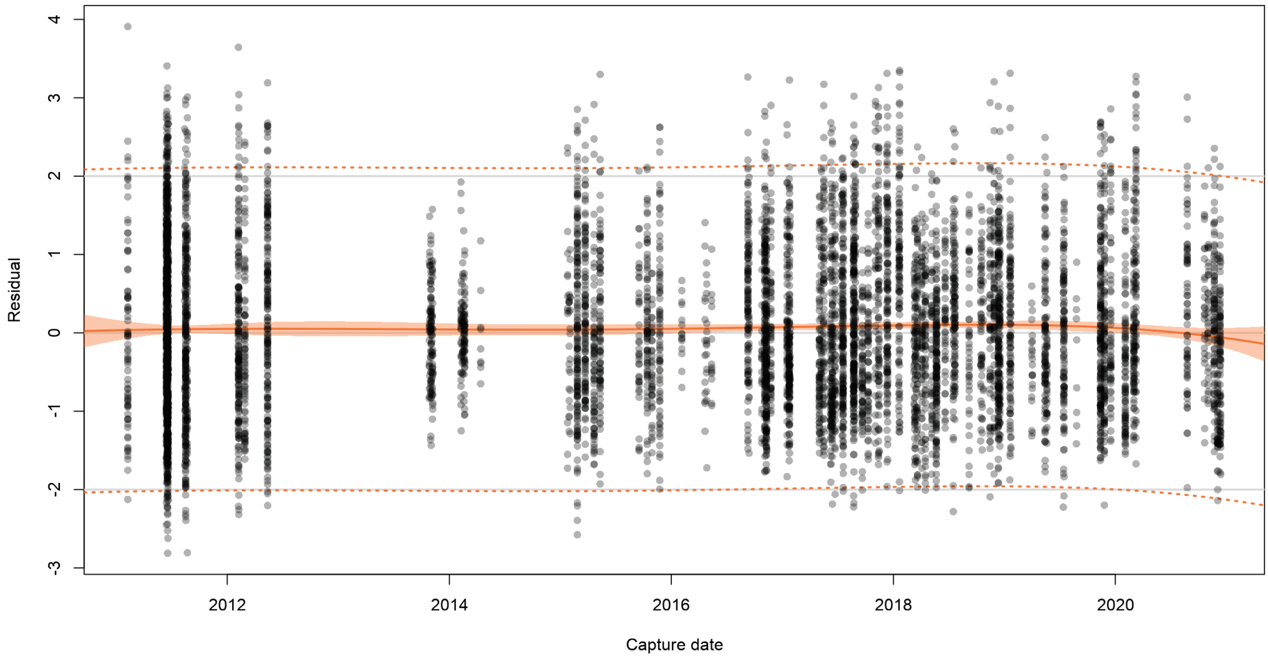
NEFD B2 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

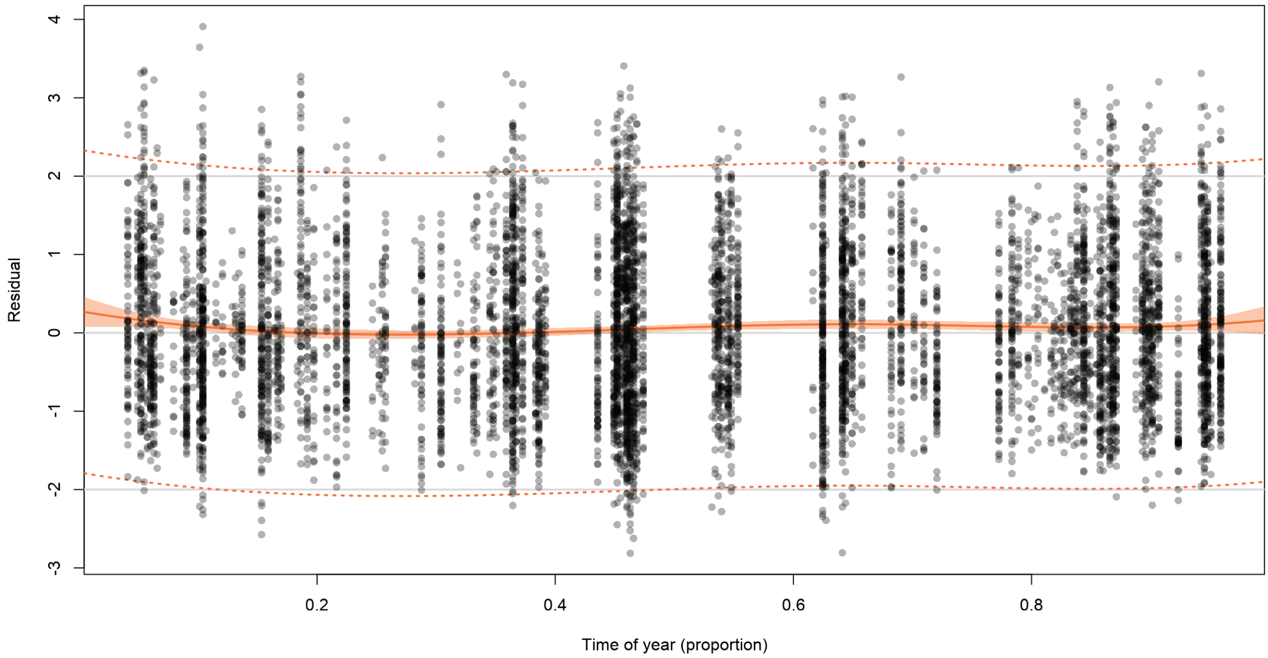
NEFD B2 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

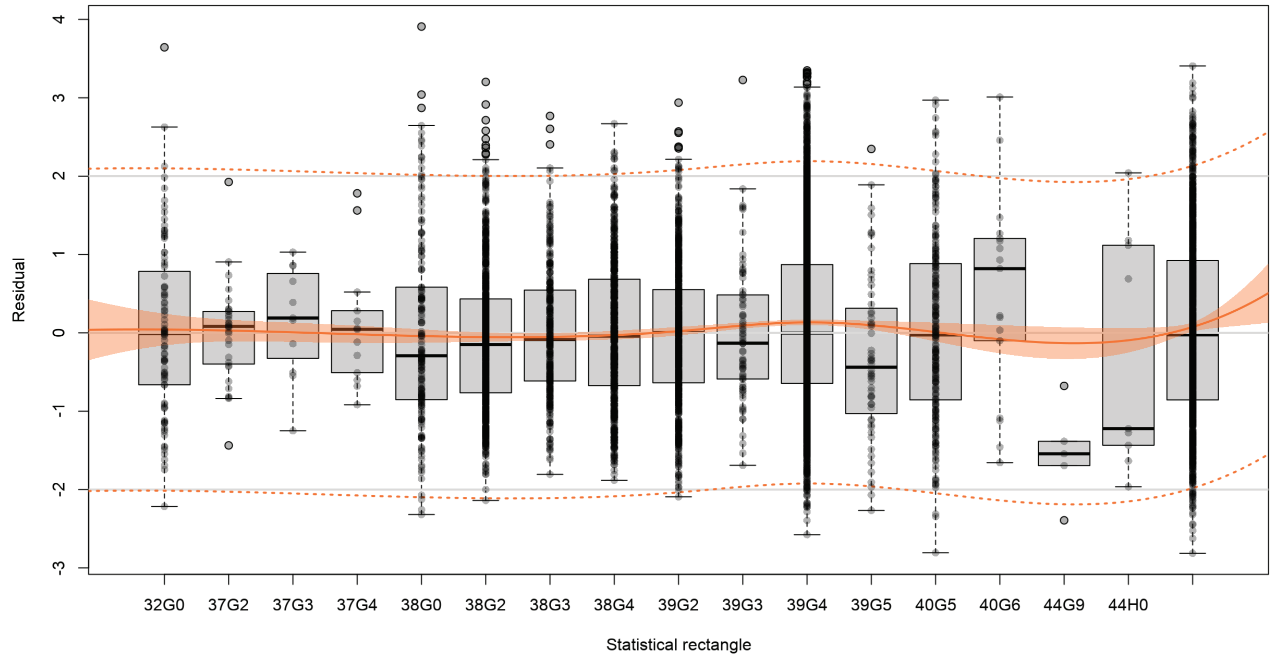
NEFD B2 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

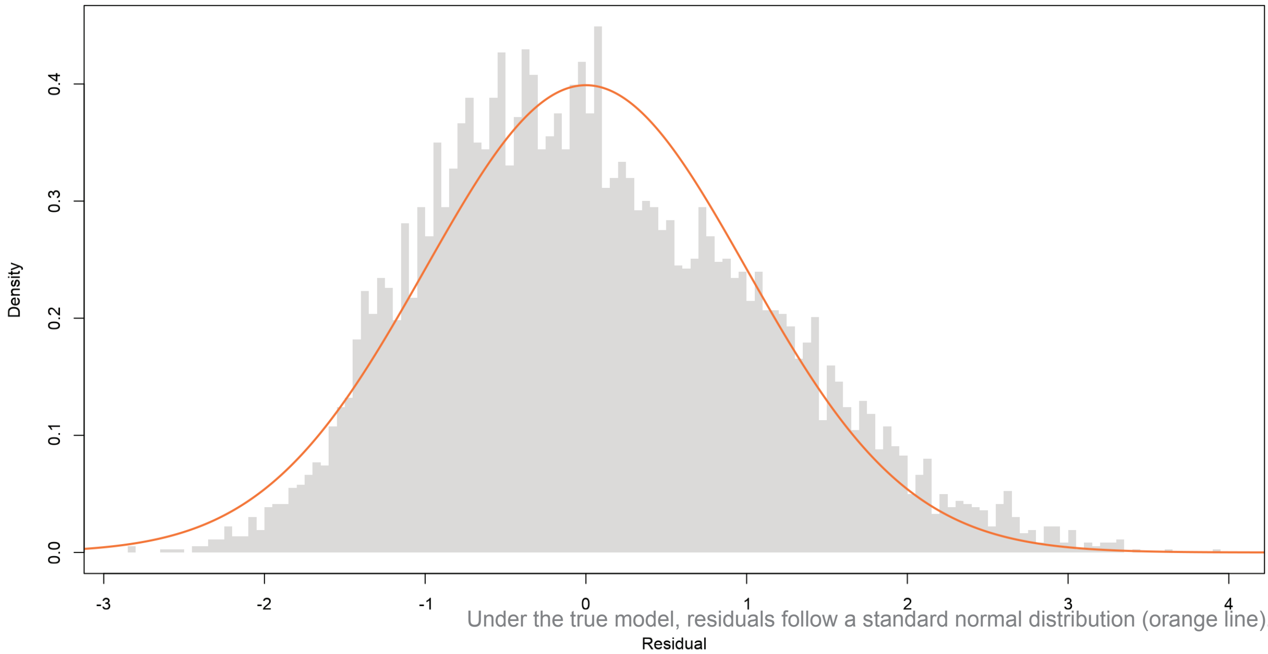
NEFD B2 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

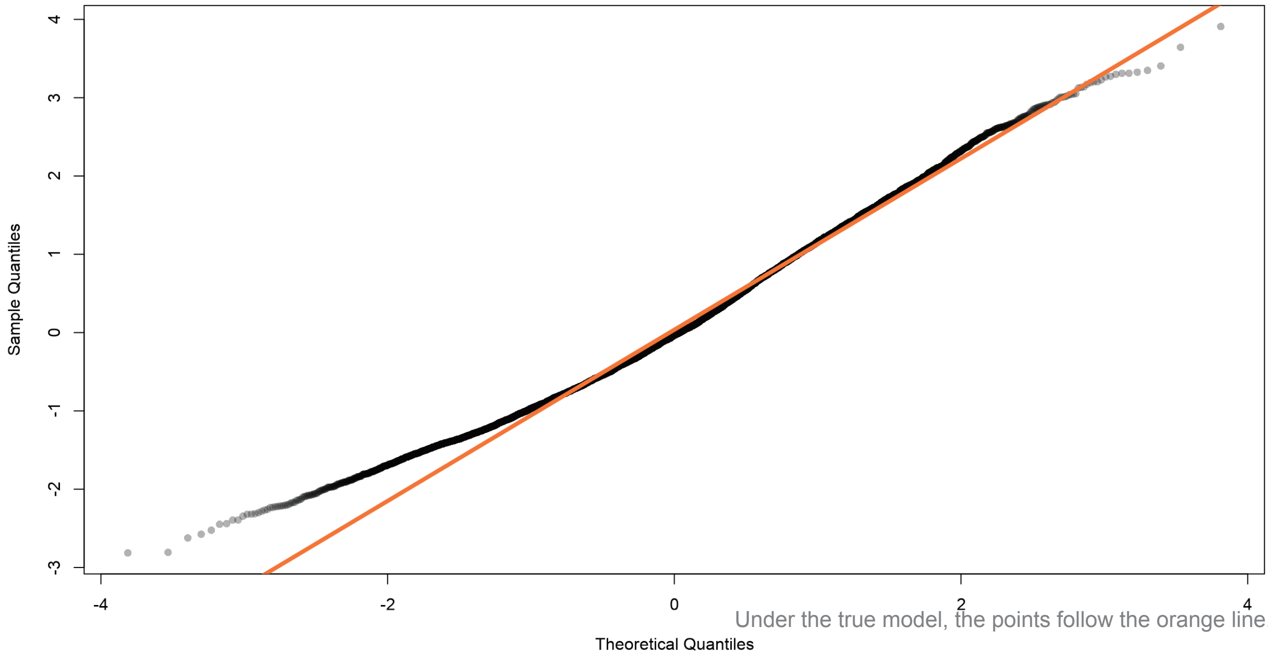
NEFD B2 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

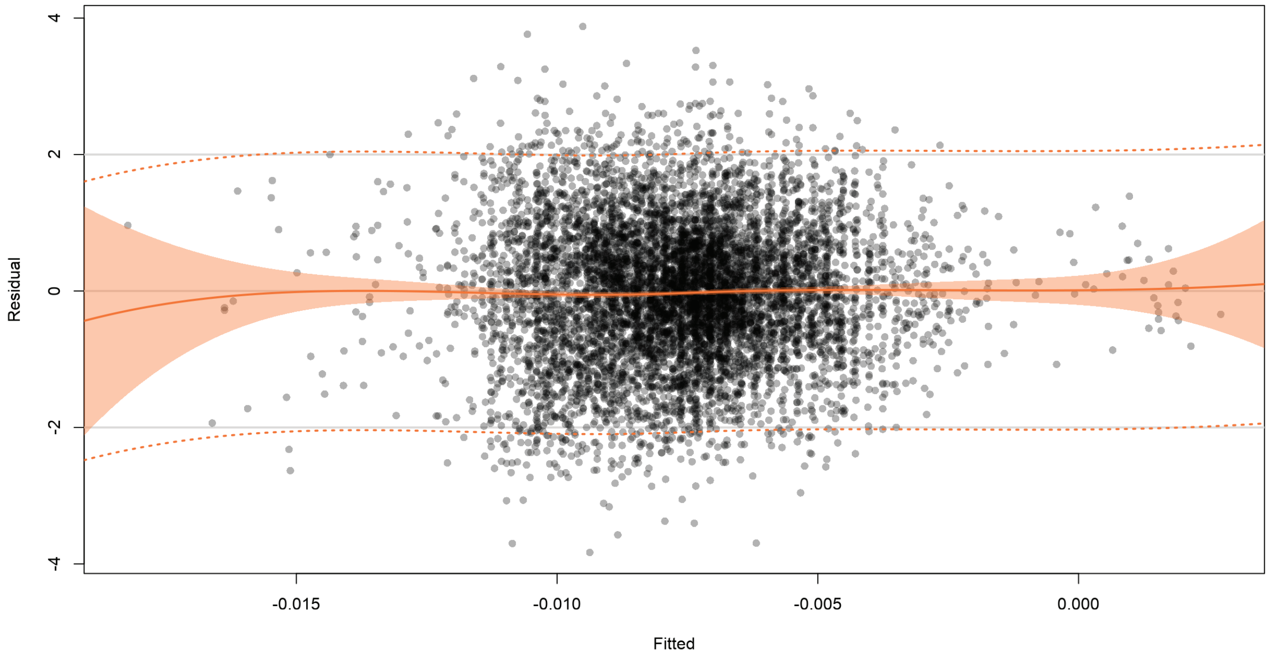
NEFD B2 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

NEFD B3 - Residuals to fitted values

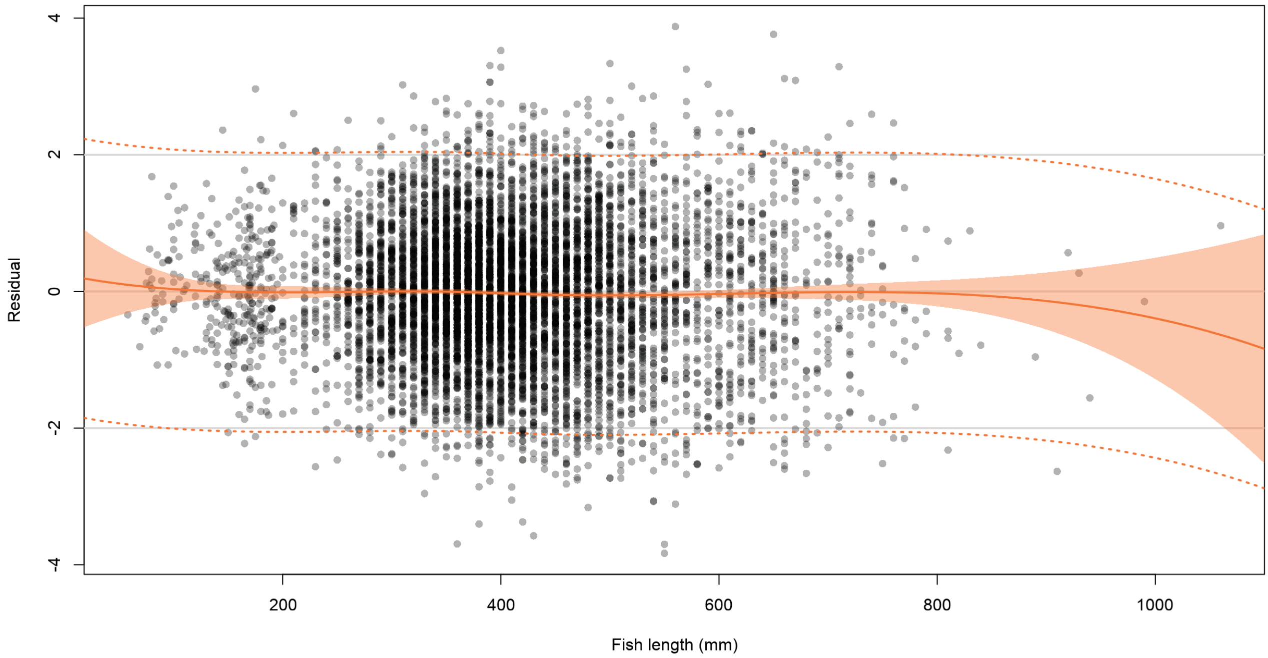


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

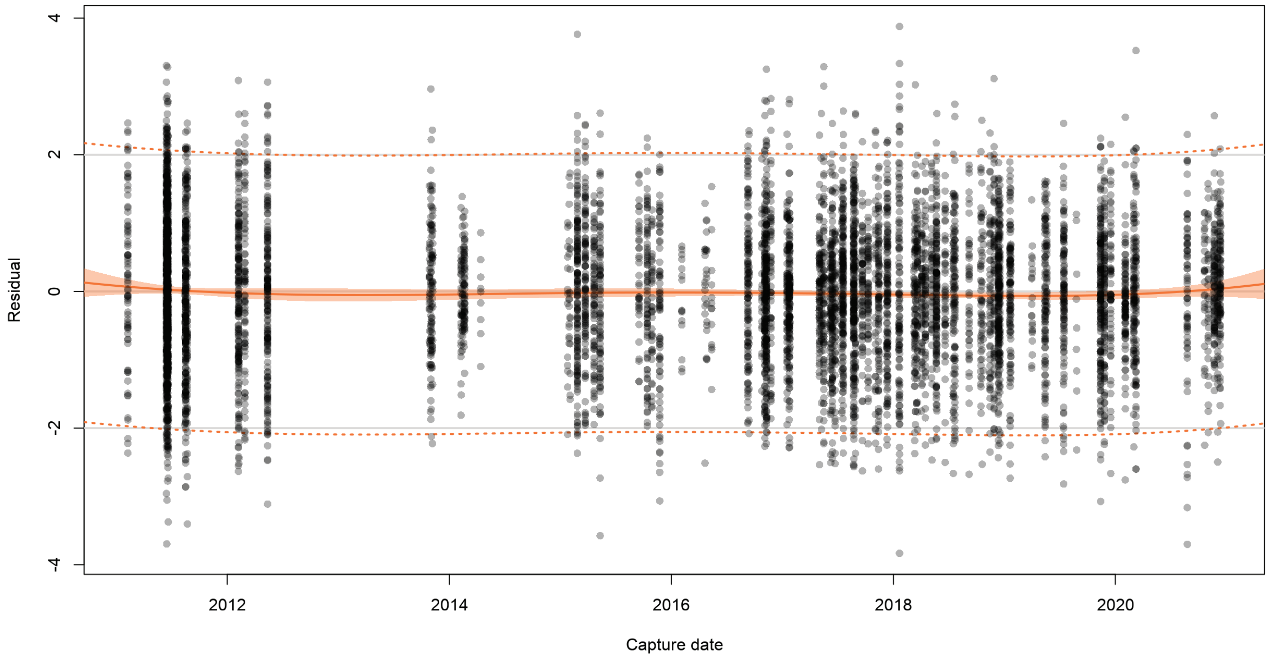
DTU Aqua

NEFD B3 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

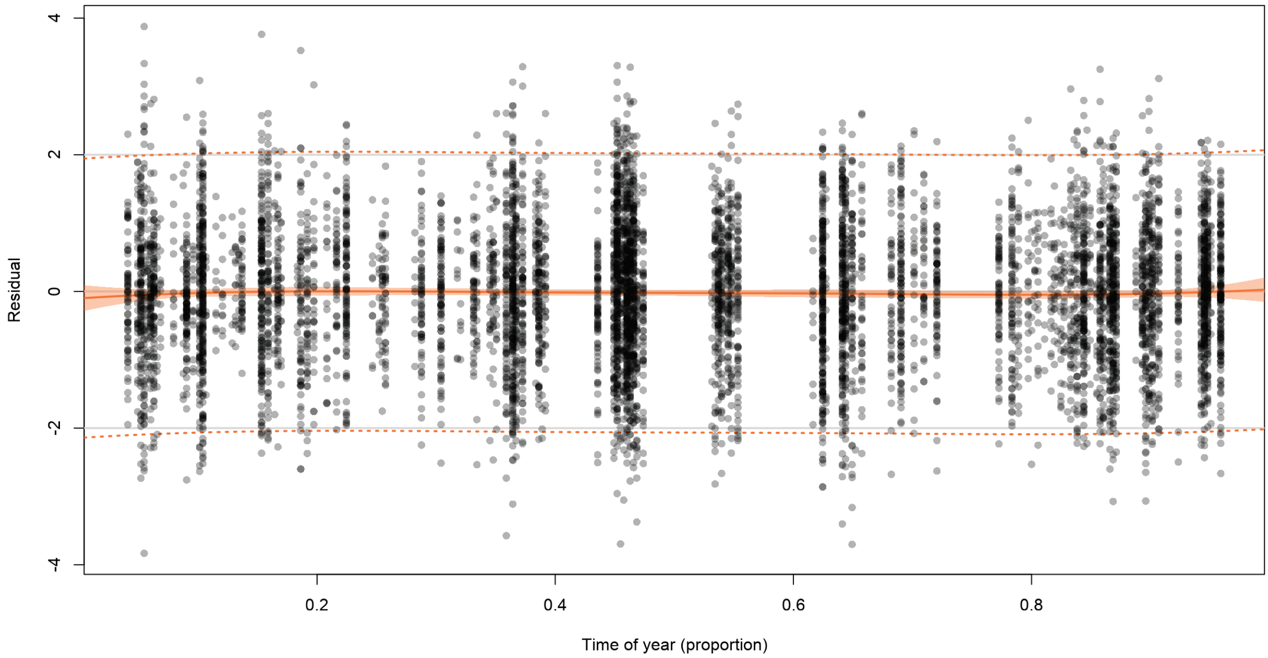
NEFD B3 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

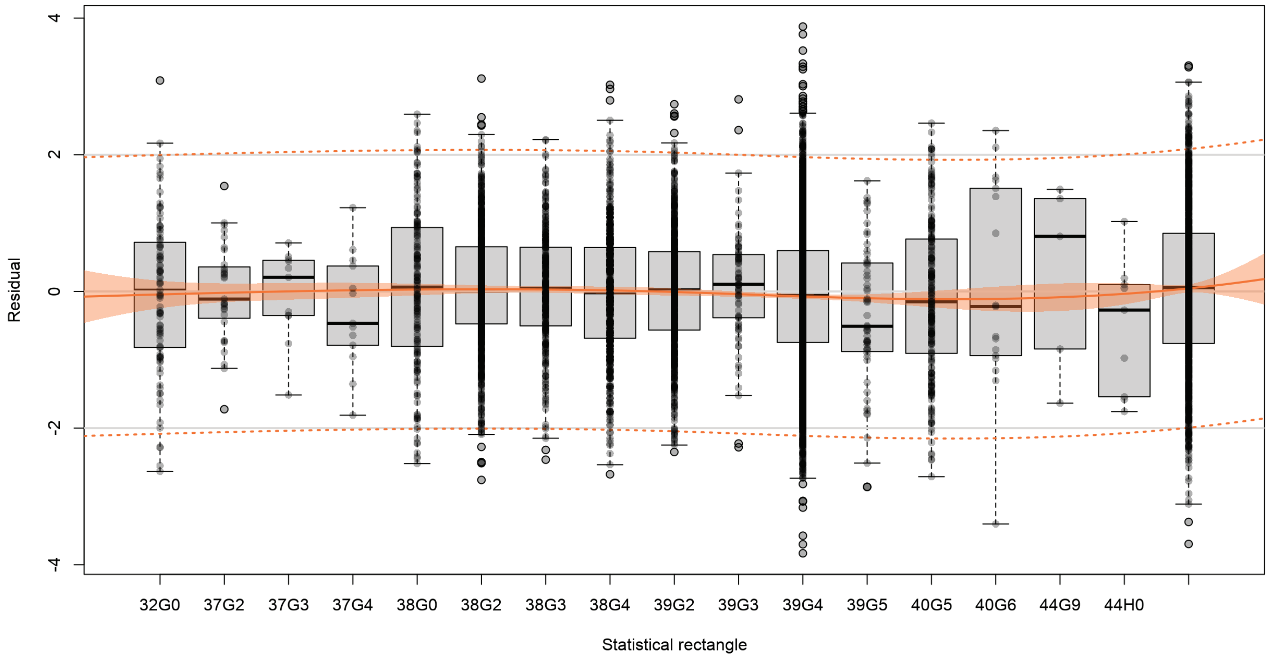
NEFD B3 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

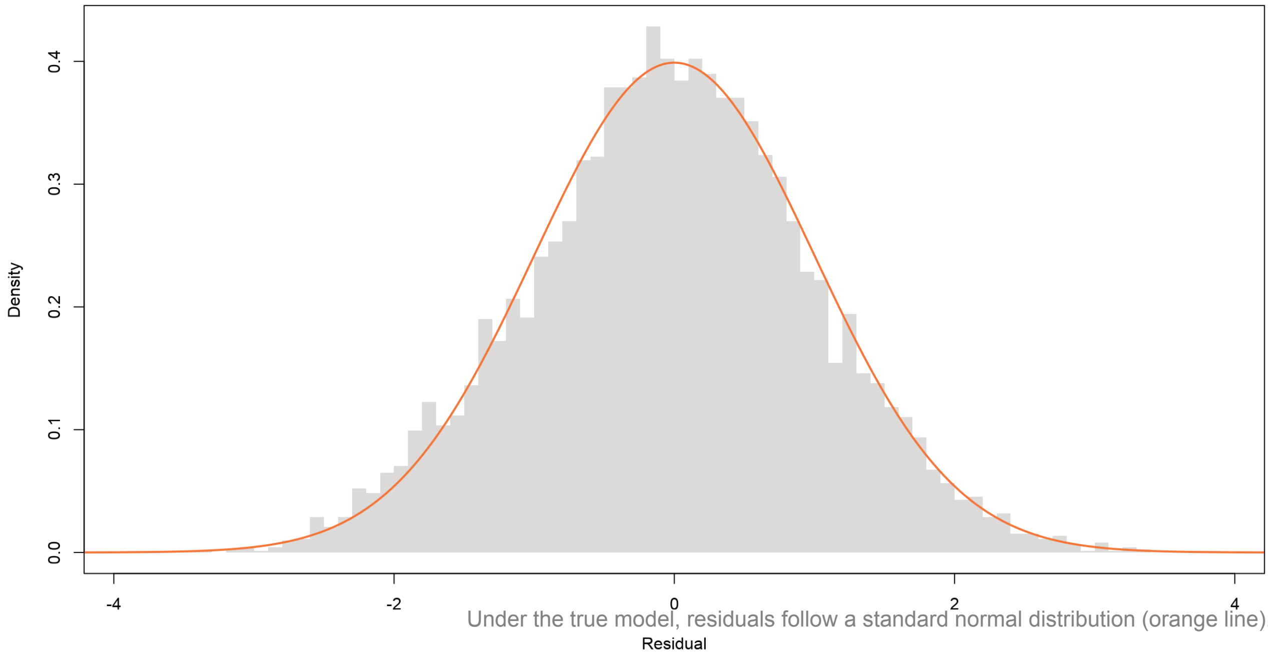
NEFD B3 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

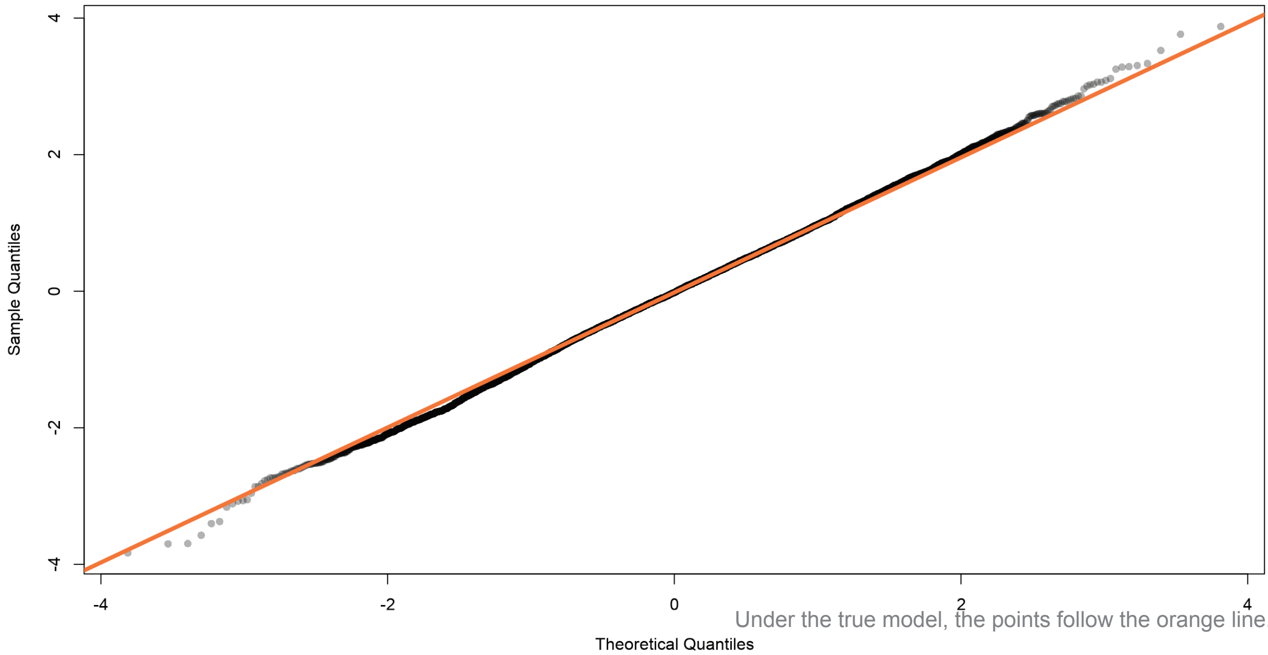
NEFD B3 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

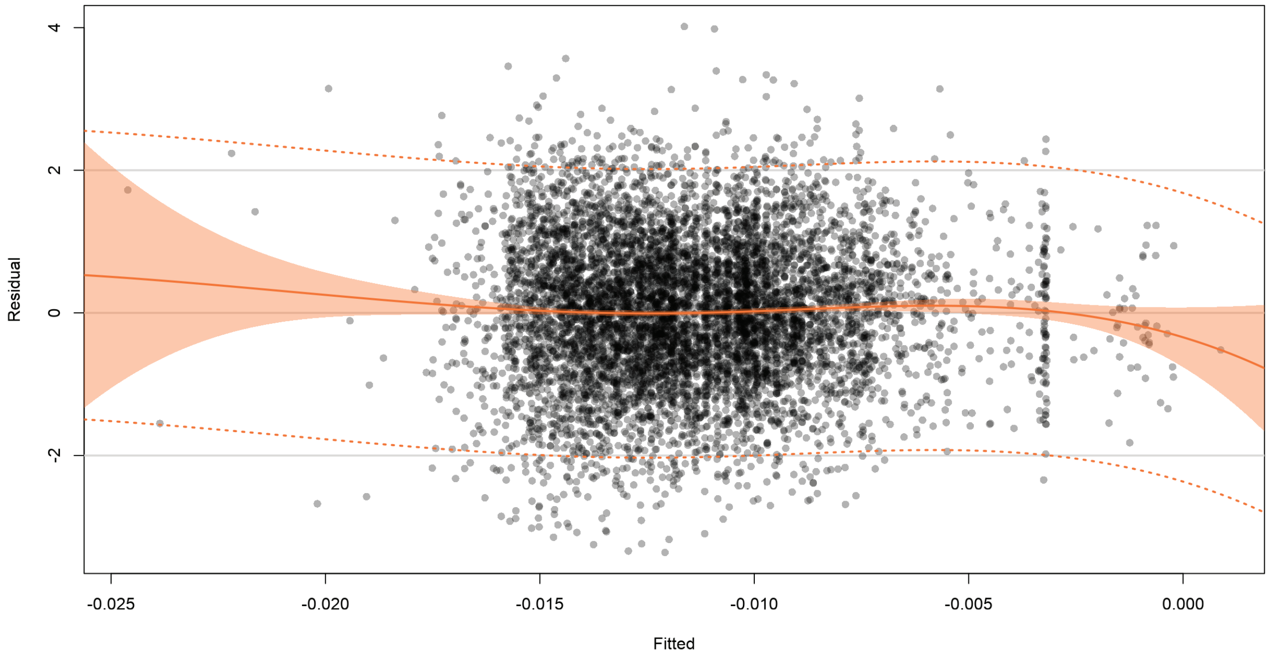
NEFD B3 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

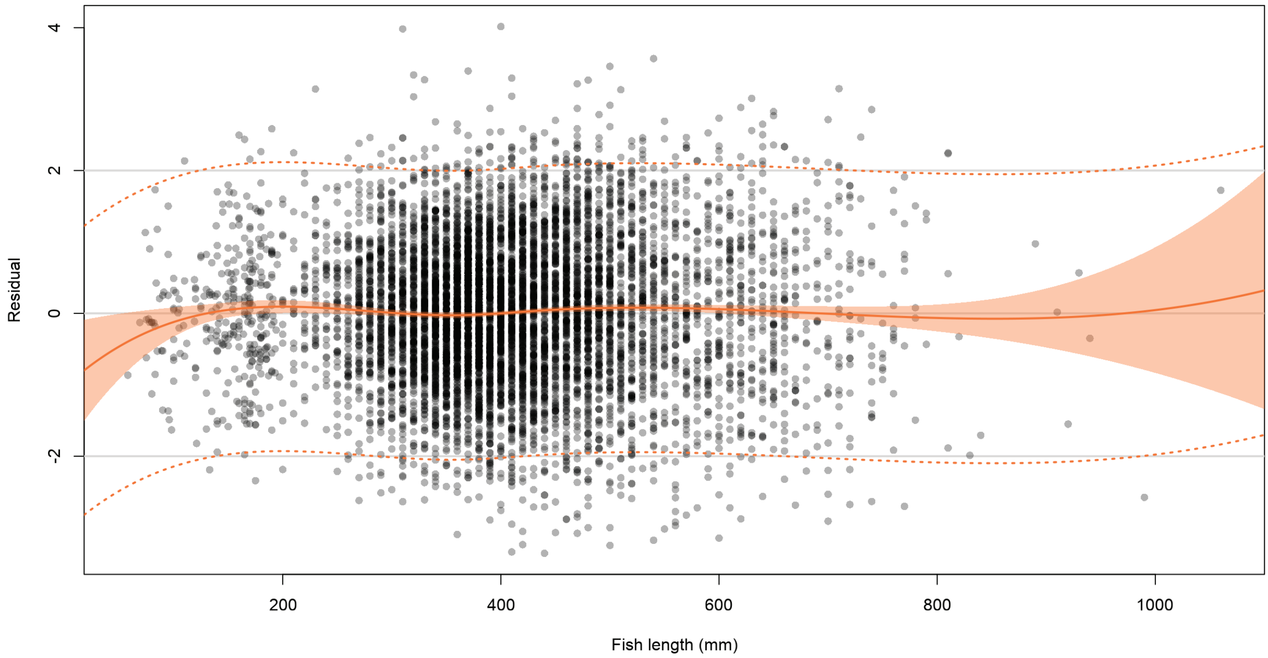
NEFD B4 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

NEFD B4 - Residuals to fish length

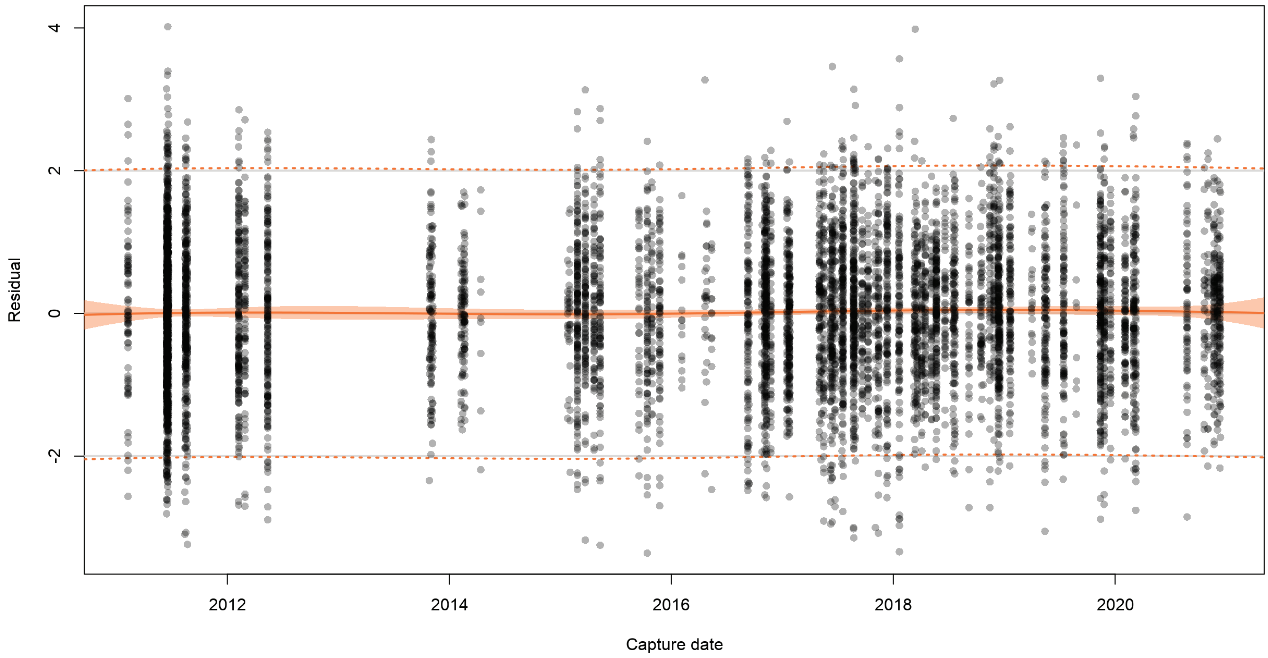


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

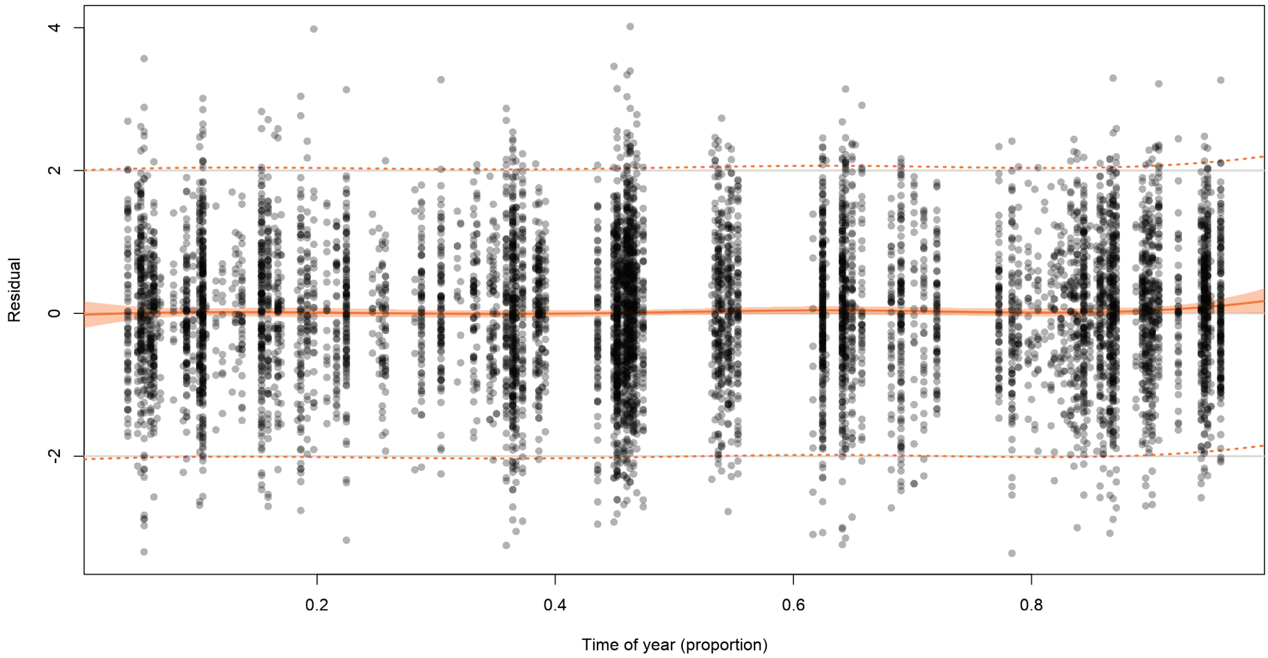
NEFD B4 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

NEFD B4 - Residuals to time of year

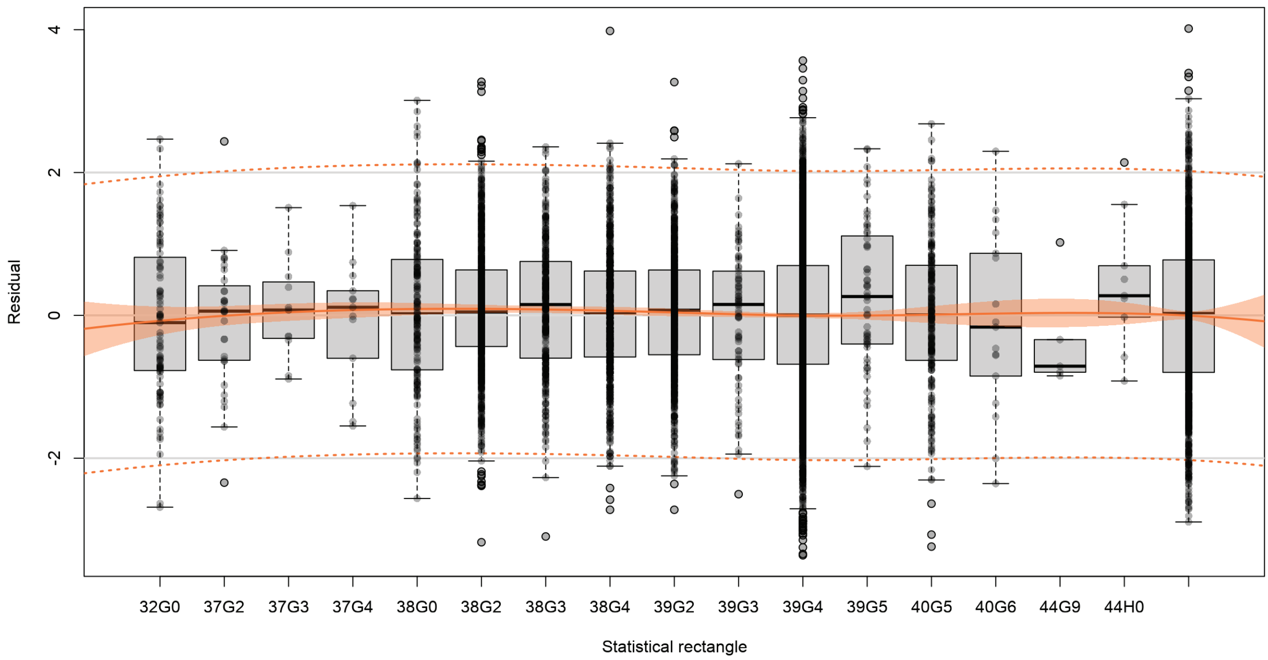


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

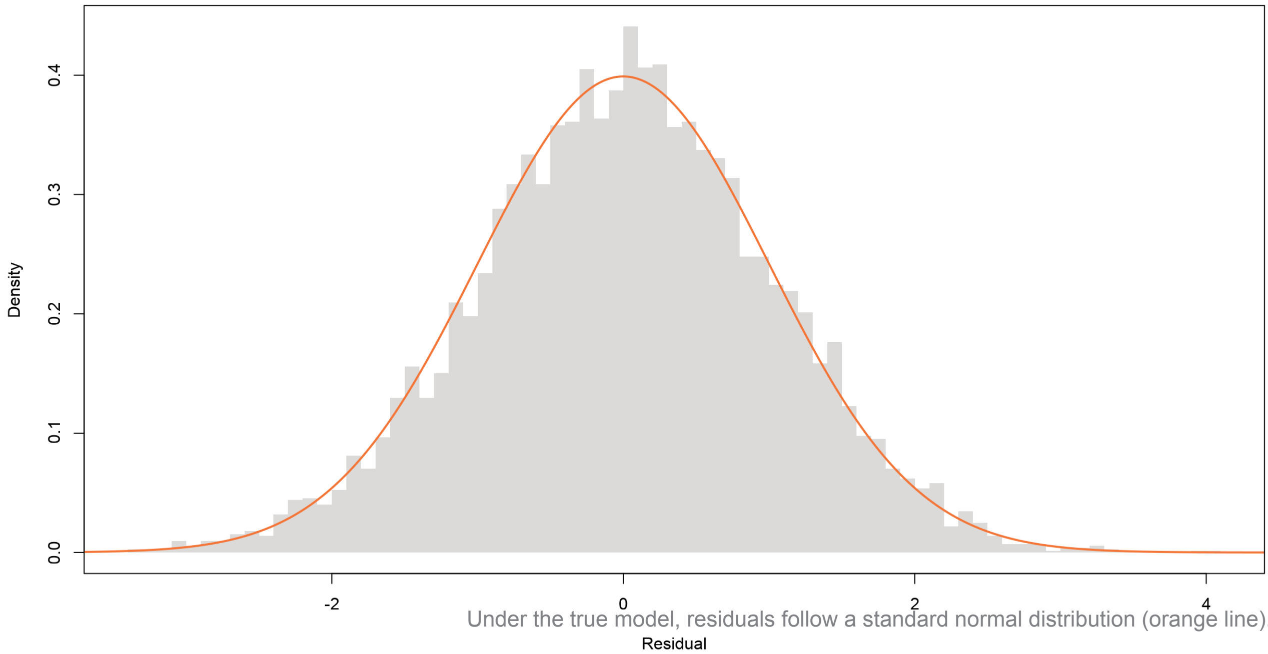
NEFD B4 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

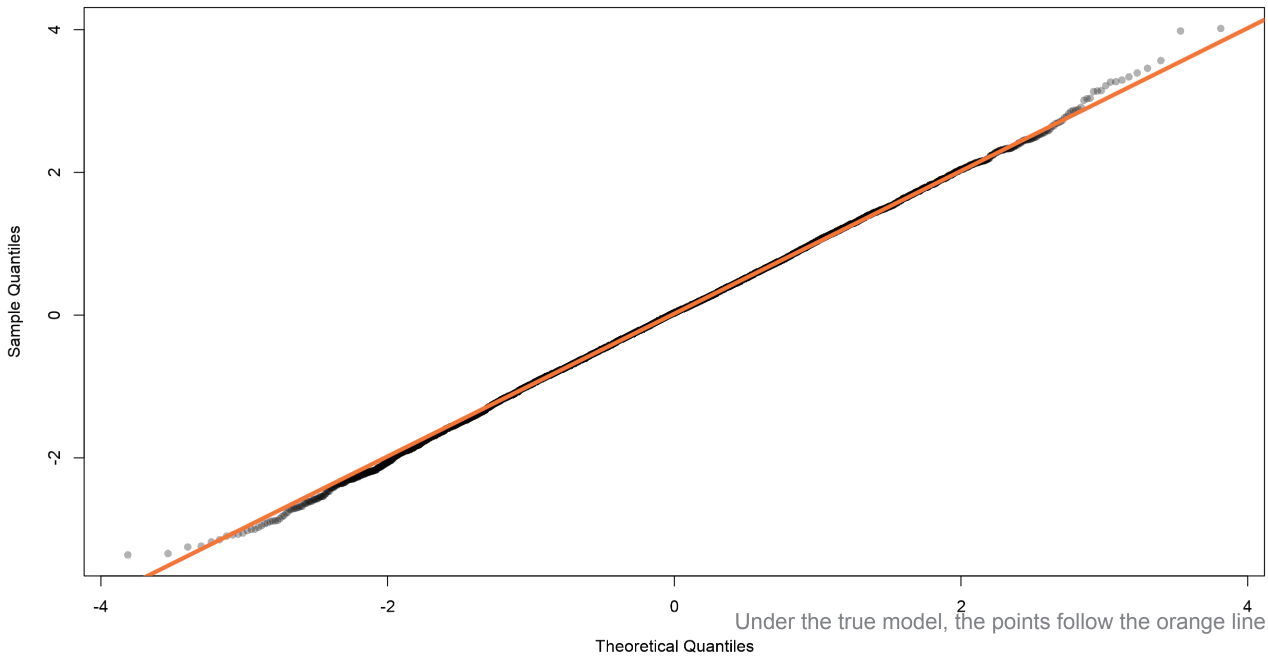
NEFD B4 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

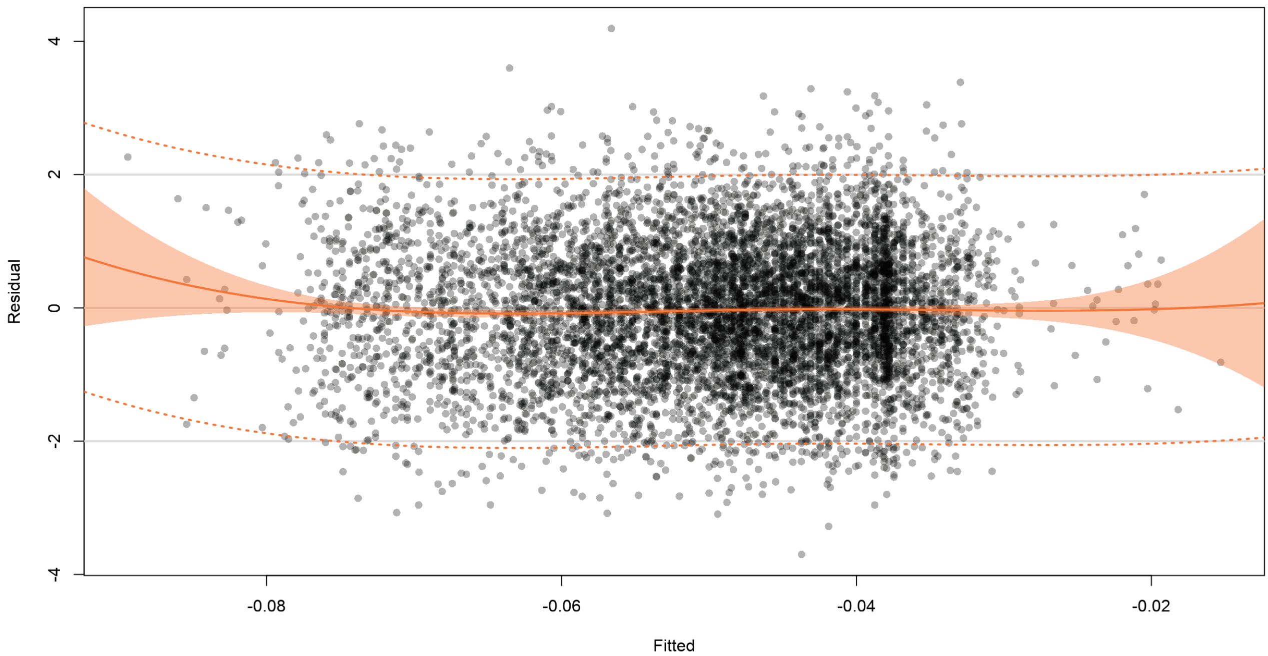
NEFD B4 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

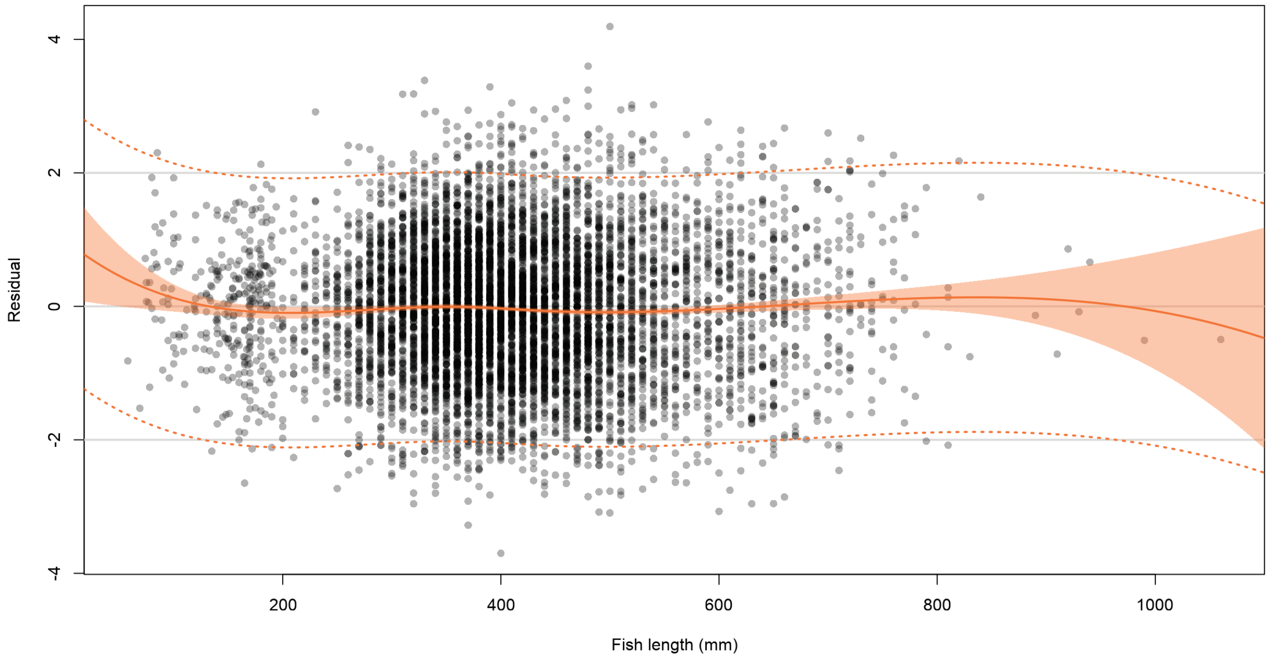
NEFD C2 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

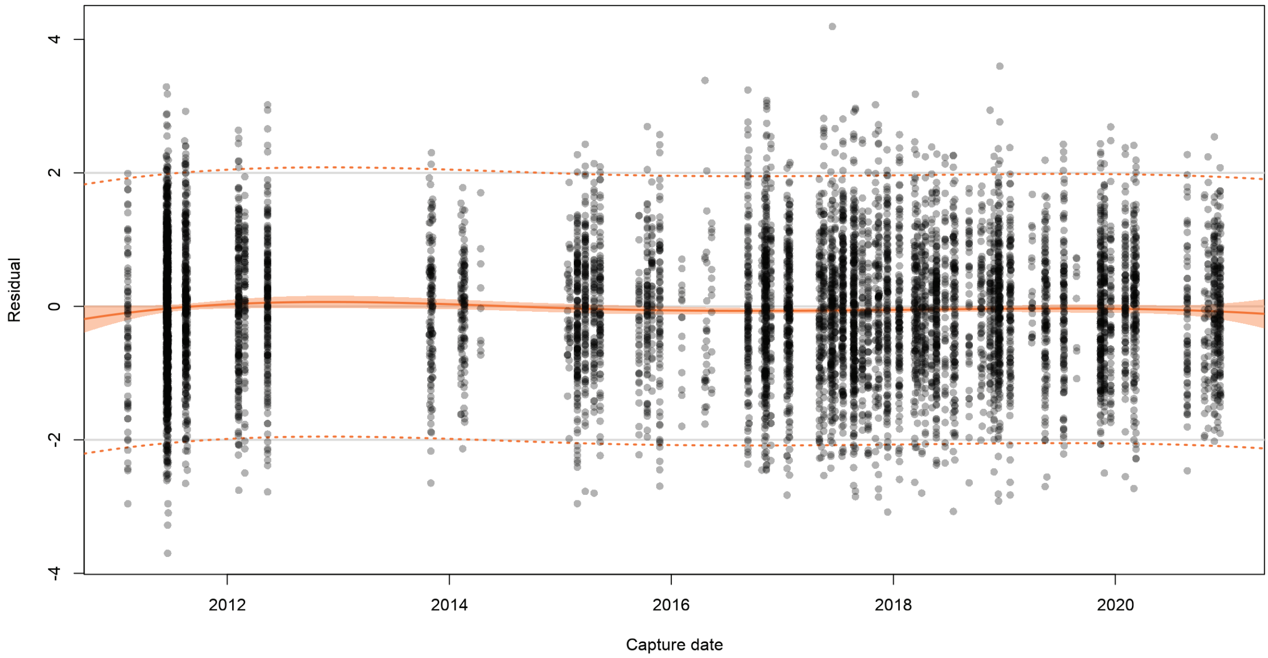
NEFD C2 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

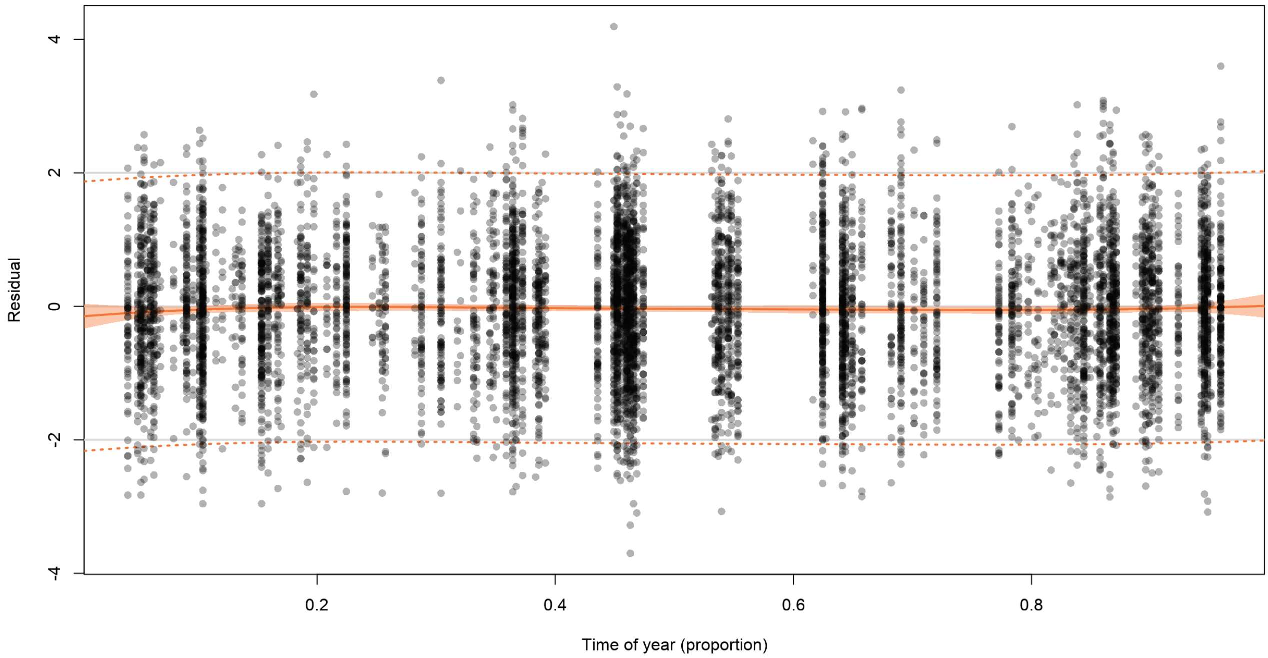
NEFD C2 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

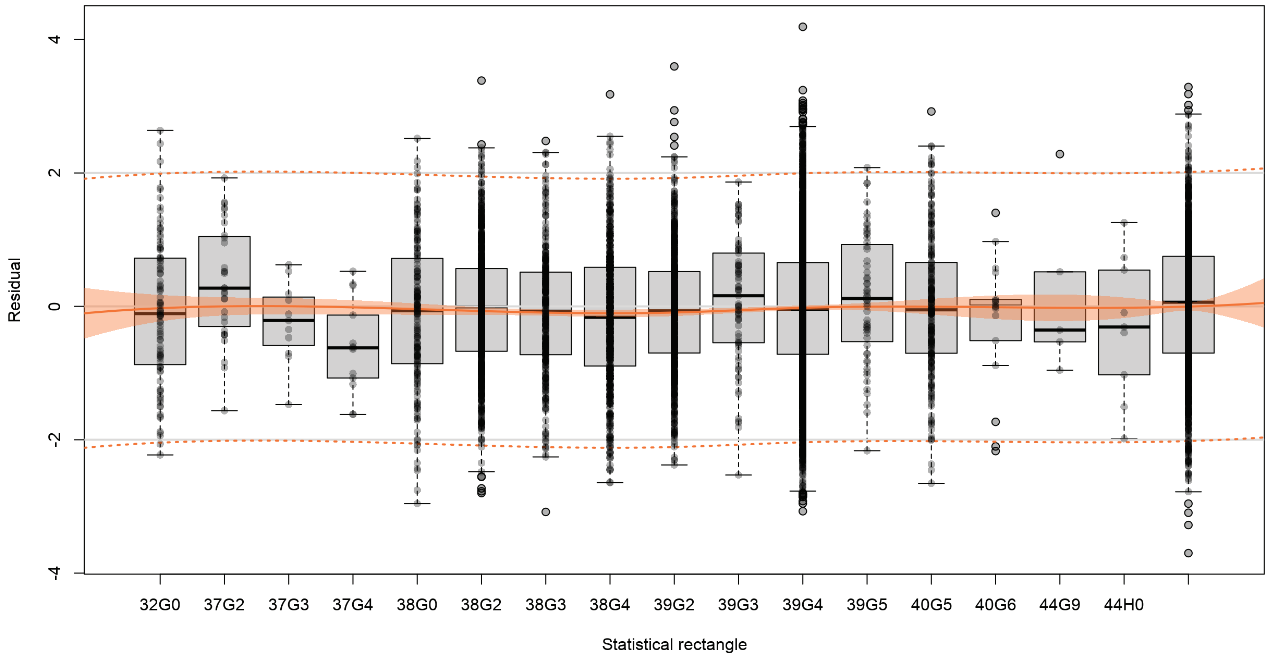
NEFD C2 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

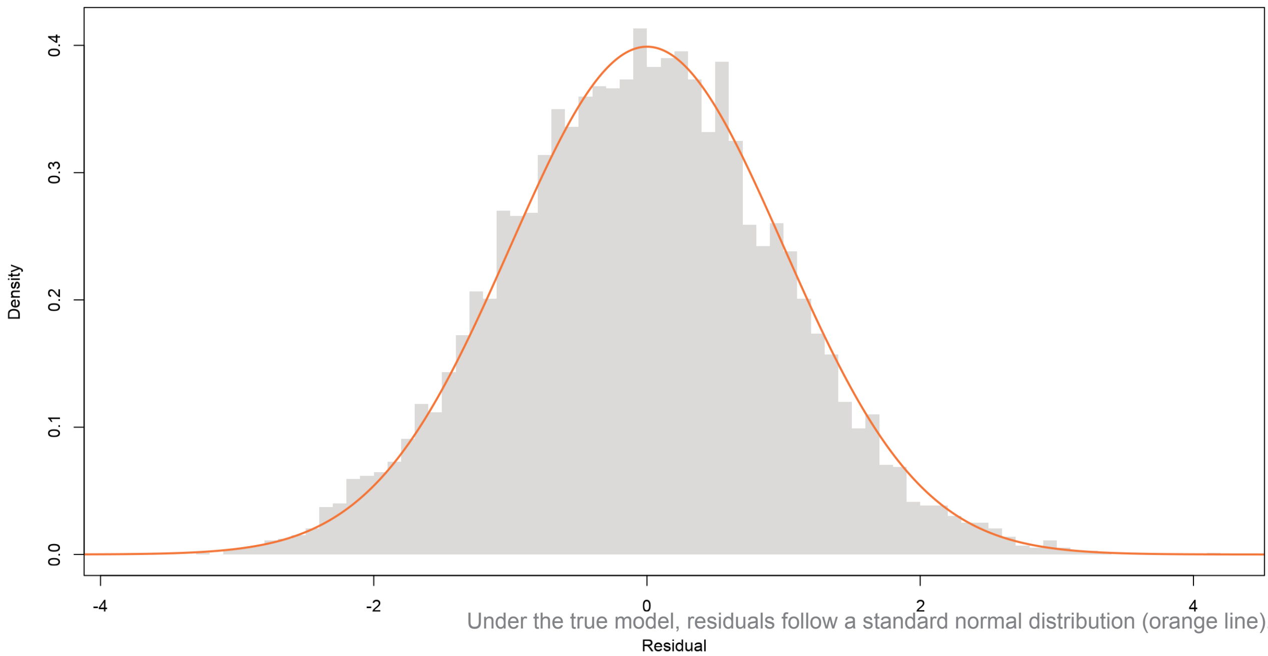
NEFD C2 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

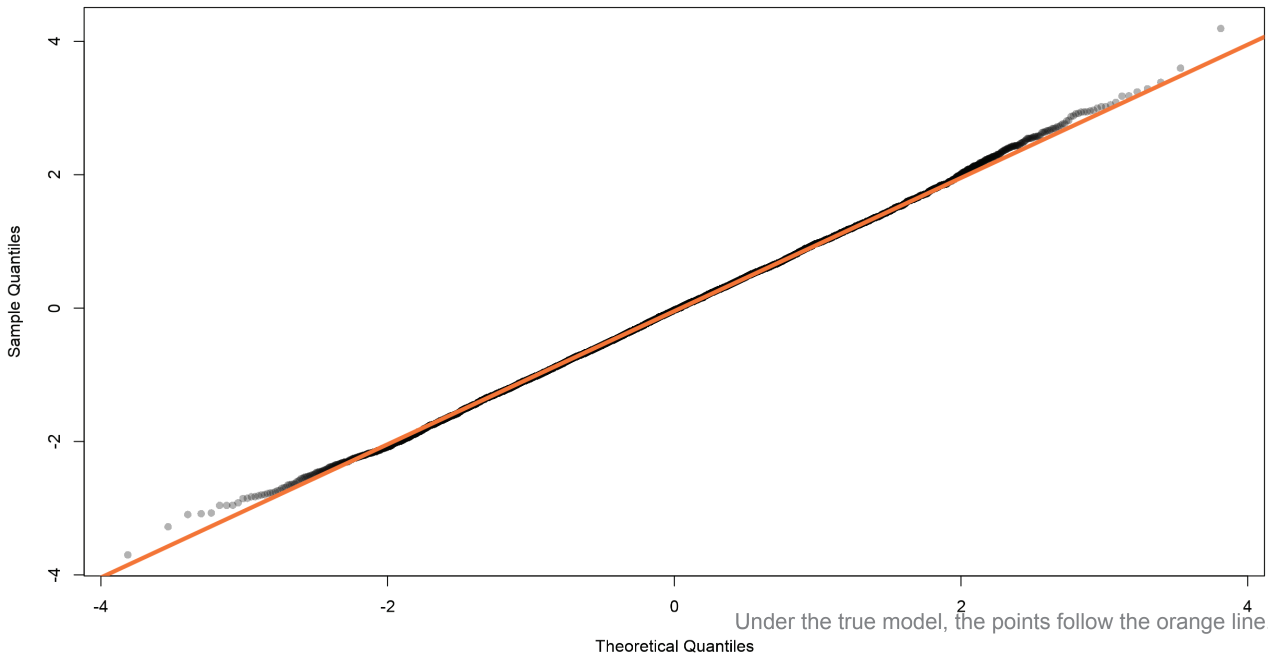
NEFD C2 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

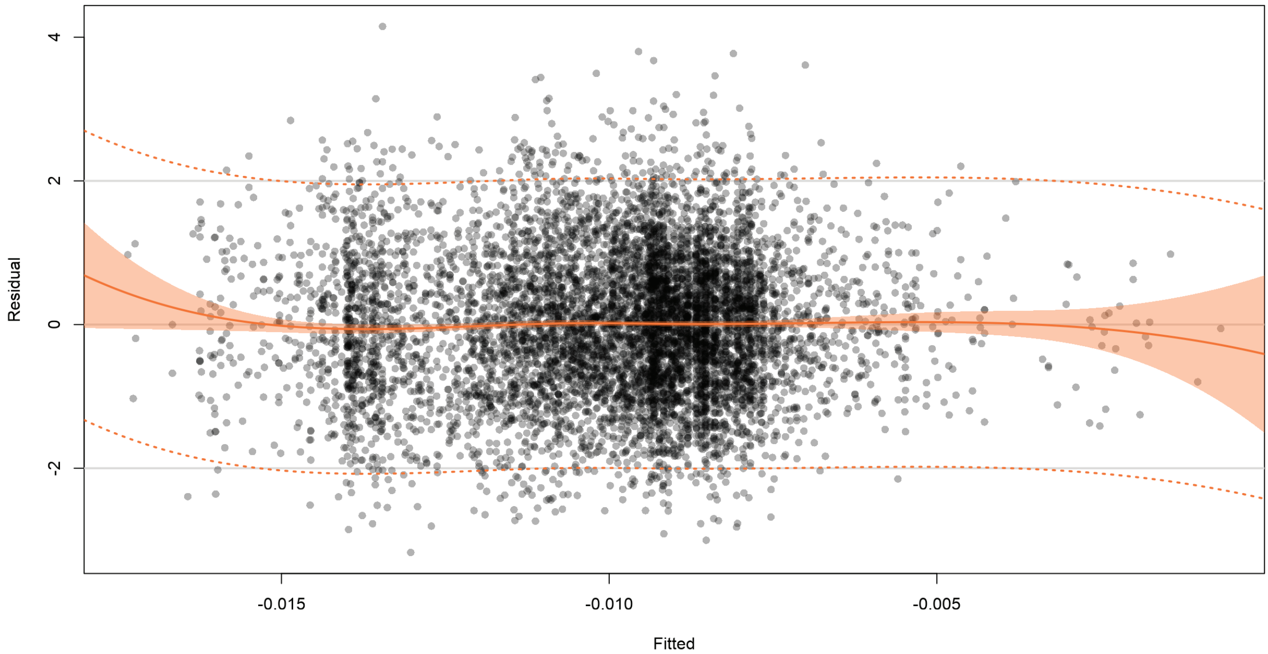
NEFD C2 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

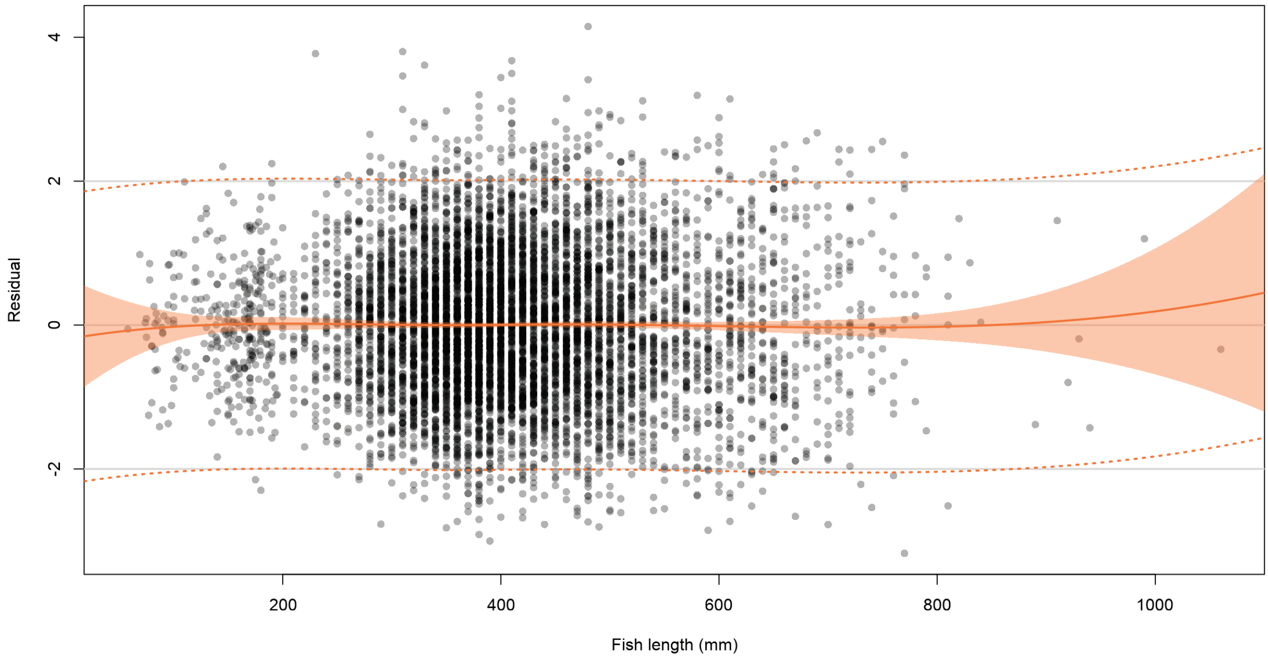
NEFD C4 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

NEFD C4 - Residuals to fish length

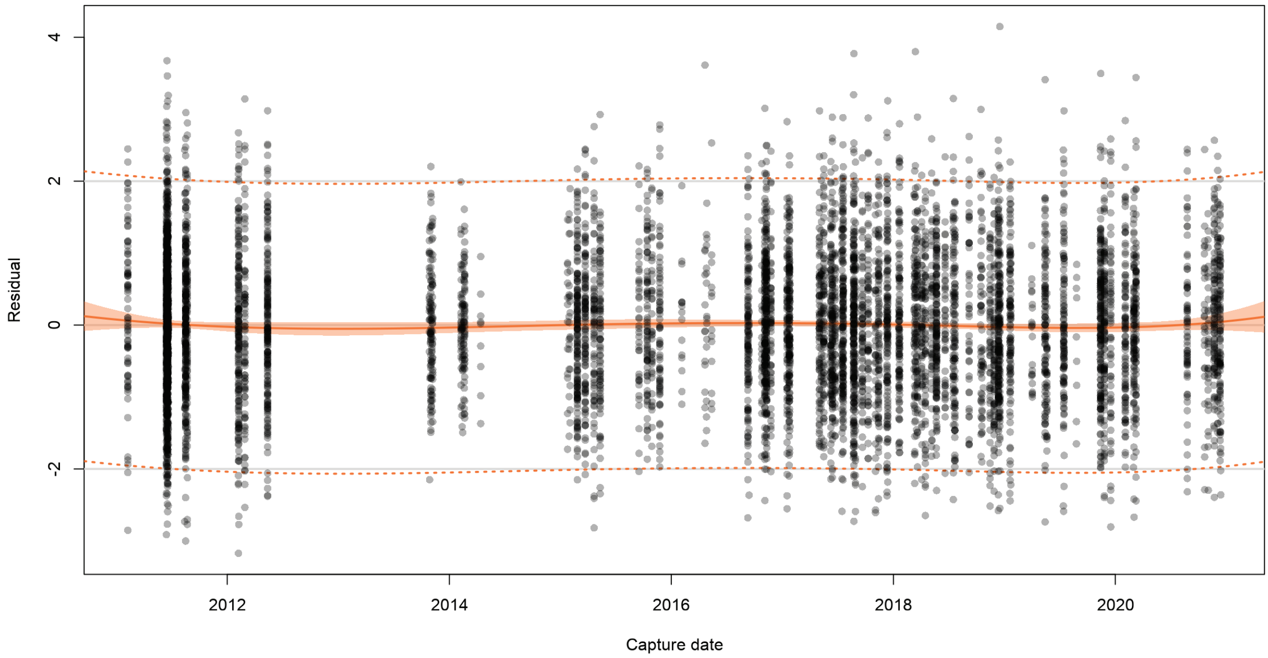


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

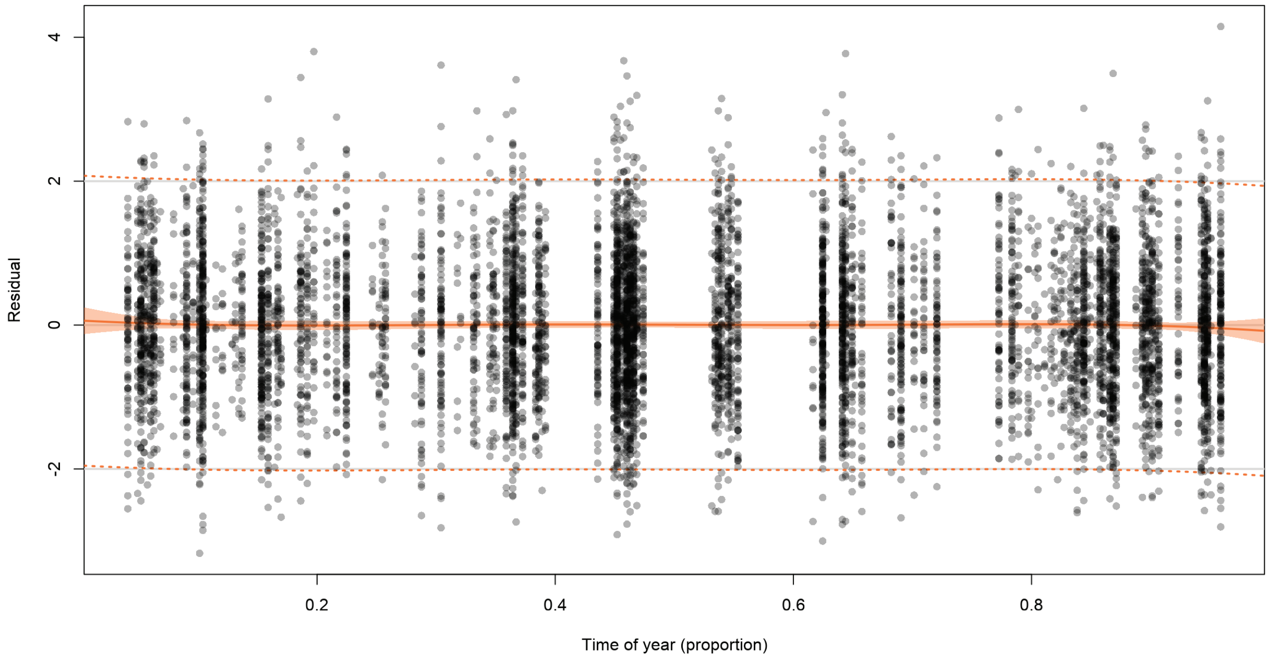
NEFD C4 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

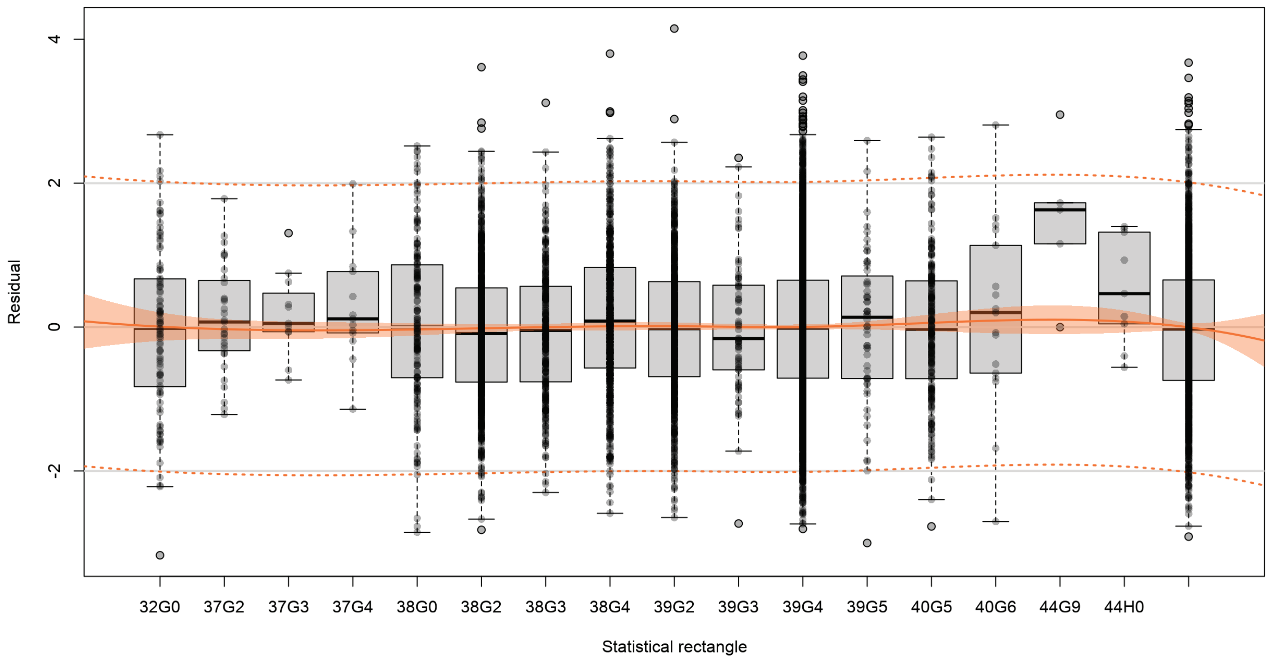
NEFD C4 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

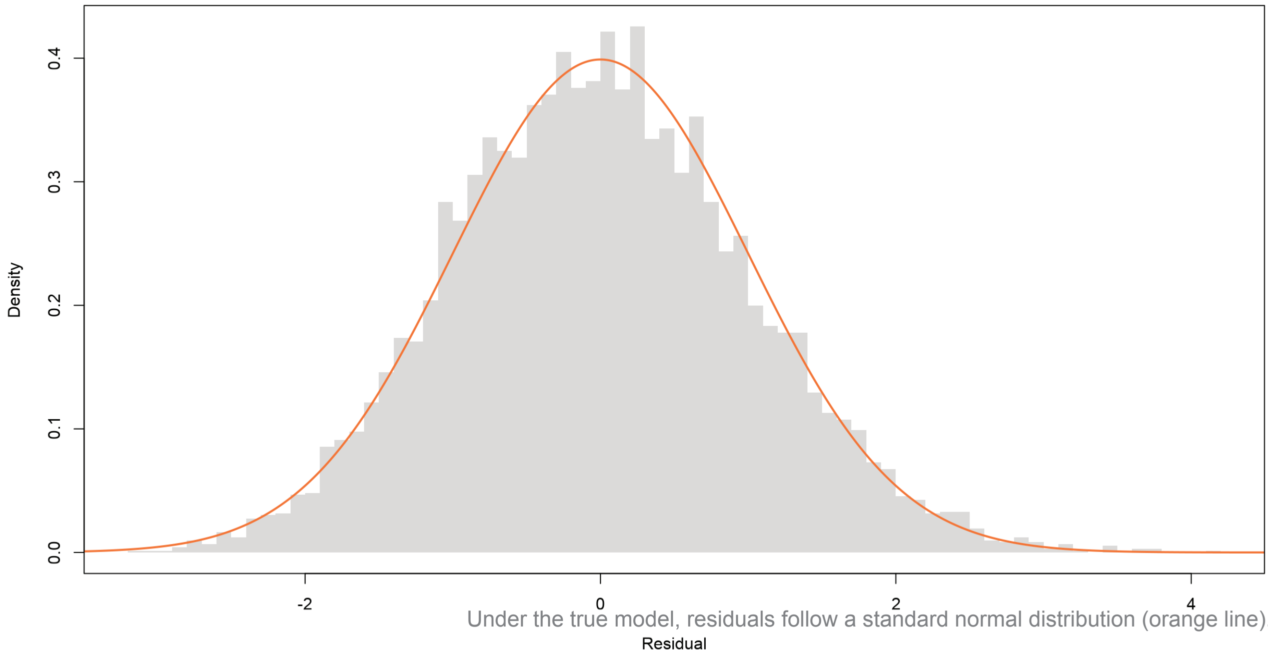
NEFD C4 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

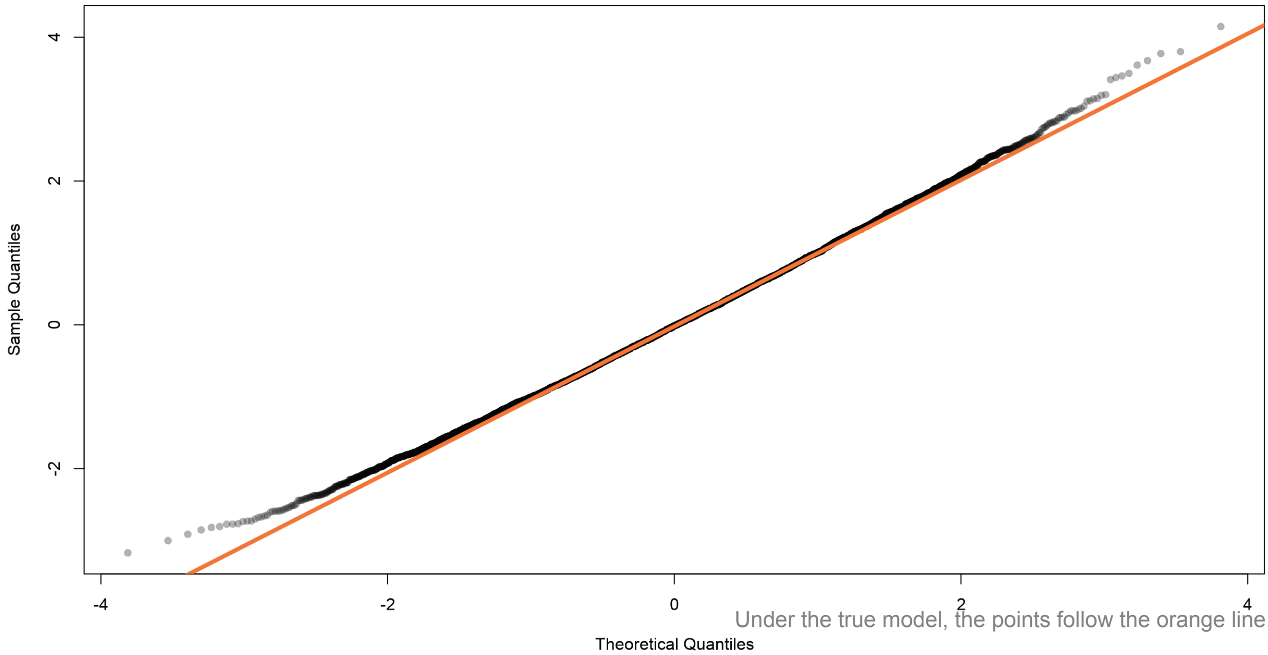
NEFD C4 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

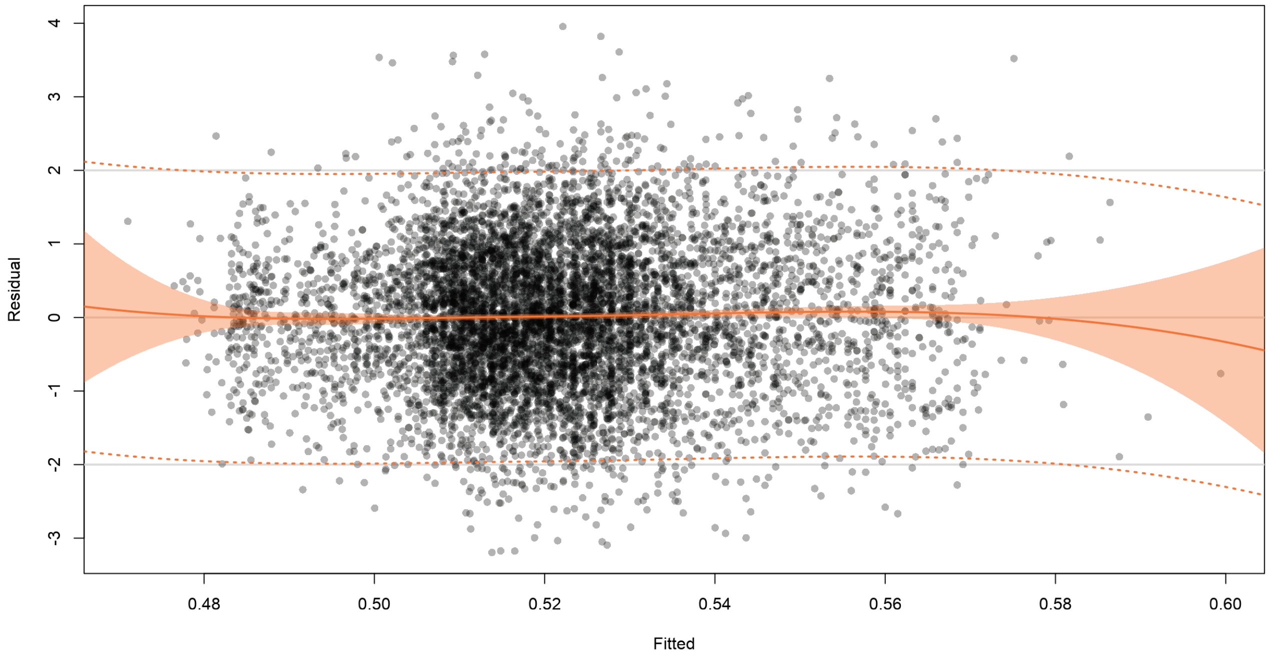
NEFD C4 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

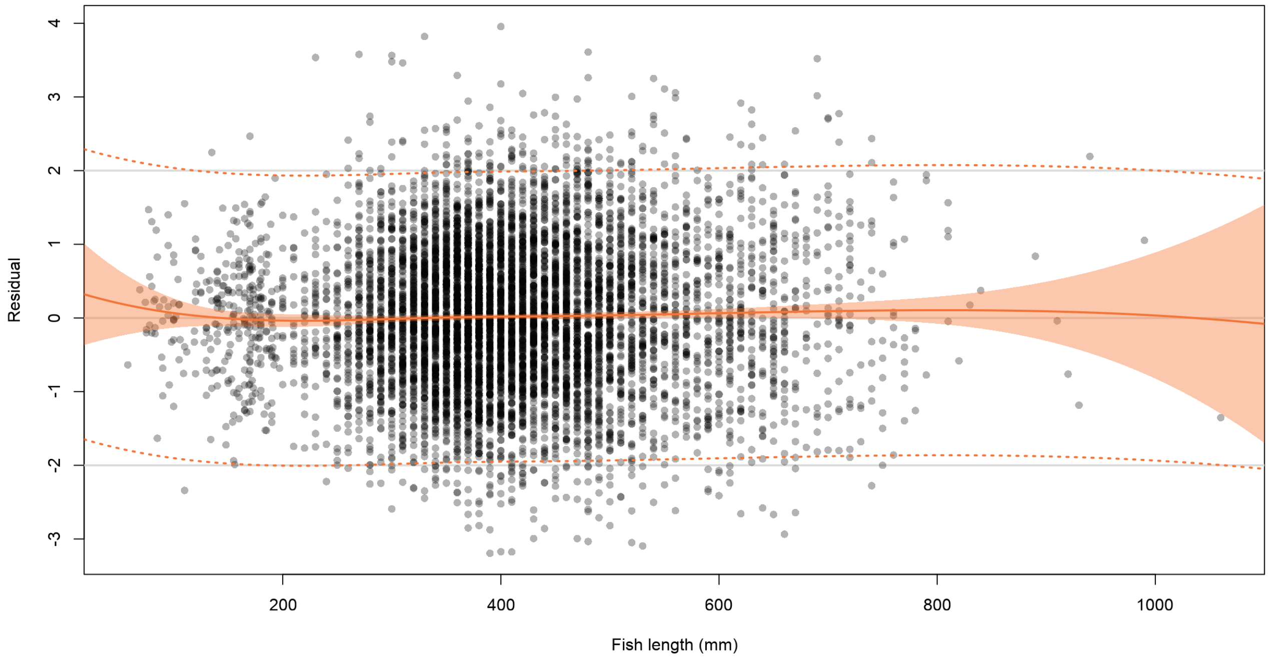
NEFD D1 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

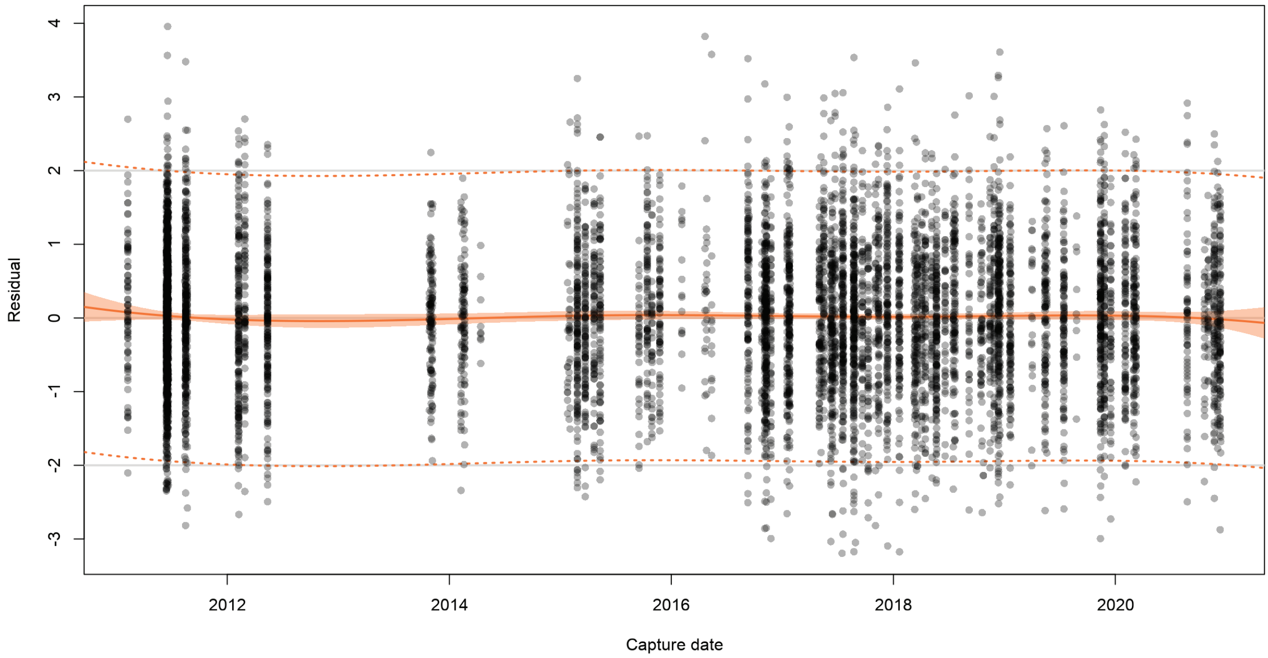
NEFD D1 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

NEFD D1 - Residuals to capture date

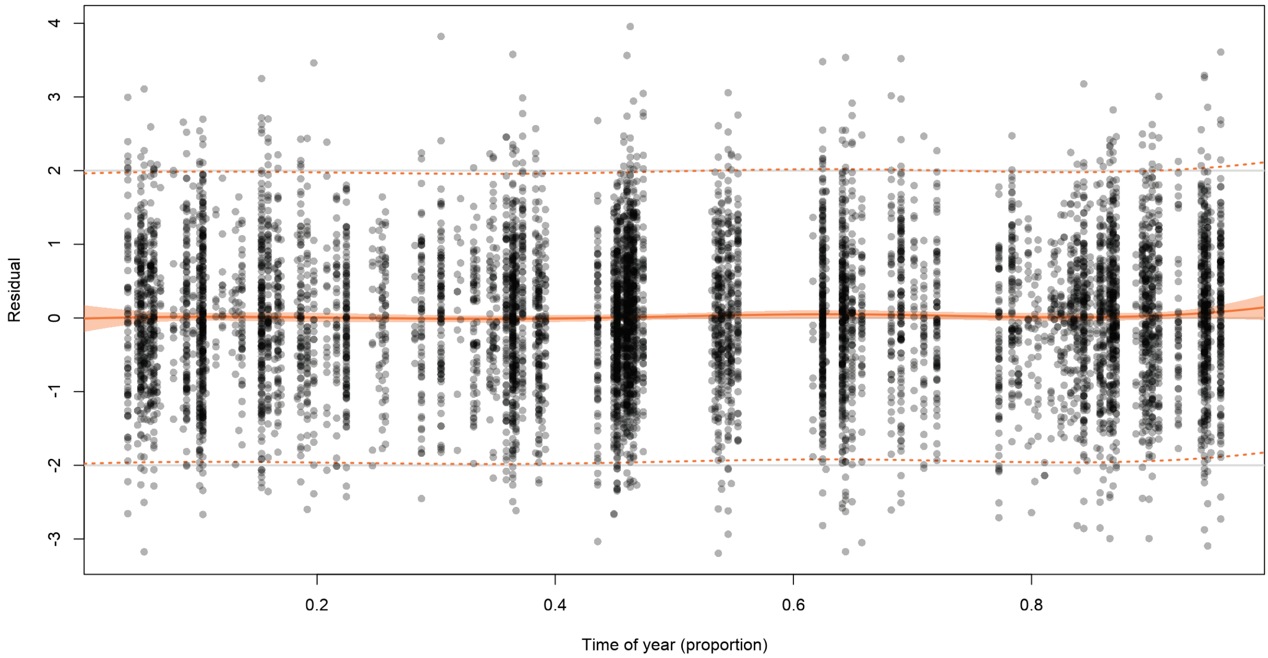


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

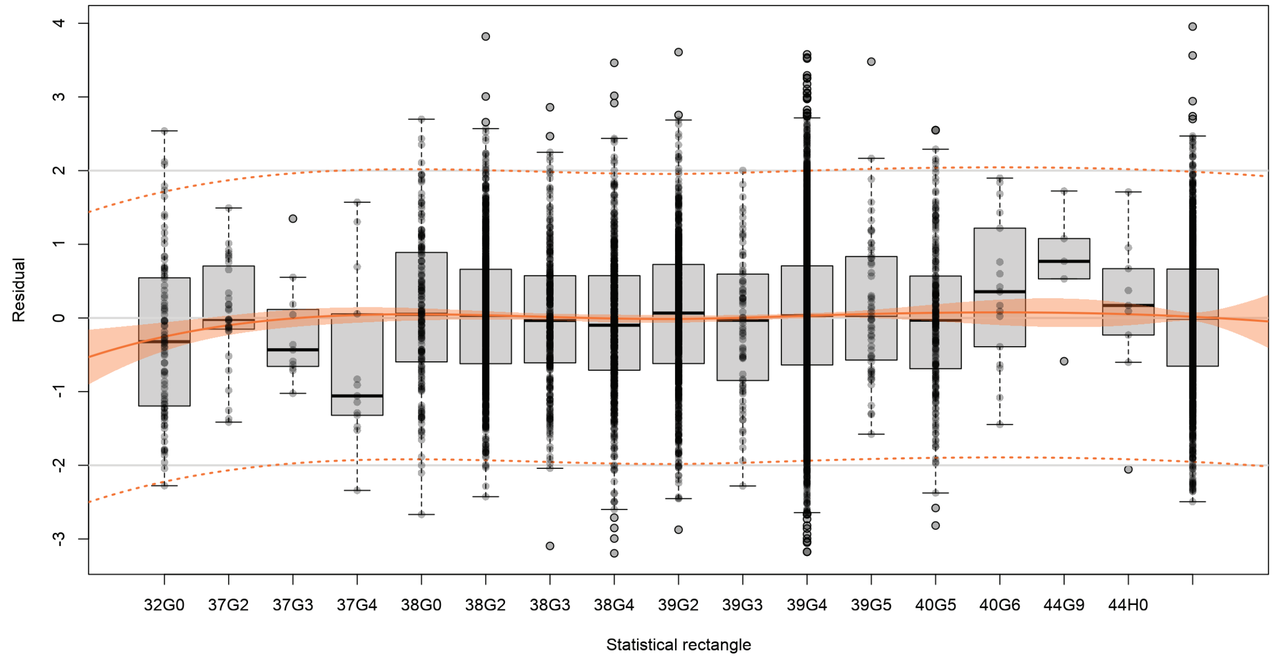
NEFD D1 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

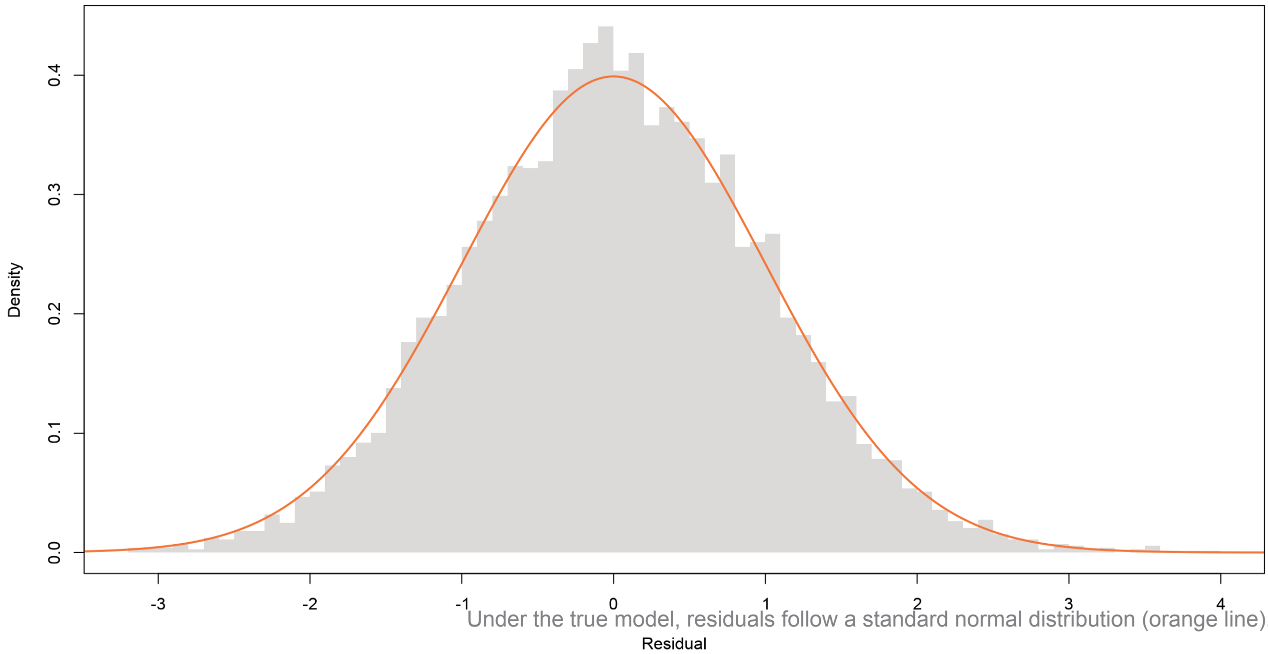
NEFD D1 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

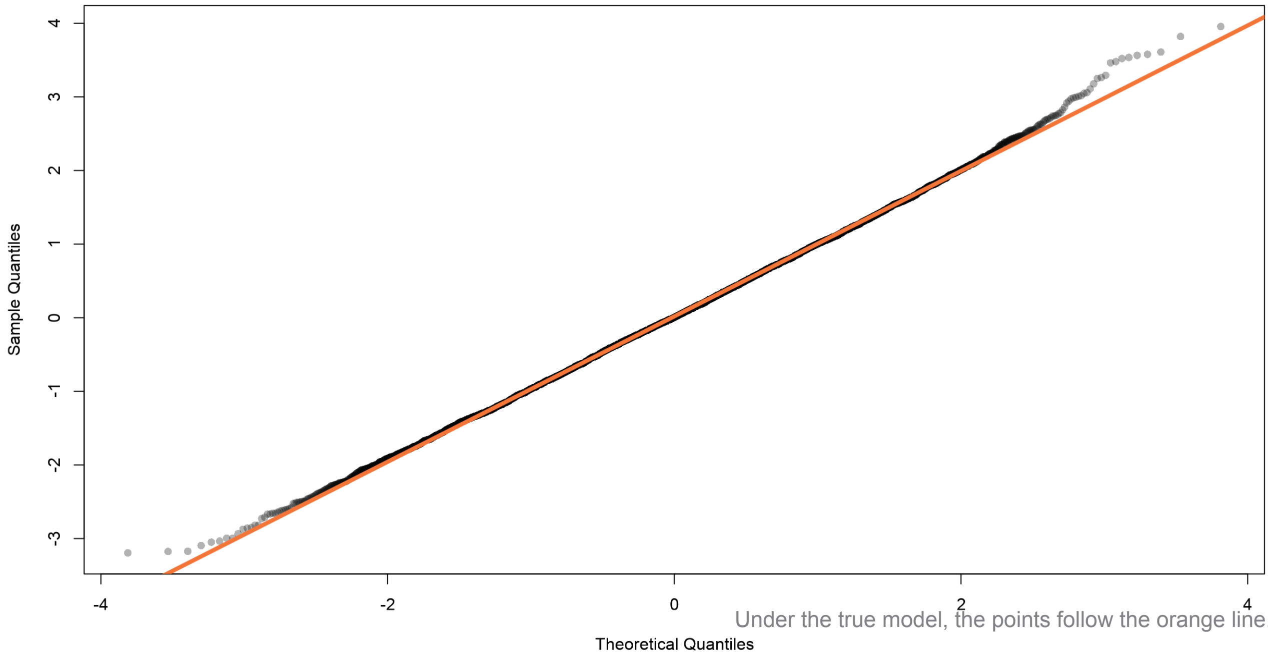
NEFD D1 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

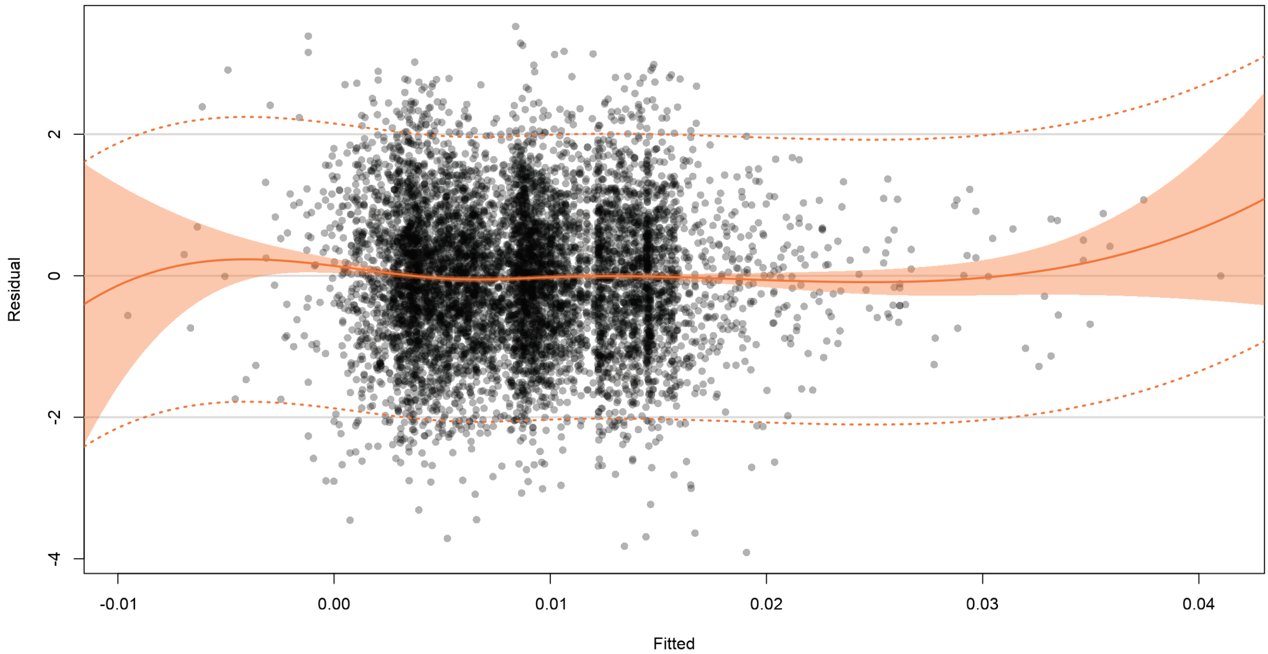
NEFD D1 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

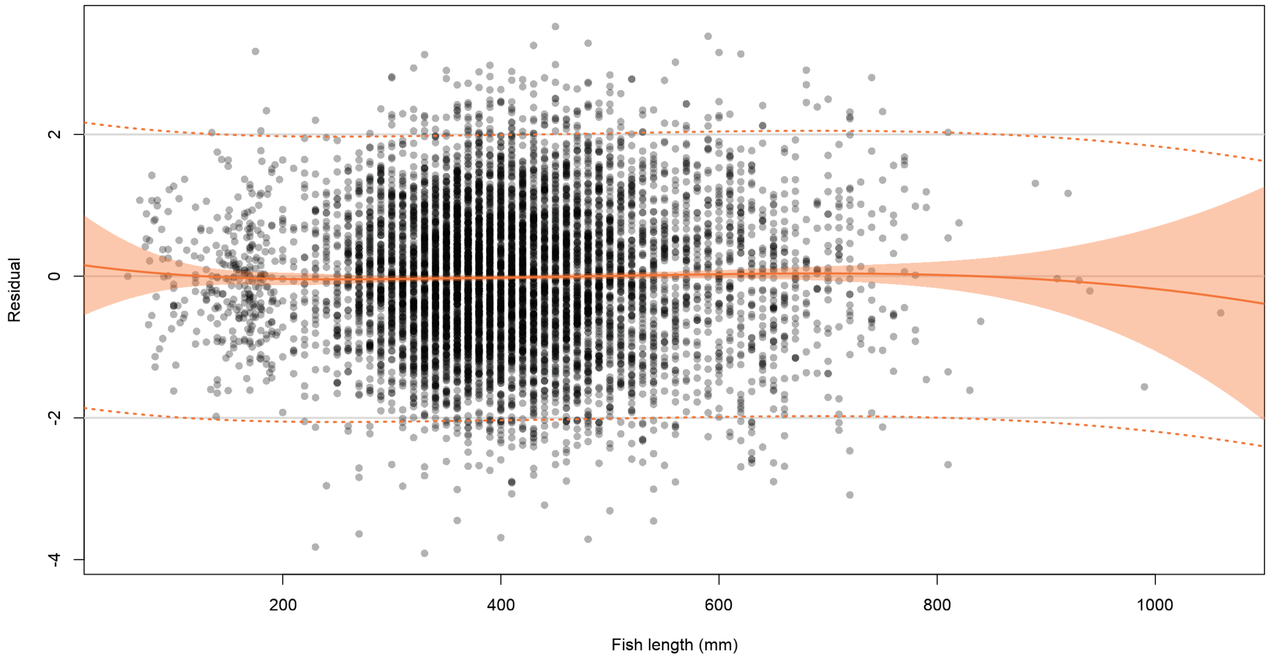
NEFD D2 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

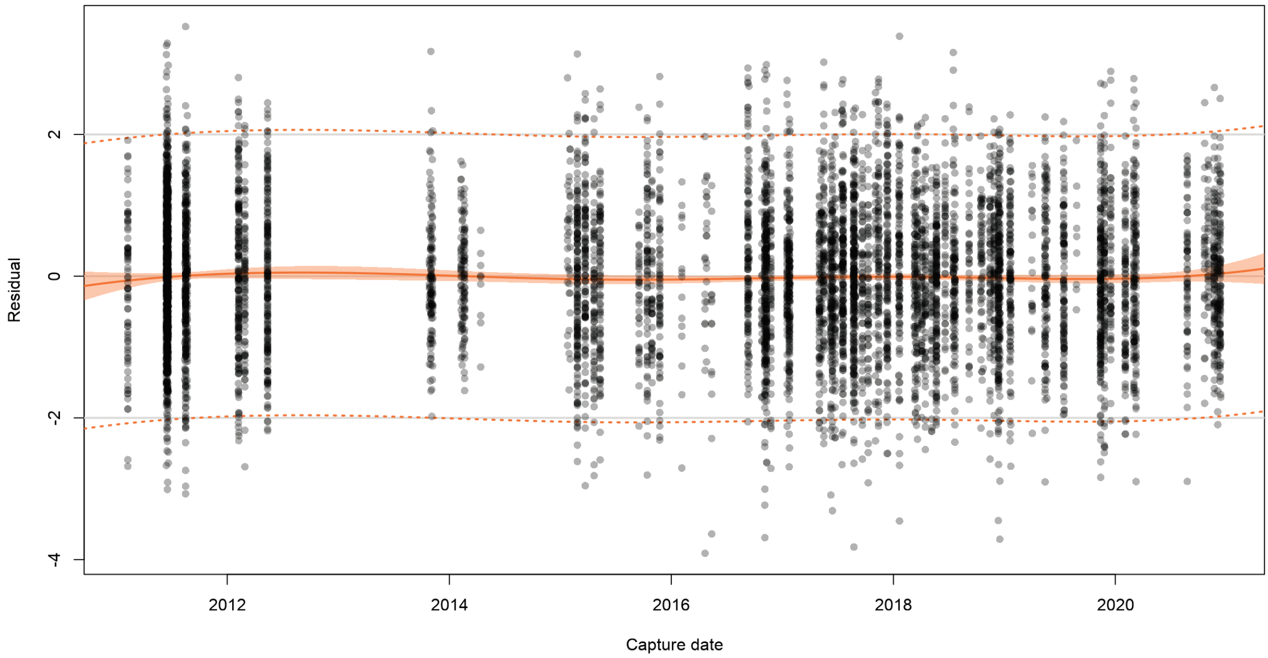
NEFD D2 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

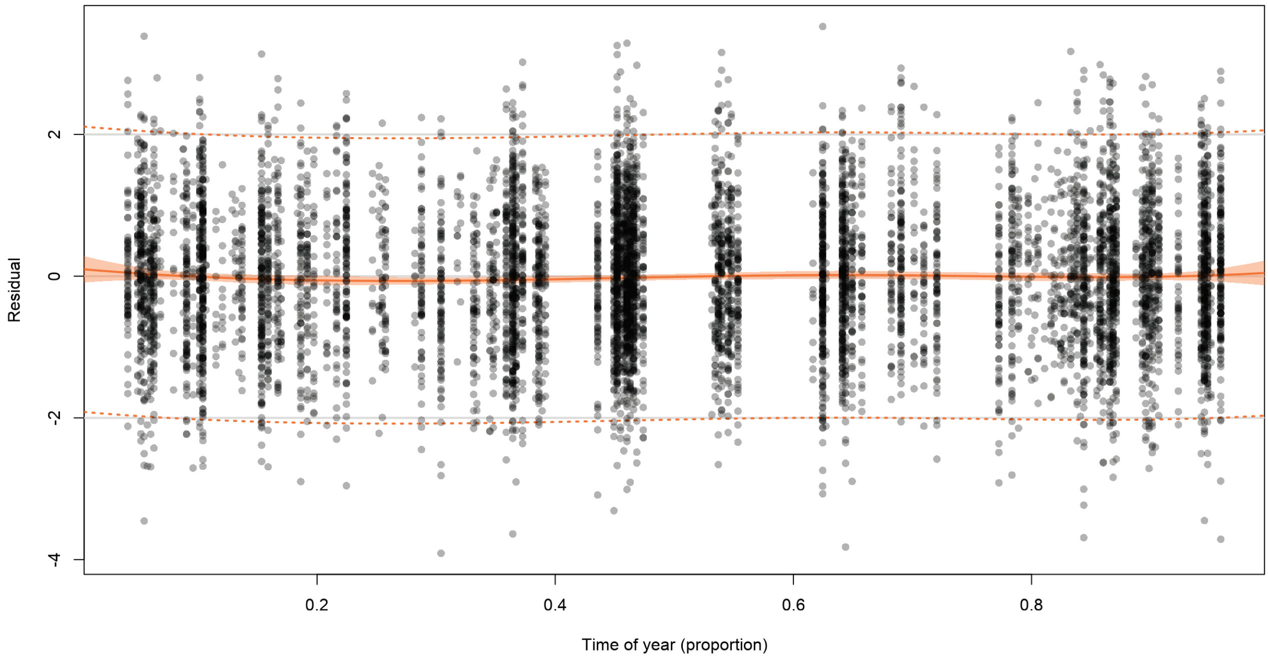
NEFD D2 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

NEFD D2 - Residuals to time of year

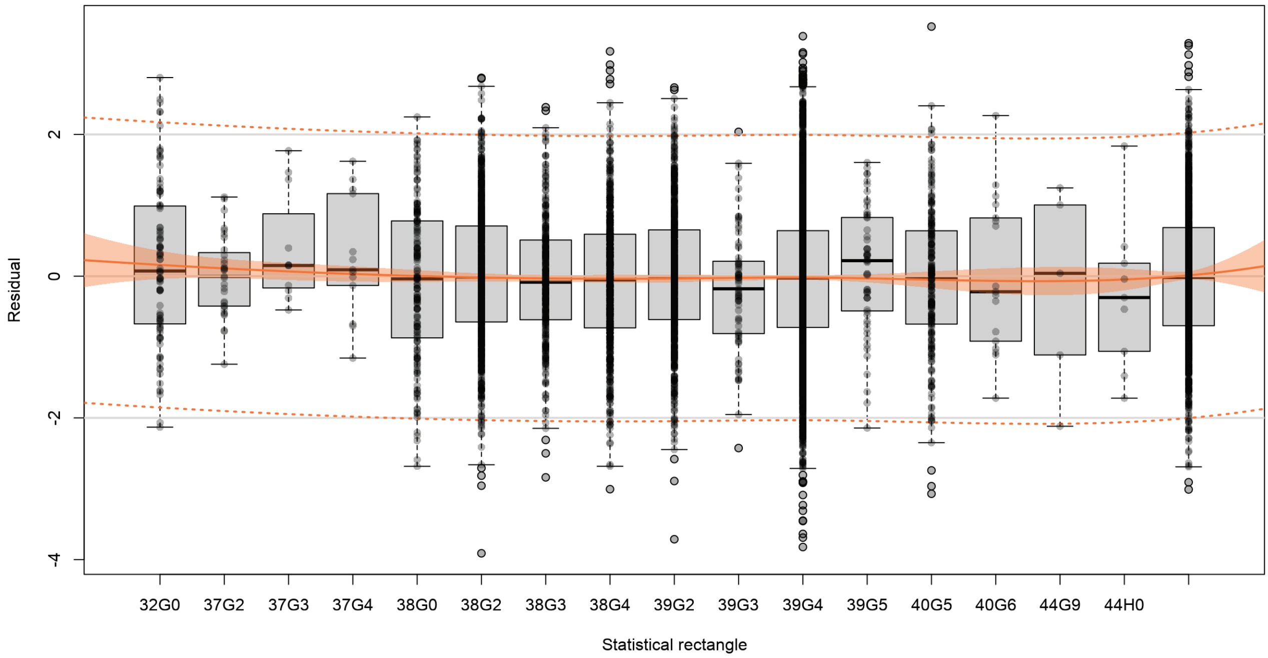


Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU

DTU Aqua

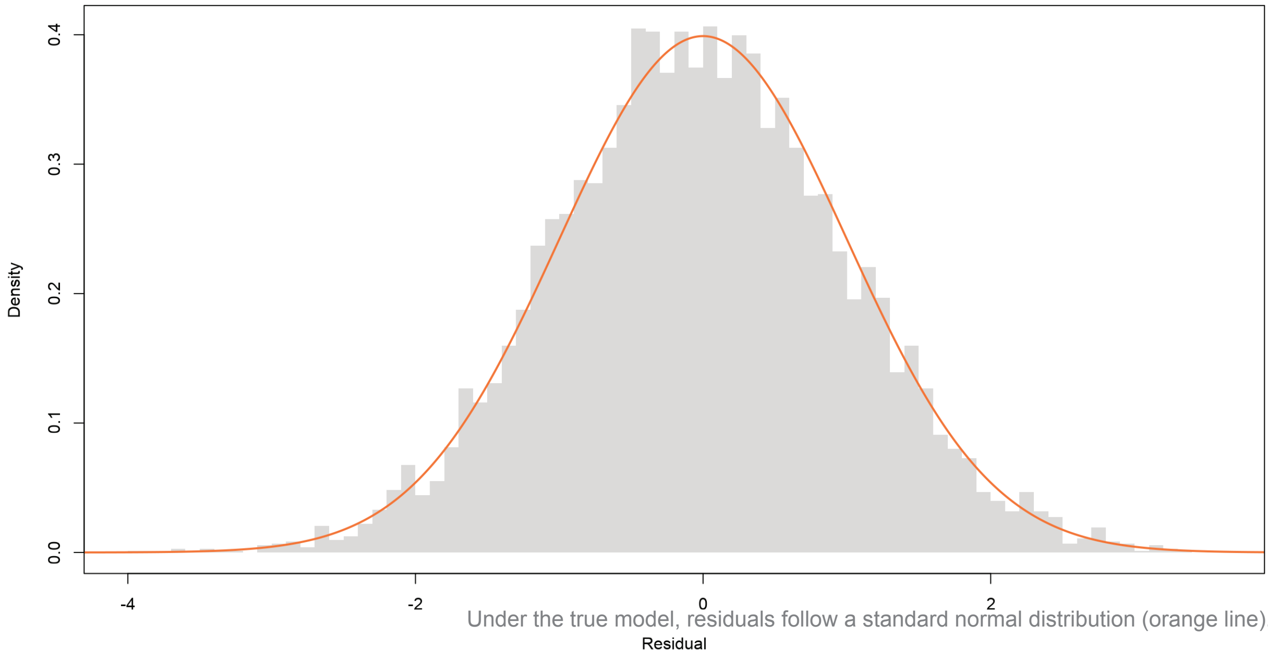
NEFD D2 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

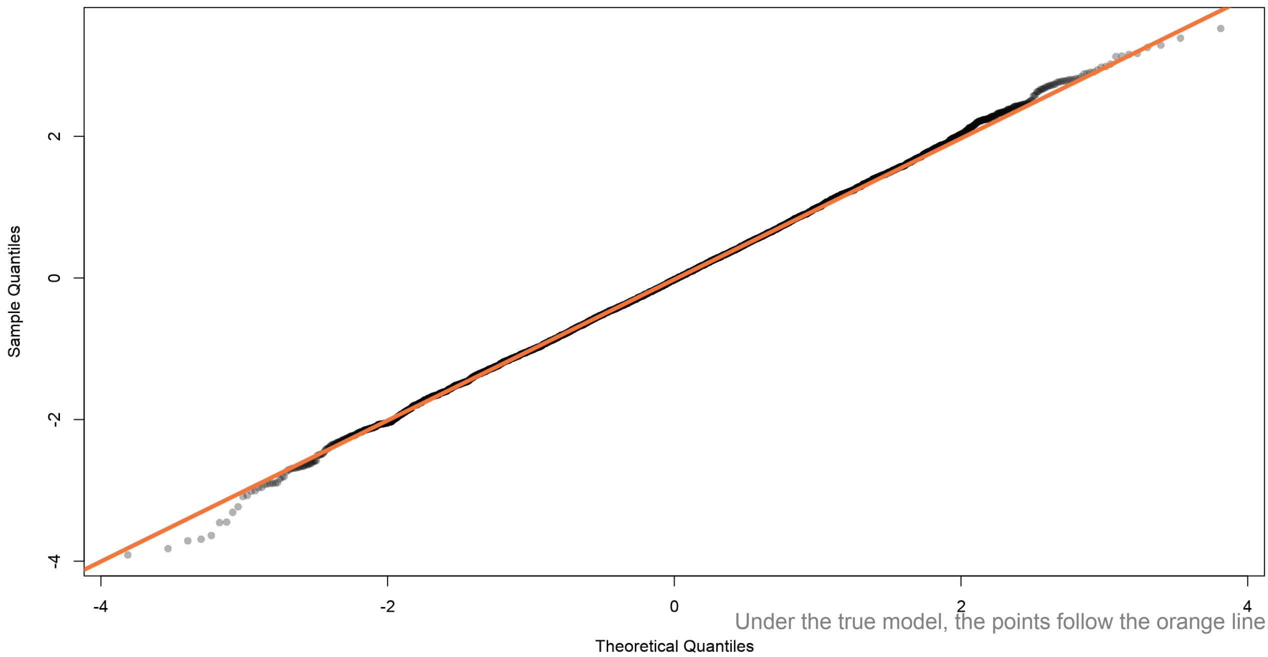
NEFD D2 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

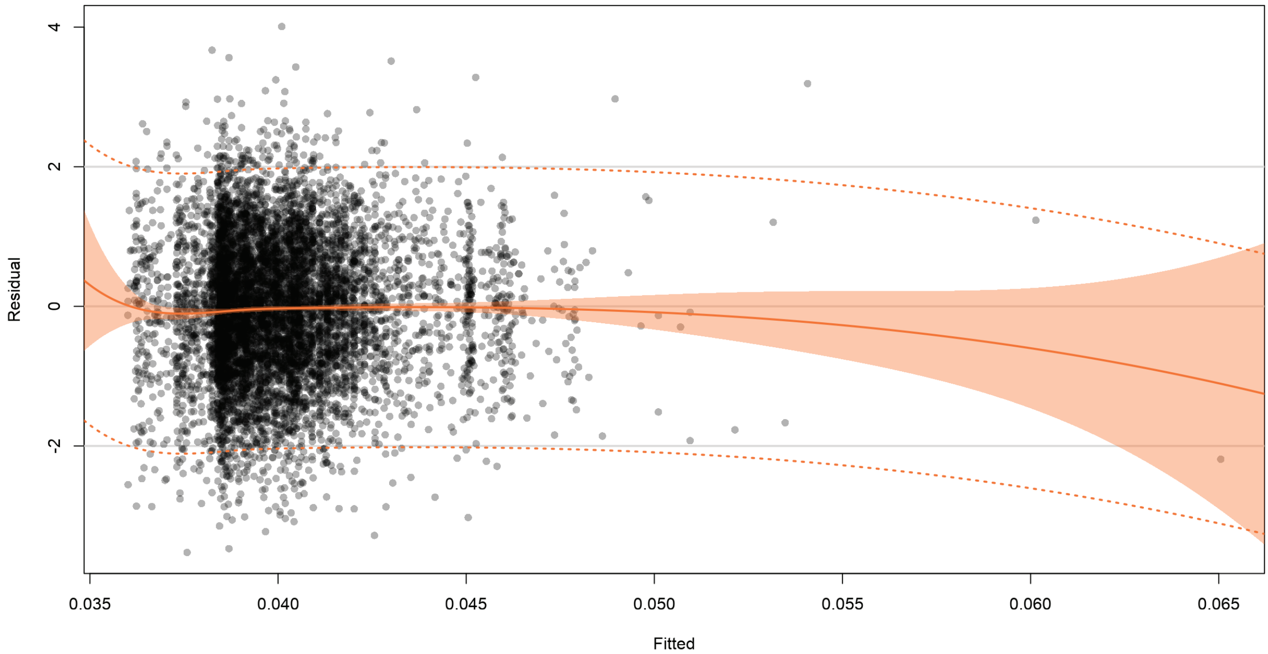
NEFD D2 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

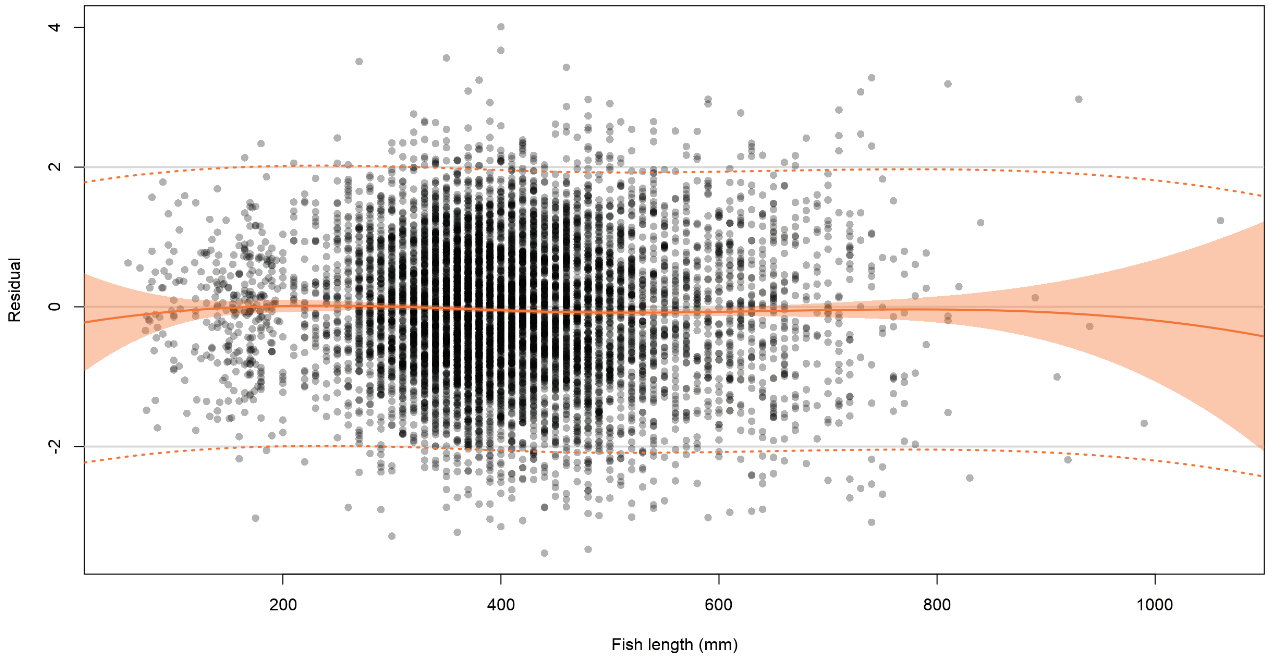
NEFD D3 - Residuals to fitted values



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

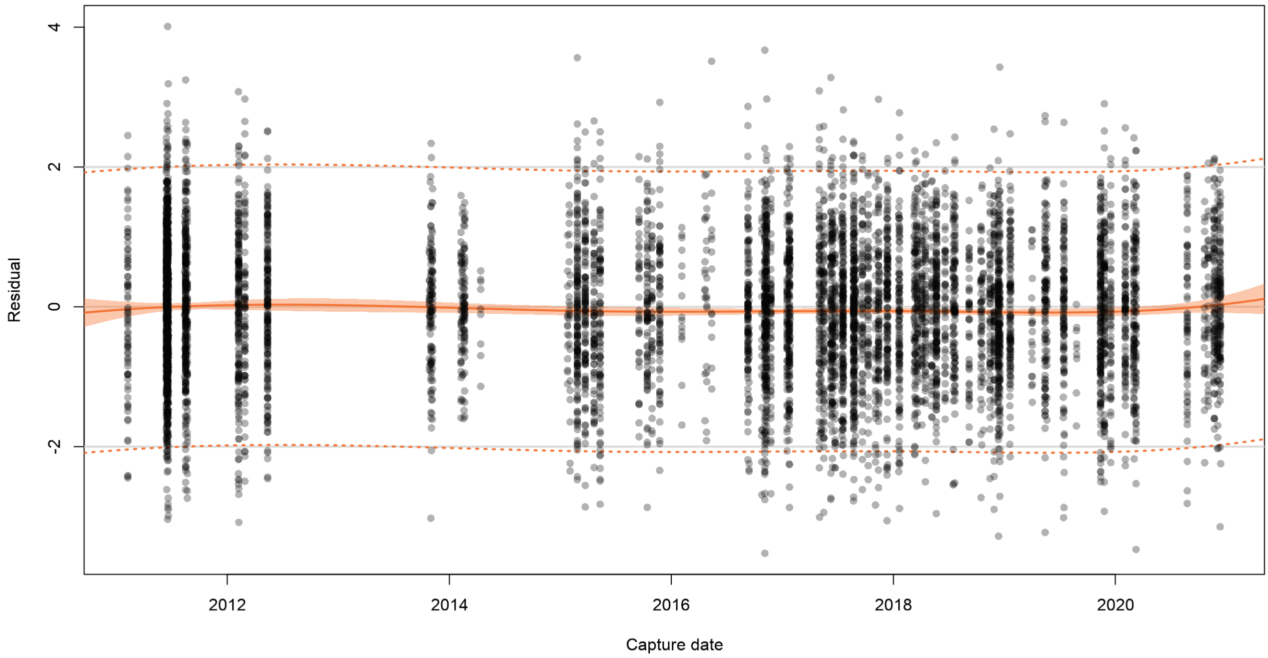
NEFD D3 - Residuals to fish length



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

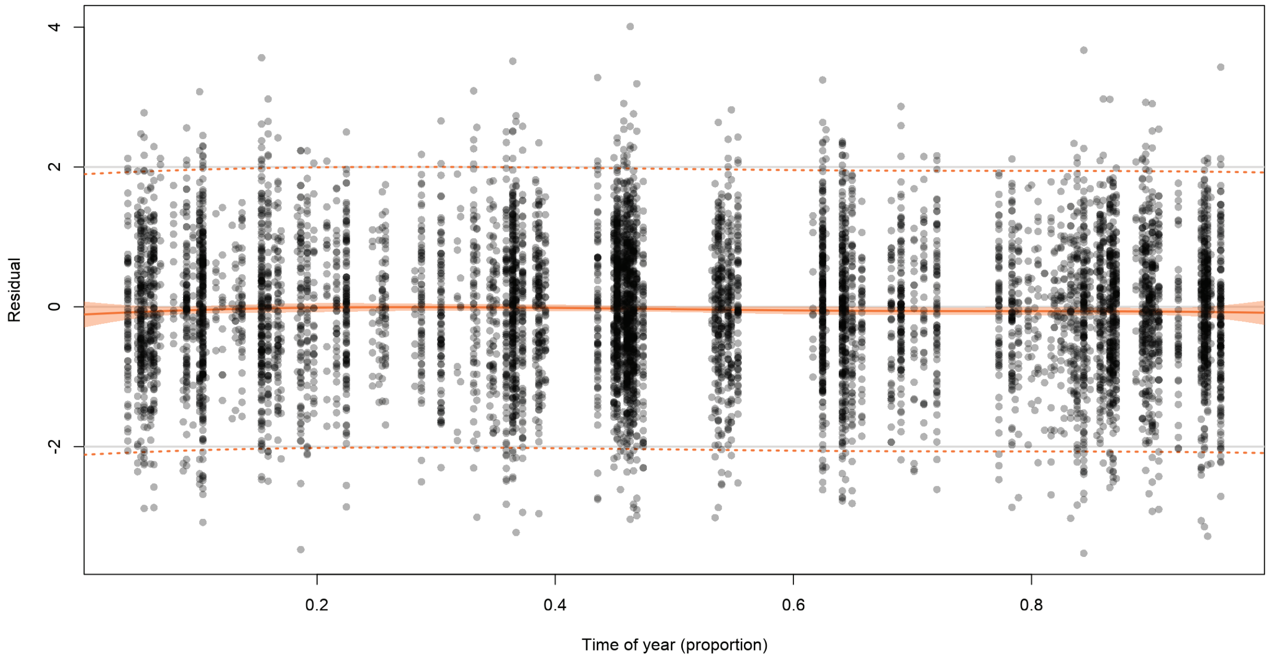
NEFD D3 - Residuals to capture date



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

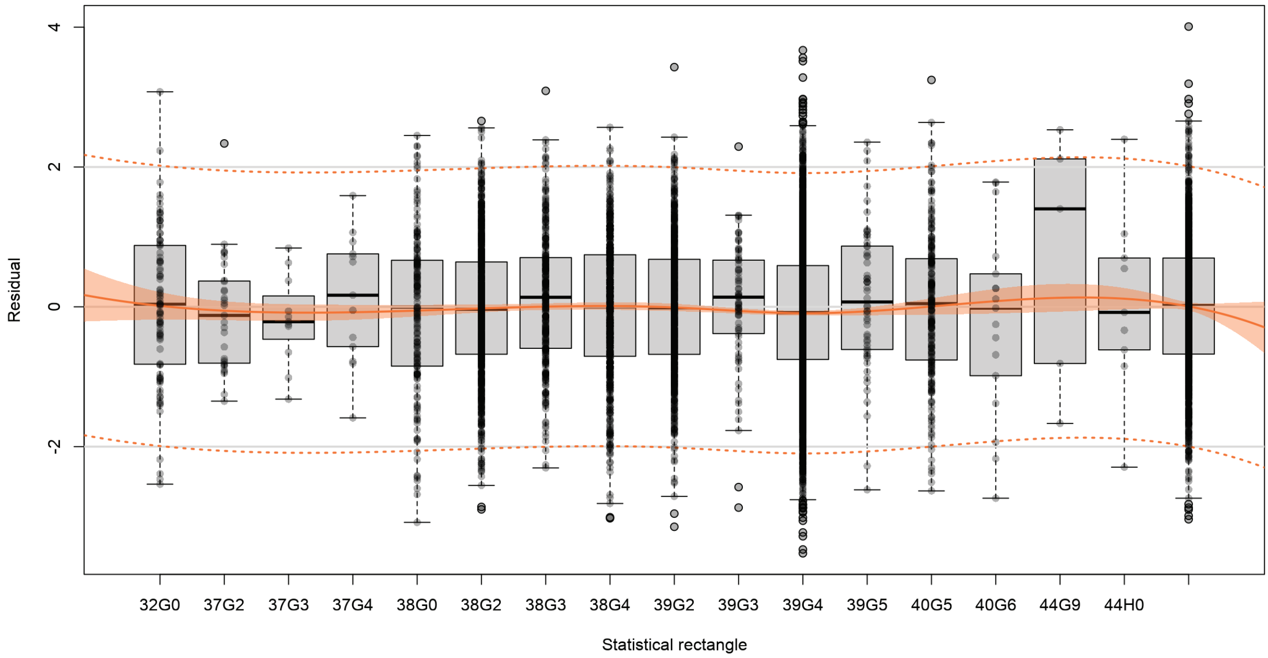
NEFD D3 - Residuals to time of year



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

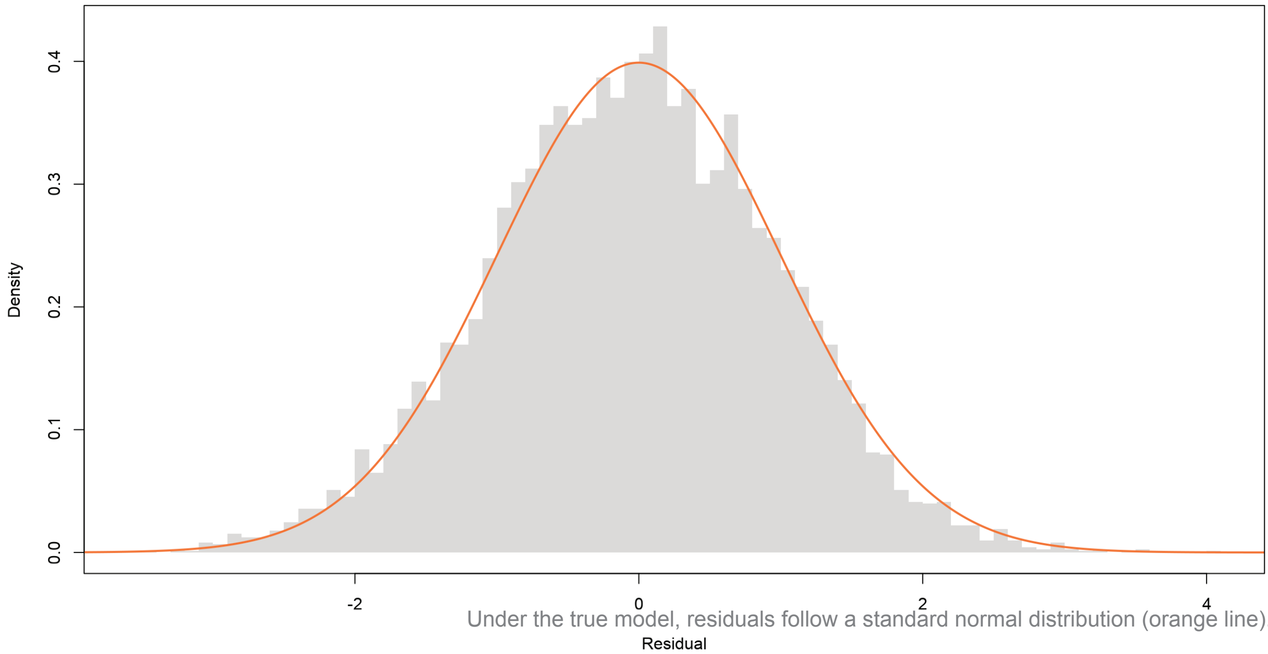
NEFD D3 - Residuals compared to statistical rectangle



Under the true model, residuals have zero mean and 95% are within -2 and 2. In orange is shown a B-spline fit with 5 degrees of

DTU Aqua

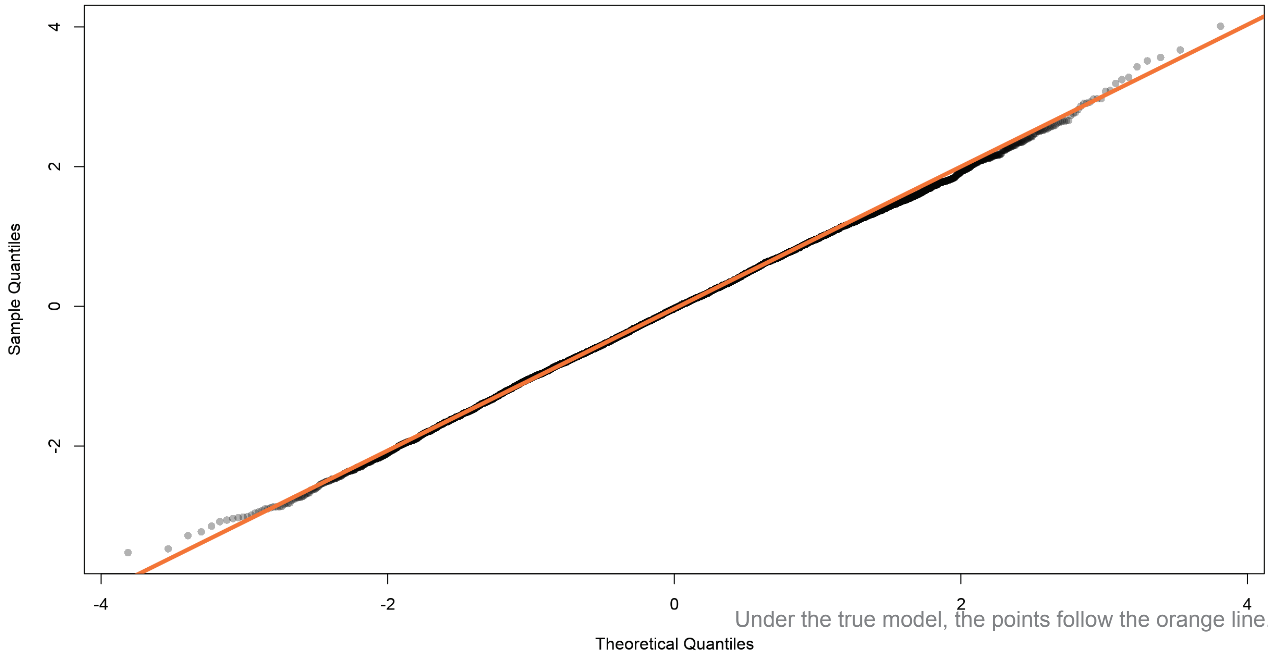
NEFD D3 - Residual histogram



Under the true model, residuals follow a standard normal distribution (orange line).

DTU Aqua

NEFD D3 - Residual Quantile-Quantile plot



Under the true model, the points follow the orange line.

DTU Aqua

Data with known stock origin - years

	Eastern Baltic	Western Baltic
2011	1172	42
2012	176	343
2013	85	41
2014	39	83
2015	18	21
2019	158	56
2020	93	254

Note: The 2019 samples also informs the mixing proportion for 2019

DTU Aqua

Data with unknown stock origin - years

	SD24 Area 1	SD24 Area 2
2015	228	437
2016	67	483
2017	45	1436
2018	531	696
2019	60	435
2020	165	96

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Data with known stock origin - quarters

	Eastern Baltic	Western Baltic
1	113	467
2	1077	64
3	349	39
4	202	270

DTU Aqua

Data with unknown stock origin - quarters

	SD24 Area 1	SD24 Area 2
1	354	702
2	362	715
3	96	878
4	284	1288

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Data with known stock origin - year/month (baseline)

	2011/06	2011/08	2012/02	2012/05	2013/10	2013/11	2014/02	2014/04	2015/09
Eastern Baltic	857	315	0	176	16	69	32	7	18
Western Baltic	42	0	338	5	11	30	81	2	21

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Data with known stock origin - year/month (2019 Area 1)

	2019/04
Western Baltic	10

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Data with known stock origin - year/month (2019 Area 2)

	2019/05	2019/07	2019/08	2019/11	2019/12
Eastern Baltic	37	16	0	69	36
Western Baltic	5	15	3	21	2

DTU

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Data with unknown stock origin SD24 Area 1 - year/month

	1	2	3	4	5	6	7	9	10	11	12
2015	27	12	113	76	0	0	0	0	0	0	0
2016	0	15	0	27	0	0	0	20	0	5	0
2017	11	0	0	0	34	0	0	0	0	0	0
2018	0	0	53	65	67	50	76	0	6	126	88
2019	0	0	0	12	31	0	0	0	0	17	0
2020	0	36	87	0	0	0	0	0	0	38	4

DTU Aqua

Data with unknown stock origin SD24 Area 2 - year/month

	1	2	3	4	5	6	7	8	9	10	11	12
2015	0	157	0	0	88	0	0	0	0	117	75	0
2016	0	0	0	0	13	0	0	0	112	21	337	0
2017	214	0	0	0	150	225	189	251	72	67	127	141
2018	117	0	100	58	132	0	50	0	46	61	0	132
2019	113	0	0	0	49	0	83	6	0	0	159	25
2020	0	0	1	0	0	0	0	69	0	26	0	0

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Data with known stock origin - statistical rectangles SD22

	32G0	38G0	NA
Western Baltic	91	166	81

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Data with known stock origin - statistical rectangles SD24

	37G2	37G3	37G4	38G2	38G3	38G4	39G2	39G3	39G4	NA
Eastern Baltic	12	4	4	20	39	33	11	22	259	514
Western Baltic	19	7	9	158	41	1	154	17	49	47

DTU Aqua

Data with unknown stock origin - statistical rectangles SD24

	38G2	38G3	38G4	39G2	39G3	39G4
2015	228	0	0	0	0	437
2016	67	0	173	0	4	306
2017	0	113	73	45	30	1220
2018	118	67	164	413	0	465
2019	48	29	42	12	0	364
2020	112	0	33	53	0	63

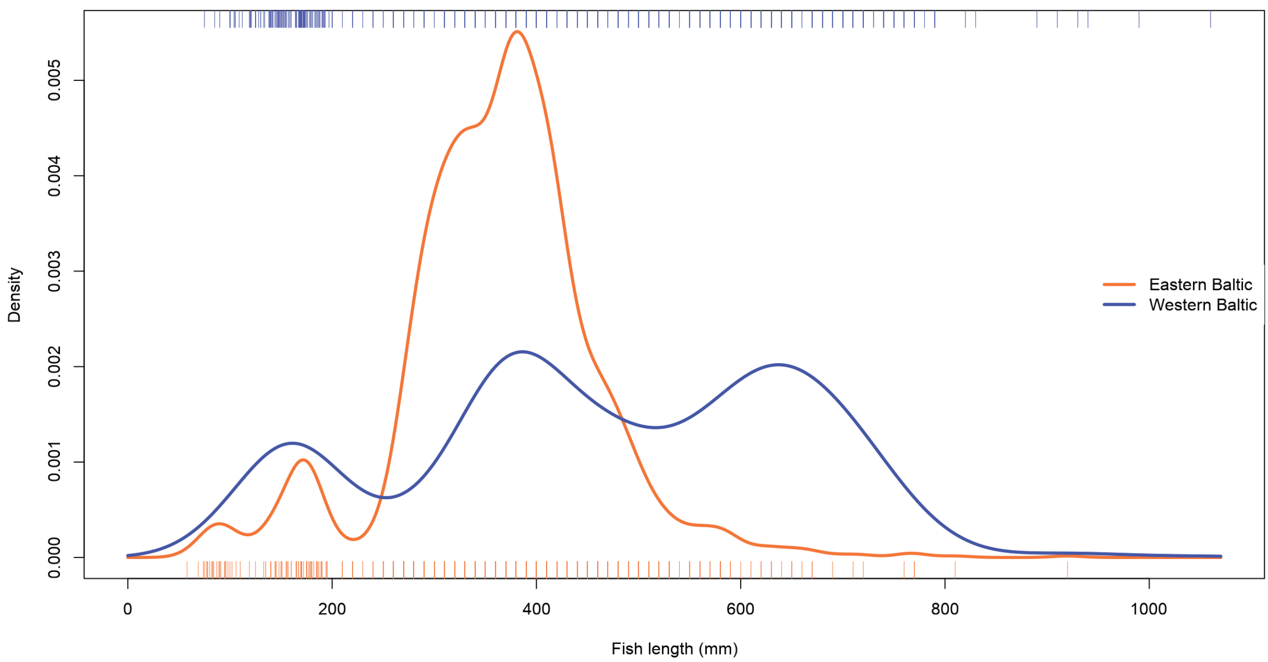
DTU Aqua

Data with known stock origin - statistical rectangles SD25

	39G5	40G5	40G6	44G9	44H0	NA
Eastern Baltic	56	217	17	5	9	519

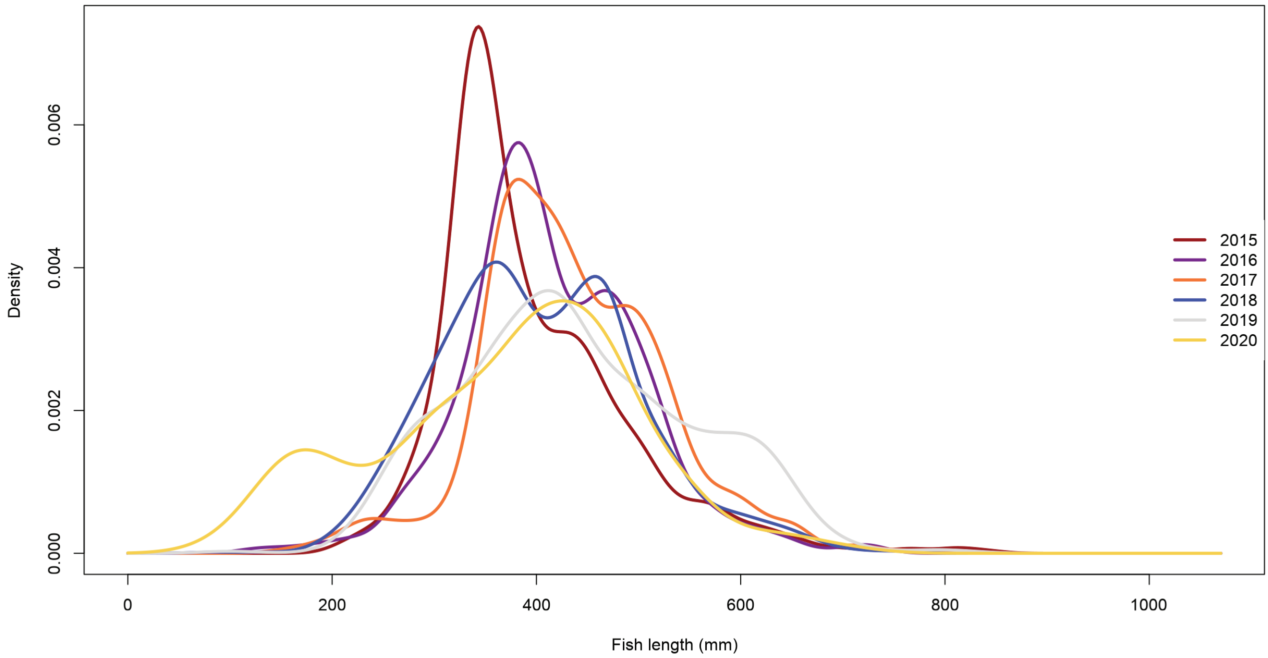
DTU Aqua

Data with known stock origin - length distribution per stock



DTU Aqua

Data with unknown stock origin - length distribution per year



Estimated standard deviations

	B2	B3	B4	C2	C4	D1	D2	D3
Eastern Baltic	0.01539	0.00423	0.00506	0.01168	0.00419	0.02551	0.00920	0.00556
Western Baltic	0.02076	0.00656	0.00734	0.01458	0.00499	0.02414	0.01019	0.00572

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Estimated correlation matrix - Eastern Baltic

	B2	B3	B4	C2	C4	D1	D2	D3
B2	1.000	0.131	0.751	-0.462	-0.475	-0.032	-0.001	0.085
B3	0.131	1.000	0.109	0.034	-0.019	-0.118	0.042	0.003
B4	0.751	0.109	1.000	-0.184	-0.334	-0.163	0.103	0.103
C2	-0.462	0.034	-0.184	1.000	0.279	-0.050	0.291	-0.075
C4	-0.475	-0.019	-0.334	0.279	1.000	0.047	0.017	-0.055
D1	-0.032	-0.118	-0.163	-0.050	0.047	1.000	0.031	0.042
D2	-0.001	0.042	0.103	0.291	0.017	0.031	1.000	0.000
D3	0.085	0.003	0.103	-0.075	-0.055	0.042	0.000	1.000

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Estimated correlation matrix - Western Baltic

	B2	B3	B4	C2	C4	D1	D2	D3
B2	1.000	-0.002	0.769	-0.656	-0.552	-0.018	-0.134	-0.148
B3	-0.002	1.000	0.015	0.065	0.072	-0.039	-0.068	-0.065
B4	0.769	0.015	1.000	-0.486	-0.504	-0.120	-0.026	-0.080
C2	-0.656	0.065	-0.486	1.000	0.567	-0.009	0.357	0.128
C4	-0.552	0.072	-0.504	0.567	1.000	0.068	0.157	0.094
D1	-0.018	-0.039	-0.120	-0.009	0.068	1.000	0.009	0.121
D2	-0.134	-0.068	-0.026	0.357	0.157	0.009	1.000	0.080
D3	-0.148	-0.065	-0.080	0.128	0.094	0.121	0.080	1.000

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Estimated t distribution contamination proportion (1/2)

	Estimate	CI lower	CI higher
EasternBaltic B2	0.9999	0.0000	1.0000
EasternBaltic B3	1.0000	0.0000	1.0000
EasternBaltic B4	0.7583	0.1028	0.9885
EasternBaltic C2	1.0000	0.0000	1.0000
EasternBaltic C4	0.9962		
EasternBaltic D1	0.0021	0.0001	0.0693
EasternBaltic D2	0.9988	0.0000	1.0000
EasternBaltic D3	0.0117	0.0001	0.5061

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Estimated t distribution contamination proportion (2/2)

	Estimate	CI lower	CI higher
WesternBaltic B2	0.8273	0.0346	0.9984
WesternBaltic B3	1.0000	0.0000	1.0000
WesternBaltic B4	0.5867	0.1960	0.8921
WesternBaltic C2	0.2562	0.0621	0.6416
WesternBaltic C4	0.6236	0.0494	0.9814
WesternBaltic D1	0.3427	0.1192	0.6677
WesternBaltic D2	0.2091	0.0756	0.4609
WesternBaltic D3	0.4053	0.0648	0.8701

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Estimated t distribution contamination degrees of freedom (1/2)

	Estimate	CI lower	CI higher
EasternBaltic B2	6.3497	5.1471	7.8333
EasternBaltic B3	5.9555	4.9492	7.1664
EasternBaltic B4	8.3336	5.1965	13.3645
EasternBaltic C2	15.8554	10.1773	24.7016
EasternBaltic C4	20.8622	12.8463	33.8797
EasternBaltic D1	1.1732	0.1634	8.4219
EasternBaltic D2	61.6971	9.6988	392.4732
EasternBaltic D3	2.4858	0.3969	15.5700

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Estimated t distribution contamination degrees of freedom (2/2)

	Estimate	CI lower	CI higher
WesternBaltic B2	7.3242	4.4271	12.1170
WesternBaltic B3	5.6645	4.4590	7.1961
WesternBaltic B4	5.1135	3.3468	7.8128
WesternBaltic C2	4.2280	2.3103	7.7376
WesternBaltic C4	6.7262	3.6149	12.5157
WesternBaltic D1	4.2083	2.6192	6.7614
WesternBaltic D2	2.8742	1.7974	4.5959
WesternBaltic D3	6.9552	3.1693	15.2639

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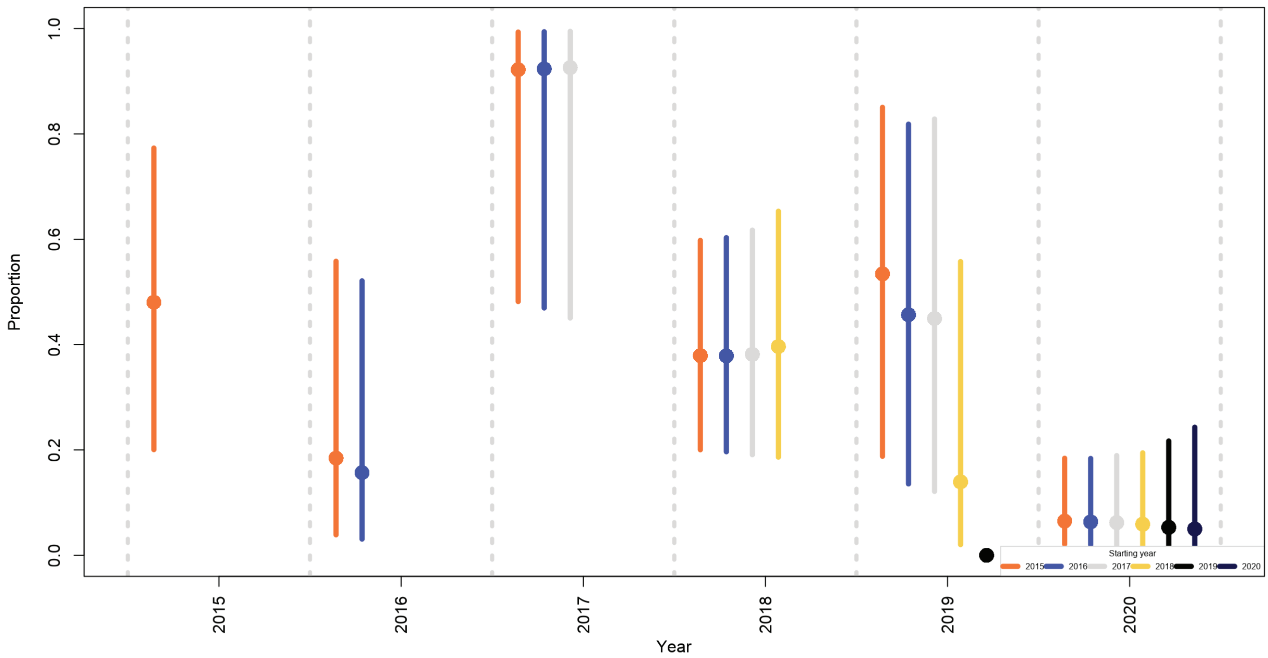
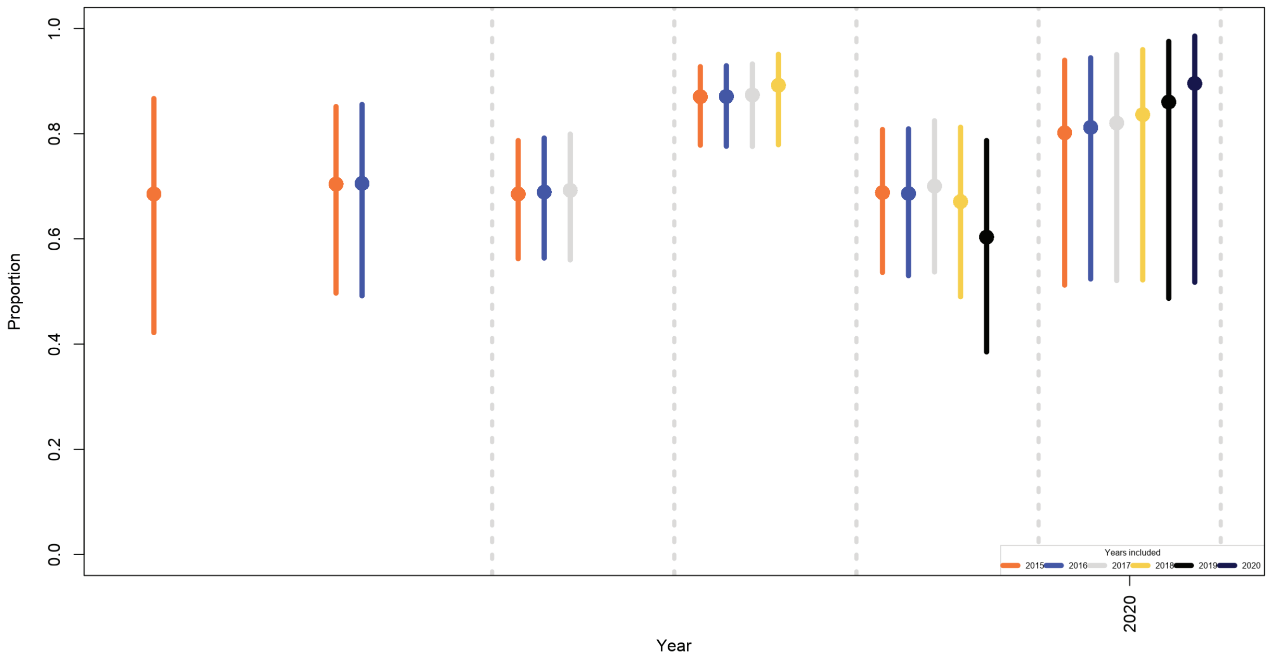
Effect of using fewer years - SD24 Area 1



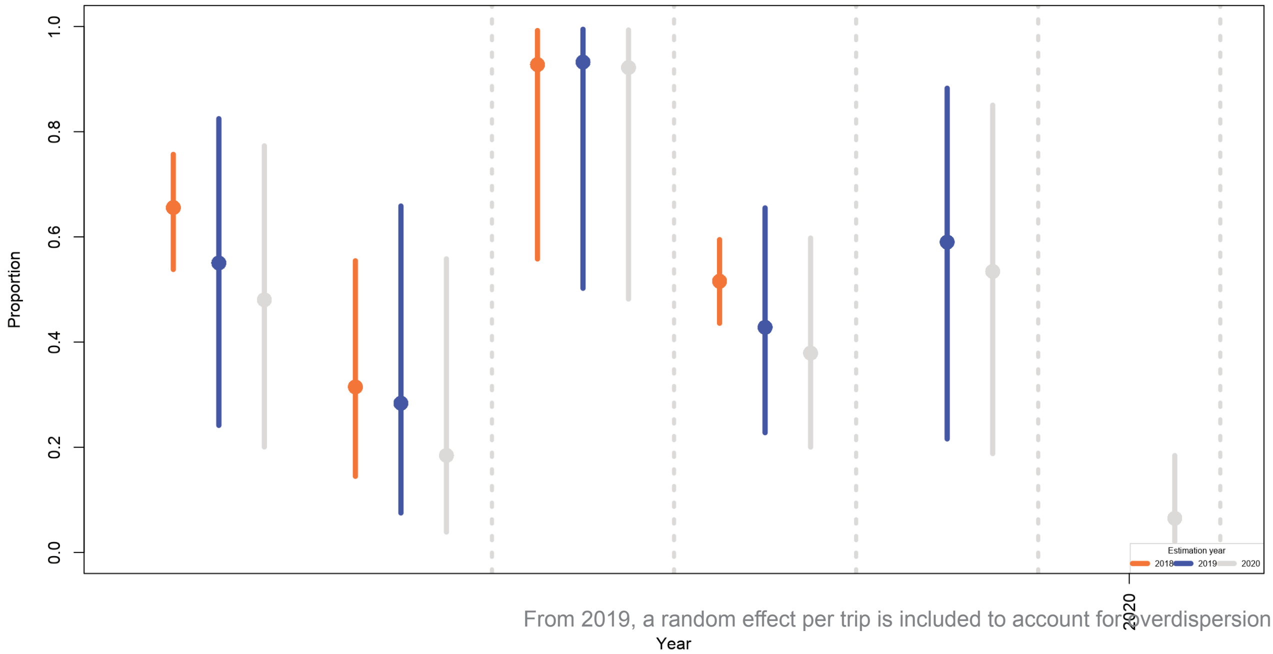
DTU Aqua

Effect of using fewer years - SD24 Area 2



DTU Aqua

Estimates compared to previous years - SD24 Area 1



From 2019, a random effect per trip is included to account for overdispersion

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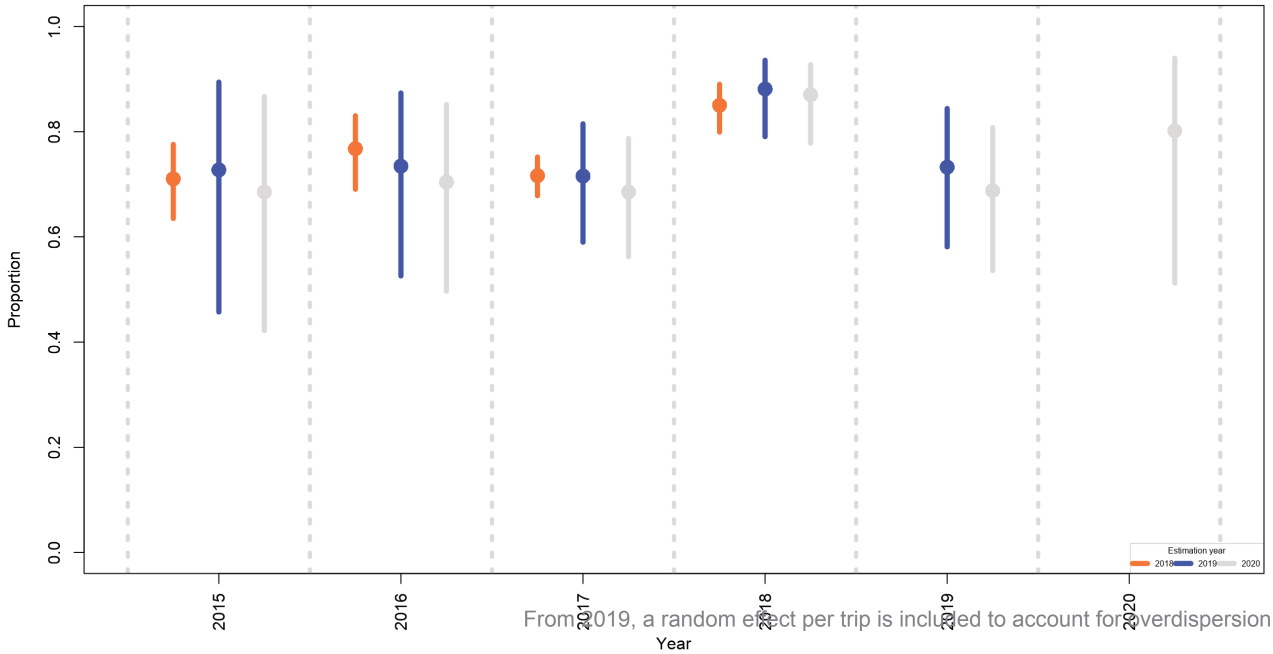
Estimates compared to previous years - SD24 Area 2



From 2019, a random effect per trip is included to account for overdispersion

Summary of the mean structure

- R language formula for stock-wise mean parameters:

~ 1 + I(length/100 - 4) + I((length/100 - 4)^2) + I((length/100 - 4)^3) + pbs(proportionOfYear, df = 5, Boundary.knots = c(0, 1))

- R language formula for common mean parameters:

~ year + year:I(length/100 - 4) + year:I((length/100 - 4)^2)

All mean structure parameters were penalized by L_2 regularization. The regularization penalty was fitted as a variance parameter.

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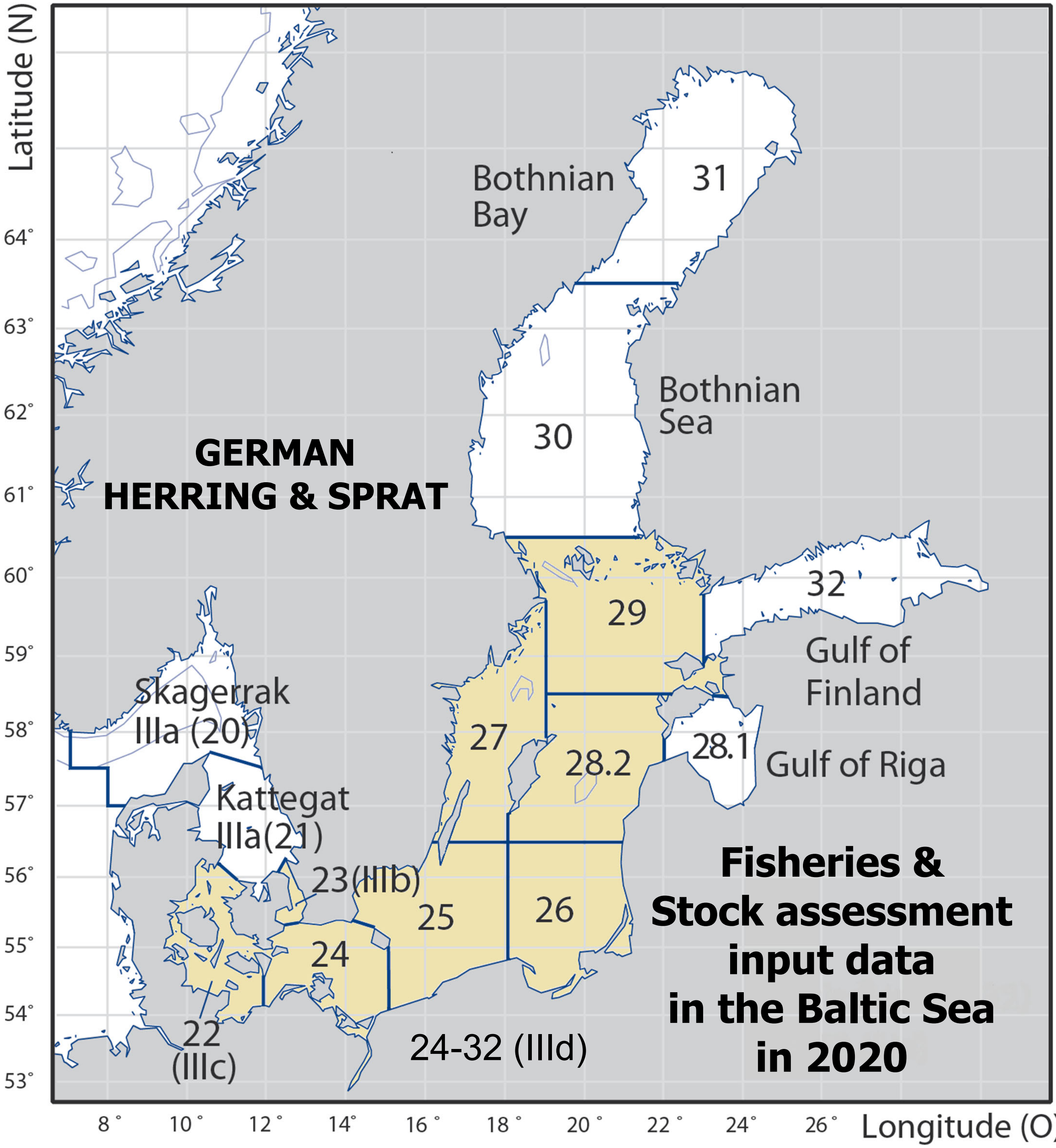

compiled by
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TABLE OF CONTENTS

1 HERRING

1.1 Fisheries

In 2019 the total German herring landings from the Western Baltic Sea in **Subdivisions (SD) 22 and 24** amounted to 2,069 t, which represents a decrease of 63 % compared to the landings in 2019 (5,571 t). This decrease was caused by a decrease of the TAC/quota (German quota for SDs 22 and 24 in 2019: 1,738 t + quota-transfer of 451 t = 2,189 t). The German quota in 2020 was used by 95 % (2019: 97 %, 2018: 94 %). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), started already at the beginning of February. The main German fishery stopped their activities at the end of April.
Only a small part of the total German landings was taken **in Subdivisions 25-29** (2020: 833 t, 2019: 1,752 t). The total quota of 928 t (German quota of 895 t + quota transfer of 33 t) was finally used by 90 % (2019: 99.7 %). All landings in this area were taken by the trawl fishery and then mostly landed in foreign ports (2020: 96 %, 2019: 95 %).

The landings (t) by quarter and Subdivision (SD) including information about the landings in foreign ports are shown in the table below:

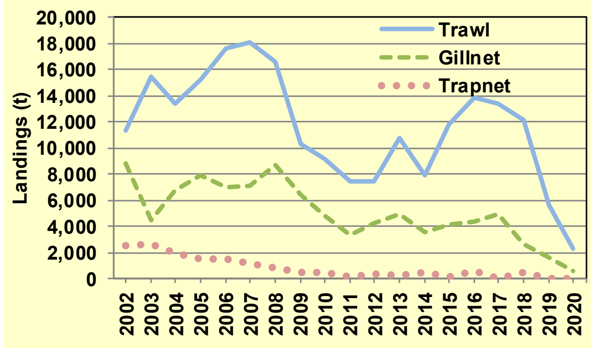
Quarter	SD 22	SD 24	SD 25	SD 26	SD 27	SD 28.2	SD 29	(1) Total SD 25-29	% (1)/(2)	(2) Total SD 22-29	% (2)
I	6.457	1,521.042	267.943	55.000	-	121.698	51.615	496.256	24.5%	**2,023.755**	69.7%
	0.004	-	262.760	55.000	-	96.385	51.615	465.760	100.0%	465.764	58.0%
II	2.723	43.645	118.161	-	-	-	-	118.161	71.8%	**164.529**	5.7%
	-	-	118.061	-	-	-	-	118.061	100.0%	118.061	14.7%
III	0.215	0.440	-	-	-	-	-	0.000		**0.655**	0.0%
	-	-	-	-	-	-	-	0.000		0.000	0.0%
IV	4.745	489.518	1.639	-	-	56.893	160.399	218.931	30.7%	**713.194**	24.6%
	-	-	1.639	-	-	56.893	160.399	218.931	100.0%	218.931	27.3%
Total	**14.140**	**2,054.645**	**387.743**	**55.000**	**0.000**	**178.591**	**212.014**	**833.348**	**28.7%**	**2,902.133**	**100.0%**
	0.004	0.000	382.460	55.000	0.000	153.278	212.014	802.752	100.0%	802.756	100.0%

= Fraction of total landings (t) in foreign ports	96.3%	27.7%
	2020/2019:	**2020/2019:**
= Fraction of total landings (t)	47.6%	39.6%
= Fraction of total landings (t) in foreign ports	48.3%	48.2%

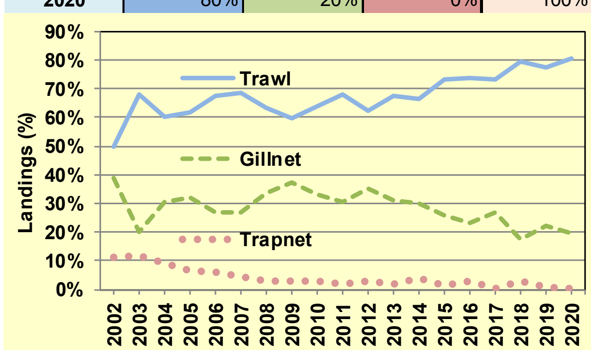
The main fishing season was during spring time as in former years. As in 2019 about 85 % of all herring (SDs 22-29) were caught between January and April. The majority of the German herring landings were taken in Subdivision 24 (2020: 71 %, 2019: 75 %). The German herring fishery in the Baltic Sea is 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 80 % in 2020 (2019: 77 %). The significant change in fishing pattern was caused by the perspective of a new fish factory on the Island of Rügen, which finally started the production in autumn 2003. This factory can process up to 50,000 t fish per year.

Landings in Subdivisions 22-29 (t)				
Year/Gear	Trawl	Gillnet	Trapnet	Total
2002	11,317.813	8,783.392	2,559.662	22,660.867
2003	15,433.154	4,545.312	2,658.148	22,636.614
2004	13,429.394	6,796.747	2,016.542	22,242.683
2005	15,277.320	7,924.007	1,551.530	24,752.857
2006	17,604.485	6,959.530	1,539.467	26,103.482
2007	18,044.233	7,077.135	1,133.806	26,255.174
2008	16,640.802	8,760.611	789.005	26,190.418
2009	10,305.056	6,403.312	523.998	17,232.366
2010	9,216.880	4,804.818	452.182	14,473.880
2011	7,424.844	3,301.890	189.673	10,916.407
2012	7,491.038	4,252.694	322.308	12,066.040
2013	10,768.220	4,933.173	304.427	16,005.820
2014	7,959.719	3,562.980	449.724	11,972.423
2015	11,839.151	4,183.129	183.533	16,205.813
2016	13,834.307	4,362.550	569.558	18,766.415
2017	13,370.750	4,898.840	19.104	18,288.694
2018	12,136.988	2,663.317	455.174	15,255.479
2019	5,664.366	1,615.909	42.112	7,322.387
2020	2,329.441	571.981	0.711	2,902.133



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%
2020	80%	20%	0%	100%



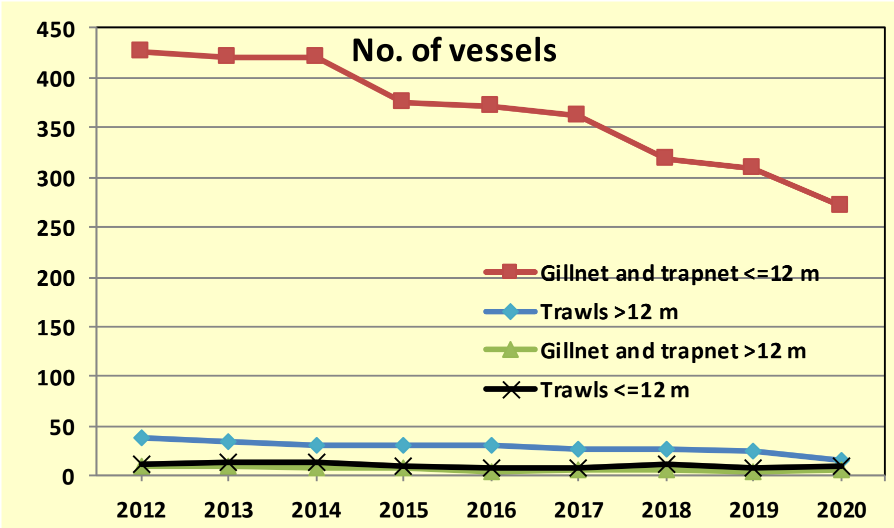
1.2 Fishing fleet

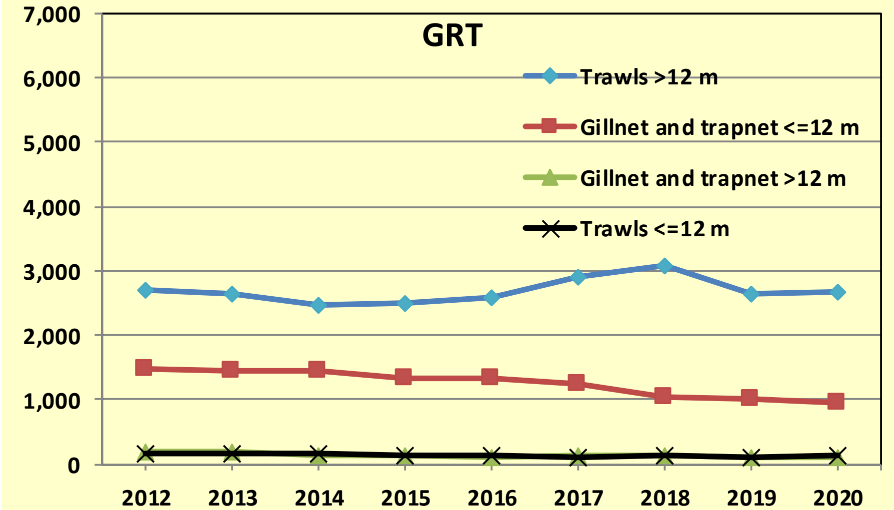
The herring fishing fleet in the Baltic Sea, where all catches are taken in a directed fishery, consists of a:

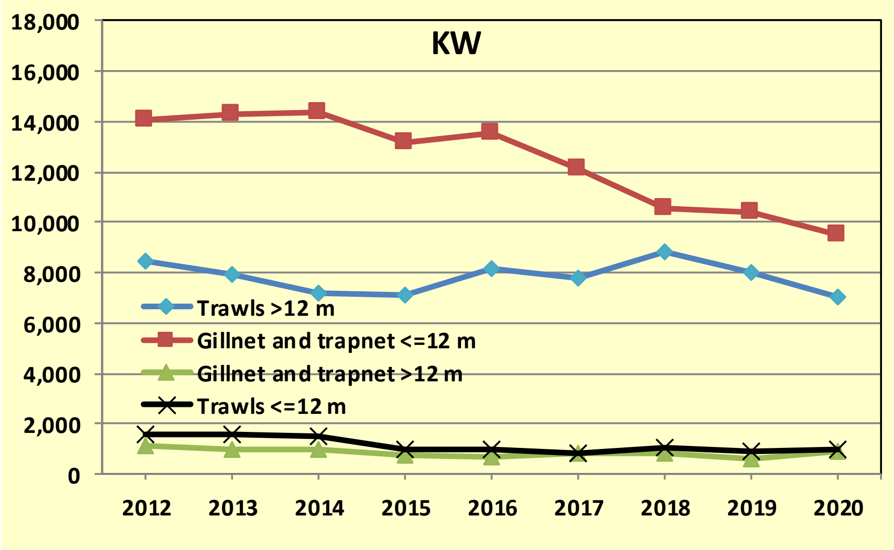
- coastal fleet with undecked vessels (rowing/motor boats <=12 m and engine power <=100 HP)
- cutter fleet with decked vessels and total lengths between 12 m and 40 m.

In the years from 2012 until 2020 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
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		**346**	**3,877**	**19,894**
2020	Fixed gears (gillnet and trapnet)	<=12	271	938	9,524
		>12	6	100	920
	Trawls	<=12	10	128	983
		>12	165	2,668	7,077
	TOTAL		**303**	**3,835**	**18,504**


No. of vessels
450
400
350
300
250
200
150
100
50
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m


GRT
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m


KW
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

1.3 Species composition of landings

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

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1 and 4 in 2020, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	58.0	0.0	0.0	0.0	58.1	99.9	0.1	0.0	0.0
	2									
	3									
	Mean	58.0	0.0	0.0	0.0	58.1	99.9	0.1	0.0	0.0
February	1	46.3	0.4	0.0	0.0	46.7	99.2	0.8	0.0	0.0
	2	59.7	0.0	0.0	0.0	59.7	99.9	0.1	0.0	0.0
	3									
	Mean	53.0	0.2	0.0	0.0	53.2	99.6	0.4	0.0	0.0
March	1									
	2	53.4	0.0	0.0	0.0	53.4	100.0	0.0	0.0	0.0
	3									
	Mean									
Q I	Mean	55.5	0.1	0.0	0.0	55.6	99.8	0.2	0.0	0.0

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1									
	2									
	3									
	Mean									
Novemb.	1	44.1	0.3	0.0	0.0	44.5	99.3	0.7	0.0	0.0
	2									
	3									
	Mean	44.1	0.3	0.0	0.0	44.5	99.3	0.7	0.0	0.0
Decemb.	1	42.3	0.6	0.0	0.3	43.3	97.7	1.5	0.0	0.8
	2	54.1	0.0	0.1	0.0	54.1	99.9	0.0	0.1	0.0
	3									
	Mean	48.2	0.3	0.0	0.2	48.7	98.8	0.7	0.1	0.4
Q IV	Mean	46.2	0.3	0.0	0.1	46.6	99.1	0.7	0.0	0.2

The officially reported total trawl landings of herring in Subdivision 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
24	I	**1,027.217**	99.8	1,025.163	-2.054
	IV	**467.578**	99.1	463.370	-4.208

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 1496 t – 6 t: -0.4 % 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 2020 (no BMS landing have been reported since 2015). A total amount of logbook registered discards (new catch categories since 2015) of 32.437 t were recorded by the German fisherman (as predation by seals?) in the gillnet/trapnet fisheries in SDs 22/24 in 2020 (2019/SD 22/24 gillnet/trapnet fisheries: 21.882 t; 2018/SD 24/gillnet fisheries: 14.510 t). Neither discards nor logbook registered discards have been reported before 2018.

		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	2.120	2.120	0.000	2.120	2.120
	2	0.000	0.000	0.000	0.005	7.615	7.620	0.005	7.615	7.620
	3	0.000	0.000	0.000	0.000	17.960	17.960	0.000	17.960	17.960
	4	0.000	0.000	0.000	0.000	2.947	2.947	0.000	2.947	2.947
	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	0.000	0.150	0.150	0.000	0.000	0.000	0.000	0.150	0.150
	10	0.000	0.150	0.150	0.000	0.000	0.000	0.000	0.150	0.150
	11	0.000	0.035	0.035	0.000	0.900	0.900	0.000	0.935	0.935
	12	0.000	0.000	0.000	0.000	0.555	0.555	0.000	0.555	0.555
Quarter	1	0.000	0.000	0.000	0.005	27.695	27.700	0.005	27.695	27.700
	2	0.000	0.000	0.000	0.000	2.947	2.947	0.000	2.947	2.947
	3	0.000	0.150	0.150	0.000	0.000	0.000	0.000	0.150	0.150
	4	0.000	0.185	0.185	0.000	1.455	1.455	0.000	1.640	1.640
Total		0.000	0.335	0.335	0.005	32.097	32.102	0.005	32.432	32.437

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 and 2020 (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, WD Gröhsler, T. and Schaber, M., 2021). 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). These results and further results of the years 2017-2019 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

ICES 2013. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2013). ICES Document CM 2013/ACOM:46.

ICES 2018. Report of the workshop on mixing of western and central Baltic herring stocks (WKMixHER 2018). ICES CM 2018/ACOM:63.

Gröhsler, T., Oeberst, R., Schaber, M., Larson, N. and Kornilovs, G. 2013. Discrimination of western Baltic spring-spawning and central Baltic herring (Clupea harengus L.) based on growth vs. natural tag information. ICES Journal of Marine Science, 70 (6): 1108-1117. doi:19.1093/icesjms/fst064.

Gröhsler, T., Schaber, M., Larson, N., Oeberst, R. 2016. Separating two herring stocks from growth data: long-term changes in survey indices for Western Baltic Spring Spawning Herring (Clupea harengus) after application of a stock separation function. J. Appl. Ichthyol. 32, 40-45; doi: 10.1111/jai.12924

Gröhsler, T., Oeberst, R., Schaber, M. 2013. Implementation of the Stock Separation Function (SF) within German Commercial Landings. Herring working document (WD 3). In: Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 4-8 February 2013, Copenhagen. ICES CM 2013/ACOM:46: 379-386.

Oeberst, R., Gröhsler, T., Schaber, M. and Larsen, N. 2013. Applicability of the Separation Function (SF) in 2011 and 2012. WD 01 for HAWG. ICES Document CM 2013/ACOM06: Sec 14: 819-825 & WD for WGBIFS. ICES Document CM 2013/SSGESST:08: Annex 9: 399-405.

Oeberst, R., Gröhsler, T. and Schaber, M. 2014. Applicability of the Separation Function (SF) in 2013. WD for WGIPS 2014.

Oeberst, R., Gröhsler, T. and Schaber, M. 2015. Applicability of the Separation Function (SF) in 2014. WD for WGIPS 2015.

Oeberst, R., Gröhsler, T. and Schaber, M. 2016. Applicability of the Separation Function (SF) in 2015. WD for WGBIFS 2016.

Oeberst, R., Gröhsler, T. and Schaber, M. 2017. Applicability of the Separation Function (SF) in 2016. WD for WGIPS 2017.

Gröhsler, T. and Schaber, M. 2018. Applicability of the Separation Function (SF) in 2017. WD for WGBIFS 2018.

Gröhsler, T. and Schaber, M. 2019. Applicability of the Separation Function (SF) in 2018. WD for WGBIFS 2019.

Gröhsler, T. and Schaber, M. 2021. Applicability of the Separation Function (SF) in 2020. WD for WGIPS 2021.

1.7 Landings (tons) and sampling effort under COVID-19 conditions

The sampling in SDs 22-24 was carried out as usual without constraints caused by COVID-19. Independent of Covid-19, it was not possible - as in the years before - to get any samples from the area of SDs 25-29 since almost all herring (96 %) were landed in foreign ports.

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	0.131	0	0	0	1,027.217	7	2,958	746	1,027.348	7	2,958	746
	Q 2	0.302	0	0	0	0.830	0	0	0	1.132	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.035	0	0	0	467.578	3	1,132	353	467.613	3	1,132	353
	Total	0.468	0	0	0	1,495.625	10	4,090	1,099	1,496.093	10	4,090	1,099
GILLNET	Q 1	6.326	3	1,135	186	493.775	9	3,152	475	500.101	12	4,287	661
	Q 2	2.420	0	0	0	42.529	2	741	92	44.949	2	741	92
	Q 3	0.154	0	0	0	0.428	0	0	0	0.582	0	0	0
	Q 4	4.450	0	0	0	21.899	0	0	0	26.349	0	0	0
	Total	13.350	3	1,135	186	558.631	11	3,893	567	571.981	14	5,028	753
TRAPNET	Q 1*	0.000	-	-	-	0.050	1	378	106	0.050	-	-	-
	Q 2	0.001	1	864	84	0.286	0	0	0	0.287	1	864	84
	Q 3	0.061	0	0	0	0.012	2	389	123	0.073	2	389	123
	Q 4	0.260	0	0	0	0.041	0	0	0	0.301	0	0	0
	Total	0.322	1	864	84	0.389	3	767	229	0.711	3	1,253	207
TOTAL	Q 1	6.457	3	1,135	186	1,521.042	17	6,488	1,327	1,527.499	20	7,623	1,513
	Q 2	2.723	1	864	84	43.645	2	741	92	46.368	3	1,605	176
	Q 3	0.215	0	0	0	0.440	2	389	123	0.655	2	389	123
	Q 4	4.745	0	0	0	489.518	3	1,132	353	494.263	3	1,132	353
	Total	14.140	4	1,999	270	2,054.645	24	8,750	1,895	2,068.785	28	10,749	2,165

*Sampled data of trapnet SD 22 Q1 (without landings!) used for trapnet SD 24 Q1

1.7.2 Subdivisions 25-29

All herring in this area was caught by trawls.

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	267.943	0	0	0	55.000	0	0	0	0.000	-	-	-
	Q 2	118.161	0	0	0	0.000	-	-	-	0.000	-	-	-
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	1.639	0	0	0	0.000	-	-	-	0.000	-	-	-
	Total	387.743	0	0	0	55.000	0	0	0	0.000	0	0	0

Gear	Quarter	SUBDIVISION 28.2				SUBDIVISION 29				SUBDIVISION 25-29			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	121.698	0	0	0	51.615	0	0	0	**496.256**	**0**	**0**	**0**
	Q 2	0.000	-	-	-	0.000	-	-	-	**118.161**	**0**	**0**	**0**
	Q 3	0.000	-	-	-	0.000	-	-	-	**0.000**	**0**	**0**	**0**
	Q 4	56.893	0	0	0	160.399	0	0	0	**218.931**	**0**	**0**	**0**
	Total	178.591	0	0	0	212.014	0	0	0	**833.348**	**0**	**0**	**0**

1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

Gear	W-rings	SUBDIVISION 22 Q1	Q2	Q3	Q4	SUBDIVISION 24 Q1	Q2	Q3	Q4	SUBDIVISIONS 22+24 Q1	Q2	Q3	Q4
TRAWL	0				0.0000				0.020				0.020
	1	0.0000	0.0000		0.0000	0.011	0.000		0.243	0.011	0.000		0.243
	2	0.0000	0.0001		0.0001	0.188	0.000		0.711	0.188	0.000		0.711
	3	0.0002	0.0004		0.0001	1.445	0.001		0.765	1.445	0.002		0.765
	4	0.0002	0.0003		0.0000	1.180	0.001		0.537	1.180	0.001		0.537
	5	0.0003	0.0006		0.0001	2.190	0.002		0.710	2.190	0.002		0.710
	6	0.0001	0.0002		0.0000	0.844	0.001		0.329	0.844	0.001		0.329
	7	0.0002	0.0005		0.0000	1.604	0.001		0.365	1.604	0.002		0.365
	8+	0.0000	0.0001		0.0000	0.387	0.000		0.086	0.387	0.000		0.087
	Sum	0.0010	0.0023		0.0003	7.848	0.006		3.766	7.849	0.009		3.766
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	0.000				0.006				0.006			
	4	0.002	0.000	0.000	0.001	0.057	0.007	0.000	0.004	0.059	0.007	0.000	0.004
	5	0.005	0.002	0.000	0.003	0.712	0.029	0.000	0.015	0.717	0.030	0.000	0.018
	6	0.006	0.003	0.000	0.006	0.584	0.053	0.001	0.027	0.591	0.056	0.001	0.033
	7	0.014	0.007	0.000	0.013	1.011	0.124	0.001	0.064	1.025	0.131	0.002	0.077
	8+	0.009	0.002	0.000	0.004	0.428	0.041	0.000	0.021	0.437	0.043	0.001	0.025
	Sum	0.037	0.014	0.001	0.027	2.799	0.253	0.003	0.131	2.835	0.268	0.003	0.157
	W-rings	Q1	Q2	Q3	Q4	*Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1			0.000	0.0000			0.00000	0.0000			0.0000	0.0000
	2		0.00000	0.000	0.0001	0.0000	0.000	0.00000	0.0000	0.0000	0.0001	0.0000	0.0001
	3		0.00001	0.000	0.0001	0.0001	0.001	0.00000	0.0000	0.0001	0.0007	0.0000	0.0001
	4		0.00001	0.000	0.0001	0.0001	0.000	0.00001	0.0000	0.0001	0.0003	0.0000	0.0001
	5			0.000	0.0005	0.0002	0.001	0.00002	0.0001	0.0002	0.0011	0.0001	0.0006
	6			0.000	0.0004	0.0000	0.000	0.00002	0.0001	0.0000	0.0003	0.0001	0.0005
	7			0.000	0.0003	0.0000	0.000	0.00002	0.0001	0.0000	0.0000	0.0001	0.0004
	8+			0.000	0.0001	0.0000	0.000	0.00000	0.0000	0.0000	0.0002	0.0000	0.0001
	Sum		0.000	0.000	0.0015	0.0005	0.003	0.00007	0.0002	0.0005	0.0027	0.0004	0.0018
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0				0.000				0.020				0.020
	1	0.000	0.000	0.0000	0.0000	0.011	0.000	0.0000	0.243	0.011	0.000	0.0000	0.243
	2	0.000	0.000	0.0000	0.0001	0.188	0.000	0.0000	0.711	0.188	0.000	0.0000	0.711
	3	0.001	0.000	0.0000	0.0001	1.451	0.002	0.0000	0.765	1.451	0.002	0.0000	0.765
	4	0.002	0.001	0.0001	0.0009	1.237	0.008	0.0001	0.540	1.239	0.009	0.0001	0.541
	5	0.006	0.002	0.0002	0.0035	2.902	0.031	0.0003	0.725	2.907	0.034	0.0005	0.728
	6	0.006	0.003	0.0003	0.0060	1.428	0.054	0.0006	0.356	1.434	0.057	0.0008	0.362
	7	0.014	0.008	0.0005	0.0133	2.615	0.125	0.0013	0.429	2.630	0.133	0.0018	0.442
	8+	0.009	0.002	0.0002	0.0044	0.815	0.041	0.0004	0.108	0.824	0.044	0.0006	0.112
	Sum	0.038	0.017	0.0013	0.0283	10.647	0.262	0.0026	3.897	10.685	0.279	0.0039	3.925

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Trawl	4	24	Trawl	4	Gillnet	3, 4	24	Gillnet	2
Gillnet	2, 3, 4	24	Gillnet	2	Trapnet	2	24 (22)	Trapnet	1
Trapnet	3, 4	24	Trapnet	3	Trapnet	4	24	Trapnet	3

*sampled data of trapnet SD 22 Q1 (without landings!) finally used for trapnet SD 24 Q1

1.8.2 Subdivisions 25-29

No sampling.

1.9 Mean weight in the catch (grams)

1.9.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0				19.9				19.9				19.9
	1	17.1	17.1		45.6	17.1	17.1		45.6	17.1	17.1		45.6
	2	57.5	57.5		78.3	57.5	57.5		78.3	57.5	57.5		78.3
	3	85.1	85.1		111.1	85.1	85.1		111.1	85.1	85.1		111.1
	4	101.7	101.7		126.2	101.7	101.7		126.2	101.7	101.7		126.2
	5	139.4	139.4		160.6	139.4	139.4		160.6	139.4	139.4		160.6
	6	156.0	156.0		159.8	156.0	156.0		159.8	156.0	156.0		159.8
	7	168.5	168.5		178.4	168.5	168.5		178.4	168.5	168.5		178.4
	8+	171.4	171.4		185.7	171.4	171.4		185.7	171.4	171.4		185.7
	Sum	130.9	130.9		124.2	130.9	130.9		124.2	130.9	130.9		124.2
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2												
	3	136.6				115.5				116.6			
	4	148.4	163.2	163.2	163.2	156.9	163.2	163.2	163.2	156.7	163.2	163.2	163.2
	5	156.6	158.0	158.0	158.0	169.0	158.0	158.0	158.0	168.9	158.0	158.0	158.0
	6	168.0	168.3	168.3	168.3	175.4	168.3	168.3	168.3	175.3	168.3	168.3	168.3
	7	174.2	167.7	167.7	167.7	180.7	167.7	167.7	167.7	180.6	167.7	167.7	167.7
	8+	184.7	174.8	174.8	174.8	183.7	174.8	174.8	174.8	183.7	174.8	174.8	174.8
	Sum	171.6	167.8	167.8	167.8	176.4	167.8	167.8	167.8	176.4	167.8	167.8	167.8
TRAPNET	W-rings	Q1	Q2	Q3	Q4	*Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1			65.8	65.8			65.8	65.8			65.8	65.8
	2		51.0	92.2	92.2	58.3	58.3	92.2	92.2	58.3	57.9	92.2	92.2
	3		64.9	70.5	70.5	72.9	72.9	70.5	70.5	72.9	72.9	70.5	70.5
	4		75.9	119.0	119.0	95.7	95.7	119.0	119.0	95.7	95.4	119.0	119.0
	5			177.8	177.8	122.4	122.4	177.8	177.8	122.4	122.4	177.8	177.8
	6			179.3	179.3	138.4	138.4	179.3	179.3	138.4	138.4	179.3	179.3
	7			194.6	194.6	156.8	156.8	194.6	194.6	156.8	156.8	194.6	194.6
	8+			196.6	196.6	162.5	162.5	196.6	196.6	162.5	162.5	196.6	196.6
	Sum		65.6	168.7	168.7	108.2	108.2	168.7	168.7	108.2	108.0	168.7	168.7
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0				19.9				19.9				19.9
	1	17.1	17.1	65.8	56.6	17.1	17.1	65.8	45.6	17.1	17.1	65.8	45.6
	2	57.5	57.1	92.2	86.0	57.5	57.8	92.2	78.3	57.5	57.6	92.2	78.3
	3	118.6	84.8	70.5	89.5	85.2	80.5	70.5	111.1	85.2	81.3	70.5	111.1
	4	144.6	134.2	141.1	156.1	104.2	153.3	160.2	126.5	104.3	151.8	152.6	126.5
	5	155.7	152.7	168.5	160.9	146.6	155.8	159.5	160.5	146.6	155.6	163.3	160.5
	6	167.8	167.4	171.9	169.0	163.9	168.0	168.7	160.4	163.9	168.0	169.8	160.6
	7	174.1	167.8	171.6	168.4	173.2	167.7	168.0	176.8	173.2	167.7	169.1	176.6
	8+	184.6	174.6	176.8	175.1	177.9	174.7	175.0	183.5	177.9	174.7	175.5	183.2
	Sum	170.5	162.6	168.0	167.4	142.9	166.3	167.8	125.6	143.0	166.1	167.9	125.9

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Trawl	4	24	Trawl	4	Gillnet	3, 4	24	Gillnet	2
Gillnet	2, 3, 4	24	Gillnet	2	Trapnet	2	24 (22)	Trapnet	1
Trapnet	3, 4	24	Trapnet	3	Trapnet	4	24	Trapnet	3

*sampled data of trapnet SD 22 Q1 (without landings!) finally used for trapnet SD 24 Q1

1.9.2 Subdivisions 25 and 29

No sampling.

1.10 Mean length in the catch (cm)

1.10.1 Subdivisions 22 and 24

Gear	W-rings	SUBDIVISION 22 Q1	SD 22 Q2	SD 22 Q3	SD 22 Q4	SUBDIVISION 24 Q1	SD 24 Q2	SD 24 Q3	SD 24 Q4	SUBDIVISIONS 22+24 Q1	SD 22+24 Q2	SD 22+24 Q3	SD 22+24 Q4
TRAWL	0				14.7				14.7				14.7
	1	14.8	14.8		19.6	14.8	14.8		19.6	14.8	14.8		19.6
	2	20.5	20.5		22.7	20.5	20.5		22.7	20.5	20.5		22.7
	3	23.2	23.2		24.8	23.2	23.2		24.8	23.2	23.2		24.8
	4	24.4	24.4		25.7	24.4	24.4		25.7	24.4	24.4		25.7
	5	26.8	26.8		27.7	26.8	26.8		27.7	26.8	26.8		27.7
	6	27.7	27.7		27.6	27.7	27.7		27.6	27.7	27.7		27.6
	7	28.5	28.5		28.7	28.5	28.5		28.7	28.5	28.5		28.7
	8+	28.6	28.6		29.2	28.6	28.6		29.2	28.6	28.6		29.2
	Sum	26.1	26.1		25.4	26.1	26.1		25.4	26.1	26.1		25.4
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2												
	3	26.0				25.1				25.1			
	4	26.7	27.6	27.6	27.6	27.2	27.6	27.6	27.6	27.2	27.6	27.6	27.6
	5	27.3	27.3	27.3	27.3	28.0	27.3	27.3	27.3	28.0	27.3	27.3	27.3
	6	28.0	28.0	28.0	28.0	28.5	28.0	28.0	28.0	28.5	28.0	28.0	28.0
	7	28.4	28.0	28.0	28.0	29.0	28.0	28.0	28.0	28.9	28.0	28.0	28.0
	8+	29.2	28.5	28.5	28.5	29.2	28.5	28.5	28.5	29.2	28.5	28.5	28.5
	Sum	28.3	28.0	28.0	28.0	28.6	28.0	28.0	28.0	28.6	28.0	28.0	28.0
TRAPNET	W-rings	Q1	Q2	Q3	Q4	*Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1			19.1	19.1			19.1	19.1			19.1	19.1
	2		19.5	24.2	24.2	20.0	20.0	24.2	24.2	20.0	20.0	24.2	24.2
	3		21.2	21.6	21.6	21.8	21.8	21.6	21.6	21.8	21.8	21.6	21.6
	4		22.5	24.2	24.2	24.1	24.1	24.2	24.2	24.1	24.0	24.2	24.2
	5			27.9	27.9	26.4	26.4	27.9	27.9	26.4	26.4	27.9	27.9
	6			28.2	28.2	27.5	27.5	28.2	28.2	27.5	27.5	28.2	28.2
	7			28.8	28.8	28.9	28.9	28.8	28.8	28.9	28.9	28.8	28.8
	8+			27.1	27.1	28.8	28.8	27.1	27.1	28.8	28.8	27.1	27.1
	Sum		21.3	27.3	27.3	25.0	25.0	27.3	27.3	25.0	24.9	27.3	27.3
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0				14.7				14.7				14.7
	1	14.8	14.8	19.1	19.3	14.8	14.8	19.1	19.6	14.8	14.8	19.1	19.6
	2	20.5	20.4	24.2	23.5	20.5	20.3	24.2	22.7	20.5	20.4	24.2	22.7
	3	25.0	23.1	21.6	23.1	23.2	22.6	21.6	24.8	23.2	22.7	21.6	24.8
	4	26.6	26.1	25.9	27.1	24.6	27.1	27.4	25.7	24.6	27.0	26.8	25.7
	5	27.2	27.1	27.6	27.4	27.1	27.2	27.3	27.7	27.1	27.2	27.5	27.7
	6	28.0	28.0	28.1	28.0	28.0	28.0	28.0	27.6	28.0	28.0	28.0	27.6
	7	28.4	28.0	28.1	28.0	28.6	28.0	28.0	28.6	28.6	28.0	28.0	28.6
	8+	29.2	28.5	28.3	28.5	28.9	28.5	28.5	29.0	28.9	28.5	28.4	29.0
	Sum	28.2	27.7	27.8	27.9	26.8	27.9	28.0	25.5	26.8	27.9	27.9	25.5

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22 Missing Gear	Missing Quart.	Replacement by Area	Replacement by Gear	Replacement by Quart.	SUBDIVISION 24 Missing Gear	Missing Quart.	Replacement by Area	Replacement by Gear	Replacement by Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Trawl	4	24	Trawl	4	Gillnet	3, 4	24	Gillnet	2
Gillnet	2, 3, 4	24	Gillnet	2	Trapnet	2	24 (22)	Trapnet	1
Trapnet	3, 4	24	Trapnet	3	Trapnet	4	24	Trapnet	3

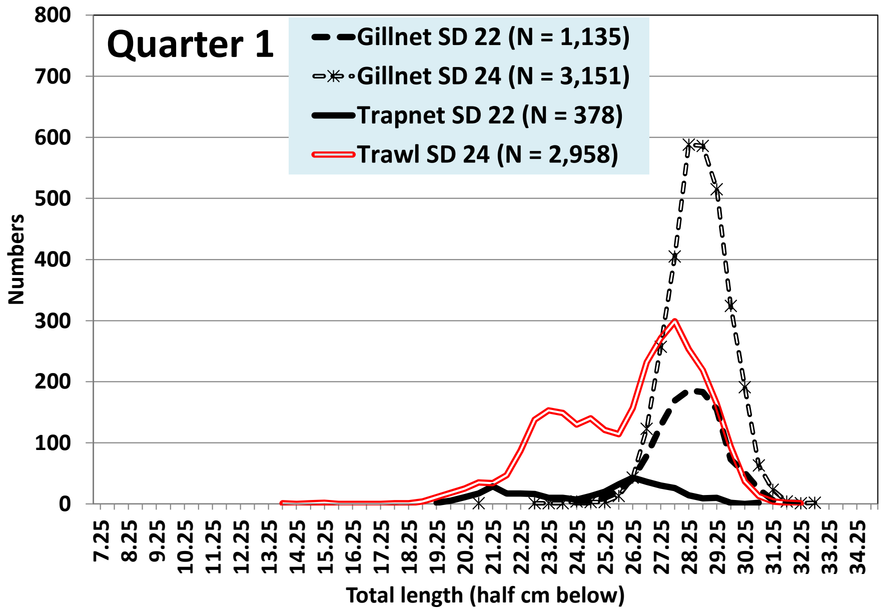
*sampled data of trapnet SD 22 Q1 (without landings!) finally used for trapnet SD 24 Q1

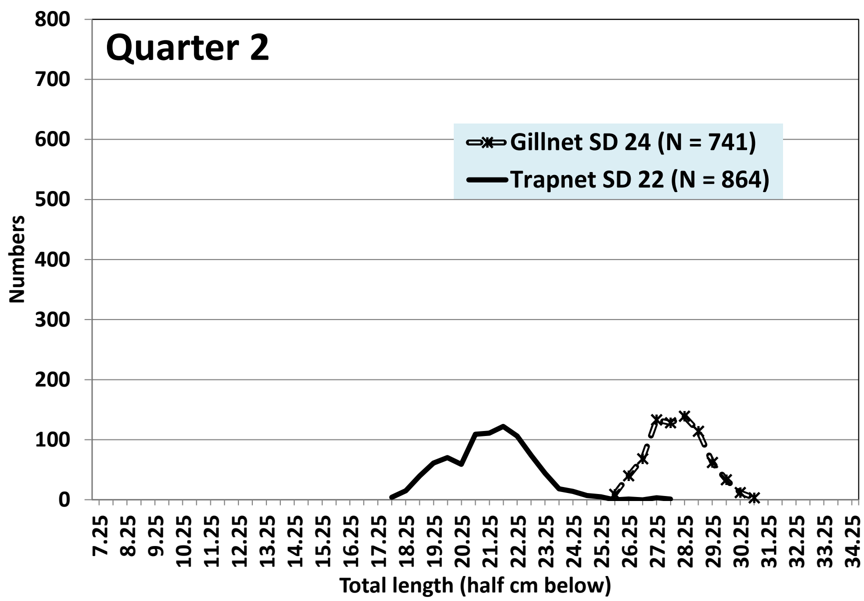
1.10.2 Subdivisions 25 and 29

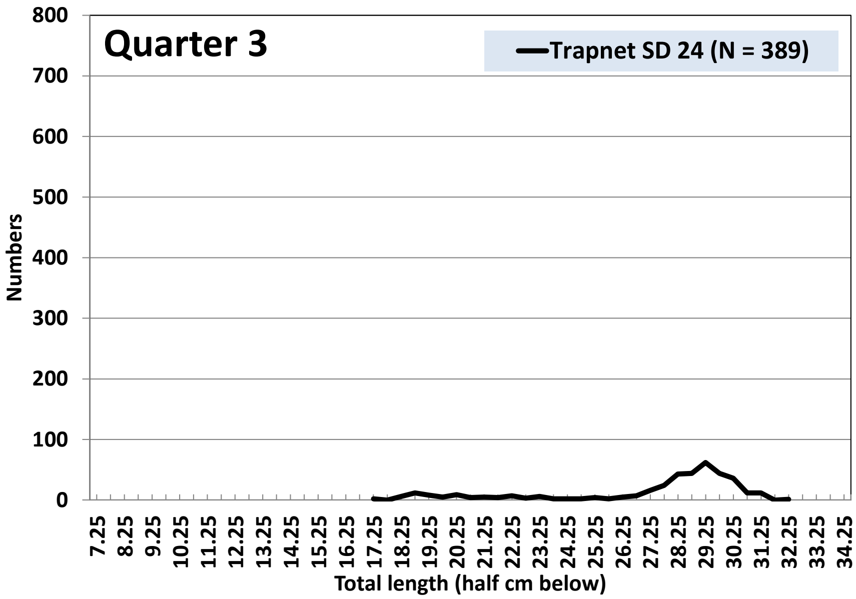
No sampling.

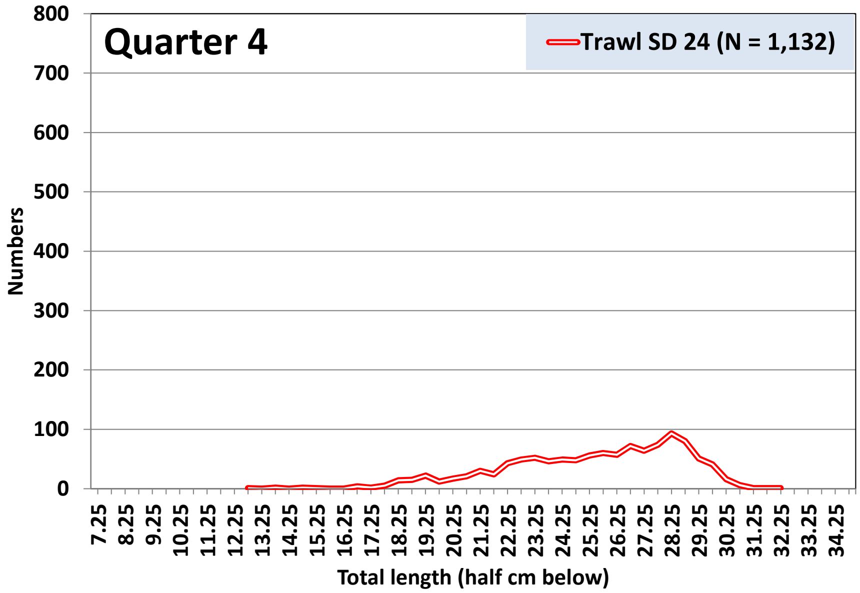
1.11 Sampled length distributions by Subdivision, quarter and type of gear

1.11.1 Subdivisions 22 and 24









1.11.2 Subdivisions 25 and 29

No sampling.

2 SPRAT

2.1 Fisheries

The provisional sprat **landings in Subdivisions 22-29 in 2020 reached** according to the
(a) share of the EU quota (2020: 13,133 t) and
(b) further transfer of quota (overall 3,851 t were transferred to other Baltic countries)

8,930 t,

which represents a final utilization of the overall 2020 quota of 9,282 t of 96 % (2019: 99 %).

As in previous years most sprat was

- landed in foreign ports (2020: 87 %; 2019: 89 %9,
- caught in the first quarter (2020: 54 %, 2019: 62 %),
- caught in Subdivisions 25-29 (2020: 99.8 %, 2019: 97 %)

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	0.050	5.327	2,449.598	373.029	0.000	1,409.549	543.278	4,775.454	99.9%	4,780.831	53.5%
	0.000	0.000	2,388.066	373.029	0.000	389.984	543.278	3,694.357	100.0%	3,694.357	47.4%
II	0.990	11.111	2,535.198	0.000	0.000	0.000	0.000	2,535.198	99.5%	2,547.299	28.5%
	0.000	11.111	2,481.996	-	-	-	-	2,481.996	99.6%	2,493.107	32.0%
III	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
IV	-	2.017	64.248	0.000	0.000	814.987	720.244	1,599.479	99.9%	1,601.496	17.9%
	-	0.000	64.248	0.000	0.000	814.987	720.244	1,599.479	100.0%	1,599.479	20.5%
Total	**1.040**	**18.455**	**5,049.044**	**373.029**	**-**	**2,224.536**	**1,263.522**	**8,910.131**	**99.8%**	**8,929.626**	100.0%
	-	-	4,934.310	373.029	-	1,204.971	1,263.522	7,775.832	99.9%	7,786.943	87.2%

		2020/2019	2020/2019
(shaded)	**Fraction of total landings (t) in foreign ports**	**62.9%**	**61.0%**
		59.7%	59.8%
	Proportion landed in foreign ports in 2020:		**87.2%**

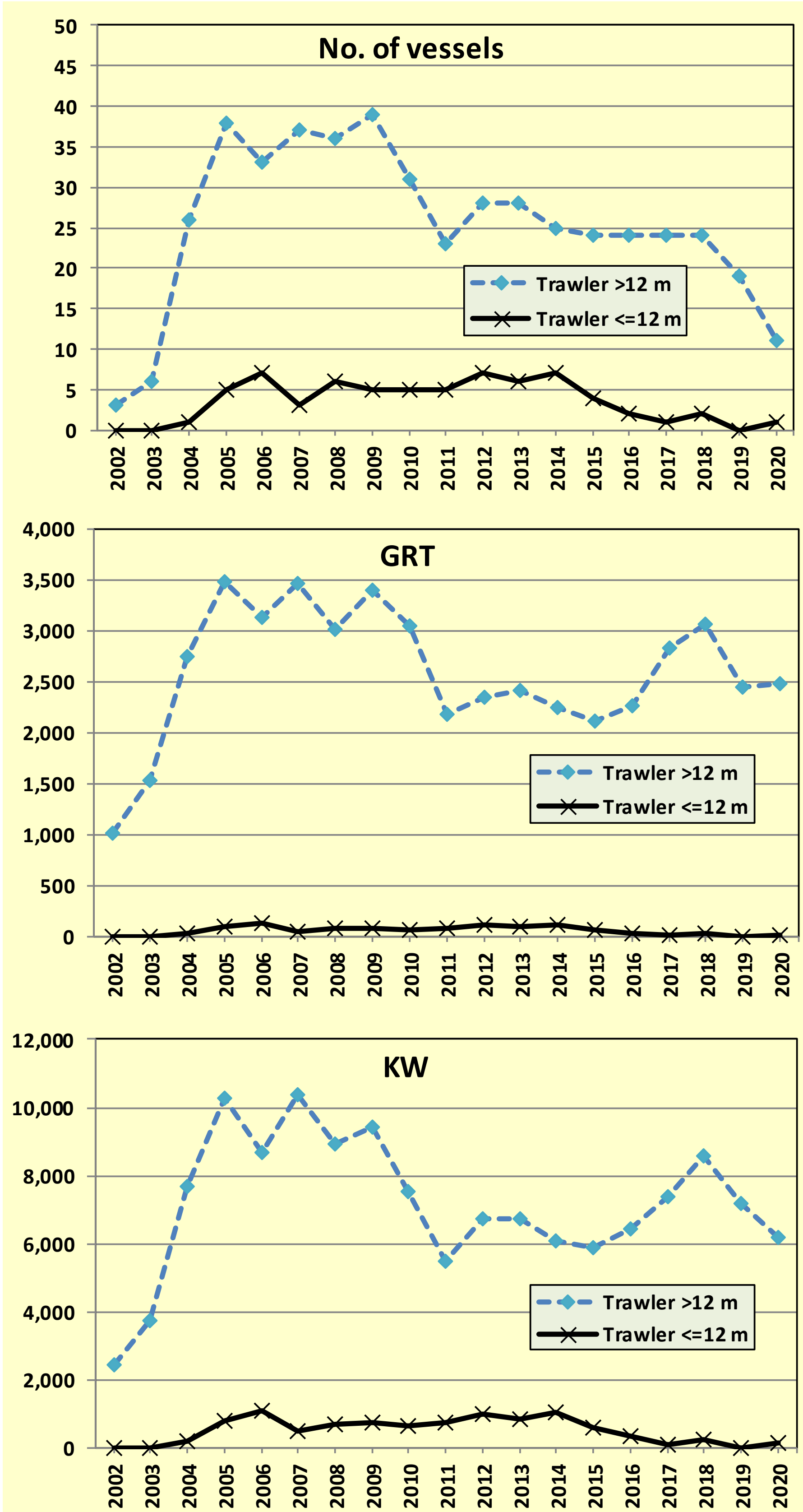
2.2 Fishing fleet

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 2002 – 2020 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
2002	<=12	0	0	0
	>12	3	1,009	2,434
2003	<=12	0	0	0
	>12	6	1,531	3,716
2004	<=12	1	24	220
	>12	26	2,750	7,682
2005	<=12	5	93	798
	>12	38	3,479	10,289
2006	<=12	7	123	1,090
	>12	33	3,134	8,685
2007	<=12	3	43	492
	>12	37	3,454	10,396
2008	<=12	6	72	679
	>12	36	3,014	8,913
2009	<=12	5	79	761
	>12	39	3,389	9,438
2010	<=12	5	69	664
	>12	31	3,041	7,525
2011	<=12	5	74	756
	>12	23	2,174	5,494
2012	<=12	7	107	1.007
	>12	28	2.345	6.727
2013	<=12	6	94	868
	>12	28	2,411	6,728
2014	<=12	7	112	1,019
	>12	25	2,241	6,070
2015	<=12	4	69	596
	>12	24	2,119	5,892
2016	<=12	2	37	345
	>12	24	2,254	6,424
2017	<=12	1	17	100
	>12	24	2,821	7,396
2018	<=12	2	32	246
	>12	24	3,052	8,560
2019	<=12	0	0	0
	>12	19	2,445	7,179
2020	<=12	1	16	143
	>12	11	2,476	6,166


No. of vessels
Trawler >12 m
Trawler <=12 m
GRT
Trawler >12 m
Trawler <=12 m
KW
Trawler >12 m
Trawler <=12 m

2.3 Species composition of landings

The results from the species composition of German trawl catches, which were sampled in **Subdivision 26 of quarter 1** in 2020, are given below:

SD 26/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February										
	Mean									
March	1	2.2	0.0	0.0	0.0	2.2	100.0	0.0	0.0	0.0
	Mean	2.2	0.0	0.0	0.0	2.2	100.0	0.0	0.0	0.0
Q I	Mean	2.2	0.0	0.0	0.0	2.2	100.0	0.0	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 28 of quarter 1** in 2020 are given below:

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	8.9	0.1	0.0	0.0	9.1	98.7	1.1	0.0	0.1
	Mean	8.9	0.1	0.0	0.0	9.1	98.7	1.1	0.0	0.1
February										
	Mean									
March										
	Mean									
Q I	Mean	8.9	0.1	0.0	0.0	9.1	98.7	1.1	0.0	0.1

The results from the species composition of German trawl catches, which were sampled in **Subdivision 29 of quarter 1** in 2020, are given below:

SD 29/Quartal 1		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	3.1	2.1	0.0	0.0	5.2	59.2	40.8	0.0	0.0
	Mean	3.1	2.1	0.0	0.0	5.2	59.2	40.8	0.0	0.0
March										
	Mean									
Q I	Mean	3.1	2.1	0.0	0.0	5.2	59.2	40.8	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 25 of quarter 2** in 2020, are given below:

SD 25/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
April	1	8.1	0.0	0.0	0.0	8.1	100.0	0.0	0.0	0.0
	Mean	8.1	0.0	0.0	0.0	8.1	100.0	0.0	0.0	0.0
May										
	Mean									
June										
	Mean									
Q II	Mean	8.1	0.0	0.0	0.0	8.1	100.0	0.0	0.0	0.0

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)
26	I	373	100.0	373	0
28	I	1,410	98.7	1,391	18
29	I	543	59.2	322	222
25	II	2,535	100.0	2,535	0

The overall difference amounted to -240 t, which would represent a change of the total landing value for Germany in 2020 of -3 % [total landings in SD 22-29 in 2020 of 8,930 t - 240 t ->8,690 t, 2019: -3 %, 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 2020. 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 2020 (almost no BMS landing have been reported in 2015 - 2018 and no discards/logbook registered discards have been reported before 2019).

2.5 Landings (tons) and sampling effort under Covid-19 conditions

Most of the sprat was landed in foreign ports in 2020 (87%) as in the years before (2019: 89 %, 2018: 90 %). As in the years before, it was then tried to get as many samples as possible in 2020. In contrast to the years before, where most of the landings were sampled (2019: 90 %, 2018: 93 %), it was in 2020 only possible to sample 55 % of the total landings (4,868 t out of 8,930 t). It is not clear whether the willingness of the fishermen to collect any sample was reduced due to COVID-19 or whether the reduced quota in 2020 (2020/2019 = -37 %, incl. transfer of quota: from 14,818 t (2019) to 9,282 t (2020) followed by reduced landings in 2020 (2020: 8,930 t, 2019; 14,645 t) lead to this reduction in sampling intensity.

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	0.050	0	0	0	5.327	2	117	89	2,449.598	0	0	0
	Q 2	0.990	0	0	0	11.111	0	0	0	2,535.198	1	226	42
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	2.017	2	85	56	64.248	0	0	0
	Total	1.040	0	0	0	18.455	4	202	145	5,049.044	1	226	42

* as by-catch in the herring trawl fishery

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	373.029	1	287	53	0.000	-	-	-	1,409.549	1	346	54
	Q 2	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	814.987	0	0	0
	Total	373.029	1	287	53	0.000	0	0	0	2,224.536	1	346	54

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	543.278	1	375	53	4,780.831	5	1,125	249
	Q 2	0.000	-	-	-	2,547.299	1	226	42
	Q 3	0.000	-	-	-	0.000	0	0	0
	Q 4	720.244	0	0	0	1,601.496	2	85	56
	Total	1,263.522	1	375	53	8,929.626	8	1,436	347

Fraction of landings in foreign ports:

[1]SD 22: 0 %
[2]SD 24: 0 %
[3]SD 25-29: 7,776 t (87 %)
[4]SD 22-29: 7,787 t (87 %)

2.6 Catch in numbers (millions)

TRAWL	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
0								0.029								
1					0.588			0.083		5.743			15.516			
2					0.086			0.035		68.226			6.645			
3					0.019			0.030		87.292			14.336			
4					0.065			0.002		50.538			5.970			
5										31.931			4.925			
6										15.850			1.012			
7																
8+																
Sum					0.758			0.179		259.580			48.404			

TRAWL	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
0																0.029
1					79.795				72.666				168.565	5.743		0.083
2					35.592				4.144				46.467	68.226		0.035
3					37.084				13.568				65.008	87.292		0.030
4					20.322				2.782				29.139	50.538		0.002
5					25.833				8.232				38.989	31.931		
6									5.053				6.065	15.850		
7																
8+																
Sum					198.626				106.445				354.233	259.580		0.179

*as by-catch in the herring trawl fishery

2.7 Mean weight in the catch (grams)

TRAWL	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
0								5.7								
1					5.4			12.1		3.2			3.4			
2					11.0			12.5		8.9			8.6			
3					14.7			12.7		9.9			9.5			
4					14.4			17.0		10.0			9.8			
5										10.8			11.3			
6										12.7			13.0			
7																
8+																
Sum					7.0			11.3		9.8			7.7			

TRAWL	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
0																5.7
1					3.0				2.9				3.0	3.2		12.1
2					9.0				8.0				8.8	8.9		12.5
3					9.5				9.3				9.4	9.9		12.7
4					10.6				11.3				10.5	10.0		17.0
5					11.0				10.7				11.0	10.8		
6									10.3				10.8	12.7		
7																
8+																
Sum					7.1				5.1				6.6	9.8		11.3

*as by-catch in the herring trawl fishery

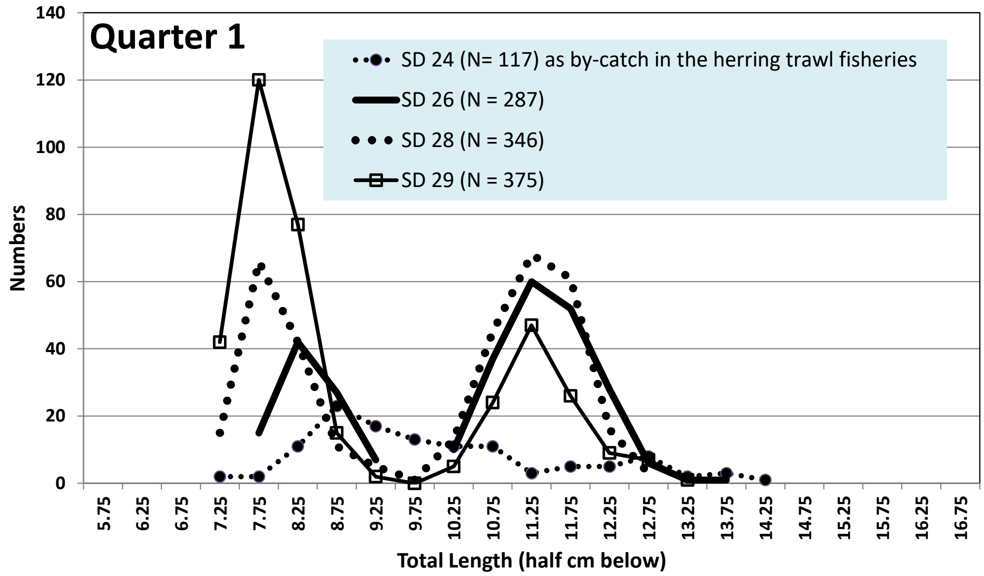
2.8 Mean length in the catch (cm)

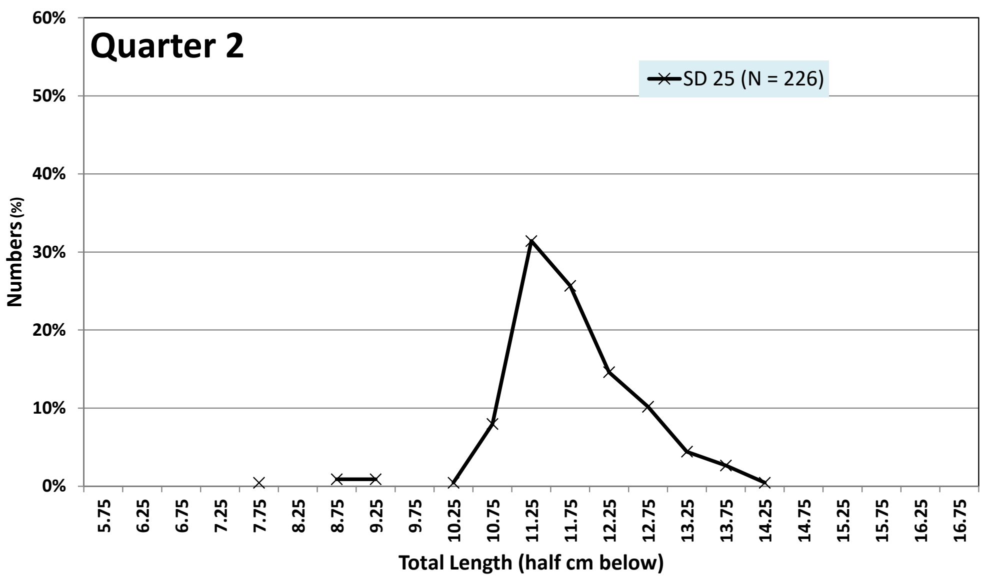
	SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION26			
Age	Q1	Q2	Q3	Q4	*Q1	Q2	Q3	*Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0								9.9								
1					9.3			12.2		8.8			8.4			
2					11.8			12.4		11.4			11.0			
3					13.3			12.4		11.8			11.4			
4					13.1			14.8		11.9			11.5			
5										12.1			12.2			
6										12.8			12.8			
7																
8+																
Sum					10.0			11.9		11.8			10.5			

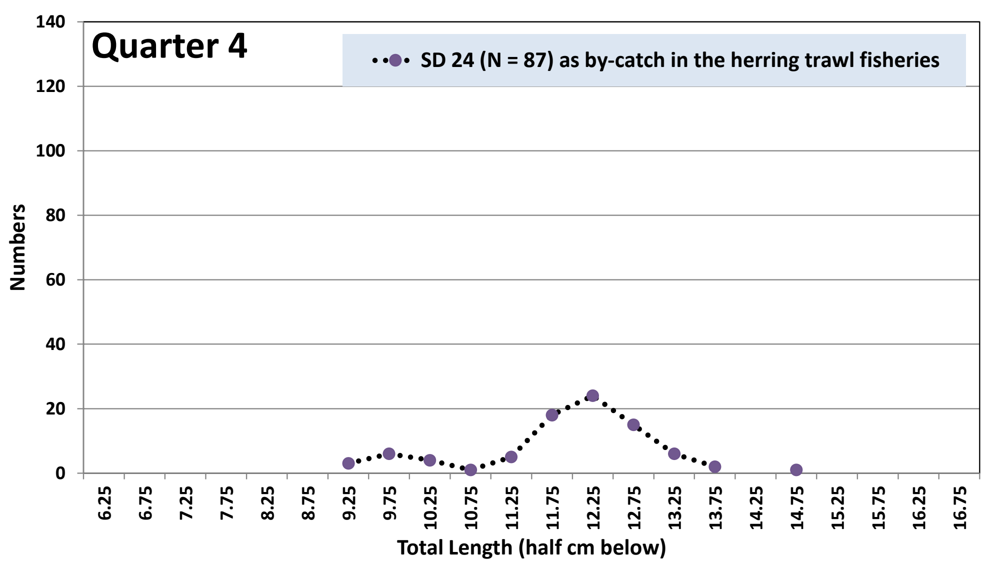
	SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0																9.9
1					8.0				7.9				8.0	8.8		12.2
2					10.9				10.6				10.9	11.4		12.4
3					11.1				11.2				11.2	11.8		12.4
4					11.7				12.1				11.7	11.9		14.8
5					11.9				11.8				11.9	12.1		
6									11.6				11.8	12.8		
7																
8+																
Sum					10.0				9.0				9.8	11.8		11.9

*as by-catch in the herring trawl fishery

2.9 Sampled length distributions of sprat by Subdivision and quarter







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 the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the year, ecoregion, species, and acronym of the relevant ICES expert group.

Name	Title
bzq.27.2628	Flounder (*Platichthys* spp.) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)
her.27.25-2932	Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)
her.27.28	Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)
her.27.3031	Herring (*Clupea harengus*) in Subdivisions 30 and 31 (Gulf of Bothnia)
ple.27.2123	Plaice in Subdivisions 21, 22, and 23 (Kattegat, Belt Sea, Sound)
sol.27.20-24	Sole in Division 3.a and subdivisions 22-24
spr.27.22-32	Sprat (*Sprattus sprattus*) in subdivisions 22–32 (Baltic Sea)

Annex 6: Audit reports

Audit of Sprat in subdivisions 27.22-32

Date: 20.04.2021
Auditor: Stefanie Haase, Szymon Smoliński

- Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment. The present assessment is based on new natural mortality (M from updated SMS for the period 1974-2018, M for 2019 assumed as in 2018, and M 2020 from regression of M2 vs cod≥20cm biomass) and updated reference points, introduced at the 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 including age-0 survey)
5) Data issues: Data provided as tables and figures in the sharepoint Report folder.
6) Consistency: The 2021 assessment is consistent with 2020 assessment and was accepted both years.
7) Stock status: The spawning-stock biomass (SSB) is above MSY Btrigger. The strong year class of 2014 is still visible in the stock. The 2019 and 2020 year classes are above long-term average. Fishing mortality (F) has remained above FMSY.
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.

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 Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea), bll.27.22-32

Date: 20.04.2021
Auditor: Anastasiia Karpushevskaia

General

There is no advice on fishing opportunities for this stock. Information on stock status only has been provided in the document.

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 described well and following the Stock Annex
5) Consistency: *n/a*
6) Stock status: Stable index with low fluctuations were observed between 2007 and 2017. Since 2018 the index increased, but decreased in 2020
7) Management Plan: No agreed management plan for this 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?
  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?
  Yes

Audit of tur.27.22-32 (Turbot in SD 22-32)

Date: 20 April 2020
Auditor: Jari Raitaniemi, Uwe Krumme

General

Stock Annex was not available during the audit.

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: trends. Commercial landings and survey data from Baltic International Trawl Survey (BITS – Q1 G2916, and BITS-Q4 G8863).
3) Forecast: not presented
4) Assessment model: Data-limited approach, length-based indicator
5) Data issues: CANUM and WECA 2014–2020 in Intercatch, biological parameters in DATRAS
6) Consistency: No advice requested by ICES
7) Stock status: Stock status below possible reference points
8) Management Plan: The EU multiannual plan for the Baltic Sea (MAP; EU, 2016) takes bycatch of this species into account.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

Discards in the report are assessed with accurate numbers, but in the advice they could not be quantified. In the report, the uncertainty could be expressed, too, though possibly estimating the discards.

Figure 1 (left) in the Advice sheet provides a time series back to 1970 while Fig. 1 (right) starts at 2000. This is fine but an explanation why Table 4 also starts only at 2000 could be useful.

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?
  N/A
- Is there any **major** reason to deviate from the standard procedure for this stock?
- No
- Does the update assessment give a valid basis for advice?
  Yes (If not, suggested what other basis should be sought for the advice?)

Audit of Plaice (*Pleuronectes platessa*) in subdivisions 24-32 (Baltic Sea, excluding Sound and Belt Sea), ple.27.24-32

Date: 20.04.2021

Auditor: Anastasiia Karpushevskaia, Maris Pliksh

General

For single stock summary sheet advice:

1) Assessment type: Age-based analytical/update
2) Assessment: SAM and additionally the surplus production model (SPiCT)
3) Forecast: Not presented
4) Assessment model: SAM
5) Data issues: The data are available as described in Stock Annex
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 recruitment (age 1) in 2020 had the highest historical value. The relative fishing mortality has been declining in the recent years, it had the lowest value in 2020
8) Management Plan: There is no management plan for this stock

General comments

This was a well-documented, well ordered and considered section

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?
  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 FLE2223

Date: 20.04.2021
Auditor: Julita Gutkowska

General

No remarks

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: trends
3) Forecast: not presented
4) Assessment model: NA
5) Data issues: There is no data issue.
6) Consistency: NA
7) Stock status: The length-based indicators are suggesting a good status of the stock.
8) Management Plan: There is 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

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 Flounder in subdivisions 27.24-25

Date 19.04.2020
Reviewer: Tiit Raid, Uwe Krumme

General

There is no advice on fishing opportunities requested for this stock. Information on stock status and occurrence of new species ("Baltic flounder") has been provided in the document.

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: Trends-based assessment, based on survey data from the Baltic International Trawl Survey (BITS – Q1, G2916) and Q4, G8863) and data from commercial catch samplings.
3) Forecast: not presented since ICES has not been requested to provide fishing opportunities for this stock.
4) Assessment model: A length-based indicator method (LBI) using catch data from commercial samplings and abundance estimates from BITS Q1 and Q4 to assess the stock status.
5) Data issues: Sampling coverage of discards differs between years and subdivisions. Compared to the previous year, some additional uncertainty in the evaluation of the stock status may come from: 1) slightly reduced biological sampling coverage due to the Covid-19 pandemic; 2) the bycatch quota for Eastern Baltic cod in 2020 reduced the fishing effort and also affected the fishing patterns on flounder and, in addition to Covid-19, negatively affected the biological sampling. and in 2020 was slightly worse than those obtained in 2018-2019. However, the level of length sampling from the fishery looks adequate to provide a reliable length-based indicator of flounder exploitation. Moreover, the background of the abnormally high landings of flounder by pelagic trawlers from SD25 could not be clarified by Poland, neither in the weeks before nor during WGBFAS. All data are made available to WGBFAS and the information is corresponding to Stock Annex.
6) Consistency: n/a
7) Stock status: F 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

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

For update assessments

- Have the data been used as specified in the stock annex?

  Yes

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

  Yes

- Is there any **major** reason to deviate from the standard procedure for this stock?

  No

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

  NA

Audit of dab in SD 22-32 (dab.27.2-32)

Date: 19.04.2021
Auditor: S. Haase

General

Information on stock status and historical trends have been provided.

For single stock summary sheet advice:

1) Assessment type: stock status update
2) Assessment: Survey trend-based assessment (biomass index)
3) Forecast: not presented since ICES has only been requested to provide stock status but not fishing opportunities for this stock.
4) Assessment model: NA
5) Data issues: Stock size indicator uncertain because mixing with dab in SD21 is unclear but significant seasonal movements are known
6) Consistency: NA
7) Stock status: Length based indicators (LBI) as developed by WKLIFE (2015) indicate that large dabs are still missing from the stock (P_{mega}=0.25, expected >0.3). In the most recent year overfishing of immature individuals is indicated (L_c/L_{mat}=0.58, 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?
  Yes.

Audit of Cod (*Gadus morhua*) in Subdivision 21 (Kattegat) cod.27.21

Date: 22.04.2021
Auditor: Margit Eero, Maris Plikshs

General

For single stock summary sheet advice:

9) Assessment type: update/SALY.
1) Assessment: trends
2) Forecast: not performed.
3) Assessment model: state-space assessment model (SAM), considered indicative of trends only, plus 4 surveys.
4) Data issues: assessment performed according to Stock Annex. No issues raised. Some errors in past survey indices were recognised and corrected in this year's assessment. Therefore, some survey indices for IBTS 1st Q, IBTS 3rd Q and BITS 4th Q, used in this year's assessment differ from those used in last year's assessment. A mistake in CODS-4Q survey data in 2020 assessment was also corrected. These corrections had minor impacts on assessment results.
5) Consistency: Same procedure as last year. Results consistant with pevious year's assessment.
6) Stock status: Ref points are not defined for this stock. SSB is last two years is at a lowest level on record, and it would be at or below possible Blim.
7) Management Plan: NA for this stock.

General comments

The assessment was performed correctly according to Stock Annex.

Technical comments

A few technical issues in the report were discovered during audit:

Report Table 2.2.2. Discards in 2020, the last colums is supposed to be in tons, thus the value 474 in this column is incorrect (corresponds to numbers).

Report Table 2.2.8. There is a discrepancy in annual stock weights presented in this table and those actually used in the assessment (from stockassessment.org) since 2014. Seems like some year's data have got misplaced.

Report Table 2.2.9. There is a discrepancy in annual maturity at age presented in this table and those actually used in the assessment (from stockassessment.org) since 2012 (visible especially for age 2-3). Seems like some year's data have got misplaced.

All these issues were corrected when finalizing the report.

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 bwp.27.2729-32 (Baltic flounder in SD 2729-32)

Date: 20 April 2021
Auditor: Jari Raitaniemi

General

ICES has not been requested to provide advice on fishing opportunities for this stock for 2022.

Two flounder species occur in the Baltic Sea, European flounder P. flesus and Baltic flounder P. solemdali. The predominant flounder species in this area is the Baltic flounder, however mixing occurs between these two species in the catches. The species can be identified with genetic methods or gamete physiology, but not from appearance.

For single stock summary sheet advice:

10) Assessment type: update
1) Assessment: trends
2) Forecast: presented
3) Assessment model: Length based indicator
4) Data issues: Commercial landings and survey data from Estonian Marine Institute in the Muuga Bay (SD 32) and Küdema Bay (SD 29) (N2197), and from Swedish University of Agricultural Sciences in Muskö (SD 27) and Kvädöfjärden (SD 27) (N1147).
5) Consistency No advice requested.
6) Stock status: Fishing pressure is below the FMSY proxy reference point, and no reference points for stocks size have been defined for this stock.
7) Management Plan: Bycatch of this species is taken into account in the EU Multiannual Plan for the Baltic Sea (EU, 2016).

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

*In the report, at the end of the introductory part of chapter 3.5., a bit of editing needed: "*However, based on work done by Momigliano *et al.*, (2019) and INSPIRE BONUS project, if is plausible to assume…"

3.5.1.3 "…majority of this is ought to be flounder."

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes – stock status advice
- 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?
  There is 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?
  Length-based indicator, yes.
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of Plaice in subdivisions 27.21-23

Date: 20.04.2021

Auditor: Jan Horbowy, Victoria Amosova

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment.

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: analytical
3) Forecast: presented, based on MSY
4) Assessment model: Age-based analytical assessment with SAM; for tuning two combined surveys indices have been used, both combine Baltic and NS surveys in 1st and 3rd - 4th quarter
5) Data issues: as in 2020 the 2019 combined survey index from 3rd&4th quarter was excluded when tuning the model; that was accepted in 2020 at ADG, these survey indices were low due to some environmental reasons. Data available for the assessment were: Commercial catches; two combined survey indices (NS-IBTSQ1 [G1022] and BITS–Q1 [G2916], NS-IBTSQ3 [G2829] and BITS–Q4 [G8863]); mean maturity data for the modelled period (Q1 surveys); natural mortalities are fixed and assumed to be 0.1 except for age 1, which has 0.2.
6) Consistency: The quality of the assessment has improved in 2021. The 2021 assessment is relatively consistent with 2020 assessment and was accepted.
7) Stock status: The spawning-stock biomass (SSB) is well above all biomass reference points. The year class 2019 is estimated very strong. Fishing mortality (F) declined below F_{MSY} in 2020.
8) Management Plan: The EU Multiannual Plan for the Baltic Sea (EU, 2016) takes bycatch of this species into account. ICES is not aware of any agreed precautionary management plan for plaice insubdivision 21.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No specific comments. The assessment and forecast have been done following procedure agreed at benchmark in 2015 and updated in 2019.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any major reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of (sol.27.20-24)

Date: 23.04.2021
Auditor: Kristiina Hommik and Zuzanna Mirny

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

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.
   Commercial catches (international landings, ages and length frequencies from catch sampling), one survey index (Fishermen–DTU Aqua sole survey, 2004–2020, G4052), two commercial indices: (private logbook gillnetters (1994–2007), private logbook 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. In 2020 landings from the Belts and the Skagerrak were not succesfully sampled. Since the discards are insignificant and constant over time seies, they were not included in the assessment.
6) Consistency: The assessment of recent years including the 2020 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. Following the ACOM decision in 2020, the basis for F_{pa} have been deciced to be based on $F_{p.05}$. This has caused F_{MSY} to change from 0.23 (capped previously by F_{pa}) to the F_{MSY} estimate derived from stochastic equilibrium scenarios at 0.26 (interbencmark in 2015). F_{lower} was not recalculated since the F_{MSY} remain the uncapped value estimated in 2015 interbencmark.

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 Gulf of Riga Herring

Date: 26.04.2021

Auditor: Olavi Kaljuste and Tomas Zolubas

General

The assessment have been conducted according to the stock annex as an update assessment. Data is available and seems correct as do the reflections of the data in the report (figures and tables).

The assessment could benefit to be changed to a stochastic assessment avoiding to rely so precisely on catch at age for this stock that mix with adjacent herring stocks.

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: analytical (category 1)
3) Forecast: presented
4) Assessment model: XSA – tuning by 1 commercial CPUE (trapnet) + 1 acoustic survey indices
5) Data issues: Data available in data folder of SharePoint, SPALY done in accordance of stock annex.
6) Consistency: The assessment is consistent with last years 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.

There was a couple of smaller mistakes in the report which have been corrected.

Stock annex was updated according to suggestions.

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 Herring in the Gulf of Bothnia (her.27.3031)

Date: 28.04.2021
Auditors: T. Gröhsler, I. Putnis

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted as an update assessment following the benchmark in early 2021, where the assessment type was updated to category 1. The stock was temporarily downgraded to category 5 before. The main features of the stock as change in age composition, in growth and in maturity are well captured by the Stock Synthesis model now applied as assessment model to this stock.

For single stock summary sheet advice:

1) Assessment type: in 2021 again category 1 after temporarily downgraded to category 5,: update assessment during WGBFAS 2021
2) Assessment: age-based analytical and fully stochastic model analytical
3) Forecast: presented
4) Assessment model: Stock Synthesis (SS3) – fitted to 2 abundance indices (one acoustic survey 2007-2020 and one commercial trapnet survey)
5) Data issues: the stock was benchmarked in early 2021, where reference points were revised. Retrospective patterns were improved compared to the previous assessment. F_{pa} changed during the meeting of WGBFAS as recommended by ACOM by changing the basis, which now is $F_{P.05}$
6) Consistency : in early 2021 upgraded to category 1, before that category 5
7) Stock status: fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa , and Blim. SSB is decreasing since 2012.
8) Management Plan: EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016).

General comments:

The report was well documented, describing the SS3 assessment in a clear way.

Technical comments:

No specific comments.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of Her.27.25-2932

Dates: 1) 19-04-2021 2) 29-4-2021

Auditors: 1) Francesca Vitale 2) Jukka Pönni

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment. The present assessment is based on new natural mortality (M from updated SMS for the period 1974-2018, M for 2019 assumed as in 2018, and M 2020 from with eastern Baltic cod biomass of individuals ≥20cm biomass and updated reference points, introduced at the interbenchmark in March 2020.

For single stock summary sheet advice:

1) Assessment type: update
2) Assessment: analytical
3) Forecast: presented
4) Assessment model: XSA + tuning with one acoustic survey index (BIAS A1588)
5) Data issues: The data, as described in stock annex, were uploaded by national laboratories and aggregated into international data in ICES InterCatch database.
6) Consistency: The 2021 assessment is consistent with 2020 assessment and was accepted both years.
7) Stock status: B< MSY $B_{trigger}$ and B_{pa}< B <B_{lim}. since 2020, F>F_{MSY} and Flim<F<Fpa, R is below the average recruitment of age 1 of the whole time series
8) Management Plan: This stock is shared between the EU and Russia. An EU multiannual plan (MAP) in place for stocks in the Baltic Sea includes herring (EU, 2016, 2019). The advice, based on the FMSY ranges used in the management plan, is considered precautionary. Russia does not have a management plan for this stock.

General comments

The report was well documented, describing the assessment in a clear way.

Technical comments

No specific comments

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any major reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of Flounder in subdivisions 27.26-28

Date: 05.05.2021
Auditor: Ivars Putnis, Inna Trufanova

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex.

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–Q4) and commercial landings. 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
6) Consistency: n/a
7) Stock status: The survey stock size indicator indicates that the stock abundance is estimated to have increased between 2016–2018 (average of the three years) and 2019–2020 (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 the 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 were some minor mistakes in the report. We have sent our comments and suggestions 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 cod.27.2432

Date: 20-04-2021
Auditor: Elliot Brown and Marie Storr-Paulsen

General

- Sensitivity analysis increased errors around catch data to see how the model responded under the current low sample sizes from catch data. The model appears robust to low data from catches.
- Generally the model underestimates the number at length for intermediate lengths in the catches (both active and passive gears)
  - Could be because of fit to broader size ranges outside of fishery but included in survey.
- Backup model (SPICT) investigated and confirms the SS model's findings.

For single stock summary sheet advice:

1) Assessment type: same as last year
2) Assessment: stock synthesis model, length and quarter
3) Forecast: presented
4) Assessment model: Stock Synthesis Model (checked against a SPICT model as informal validation)
5) Data issues:
   a. Catch Data, Poor data due to regulatory limitations on the stock (Cod ban)
      i. Low sample sizes for length frequency data but still matches.
   b. Some doubts about the validity of the reported landings across other stocks.
   c. Catch for 2021 assumed to be TAC
   d. Biological data remains within previous observed relationships.
   e. Survey based biomass from Q1 and Q4
6) Consistency:
   a. Assessment results aligned with previousl years (retros fit reasonably well).
7) Stock status: SSB<Blim continues, F/FMSY remains high due to poor productivity of the stock. No scope for exploitation. Recruitment continues to be low, although the 2020 and intermediate year (2021) values are higher because they are based on an average over a longer time series.
8) Management Plan:
   This stock is shared between the EU and Russia. An EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016, 2019,) but FMSY ranges are not available for this stock. Russia does not have a management plan for this stock.

General comments

This presentation of this assessment was comprehensive and thorough, in spite of data limitations. Alternative assessment methods were appropriately employed to validate results from the methods described in the annex.

Technical comments

There are some concerns about catches reported as other species, in other fleets, from cod producing areas that may represent cod catches that are not included in this assessment. However, there is no way for WGBFAS members to explore these catches in any more detail.

Conclusions

The assessment has been performed correctly. The outcome can be used for basis of advice

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?
  Although there is a management plan FMSY ranges are not available 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?
  Yes

Annex 7: Revised Fishing Mortality reference points for Gulf of Bothnia herring her.27.30-31

During the ADGBS 2021 review stage an issue was identified with the reference points for the Gulf of Bothnia herring. According to the ICES guidelines for estimating reference points for category 5 and 6 stocks "where constant recruitment appears to be an appropriate model, this should be replaced by segmented regression relationships with the lowest observed SSB as the forced change point (ICES, 2021a and ICES, 2017). In the WKCLUB 2021 report (ICES, 2021b) it is stated that "The S–R relationship selected was a hockey-stick with the breakpoint set at B_{pa} (equal to B_{loss})" however, it transpired that the break-point had been set to B_{lim} = 376 571 t as can be seen in Figure 2 (Annex 2).

This was discussed with the experts and the ACOM leadership and it was decided to follow ICES guidelines noting that these may not be consistent with how reference points are set for other stocks. For category 5 and 6 stocks where there is no clear pattern in the stock and recruit relationship it is arguable more precautionary to fix the SSB breakpoint within the observed range of observations.

The revised Stock-Recruitment plot is shown in Figure 1 with the breakpoint at B_{loss} = B_{pa} = MSY $B_{trigger}$ = 533 515 t. The results of the Eqsim analysis are shown in Figure 2. The F_{p05} value is very close to F_{MSY} with a median long term MSY catch around 100kT. The new fishing mortality reference points are provided in Table 1. The F_{MSY} is reduced from 0.384 to 0.271.

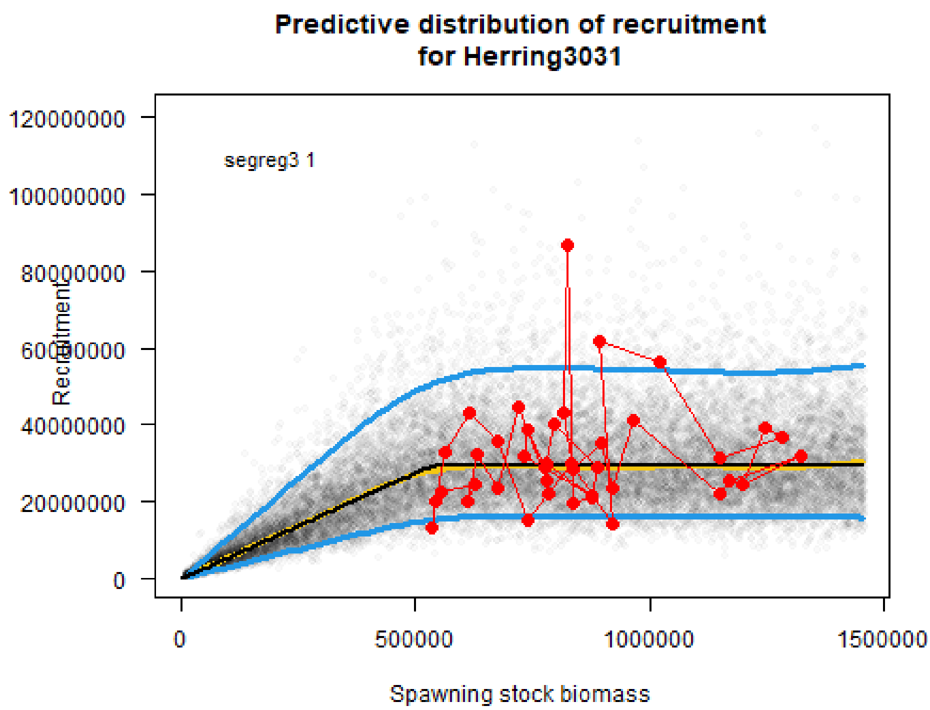


Figure 1. Stock–recruitment relationship (i.e. segmented regression with breakpoint at B_{pa}) for Herring in subdivisions 30 and 31 (her.27.30-31) used in the EqSim simulations for the estimation of the F_{MSY} reference points.

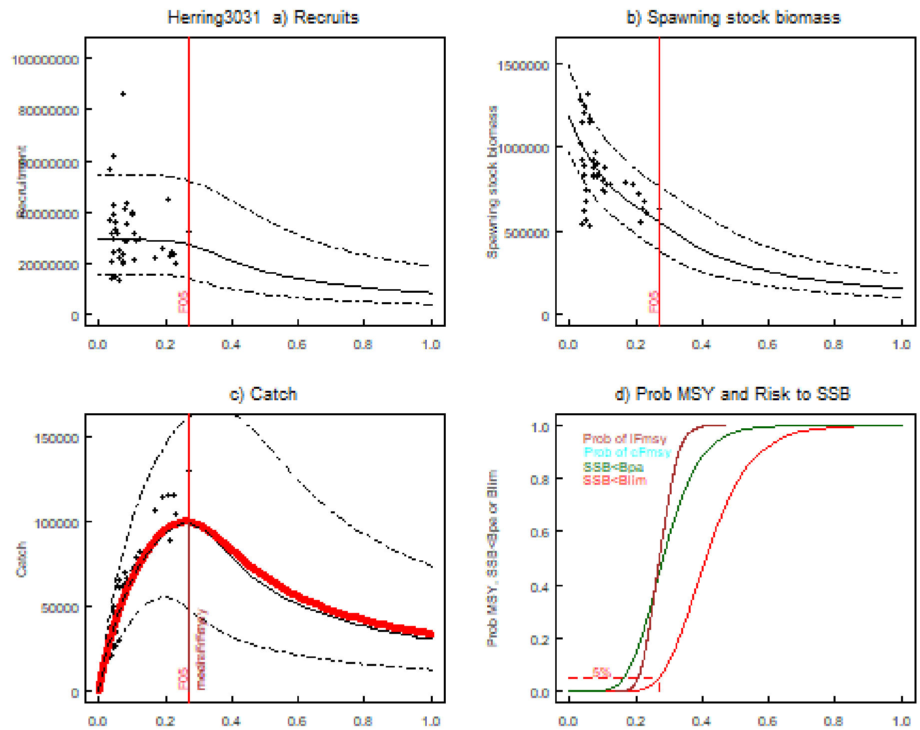


Figure 2. EqSim results for Herring in subdivisions 30 and 31 (her.27.30-31) with $B_{trigger}$.

Table 1. Revised fishing mortality reference points for Herring in subdivisions 30 and 31 (her.27.30-31).

Reference Point	Value
F_{MSY}	0.271
F_{p05}	0.272
F_{pa}	0.272
F_{lower}	0.206
F_{upper}	0.272
F_{lim}	0.290

References:

ICES 2017. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. In ICES in ICES Advice 2017, Book 12. Section 12.4.3.1, DOI: https://doi.org/10.17895/ices.pub.3036.

ICES. 2021a. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.4.3.1. https://doi.org/10.17895/ices.advice.7891.

ICES. 2021b. Benchmark Workshop on herring (*Clupea harengus*) in the Gulf of Bothnia (WKCLuB 2021). ICES Scientific Reports. 3:9. 110 pp. http://doi.org/10.17895/ices.pub.5989

The R Code is available at:

https://community.ices.dk/ExpertGroups/WGBFAS/2021%20Meeting%20Documents/06.%20Data/her.27.3031/MSY_GOB%20herring_new_type6.r

The Input data are available at:

https://community.ices.dk/ExpertGroups/WGBFAS/2021%20Meeting%20Documents/06.%20Data/her.27.3031/stk.rdata