REPORT ON EASTERN BALTIC COD BYCATCH IN NON-TARGETED FISHERIES, MIXING WITH WESTERN BALTIC COD IN SD24, AND STOCK SITUATION IN SDS 27-32

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Contents

i Summary

1. Bycatch of Eastern Baltic cod in non-targeted fisheries

1a.Total cod bycatch in 2018 was in the range of 360-1306 *tonnes in subdivisions 25-32 (eastern stock) and 66-417* tonnes in subdivision 24 (eastern and western stock combined). The ranges correspond to different bycatch thresholds from 10 to 50% cod in the landings in a fishing trip. These cod bycatch amounts correspond to fishing patterns in 2018 when cod was a target species, and fishers did not attempt to avoid catching cod.

1b. Bycatch of cod in demersal trawl fisheries for flatfish could be substantially reduced when applying selectivity devices in fishing gear. Three selectivity strategies are possible: i) species specific size selection, ii) selection by behavioural differences of the species and iii) a strategy that combines i and ii. Strategy i can be efficient to reduce bycatch of small but not larger cod, while strategies ii and iii can be applied to minimise bycatches of cod at all sizes in targeted flatfish fisheries.

1c. Cod and flounder overlap in the entire distribution area of the eastern Baltic cod stock; plaice and eastern Baltic cod overlap in subdivisions 24-25. Therefore, there are no areas or months where flatfish fisheries with non-selective gears could be conducted in subdivisions 24-26 without a risk of bycatch of cod. Only a small fraction of EU flatfish landings were taken in subdivision 26 in later years (6% of flounder landings in 2018). Therefore, a potential closure of subdivision 26 for demersal fisheries would have limited implications for EU flatfish fisheries, while protecting a substantial part of the eastern Baltic cod stock.

2. Mixing of eastern and western Baltic cod in subdivision 24

2a Eastern Baltic cod (EBC) occurs throughout subdivision 24 and in all seasons. However, the proportion of EBC is lowest: (i) in the area west of 13°E (on average 47% EBC in last 11 years), compared to the area east of 13°E (on average 78% EBC) and (ii) in waters between 0-10m or 0-20m deep (on average 27% or 39% EBC, respectively). The latter is assumed not to include the coastal waters around Bornholm Island. The proportion of eastern Baltic cod is lower in fisheries by passive gears due to their use mostly in shallow areas.

2b. Bycatch of eastern Baltic cod in fisheries targeting western Baltic cod can be calculated by multiplying the TAC for the management area with the fraction of it taken in subdivision 24 (0.53 in the last 3 years) and the proportion of cod in subdivision 24 that belongs to the eastern stock (0.74 in the last 3 years). The additional fishing restrictions applied in 2020 in subdivision 24 are expected to reduce the fraction of the cod TAC taken in subdivision 24, and thus reduce the bycatch of eastern Baltic cod.

2c. A closure of subdivision 24 could result in up to 25% loss of western Baltic cod commercial landings, at the fishing patterns observed in latest years. It is difficult to foresee to what extent effort reallocation to subdivisions 22-23 would be possible for different fleets. The cod TAC at 3806 tonnes set for the western Baltic management area for 2020 is close to the amount that has been taken in subdivisions 22-23 in later years. Thus, the TAC at 3806 tonnes would likely be possible to take in subdivisions 22-23.

* Modified following reviewers' comments

Cod in subdivisions 27-32

3a. Eastern Baltic cod annual catches in subdivisions 27-32 were between 150-400 tonnes in 2010-2018, with the exception of 2017 (883 tonnes). This corresponds to less than 1% of the total catch from the eastern Baltic cod stock in these years, with the exception of 3% in 2017. Most catches within this area were taken in subdivisions 27-29, both by active (trawls) and passive (gillnets) gears.

3b. Fishing at status quo effort in subdivisions 27-32, corresponding to total cod catch of 168 tonnes in 2020, is estimated to result in 0.08 % lower SSB in 2021 compared to the scenario of zero catch.

3c. Potential effort reallocation to subdivisions 27-32 could result in removing up to 3% of the total biomass of the eastern Baltic cod stock.

Background

The spawning-stock biomass (SSB) of the eastern Baltic cod has been declining since 2015 and is estimated to have been below Blim in the last two years. The biomass of commercial sized cod (≥ 35 cm) is presently at the lowest level observed since the 1950s. Fishing mortality (F) has declined since 2012. The fishing mortality estimated for 2018 is the lowest on record, and substantially lower than the estimated natural mortality. Recruitment has been declining since 2012, and the recruitment in 2017 is estimated to be the lowest 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. Growth, condition (weight at length), and size at maturation have substantially declined. The size of the largest fish in the population has shown a decline since 1990. 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. (ICES 2019a, b).

At the present low productivity, the stock is estimated to remain below Blim in the medium term (2024), even with no fishing. Furthermore, fishing at any level will target the remaining few commercial sized (≥ 35 cm) cod, thereby further deteriorating the stock structure and reducing its reproductive potential. ICES advised that when the precautionary approach is applied, there should be zero catch from the stock in 2020 (ICES 2019b).

Cod has so far been both targeted and taken as a bycatch in fisheries in subdivisions 24–32. The eastern Baltic cod stock is mainly distributed and caught in the eastern Baltic cod management area (SDs 25–32), but it is also distributed and caught mixed with western Baltic cod in SD 24; which is part of the western Baltic management area (SDs 22–24). Cod has generally been caught together with flatfishes in a mixed fisheries, and may occur as bycatch in fisheries targeting other species.

Request to ICES

1. ICES is requested to estimate the levels of unavoidable bycatches of eastern Baltic cod in fisheries not targeting eastern Baltic cod (such as e.g. pelagic fisheries, flatfish fisheries, small-scale coastal fisheries when not targeting cod, and fisheries targeting western Baltic cod in subdivision 24), where possible broken down by fishery and Member State, respectively in subdivisions 25-32 and subdivision 24. In that respect, ICES is requested to establish different scenarios and estimate their respective effect on the level of unavoidable bycatches: a baseline scenario which assumes unchanged fishing patterns in terms of effort and behaviour in fisheries not targeting eastern Baltic cod; at least one, but preferably several, other scenarios in which bycatches are reduced by e.g. using more selective gears and/or closures. Such scenarios would be particularly important for demersal flatfish fisheries, which traditionally have been mixed fisheries of flatfish and cod.
2. ICES is requested to provide more details on the geographical distribution within subdivision 24 of the western and the eastern Baltic cod stock. For example:

- Are there areas or time periods where eastern Baltic cod stock are more abundant which might be suitable for closure to minimize catches. What would be the impact of such closures on the western Baltic cod catches.

3. ICES is requested to

- provide data about eastern Baltic cod catches in subdivisions 27-32, where possible by subdivision and fishery.
- quantify the effect on the biomass of the eastern Baltic cod stock if the fishing effort in subdivisions 27-32, ideally broken down by subdivision, remained at status quo levels.
- quantify the impact on the biomass of the eastern stock of a potential effort reallocation to subdivisions 27-32 in case fisheries for the eastern Baltic cod were closed in subdivisions 24-26 but remained open in subdivisions 27-32.

1 Bycatch of eastern Baltic cod in fisheries not targeting cod

1.1 Baseline scenario corresponding to fishing patterns in 2018

Data

A data call was sent out to all EU countries fishing in the Baltic Sea, requesting data on landings of all species from all gears in subdivisions 24-32 in 2018 by haul, to get the highest resolution possible. All EU countries provided the data. Russian data are not included in the analyses.

Some countries were not able to provide data by haul and provided data by trip instead. In addition, some countries could not identify trips for small vessels not carrying logbooks. For those vessels, data were provided by vessel, month, ICES rectangle, landing location and métier. The analysis was therefore conducted on trip level for all countries, with the exception of the vessels without logbooks for which the combination of vessel, month, rectangle, landing location and métier had to be used instead.

It is important to note that the analyses presented here are based on landings and not on total catches. This is because discards estimates were not available at the aggregation level needed for the analysis presented in this report. Additionally it should be noted that the values of cod landings reported for SD24 are a combination of eastern and western Baltic stock, which are not possible to separate in the analyses presented in this section. For information on mixing of eastern and western cod stocks in SD24, see Section 2.

Methods

When is cod a bycatch?

The main challenge for calculating bycatch of cod in "non-targeted fisheries" is to define precisely what "non-cod targeting fisheries" are. In some cases, the target species group can be defined based on gear and mesh size (described in the métier), e.g. the pelagic fisheries for sprat and herring. However, flatfish species are usually caught with the same gears and mesh sizes that are used for targeting cod. This is especially the case for the demersal trawl fishery, where cod and flatfish were frequently targeted together in a mixed fishery in 2018.

A common way to deal with target species in mixed fisheries is to define the target species post hoc by the species composition, in weight or in value, in the landings of a trip/haul. In order to do this, a threshold of landings/value proportion needs to be defined. The request to ICES provided no guidelines to define bycatch threshold for mixed fisheries in the Baltic Sea. Therefore, different thresholds for defining cod bycatch were applied. These were 10%, 20%, 30%, 40% and 50% of cod in total landings in each trip. First, the percentage of cod in the landings was calculated for each trip. Then the cod landings of each trip were categorized as bycatch or target based on whether they were below (bycatch) or above (target) a specific threshold. Cod bycatches are reported as the sum of cod landings in the trips that fell below each threshold in each fishery, country and/or area (SD24 and SDs 25-32).

Aggregation of métiers to fisheries

Métiers were grouped into five fisheries as described in Table 1.1. A full list of métiers included for each fishery and their total cod landings is given in Annex 1.

Table 1.1. Definitions of fisheries.

Fishery	Definition
Active pelagic	Defined by gear and mesh size. Includes all active gears targeting pelagic species (sprat and herring) (trawls and purse seines)
Active demersal	Demersal trawls targeting cod and flatfish
Passive gears (not included in coastal small-scale)	Demersal nets and longlines for vessels ≥10 m LOA
Coastal/small scale fisheries	Demersal nets and lines for vessels <10 m and all other passive gears regardless of vessel length.
Other*	Gears not included in other categories above, mostly trawls for freshwater species and sandeel

*** Some of these métiers can also be considered coastal but were kept separate since the coastal small-scale group was restricted to passive gears.**

Defining coastal small-scale fishery is problematic since this group can be defined differently depending on the context. In the analysis presented in this report, the coastal small-scale fishery includes demersal nets (gill and trammel) and longlines used by vessels <10 m LOA and all other passive gears known to generally operate only in coastal areas (such as pots, fyke nets, etc.), regardless of vessel length. The reason for the <10 m LOA threshold is that vessels <10 m are not obliged to carry logbooks in all Baltic countries, and this length group is generally defined as small-scale fisheries by ICES expert groups dealing with this subject (e.g. WGCATCH).

Main shortcomings and uncertainties

- Discards are not included in the analysis. The results shown only correspond to landed cod and not the actual catches. BMS landings are included in the landings of the requested data, but are known to be considerably underreported (ICES 2019a).
- Post hoc definition of target species only provides a description of the outcome of the fishing operation and not the intention of the fishers. When using post hoc data such as landings it is not always possible to know the intended target species or if the amount of cod in the catches was predicted by the fishers before starting the fishing operation.
- The definition of coastal/small scale fisheries is only based on gear and, in some cases, vessel length. A more accurate definition of coastal fisheries would take into account geographical information (position relative to coast) and fishing depth. This information was not considered in the present study as it is time consuming to obtain and generally not available for non-logbook vessels.
- The results presented reflect the fishing patterns of 2018, when cod was still a target species, and the fishers had no need to avoid cod in the catches. Limitations imposed on cod fishing may affect the amount of cod bycatch in mixed fisheries, as well as to what extent this bycatch is landed, since targeting cod is no longer allowed.

Results and conclusions

Number of trips by bycatch threshold

Figures 1.1 and 1.2 show number of trips by percentage of cod in trips both cumulatively (left panels) and in total trip numbers (right panels) for both active demersal fisheries and passive (non-coastal) gears and subdivisions 24, 25, 26, and 28 during 2018. In these figures, a low percentage of cod (y-axis) is indicative of trips targeting other species (i.e. cod is bycatch or highly discarded), and a high percentage of cod is indicative of trips targeting cod (i.e. cod is target species). In between these two extremes, mixed fisheries occur that generally target both cod and flatfish in different amounts. Note that since data on trip level was not available for vessels <10 m from all countries, only vessels ≥10 m were included in the figures.

For the active demersal gears, subdivision 24 had a rather high amount of trips with mixed landings, as well as many trips with small percentages of cod (27% of the trips had less than 10% cod in the landings) (Figure 1.1, upper left panel). In subdivision 25, 19% of the trips had less than 10% cod (Figure 1.1, upper right panel). In subdivision 26 less than 2% of the trips landed below 10% of cod (Figure 1.1, bottom left panel) and a small proportion of trips landed between 10 and 90% cod, which implies that no significant flatfish fishery has been carried out by demersal trawls in subdivision 26 in 2018. In subdivision 28, very few trips were conducted with active demersal gears, most of them with less than 10% cod.

For the passive gears (non-coastal, demersal nets and longlines for vessels ≥10 m), the proportion of trips with mixed landings was generally smaller with most trips landing either very high or very small proportions of cod (Figure 1.2 compares with the active demersal gears in Figure 1.1). Still, it is noticeable that subdivisions 24 and 25 had some mixed trips (ca. 20%), while in subdivisions 26 and 28 the vast majority of trips had either <10% or >90% cod. The trips below the 10% cod threshold represented 42% of the trips in subdivision 24, 31% in subdivision 25, 47% in subdivision 26 and 43% in subdivision 28 indicating that cod is a bycatch for many of the trips carried out with these gears.

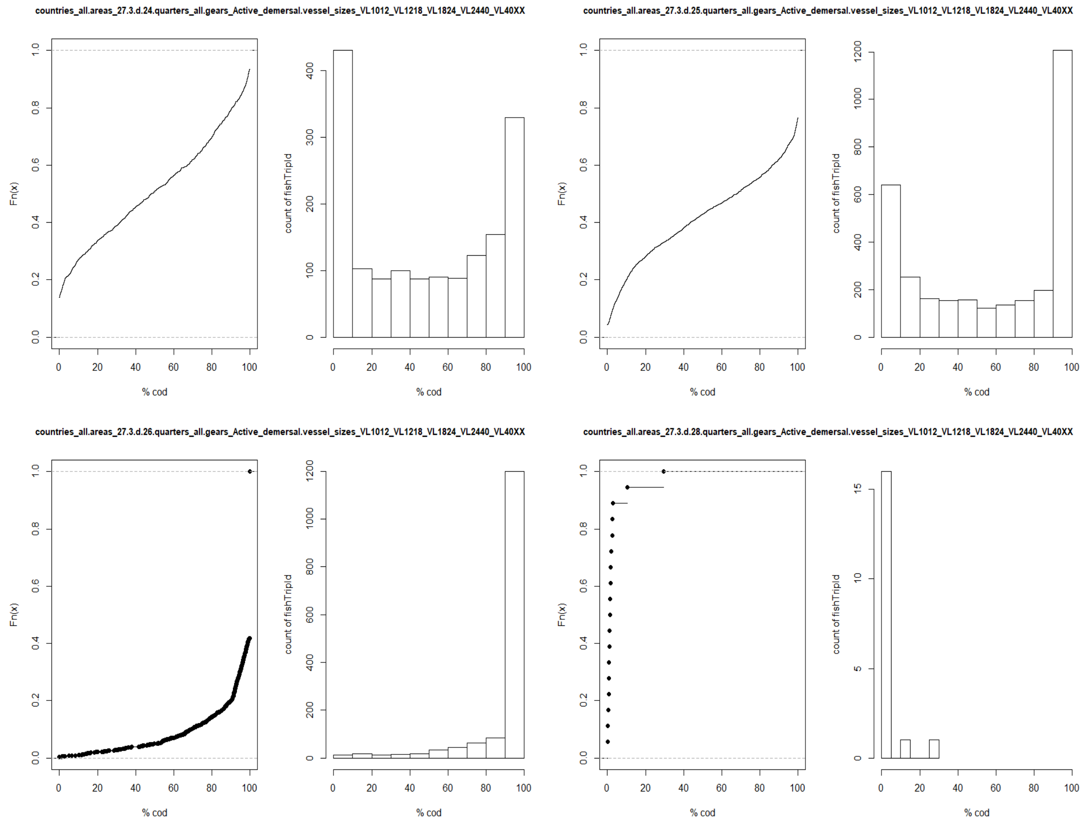

Figure 1.1. Cumulative number of trips (left) and total number of trips (right) by percentage of cod landings in trips for Active demersal gears in subdivision 24 (upper left panels), 25 (upper right panels), 26 (bottom left panels) and 28 (bottom right panels). Note the different scales on the histogram y-axis between subdivisions.

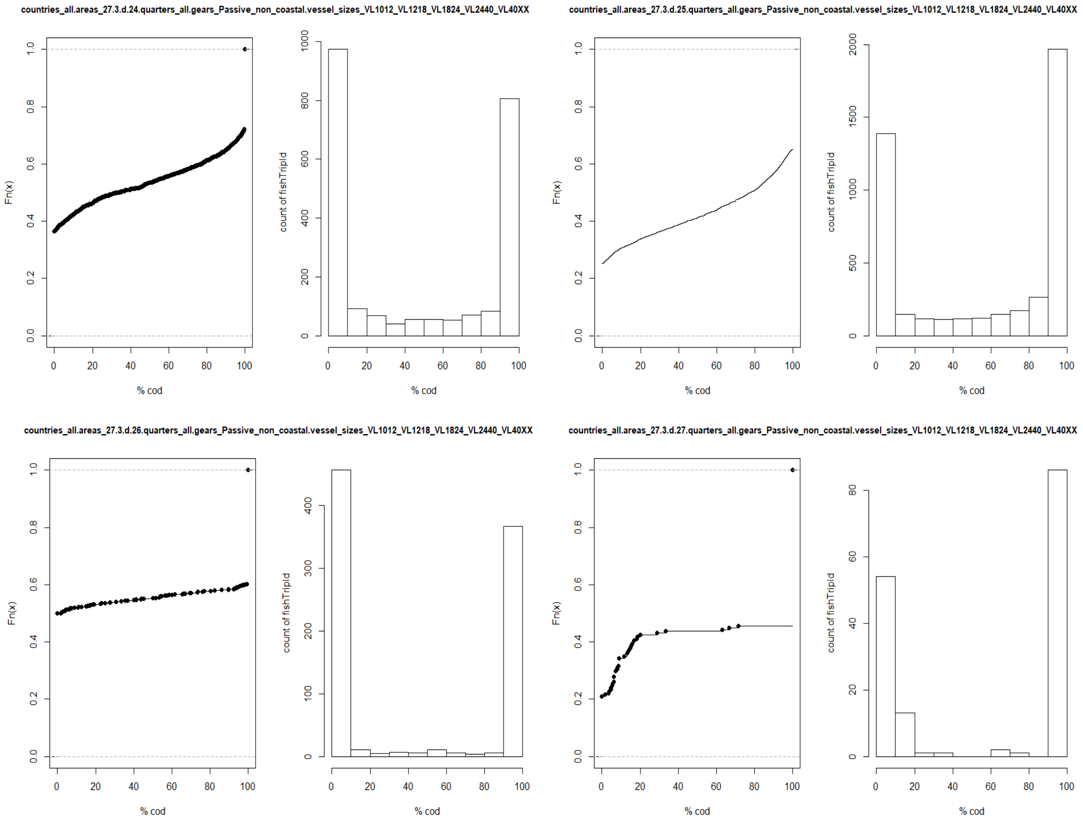

Figure 1.2. Cumulative number of trips (left) and total number of trips (right) by percentage of cod landings in trips for passive gears (nets and longlines, vessels ≥10 m) in subdivision 24 (upper left panels), 25 (upper right panels), 26 (bottom left panels) and 28 (bottom right panels). Note the different scales on the histogram y-axis between subdivisions.

Volume of cod bycaught at different bycatch definitions

Results are presented for five different bycatch definitions (or thresholds), from 10 up to 50 percent of cod in the landings by trip. This illustrates the increase in cod landings with different thresholds for bycatch definition. The results are shown separately for SD 24 (Table 1.1.2) and SDs 25-32 (Table 1.3).

In "Active pelagic" trawl fishery targeting small pelagics, as well as in some métiers included in category "Other", all cod landings could be considered as bycatch. For consistency, the results for these fisheries are also presented for the five different bycatch thresholds, where it is evident that most cod landings in pelagic fisheries fall below the 10% cod threshold.

In SD24, total cod bycatch for thresholds between 10-50% was in the range of 66-417† tonnes. Most of the cod bycatch occurred in Active demersal fishery (30-286 tonnes). In Active pelagic fishery, cod bycatch was 18 tonnes, and in small scale coastal fishery in the range of 11-55 tonnes. Note that the cod landings presented for SD24 combine the eastern and western Baltic stock. For bycatch of eastern Baltic cod in fisheries targeting western Baltic cod, see Section 2.

In SDs 25-32, total cod bycatch for thresholds between 10-50% was in the range of 360-1306† tonnes. As in SD 24, most of the cod bycatch occurred in Active demersal fishery (186-973 tonnes). In Active pelagic fishery, cod bycatch was 181 tonnes, and in small scale coastal fishery in the range of 7-50 tonnes.

† Modified following reviewers' comments.

These results show that 14%‡ of cod landings in SD24 and 10 %‡ of cod landings in SDs 25-32 were taken in trips with maximum 50% cod bycatch in the landing. This implies that most of the cod landings (86%‡ and 90%‡ in SD24 and SDs 25-32) were taken in trips with more than 50% of cod in the landings.

Tables 1.1.4 -1.1.7 show the landings of plaice and flounder corresponding to the 10-50% thresholds of cod bycatch, i.e. what amounts of flatfish species were landed from the trips with 10-50 % of cod in the landings in 2018. These results show that 59-89% of the plaice landings in SD24 and 60-90% of plaice landings in SDs 25-32 in 2018 were taken in trips with 10-50% cod in the landings. For flounder, 71-92% of the landings in SD24 and 75-94% in SDs 25-32 were taken in trips with 10-50% cod in the landings.

Table 1.2. Bycatch landings (tonnes) of cod in subdivision 24 in 2018, corresponding to the different thresholds for bycatch definition (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of cod landed by the fishery (i.e. including landings with more than 50% cod bycatch).

			Bycatch threshold of cod landings in trips					
Area	**Fishery**	**Country**	**Max 10%**	**max 20%**	**max 30%**	**max 40%**	**max 50%**	**All cod landings**
24	Active demersal	DEU	11.2	26.8	43.0	53.4	63.6	181
		DNK	7.3	31.1	55.4	83.3	99.4	996
		FIN	0.5	0.5	0.5	0.5	0.5	0.5
		POL	10.6	22.2	38.6	72.5	121.9	734
		SWE	0	0	0.1	0.3	0.9	237
	Total Active demersal (t)		**29.6**	**80.5**	**137.5**	**210.0**	**286.4**	**2148**
	Coastal small scale	DEU	4.9	9.7	14.6	20.8	28.3	110
		DNK	2.2	4.8	8.4	10.0	14.2	151
		POL	4.2	8.3	10.6	11.3	11.3	14
		SWE	0.1	0.2	0.3	0.4	0.9	43
	Total Coastal small scale (t)		**11.3**	**23.1**	**33.9**	**42.5**	**54.8**	**318**
	Passive, non-coastal	DEU	0.5	2.4	5.5	6.7	9.0	76
		DNK	0	0	0.2	0.4	1.1	59
		POL	5.9	14.7	26.7	39.0	42.8	132
		SWE	0.3	0.6	0.9	1.2	2.1	187
	Total Passive non-coastal (t)		**6.7**	**17.8**	**33.3**	**47.3**	**55.0**	**454**
	Active pelagic	DEU	12.6	12.6	12.7	12.7	12.7	12.7
		DNK	0.3	0.3	0.3	0.3	0.3	0.3

‡ Modified following reviewers' comments

Area	Fishery	Country	Max 10%	max 20%	max 30%	max 40%	max 50%	All cod landings
			Bycatch threshold of cod landings in trips					
		POL	3.0	3.2	3.3	3.6	3.6	3.6
		SWE	1.0	1.0	1.0	1.0	1.0	1.0
	Total Active pelagic (t)		**17.0**	**17.1**	**17.3**	**17.6**	**17.6**	**17.6**
	Other	DEU	0.5	0.7	0.7	0.8	0.8	0.8
		DNK	0.6	0.7	0.7	0.7	0.7	0.7
		POL	0.0	0.4	2.0	2.2	2.2	6.4
	Total Other (t)		**1.1**	**1.8**	**3.4**	**3.6**	**3.7**	**7.8**
	Total cod bycatch (t)		65.6	140.3	225.4	321.0	417.4	2946
	% of total cod landings in 2018		2.2	4.8	7.7	10.9	14.2	100

Table 1.3. Bycatch landings (tonnes) of cod in subdivisions 25-32 in 2018, corresponding to the different thresholds for bycatch definition (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of cod landed by the fishery (i.e. including landings with more than 50% cod bycatch).

Area	Fishery	Country	max 10%	max 20%	max 30%	max 40%	max 50%	All cod land-ings
			Bycatch threshold of cod landings in trips					
	Active demersal	DEU	6.3	13.4	37.3	60.9	61.4	245.1
		DNK	20.1	34.0	44.6	72.2	84.3	2569.4
		FIN	4.2	4.2	4.2	4.2	4.2	4.2
		LVA	3.5	17.9	30.4	37.6	51.4	970.5
		LTU	3.6	14.2	36.4	51.4	55.0	590.4
		POL	148.4	287.0	397.1	534.3	716.1	3876.5
		SWE	0.1	0.1	0.1	0.1	0.8	1652.9
25-32	**Total Active demersal (t)**		**186.2**	**370.8**	**550.1**	**760.8**	**973.2**	**9909**
	Coastal small scale	DEU	0	0.1	0.1	0.2	0.2	0.2
		DNK	0.6	0.9	1.0	1.2	1.6	35.2
		EST	0.4	0.5	0.5	0.5	0.6	0.8
		FIN	0	0	0	0	0	9.8
		LVA	0.1	0.3	0.7	1.2	1.8	39.0
		LTU	0.8	1.1	1.4	1.5	2.8	42.1

Area	Fishery	Country	Bycatch threshold of cod landings in trips max 10%	max 20%	max 30%	max 40%	max 50%	All cod landings
		POL	3.9	10.7	16.7	23.0	29.6	462.9
		SWE	1.1	3.2	6.0	7.1	13.2	117.5
	Total Coastal small scale (t)		**6.9**	**16.6**	**26.5**	**34.7**	**49.7**	**707**
	Passive, non-coastal	DNK	0	0	0	0	0	4.9
		FIN	0	0	0	0	0	39.2
		LVA	0	0	0.1	0.1	0.1	54.6
		LTU	0	0	0	0.2	0.2	126.4
		POL	15.9	38.1	58.5	79.7	105.2	1346.1
		SWE	0.4	0.7	0.8	1.1	1.3	131.9
	Total Passive non-coastal (t)		**16.4**	**38.8**	**59.4**	**81.0**	**106.7**	**1703**
	Active pelagic	DEU	1.3	1.3	1.3	1.3	1.3	1.3
		DNK	0.3	0.3	0.3	0.3	0.3	0.3
		FIN	0.4	0.4	0.4	0.4	0.4	0.4
		LVA	8.9	8.9	8.9	8.9	8.9	14.8
		LTU	9.8	9.8	9.8	9.8	9.8	9.8
		POL	120.5	138.2	144.5	144.5	144.5	144.5
		SWE	9.6	9.6	9.6	9.6	9.6	9.6
	Total Active pelagic (t)		**151**	**169**	**175**	**175**	**175**	**181**
	Other	DNK	0	0	0	0	0	8
		POL	0.1	0.1	0.2	1.3	1.3	6
		SWE	0	0	0	0	0	0
	Total Other (t)		**0.1**	**0.1**	**0.2**	**1.3**	**1.3**	**13.6**
	Total cod bycatch (t)		360.4	594.9	811.1	1052.6	1305.8	12513.8
	% of total cod landings in 2018		2.9	4.8	6.5	8.4	10.4	100

Table 1.4. Landings of plaice in subdivision 24 in 2018, corresponding to the different cod bycatch thresholds (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of plaice landed by the fishery (i.e. including landings from trips with more than 50% cod bycatch).

			Bycatch threshold of cod landings in trips					
Area	**Fishery**	**Country**	**max 10%**	**max 20%**	**max 30%**	**max 40%**	**max 50%**	**All plaice landings**
24	Active demersal	DEU	265.2	302.6	321.3	329.2	332.3	338.8
		DNK	195.2	295.6	355.3	390.1	398.7	470.1
		POL	44.8	56.0	61.9	71.7	81.6	120.1
		SWE	0.0	0.0	0.2	0.3	0.8	9.7
	Total Active demersal (t)		**505.2**	**654.3**	**738.7**	**791.4**	**813.5**	**938.7**
	Coastal small scale	DEU	5.0	6.6	8.2	10.0	11.0	12.0
		DNK	3.4	5.1	6.1	6.6	7.1	9.3
		POL	8.5	9.8	10.3	10.3	10.3	10.3
		SWE	0.0	0.0	0.0	0.0	0.1	0.2
	Total Coastal small scale (t)		**16.9**	**21.4**	**24.6**	**26.9**	**28.5**	**31.8**
	Passive, non-coastal	DEU	5.1	5.9	6.1	6.2	6.3	6.6
		DNK	0.0	0.0	0.0	0.0	0.1	0.9
		POL	172.1	188.8	199.0	206.0	206.5	208.1
		SWE	0.6	0.9	1.0	1.1	1.2	2.0
	Total Passive non-coastal (t)		**177.8**	**195.5**	**206.0**	**213.2**	**214.1**	**217.5**
	Active pelagic	DEU	0.8	0.8	0.8	0.8	0.8	0.8
		DNK	0.0	0.0	0.0	0.0	0.0	0.0
		POL	0.2	0.2	0.2	0.2	0.2	0.2
	Total Active pelagic (t)		**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
	Other	DNK	0.0	0.7	0.7	0.7	0.7	0.7
		POL	0.0	0.0	0.8	0.8	0.8	1.5
	Total Other (t)		**0.0**	**0.7**	**1.5**	**1.5**	**1.5**	**2.2**
	Total plaice landings by cod threshold		700.8	872.9	971.9	1034.0	1058.6	1191.2
	% of total plaice landings in 2018		59	73	82	87	89	100

Table 1.5. Landings of plaice in subdivisions 25-32, corresponding to the different cod bycatch thresholds (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of plaice landed by the fishery (i.e. including landings from trips with more than 50% cod bycatch).

			Bycatch threshold of cod landings in trips					
Area	**Fishery**	**Country**	**max 10%**	**max 20%**	**max 30%**	**max 40%**	**max 50%**	**All plaice landings**
25-32	Active demersal	DEU	0.1	0.2	2.3	3.0	3.0	3.0
		DNK	80.8	113.0	121.3	130.1	132.9	153.7
		LVA	0.1	0.1	0.1	0.1	0.1	0.1
		POL	83.6	122.2	141.8	159.4	170.1	194.2
		SWE	0.7	1.0	1.0	1.0	1.5	6.7
	Total Active demersal (t)		**165.2**	**236.5**	**266.5**	**293.7**	**307.6**	**357.7**
	Coastal small scale	DNK	9.3	9.7	9.8	9.8	9.8	9.9
		POL	23.5	24.3	24.7	24.8	24.9	25.2
		SWE	0.3	0.9	1.0	1.1	1.3	2.0
	Total Coastal small scale (t)		**33.2**	**35.0**	**35.5**	**35.8**	**36.1**	**37.1**
	Passive, non-coastal	DNK	0.0	0.0	0.0	0.0	0.0	0.0
		POL	95.7	100.5	103.3	104.6	105.5	107.6
		SWE	0.0	0.0	0.1	0.1	0.1	0.2
	Total Passive non-coastal (t)		**95.7**	**100.5**	**103.3**	**104.7**	**105.7**	**107.8**
	Active pelagic	POL	16.1	16.1	16.1	16.1	16.1	16.1
	Total Active pelagic (t)		**16.1**	**16.1**	**16.1**	**16.1**	**16.1**	**16.1**
	Other	DNK	0.0	0.0	0.0	0.0	0.0	0.1
		POL	0.0	0.0	0.0	0.5	0.5	0.5
	Total Other (t)		**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	Total plaice landings by cod threshold		310.8	388.7	422.0	450.8	466.1	519.3
	% of total plaice landings in 2018		60	75	81	87	90	100

Table 1.6. Landings of flounder in subdivision 24 in 2018, corresponding to the different cod bycatch thresholds (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of flounder landed by the fishery (i.e. including landings from trips with more than 50% cod bycatch).

			Bycatch threshold of cod landings in trips					
Area	**Fishery**	**Country**	**max 10%**	**max 20%**	**max 30%**	**max 40%**	**max 50%**	**All flounder landings**
24	Active demersal	DEU	298.1	344.8	375.3	386.7	394.4	407.6
		DNK	46.7	56.7	62.9	78.7	87.9	109.5
		POL	390.4	483.7	543.8	594.8	642.7	776.1
		SWE	0.0	0.0	0.1	0.2	0.2	1.2
	Total Active demersal (t)		**735.1**	**885.2**	**982.1**	**1060.5**	**1125.3**	**1294.5**
	Coastal small scale	DEU	125.1	133.2	139.3	143.1	148.2	161.9
		DNK	9.4	12.5	14.7	15.9	17.4	24.3
		POL	176.0	193.5	198.6	198.6	198.7	198.7
		SWE	0.1	0.1	0.2	0.3	0.6	2.1
	Total Coastal small scale (t)		**310.6**	**339.3**	**352.8**	**358.0**	**364.8**	**387.0**
	Passive, non-coastal	DEU	59.9	67.2	74.3	76.0	77.9	84.0
		DNK	0.3	0.4	0.9	1.3	2.0	5.6
		POL	671.9	702.4	727.7	743.1	746.2	761.2
		SWE	0.6	0.9	1.1	1.2	1.5	2.6
	Total Passive non-coastal (t)		**732.7**	**770.9**	**804.1**	**821.6**	**827.5**	**853.4**
	Active pelagic	DEU	1.7	1.7	1.7	1.7	1.7	1.7
		DNK	0.0	0.0	0.0	0.0	0.0	0.0
		POL	23.0	23.0	23.0	23.0	23.0	23.0
		SWE	0.5	0.5	0.5	0.5	0.5	0.5
	Total Active pelagic (t)		**25.1**	**25.1**	**25.1**	**25.1**	**25.1**	**25.1**
	Other	DEU	0.0	0.0	0.0	0.0	0.0	0.0
		POL	23.2	23.2	25.7	25.7	25.7	26.3
	Total Other (t)		**23.2**	**23.2**	**25.7**	**25.7**	**25.7**	**26.3**
	Total flounder landings by cod threshold		1826.7	2043.8	2189.8	2291.0	2368.5	2586.4
	% of total flounder landings in 2018		71	79	85	89	92	100

Table 1.7. Landings of flounder in subdivision 25-32 in 2018, corresponding to the different cod bycatch thresholds (0-10%, 0-20%, 0-30%, 0-40%, 0-50% cod in the landings). Last column shows the total amount of flounder landed by the fishery (i.e. including landings from trips with more than 50% cod bycatch).

			Bycatch threshold of cod landings in trips					
Area	**Fishery**	**Country**	**max 10%**	**max 20%**	**max 30%**	**max 40%**	**max 50%**	**All flounder landings**
25-32	Active demersal	DEU	77.8	125.7	195.9	243.2	243.7	245.1
		DNK	383.3	437.7	463.0	502.8	514.8	579.2
		LVA*	157.2	245.6	282.2	296.4	314.2	340.8
		LTU	57.3	116.0	184.8	212.9	217.5	275.2
		POL	5158.2	5934.8	6231.2	6459.4	6665.2	7083.2
		SWE	0.0	0.1	0.1	0.1	0.4	20.7
	Total Active demersal (t)		**5833.9**	**6859.8**	**7357.2**	**7714.8**	**7955.9**	**8544.2**
	Coastal small scale	DEU	1.4	1.4	1.6	1.8	1.8	1.8
		DNK	49.6	50.6	51.0	51.3	51.6	53.5
		EST	126.3	126.6	126.7	126.7	126.7	126.7
		FIN	0.0	0.0	0.0	0.0	0.0	0.0
		LVA*	0.4	0.8	1.0	1.5	1.7	3.0
		LTU	27.2	27.2	27.2	27.2	27.3	28.9
		POL	733.1	771.2	787.9	798.8	805.9	820.0
		SWE	19.1	21.9	23.1	23.7	25.1	27.7
	Total Coastal small scale (t)		**957.0**	**999.5**	**1018.5**	**1031.0**	**1040.1**	**1061.7**
	Passive, non-coastal	DNK	0.0	0.0	0.0	0.0	0.0	0.3
		FIN	0.0	0.0	0.0	0.0	0.0	0.1
		LVA*	0.1	0.1	0.1	0.1	0.1	0.9
		LTU	0.9	0.9	0.9	1.1	1.1	2.5
		POL	1362.4	1483.1	1540.0	1576.6	1606.6	1699.5
		SWE	11.8	13.1	13.3	13.4	13.6	14.1
	Total Passive non-coastal (t)		**1375.1**	**1497.1**	**1554.3**	**1591.2**	**1621.4**	**1717.4**
	Active pelagic	DNK	1.5	1.5	1.5	1.5	1.5	1.5
		LVA	12.0	12.0	12.0	12.0	12.0	12.0
		LTU	57.2	57.2	57.2	57.2	57.2	57.2

Area	Fishery	Country	Bycatch threshold of cod landings in trips max 10%	max 20%	max 30%	max 40%	max 50%	All flounder landings
		POL	1093.4	1093.6	1093.6	1093.6	1093.6	1093.6
		SWE	61.4	61.4	61.4	61.4	61.4	61.4
	Total Active pelagic (t)		**1225.5**	**1225.7**	**1225.7**	**1225.7**	**1225.7**	**1225.7**
	Other	POL	251.7	251.7	251.7	253.4	253.4	253.5
	Total Other (t)		**253.5**	**253.5**	**253.5**	**253.5**	**253.5**	**253.5**
	Total flounder landings by cod threshold		9644.9	10 835.6	11 409.1	11 816.1	12 096.5	12 802.5
	% of total flounder landings in 2018		75	85	89	92	94	100

*** Latvian landings of flounder reported to WGBFAS were 1326 tonnes for subdivision 25-32, and only 357 tonnes in Table 1.7. The discrepancy is likely due to some métiers with zero cod landings not being submitted (which was allowed in the data call). All missing Latvian flounder landings would have been caught below the max 10% cod threshold.**

Comparison of cod bycatch in pelagic fisheries estimated from logbooks with samples from control agency

As stated above, one of the shortcoming of the bycatch analyses presented in this report is that discard information is not included, implying that cod bycatch could be higher in some fisheries than presented here. For example, for pelagic fisheries there are presently no at-sea observer programs in the Baltic Sea to sample discard information.

For pelagic fisheries, information on cod landings in samples taken by Danish control agency were available, to compare with the logbook information. Control takes place at landing sites, so if significant at-sea discards of cod in this fishery take place, this is not reflected in the control data either. However, the samples by control agency provide information of cod landings in this fishery independent from logbook information, and are therefore included here for comparison.

Danish control agency samples on a regular basis the landings in Denmark from unsorted industrial fishery. In 2018, Danish control agency sampled landings from 77 trips where sprat and herring were the target species. The sample size was on average 10 kg, and between 1-20 samples per landing were taken. All species in the sample were registered. These data showed on average 0.10% of cod in pelagic fisheries landings, which is in line with the logbook information.

1.2 Changes in fishing patterns possibly affecting cod by-catch in 2020 compared to 2018

The amounts of cod bycatch calculated in Section 1.1 based on data from 2018 may not fully reflect the situation in 2020. This is mainly because in 2018, cod was a target species and therefore fishers did not attempt to avoid catching cod. However, it is not possible with the existing data to estimate at what extent it would be possible for fishers to avoid cod, when applying the same gears as in 2018. This is because no data are yet available from a situation when cod has not been a target species.

Cod stock size would likely affect the level of bycatch. The biomass of eastern Baltic cod is predicted to further decline in 2020 from the level estimated for 2018 (ICES 2019a). This would likely reduce cod bycatch in 2020 compared to 2018.

Other factors that likely would affect cod bycatch in 2020 compared to 2018 include fishing opportunities for other species, where cod could be caught as bycatch. EU quotas for sprat and central Baltic herring in 2020 were set lower than the EU quotas for 2018, while the TAC for plaice for 2020 is similar as in 2018 (Table 1.8). Based on this, the cod bycatch in pelagic fisheries for sprat and herring can be assumed to decline, while it could remain similar in fisheries targeting plaice.

Table 1.8. EU quotas (tonnes) of sprat, herring and plaice in 2018–2020.

Year	Sprat SD22-32	Herring SD25-29,32, excl. GoR	Plaice SD22-32
2018	262 310	229 355	7076
2019	270 772	170 360	10 122
2020	210 147	153 384	6894

Vessels that used to target cod will likely shift to targeting e.g. flatfish instead. This may lead to increased cod bycatches in some fisheries compared to 2018, but the magnitude of increase will depend on the choice of the limit for allowed percentage for cod bycatches in these fisheries and whether additional technical measures will be introduced.

The choice of future allowed cod bycatch threshold level could create incentives for changing fishing patterns and thus cod bycatches. For example if the threshold is set high, i.e. allowing for a higher bycatch percentage of cod, this may cause higher total cod bycatches compared to setting the threshold at a lower level.
It should be noted that even if 2020 values will indicate less cod being landed, this does not necessarily mean that cod is being successfully avoided by fishermen and cod fishing mortality decreased. Rather, in response to lack of possibility to land cod, discards may increase, particularly in areas where flatfish and cod distributions overlap and non-selective gears are used. A major factor that can influence future cod bycatches is the introduction of revised gear measures in demersal trawls (see section 1.3).

1.3 Technical strategies to avoid cod catches in Baltic Sea trawl fisheries

Background

The Baltic Sea is one of the marine regions with the longest tradition in trawl selectivity research. Over the last three decades, fishing technologist have developed numerous codend designs with the sole objective of adjusting the cod size selectivity of trawl fisheries targeting demersal species according to the management objectives for Baltic cod stocks.

This report focuses on solutions developed for the trawl fishery targeting flatfish. In the last five years, issues others than those related to cod size selection have been addressed by technological means, e.g. devices specifically developed to reduce the bycatch of flatfish in the cod-directed fishery (Santos *et al.,* 2016) or alternative selectivity strategies for trawl fisheries (Stepputtis *et al.,* 2016). However, little efforts have so far have been invested in developing technologies for avoiding all cod catches in demersal trawls.

Madsen *et al.* (2006) tested a flatfish-selective trawl, developed to reduce bycatches of cod while increasing the catch efficiency on flatfish relative to standard trawls. The presented trawl concept is not considered in this report for two main reasons: First, the experimental catch results obtained were not consistent among the different trials conducted. During the experimental phase, the authors tried to address practical issues observed in the test trawl, however the final results obtained were not conclusive. Second, the Madsen *et al.* (2006) concept involves the design and construction of the entire trawl gear and proposes a totally new trawl. This involves a significant economical investment that might not be affordable for the fishers involved in the fishery. Additionally, due to the large variation in vessel size and vessel configuration the implementation of one concept requires significant adaptations. The present report presents technical solutions that can be mounted in the standard trawls currently used in the fishery.

No or little research effort has been focused on the reduction of cod by technical means in other Baltic trawl fisheries with reported bycatches of cod (e.g. the trawl fishery targeting small pelagics). This does not imply that bycatches in these fisheries are unavoidable by technical means. It is assumed that it is possible to develop technical solutions for these fisheries as well, if requested.

Methods

The selective concepts can be organized in three different categories based on the selection strategy utilized to achieve the goal of avoiding cod catches as much as possible. These three categories or strategies are briefly described below. For each strategy, technical solutions are listed. More information for each design (general information, experimental results, and conclusions) is given in the form of Fact sheets (Annex 2).

Considerable efforts have been invested in trying to standardize the available information as much as possible, to facilitate the best possible comparison of the concepts presented. This standardization also aimed to show the degree of development of each concept and its proof of efficiency (if available) for comparative purposes. This comparison among concepts should be done in the view of avoiding cod catches, considering the specific aspects of the demersal trawl fisheries in the Baltic (e.g. population structure of the species available, fleet characteristics, etc.).

When identifying specific selectivity concepts for implementation in Baltic fishery, a number of criteria can be taken into account. The most important parameters are:

1. efficiency to reduce the catch of cod (of all length classes, i.e. little or no size selectivity);
2. efficiency to catch (retain) flatfish larger than MCRS;
3. conducted trials with good data basis (e.g. number of hauls) or more upcoming trials conducted within short time;
4. usability (e.g. the use of large rigid grids/frames might be difficult at sea);
5. costs;
6. aspects regarding control and enforcement.

Selectivity strategies

Information regarding the potential species-selection concepts to avoid/reduce the catch of cod has been collected from different national sources, presenting differences in the conditions and the nature of the original studies. In this report, the different selectivity concepts are organized and presented in a structure that follows the selectivity strategy. These are:

1. mechanical size selectivity devices (i.e. based on morphological differences, such as the use of different nettings in codends);
2. selectivity devices that make use of differences in behavior to sort and exclude species;
3. selectivity devices which combine the two previous strategy (1 and 2) in a sequential process.

It is very important to note that for all selectivity devices where size selection occurs (strategy 1 and strategy 3) is population dependent, i.e. the final catch (and hence the percentage of cod catch reduction) depends on the specific size selectivity of that specific device, but also on the available length distribution in the population. For example, a selection device (e.g. codend) with a L_{50} of 37 cm (L_{50} = length at which 50% of the fish entering the trawl are retained in the codend) can have exactly the same catch of cod as a codend with an L_{50} of 45 cm when the population only consists of individuals larger than 60 cm. On the other hand, the same devices will have significant different catches for a population of cod between 30 and 50 cm. Therefore, percentages given for cod-reduction given for those devices (strategy 1 and strategy 3) cannot be generalized and are only valid for the specific size selectivity of that device (e.g. the used codends) and the specific population structure found during the specific experiment. If the selectivity properties (selectivity curve) of a device are known (some codends for strategy 1), the theoretical catch could be simulated for different population structures.

The different selectivity strategies are explained in further detail below.

1.Selecting species by mechanical selection (species specific size selection)

Historically, alterations in the selectivity aimed to reduce the catch of undersized Baltic cod while keeping as much as possible cod above landing size. These selectivity alterations of Baltic trawls were achieved by changes in codend **mesh size** of standard netting. A number of studies indicated that such classical approach did not always deliver the desired selection patterns for Baltic cod. The reason is that the rounded cross section of cod does not fit well through the opening of diamond-mesh netting when stretched by the towing forces. Therefore, the classical modification of changing the mesh size was subsequently combined with other modifications (e.g. mesh configuration) that aimed to keep the meshes open during towing. Applying either square-mesh netting or diamond-mesh netting turned 90 degrees (T_{90}) were found the most successful approaches to increase the escape possibilities of (undersized) cod.

However, it was also found that using these netting configurations have neutral or even negative effects on flatfish selectivity. Such contrast in performance is a consequence of differences in body morphology of cod and flatfish species. The first strategy to avoid cod from catches takes advantage of such morphological differences among species by choosing sufficient net configurations (e.g. T_0, T_{90}, square mesh) and mesh sizes in the codend to release as much cod as possible while keeping catch efficiency of flatfish high.

Presented concepts (fact sheets):
MESH-configuration (Alternative codend designs)

2.Selecting species by behaviour

Recent investigations combining underwater video recordings and analysis of experimental catch data demonstrated that cod and flatfish show different behavior inside the trawl, which could be used to separate the different species. These behavioral differences include different swimming path preferences once they entered the trawl. While roundfish tend to swim in the water column staying clear off the netting, flatfish´ swimming and avoidance behavior is usually characterized by staying close to the floor of the net. Consequently, strategy 2 is based on taking advantage of the behavioural differences observed for cod and flatfish during the catch process with the aim to separate the species and guide them either into a codend or towards an escapement exit.

Presented concepts (fact sheets):
CODEX (COD EXcluder)

STIPED (StiTImulation Escapement Device)

3.Combined selection

Over the last few years of fishing gear development in the Baltic, an aim has been to find optimized, specific selectivity properties for the different species groups (i.e. flatfish and roundfish). As described above, it is unlikely to find one type of netting which fits all requirements of optimized mechanical selection for all species due to the differences in morphology. To achieve this optimized selectivity for the two main species groups, strategies 2 (separating using differences in behaviour) and 1 (mechanical selection) were combined into a sequential selection process in which fish species are sorted and directed to selection devices with adapted selectivity characteristics.

It is important to note that the test of such combined selection devices is more complex than for single strategy devices, which are described above. The overall catch result (e.g. the reduction of cod catch) depends on both selectivity processes, which interact and influence the final result. For instance, the catch of cod depends on the separation efficiency of the sorting device and the used codends, resulting in specific overall size selectivity. To understand the different processes acting sequentially, is essential to estimate how these devices would behave under changed conditions (e.g. different codends used or changing population structure of fish species).

Presented concepts (fact sheets):

SORTEX (SORTing EXtension)

ADEM-4 (Trawl separating flatfish and roundfish)

Description of selective properties from cod-reduction devices

An important decision criterion for specific gear designs is the effect on the catch. This includes two main aspects:

- the potential reduction of cod catch;
- the ability to keep catches of flatfish (mainly plaice and flounder) high.

The aim was to standardize the information in the different fact sheets as much as possible. Therefore, the performance of the different cod-reduction concepts proposed is quantified by two selectivity indicators. For each studied species, these selectivity indicators are calculated as the ratio of the catch fractions below and above Minimum Conservation Reference Size (MCRS) obtained in a given test gear relative to same catch fractions obtained in a control/reference gear. These ratios are given in percent. A value of 100% for a given catch fraction refers to equal catch share in test and control gear, whereas 50% refers to reduction of catch in the test gear to the half.

For the purpose of avoiding cod catches regardless of length size, it is desirable to obtain low values of the two indicators for cod and high values for flatfish. Any length-dependency in the release efficiency of cod would be expressed by differences in values from the two calculated indicators.

Calculation of selectivity indicators

The selectivity indicators for fish below MCRS (nR-) and fish above MCRS (nR+) are calculated as:

$$nR+=\frac{\sum_i\left\{\sum_{l\geq mcrs} nT_{igl}\right\}}{\sum_i\left\{\sum_{l\geq mcrs} nC_{il}\right\}}$$
$$nR-=\frac{\sum_i\left\{\sum_{l<mcrs} nT_{igl}\right\}}{\sum_i\left\{\sum_{l<mcrs} nC_{il}\right\}} \quad (1.3)$$

where the sum of i is for hauls, g is for a specific codend of the test trawl (some concepts presented here involve double-codend setup), and l is for length classes. The fishery selectivity indicators in Equation 1.3 are calculated as the ratio of catches from each of the species studied observed in codend g from the test trawl using the cod-reduction device proposed (nT) to the catches in the control gear (nC). As experiment 1 from SORTEX investigates the efficiency of SORTEX to sort the species into two codends, nT refers to the upper codend, while nC refers to the total catch in upper and lower codends. The ratio of catches in Equation 1.3 are calculated for the total catch (nR), and for the fractions below (nR-) and above (nR+) the species Minimum Conservation Reference Size (MCRS), and presented in percentage terms.

Confidence Intervals associated to these indicators were obtained by including the calculations in Equation 1.3 into a block-bootstrap scheme usually applied in selectivity studies. Such bootstrap scheme was not applied for the MESH case, as it is based on a theoretical simulation where it was only possible to obtain average values of the indicators in Equation 1.3.

Information provided in Fact sheets

The different cod-avoidance devices reported are categorized by the three selectivity strategies (Mechanical selection, Selection by behavior, Combined selection):

Mechanical selection:

MESH-configuration (Alternative codend designs) (Annex 2)

Selection by behavior:

CODEX (COD EXcluder) (Annex 2)

STIPED (StiTImulation Escapement Device) (Annex 2)

Combined selection:

SORTEX (SORTing EXtension) (Annex 2)

ADEM-4 (Trawl separating flatfish and roundfish) (Annex 2)

Each fact sheet (Annex 2) provides a description of each concept, information related to experimental tests (or theoretical studies), indicators of selectivity performance, and conclusions.

Additionally, a summary table is inserted at the top right corner of each fact sheet to provide a fast overview about the status of development and testing of a specific device. The information contained in the summary table is described below using an example:

Information	Conditions	Target investigation		
				
Theoretical	-			
Experimental	Research		41/1	15/1
	Commercial			(Nov. 2019)

Origin of information:

- Theoretical: Information bases on theoretical approaches
- Experimental: Information bases on experimental tests
- Numbers in cell: Number of hauls and cruises used for testing the device (e.g. 41/1 = 41 hauls during 1 cruise)

Conditions of experimental testing:

- Research: Experiments were conducted on a research vessel
- Commercial: Experiments were conducted on a commercial vessel

Target investigation:

Mechanical selection (strategy 1; or part of selection process in strategy 3): Investigation of size selection of selection device

Selection by behavior (strategy 2; or part of selection process in strategy 3): Investigation on Sorting/Selection of species based on behavior

Combined selection (strategy 3): Investigation of combined effect of mechanical sorting and selection based on behavior

Colors of cells:

The colors of the cells indicate the current status of the tests:

- white: not conducted
- yellow: tests conducted, but
    - using codends chosen for other purpose than full avoidance of cod catch and/or
    - or
    - tests conducted in other areas or focusing on other species
- green: tests aiming at an avoidance of cod conducted in the Baltic Sea

Conclusions and final remarks

In this section we presented three different strategies to reduce cod bycatches in Baltic flatfish trawl fisheries. The strategies are 1: Mechanical size selectivity devices based on morphological differences. 2: Selectivity devices based on behavioral differences between flatfish and cod and 3: Selectivity devices that combines strategy 1 and 2. The results are shown in Fact Sheets presented in Annex 2, that the conclusions below are based on.

A simple way to reduce cod catches in flatfish trawl-fisheries is by changing the mechanical selectivity provided by codends (**strategy 1**). This strategy has however limitations e.g. in reducing catches of large cod – whereas this fraction of the population is important for the recovery of the stock. Considering the structure of cod and plaice populations from ICES SD 24, 2018, Quarter 4, the theoretical study presented here indicates that adapting the mechanical selection in Baltic codends could lead to a massive reduction in cod catches (mostly on small and medium length classes), while improving the selectivity of flatfish species. In particular, T90 codends made of 140 mm mesh size are expected to achieve ~80% and ~100% bycatch reduction of cod above and below MCRS, respectively. Also, undersized plaice is expected to be reduced by ~80% while not compromising catches of marketable plaice. Important to note is that the theoretical study was based on a “static picture” of the exploited fish populations, however the effect of codend size selectivity on catches would vary under variations in the population structure. For example, an increased abundance of large cod would lead to an increase in cod bycatch. The theoretical assessment conducted can provide indications of performance, however it is strongly recommended to invest efforts on designing the advised codend and test its selective properties experimentally. Initial tests could be done on short-term.

We also presented two selection devices following **strategy 2** (species selection taking advantage of behavioral differences) as an alternative strategy to reduce the catch of cod (including large individuals). These modifications use selection devices which separate cod and flatfish in front of the codend. Usually flatfish follow the trawl extension along the bottom whereas cod is directly guided upwards to an escapement opening. The two concepts are denoted CODEX and STIPED. Experimental trials showed that STIPED can prevent +90% of cod from entering the codend, while losses of flounder were less than 10%. However, the larger reduction in catches of plaice (>50%) indicates potential for further improvement of the device. CODEX is a very recent concept proposed by the industry. Both devices are currently (October-December 2019) being further developed in commercial and research vessels to improve their efficiency.

To further improve the escapement of cod, codend selectivity (strategy 1) and species separation (strategy 2) could be combined (**strategy 3**). This could be achieved sequentially by supplementing codend selectivity with any of the strategy 2 devices (CODEX or STIPED) that can be mounted in front of it, or simultaneously by applying either SORTEX or ADEM-4 devices. SORTEX or ADEM-4 share the same functioning concept, and are based on separating cod and flatfish vertically into two codends with adapted selectivity. Experimental trials demonstrated that these devices effectively separated cod from flatfish catches. SORTEX achieved ~90% separation efficiency (experiment 1). ADEM-4 was tested commercially in Skagerrak and Katterrak, resulting in catch ratios of ~100% of plaice above MCRS in the lower codend relative to a control trawl, while less than 2% of cod were caught in the same codend. Further investigations with SORTEX and ADEM-4 are still required, specially by combining the separation efficiency provided by both devices with codends designed to adress management strategies defining catch possibilities for cod in the Baltic Sea.

1.4 Effects of spatio-temporal closures on reducing cod bycatch

Cod is caught together with flatfishes in demersal fisheries. In the area of SDs 24-32, the main target flatfish species are plaice and flounder. Within this area, plaice is most abundant in SD 24, where close to 70% of the plaice landings were taken in 2018; and it occurs also in SD25 (Figure 1.3). Flounder is distributed in the entire area covered by the bottom trawl survey (SDs 24-28) (Figure 1.3). Thus, cod and flounder overlap in the entire distribution area of the eastern Baltic cod stock, whereas plaice and eastern Baltic cod overlap mainly in SDs 24-25.

The largest proportion of EU flounder landings in SDs 24-32 are taken in SD25 (68% in 2018), followed by SD24 (15% in 2018), SD28 (10% in 2018) and SD26 (6% in 2018) (Figure 1.4). Most of the EU flounder landings in the Baltic Sea are taken by Poland (75% in 2018), where flounder is an important supplement to demersal fisheries catches. Relatively low EU flounder landings in SD26 are likely related to a Polish fishing ban for flounder in SD26 from 15 February to 15 May.

Largest amount of flounder landings are taken in the 1st quarter of the year (44% in 2018), (Figure 1.4). It is different for plaice, where the highest landings in 2018 were taken in the 4th quarter (Figure 1.4). Most of plaice landings are taken in SD24, thus the 1st quarter plaice landings in 2018 were affected by a cod spawning closure at that time.

Maps with EU landings of cod, flounder, and plaice, by months and rectangle in 2018 are shown in Figure 1.4.4. These data show that both cod and flatfishes occur together in landings in all areas in SDs 24-26. The fraction of cod is generally low in flounder fisheries in more northern areas (i.e. in SD28). The amounts and fractions of cod in the landings vary between rectangles and months. In some areas, major parts of landings were cod (e.g. in April-June in the western part of SD26).

The analyses presented in section 1.1 showed that a large part of plaice and flounder landings in 2018 were taken with a relatively low bycatch of cod (<10% cod in landings per trip). However, it is presently not possible to point out larger areas within SDs 24-26 or months where cod bycatch in flatfish fisheries would be consistently relatively lower compared to other areas or months, when using same fishing gears. This would require comprehensive analyses including several years' data to investigate whether there are spatio-temporal patterns in cod bycatch (when using same gears) that would be stable between years. Such analyses were not possible to conduct for this report. Thus, there could potentially be areas and months where cod bycatch would be consistently relatively lower, but this has presently not been thoroughly investigated. Considering the spatial overlap between the flatfish and eastern Baltic cod stock (Figure 1.3), there are no areas within SDs 24-26 where flatfish fisheries with non-selective gears could be conducted without a risk of bycatch of cod. Therefore, it would not be possible to design spatio-temporal closures that would avoid any bycatch of cod.

In terms of spatial distribution of EU flatfish landings, SD26 has had a relatively little importance in later years (6% of EU flounder landings in SDs 24-32 were taken in SD26 in 2018). A largest fraction of cod landings (50% in 2018) has in later years been taken in SD26 (Figure 1.5). Also survey information supports that a substantial part of the eastern Baltic cod stock is distributed in SD26 (Figures 1.3 and 1.5). Therefore, a potential closure of SD26 for demersal fisheries would protect a substantial part of the eastern Baltic cod stock, while having limited implications for EU flatfish fisheries.

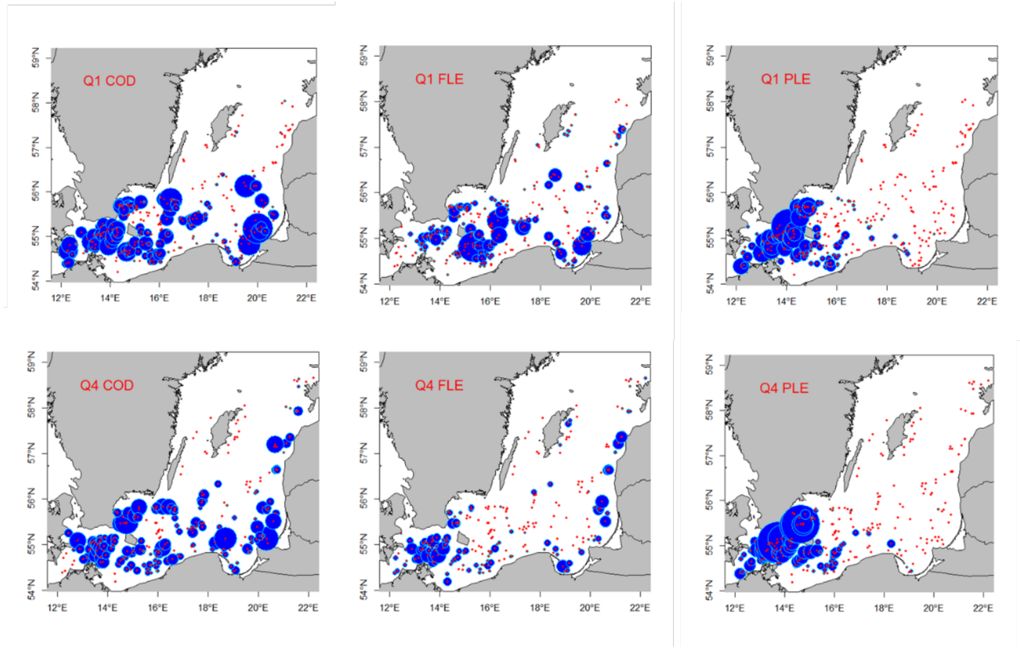

Figure 1.3. Distribution of cod (all sizes), flounder (FLE, >23cm) and plaice (PLE, >25cm) in BITS surveys in 1st and 4th quarter (data are shown for Q4 in 2017 and Q1 in 2018).

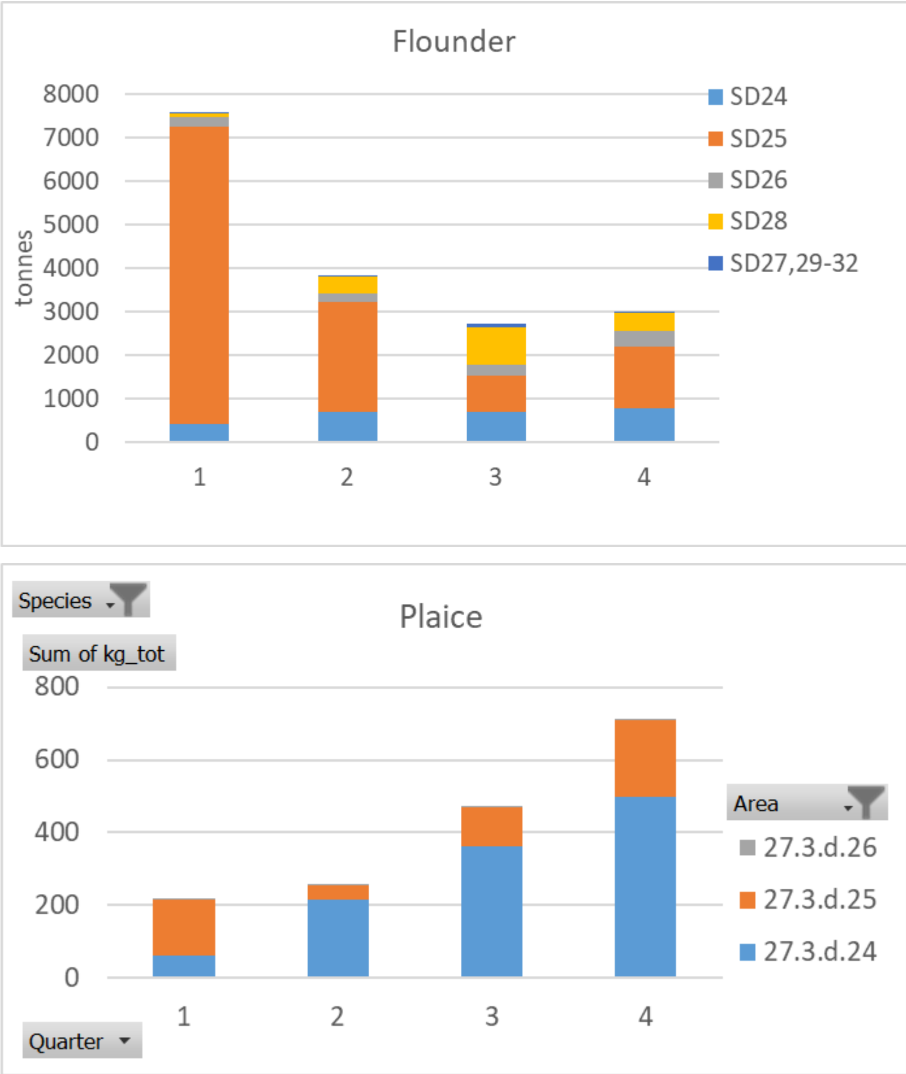

Figure 1.4. Flounder and plaice landings (EU countries) in 2018, by quarter and SD (RDB data).

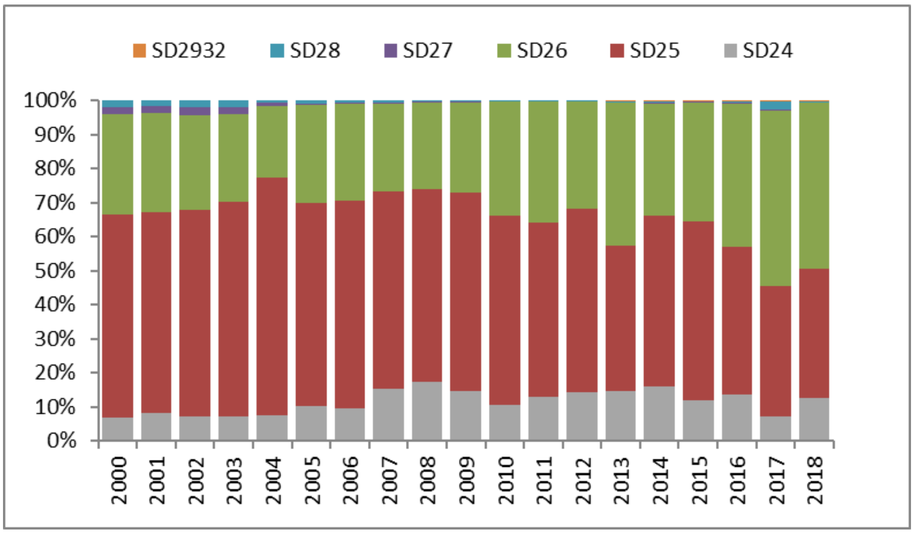

Figure 1.5. Relative distribution of total landings of the eastern Baltic cod stock by SD (Data from ICES WGBFAS 2019a).

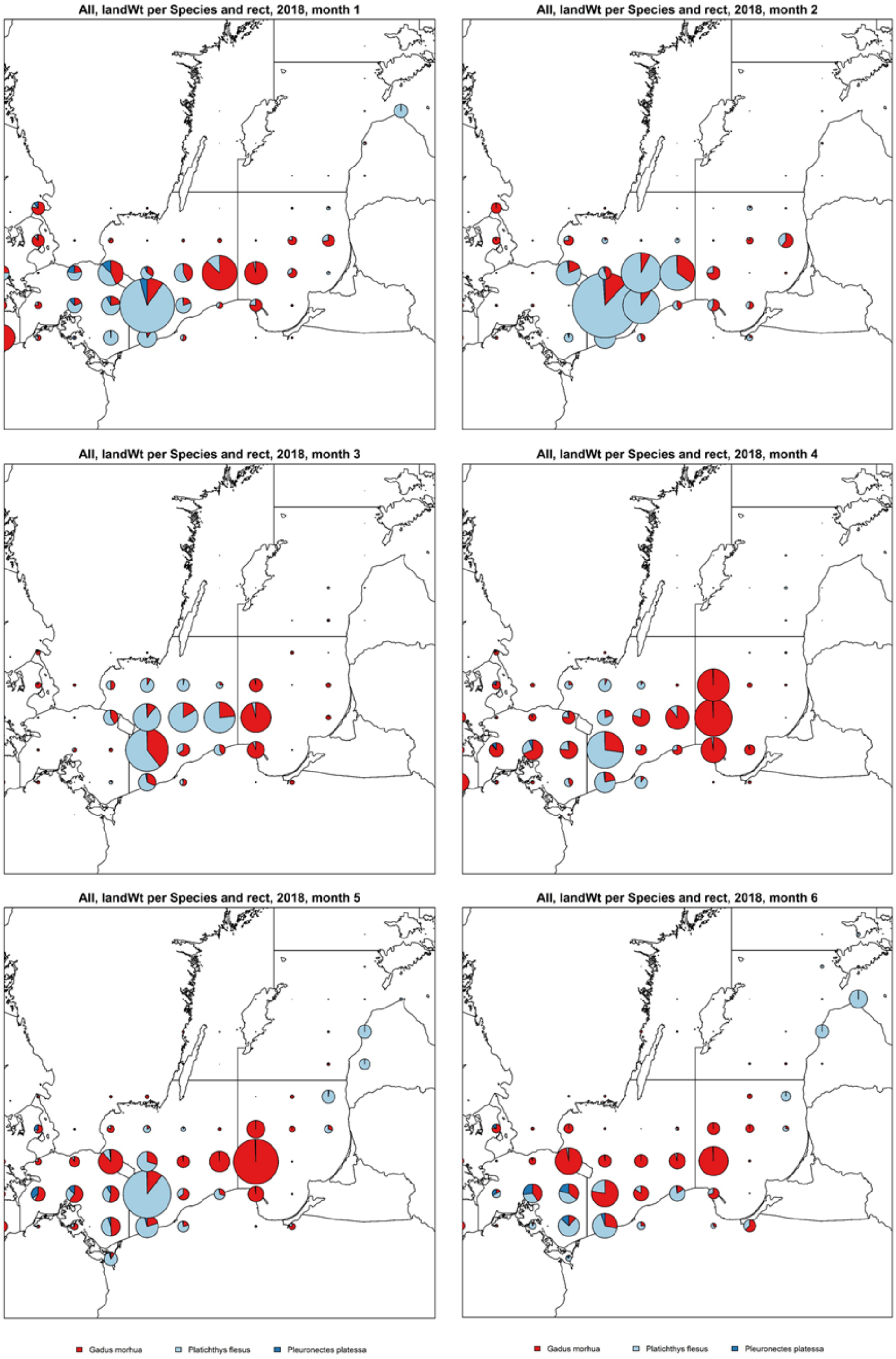

Figure 1.6. to be continued

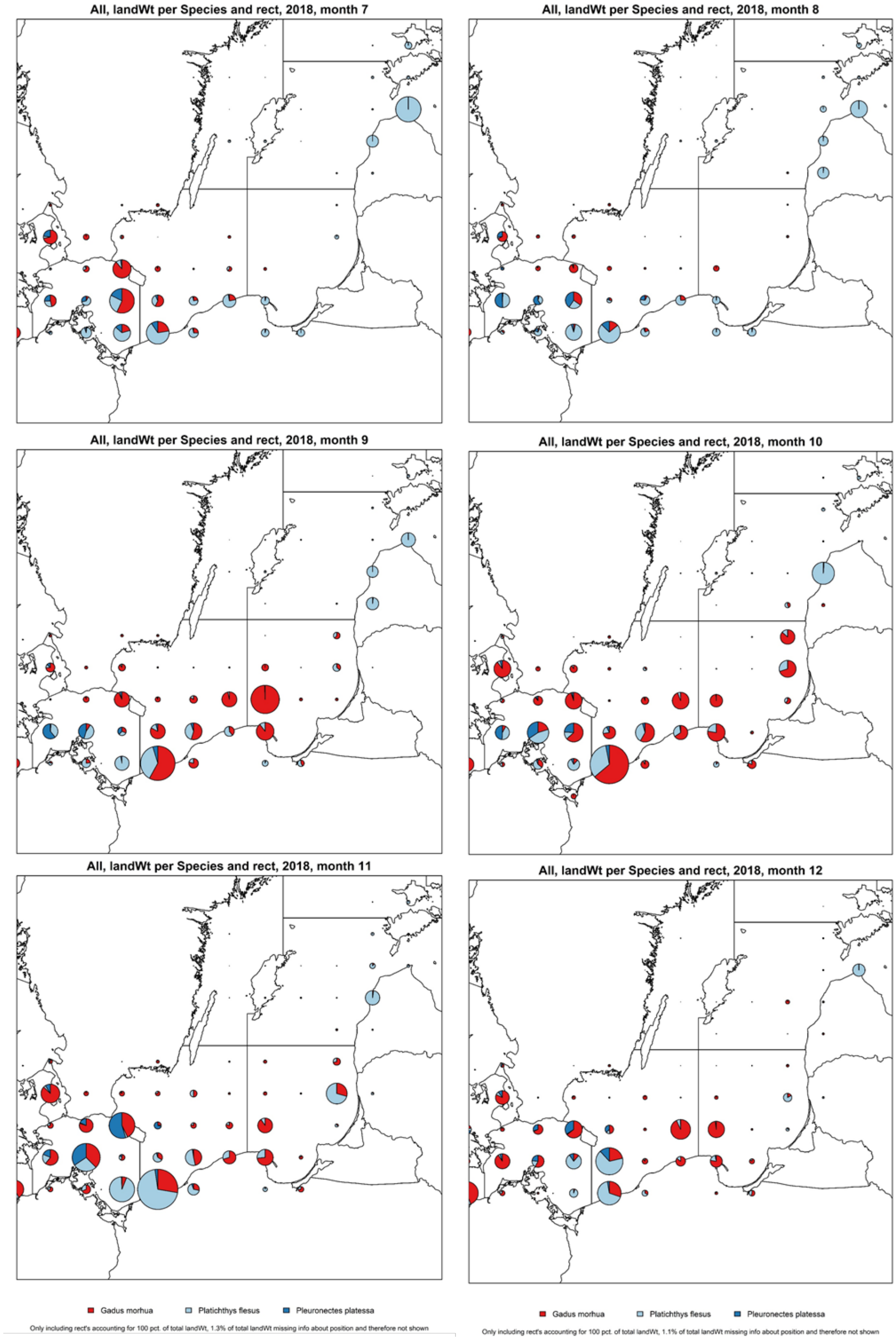

Figure. 1.6. Landings of cod (in red), flounder (light blue) and plaice (dark blue) in 2018, by month. The size of pie charts corresponds to the amount of landings and is comparable across months. The data are for EU countries from RDB. The pie charts are placed in the middle of the rectangles, thus do not show the exact location of the landings within a rectangle.

2 Eastern and Western Baltic cod stocks in SD 24

Since 2003, there are two management areas for cod in the Baltic Sea, Western (ICES SD 22–24) and Eastern (ICES SD 25–32). These corresponds to the main distribution areas of the Western and Eastern Baltic cod stocks, however both cod stocks occur in SD24. The stock separation has been confirmed in genetic studies (Hemmer-Hansen *et al.* 2019; Weist *et al.* 2019) and is maintained primarily through differences in spawning areas, spawning time and egg characteristics. These genetically divergent stocks differ with respect to growth, recruitment and exploitation rates (Bagge *et al.,* 1994; Hüssy *et al.,* 2016). Since the ICES Baltic cod benchmark in 2015, mixing of the two cod stocks is accounted for in stock assessment. Separation of catches to stocks is based on a combination of genetics and otolith shape analyses (ICES WKBALTCOD2 2019). Thus, the ICES stock assessments are conducted separately for the eastern (EBC) and western (WBC) cod stocks (not by management areas). In SD24, which is part of the western management area, both Baltic cod stocks are unavoidably caught together. The following sections present the state of knowledge on spatio-temporal patterns in stock mixing in SD24, and bycatch on EBC in cod fisheries in SD24.

2.1 Geographical distribution of eastern and western Baltic cod stocks in SD 24

2.1.1 East-west gradient in stock mixing

Methods

Information on mixing proportions of eastern and western Baltic cod in SD24 is based on Danish and German samples, originating from commercial and survey catches. Part of this information is used in the stock assessments and management advice of ICES.

Commercial samples

The cod samples for deriving stock mixing proportions for stock assessment purposes mostly come from Danish commercial landings, in recent years supplemented by German data in some years (ICES WKBALTCOD2 2019). Danish and German samples cover both the active gear (trawls) and passive gear fleet. Information on geographical location of the Danish samples is limited to ICES rectangle and is only based on logbook information as landings are sampled at landings locations. It should be noted that the rectangle shown in Danish logbooks may not always correspond to the actual catch position of the sampled cod, e.g. if several rectangles were covered during one fishing trip. This is different for German commercial samples that can be traced back to the GPS position as catches are sampled by observers at sea and fishers provide this information for each self-sample.
To check the influence of the possible mismatch between the area noted in Danish logbooks and the actual fishing location, VMS data in combination with logbook information was used. The stock mixing proportions applied in stock assessment context are calculated separately for subarea 1 (west of 13° E) and subarea 2 (east of 13° E) within SD24. Thus, if a sample originates from a trip that according to logbook information is from Area1, but in reality, the fish have been caught in Area 2 during the same trip, this could introduce some bias in the spatial information on stock mixing proportions. To check whether this could be the case, all Danish landings in the timeframe 2016-2018 from SD24 where analysed for the position of the haul (estimated from VMS data) compared to the ICES rectangle noted in the logbook. The results of this analysis indicate that for nearly all of the trips, where the landings have been assigned to area 2, the hauls were

actually conducted in area 2 (99-100%). However, between 78 and 92% of the hauls, where the ICES rectangle noted in the logbook corresponded to area 1, were conducted in area 1. This implies that 8-22% of the hauls allocated to area 1 based on logbook information were actually conducted in area 2. This indicates that the fraction of the eastern Baltic cod estimated for area 1 based on Danish commercial data can to some extent be an overestimate. Therefore, validation of these estimates with survey based data (where catch position is exactly known) is useful.

Table 2.1. Analysis conducted on fishing area (1 or 2) based on VMS information. The first column indicate the area (Area 1 or Area 2) where a given fishing trip has been assigned, based on information in logbooks. Columns Area1_vms and Area2_vms show how many fishing hauls have been assign to either areas, based on VMS data. The last 2 columns indicate the percentage of the fishing trips conducted in either area 1 or 2.

Year	Area_log	n_trips	Area1_vms	Area2_vms	pct_fishery_Area1	pct_fishery_Area2
2016	Area 1	189	781	220	78	22
2017	Area 1	157	801	67	92	8
2018	Area 1	196	924	122	88	12
2016	Area 2	600	6	3611	0	100
2017	Area 2	218	12	1619	1	99
2018	Area 2	224	13	1975	1	99

Survey samples:

Germany conducts the Baltic International Trawl Survey (BITS) in the 1st quarter (February-March) and in the 4th quarter (November) in SD24. Survey data have the advantage that the catch position of the analysed cod is exactly known compared to commercial data, and the estimates are therefore useful for validating the spatial differences in the estimates of stock mixing from commercial catch samples.

Estimating stock mixing proportions:

Cod otoliths are assigned to the stock of origin using otolith shape analysis. Danish commercial otoliths are analysed using methodologies described in Hüssy *et al.* (2016) and ICES (WKBALTCOD2 2019). German commercial and survey otoliths are analysed using the methods described by Schade *et al.* (2019). These methodologies have recently been evaluated during the cod benchmark process in ICES; further details can be found in ICES WKBALTCOD2 (2019).

Results

Analyses of both commercial and survey samples show that there is an east-west gradient in the proportion of EBC within SD24, with the proportion of EBC increasing towards the east. Genetic analyses have shown that the proportion of EBC increases in the area around 13° E (Figure 2.1; Hemmer-Hansen *et al.*, 2019; Weist *et al.*, 2019).

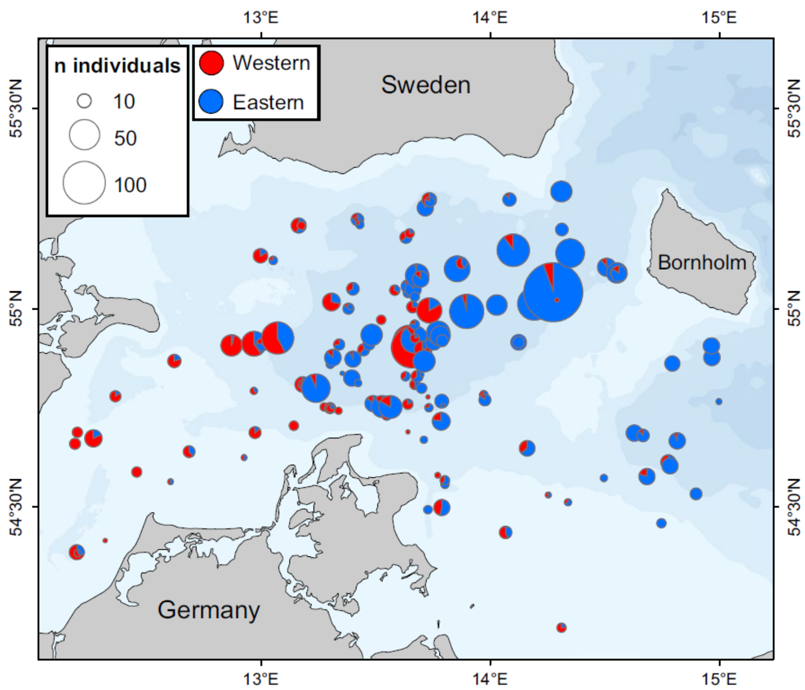

Figure 2.1. Proportions of eastern (EBC) and western Baltic cod (WBC) for juvenile and adult samples collected from 2011 to 2015 in SD24 (from Hemmer-Hansen *et al.*, 2018). Stock assignment based on genetics.

This was confirmed by otolith shape analyses showing a higher proportion of EBC in areas east of 13°E within SD24, compared to the area between 12° and 13°E (Figure 2.2). For simplicity, ICES uses two subareas (areas 1 and 2) within SD24 when calculating mixing proportions in commercial catches of EBC and WBC, which separate at 13°E (Figure 2.2).

Based on the otolith shape analyses of commercial catch samples, used in ICES stock assessment, most cod caught in the area east of 13° E (Area 2 in Figure 2.2) were assigned to the EBC stock (78% on average in last 10 years). In the area between 12° and 13°E (Area 1), on average, slightly less than half of the cod were assigned to the EBC stock (46% in last 10 years). The proportion of eastern cod may be lower close to the border of SD 22, however, the data presently available do not allow quantifying mixing proportions at a finer spatial scale.

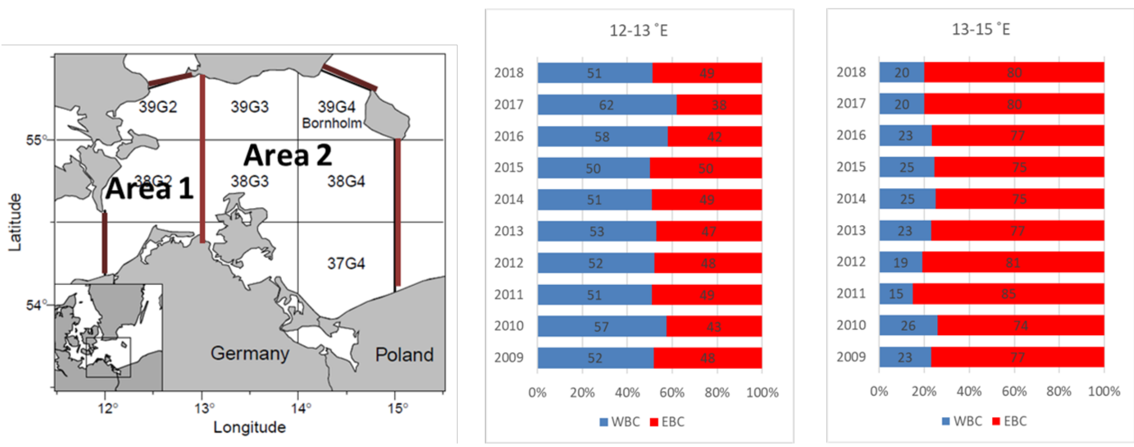

Figure 2.2. Proportion (%) of EBC (in red) and WBC (in blue) in SD24 from commercial samples, shown separately for two subareas, i.e. west (Area 1, 12-13 °E) and east (Area 2, 13-15 °E) (from ICES 2019a). Stock assignment based on otolith shape analysis.

The estimated mixing proportions based on survey samples in SD24 are generally in line with the presented estimates based on commercial catch samples. This is despite some differences in size distribution of cod between commercial catch and surveys, as the survey catches generally contain smaller individuals.

In surveys, constantly high proportions of EBC were found east of 14°E (on average 77% in the past 11 years), while the proportion of EBC was significantly lower west of 13°E and west of 14°E (on average 48% and 58%, respectively; Figure 2.1.3). However, the mixing proportions of the two cod stocks in the area west of 13°E showed marked fluctuations (from 17 to 60% EBC; Figure 2.3). The variability may be due to lower sample size in the area west of 13°E. Variability in mixing proportions could also be attributable to the strong interaction with water depth that has an effect on the stock composition of the catch (see chapter 2.1.2).

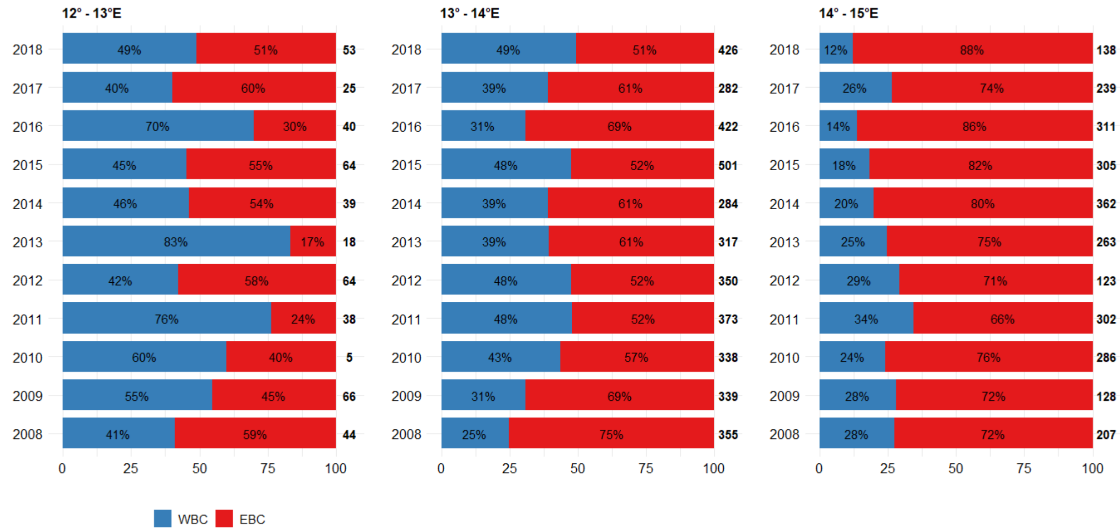

Figure 2.3. Mixing proportions of WBC and EBC in SD24 from scientific trawl samples from the German BITS in the 4th quarter between 2008 and 2018. Stock assignment based on otolith shape analysis. Numbers of otoliths per year used in the shape analysis are given on the right side of each plot.

Genetic analyses of cod covering SD24 and adjacent areas suggested that there is very little EBC west of SD24, i.e. SD22 and SD23; and very little WBC east of SD24, i.e. in SD25 and SD26 (Figure 2.4, Weist *et al.*, 2019). This shows that according to our present understanding, mixing is restricted to SD24, and cod in SD2223 can be considered to be largely WBC, and cod in SD2526 can be considered to be largely EBC.

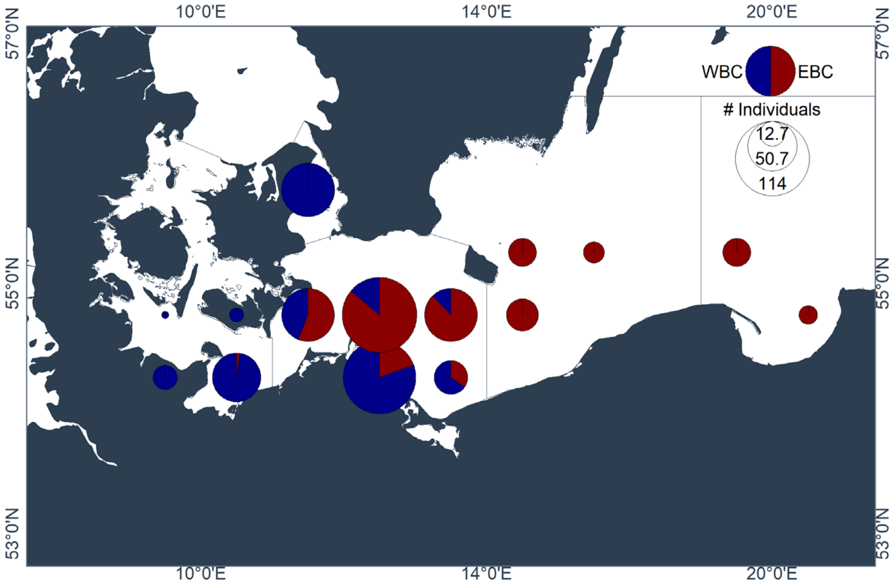

Figure 2.4. Mixing proportions of EBC and WBC in SD22 to SD26 based on commercial (active and passive gear) and survey samples (active gear) from 2015 and 2016 (N=554, from Weist *et al.*, 2019). Stock assignment based on genetics.

Seasonal variation

Seasonal variations in mixing proportions have been investigated based on data from Danish commercial samples (Hüssy *et al.*, 2016) and from scientific survey samples from the German BITS (Figure 2. 5). In the commercial samples, stock mixing proportions varied over the seasons for all analysed years, but no consistent seasonal pattern was evident. Consequently, samples from all quarters were pooled in the analyses of mixing proportions for stock assessment purposes.

The comparison of mixing proportions based on samples from BITS in the 1st and 4th quarter from selected years between 1995 and 2016 did not show significant differences (1 to 10% deviation between quarters within the same year, Figure 2.5). This suggests that survey data from the 1st quarter can also be used as proxies for the mixing proportions of the 4th quarter survey within the same year and vice versa.

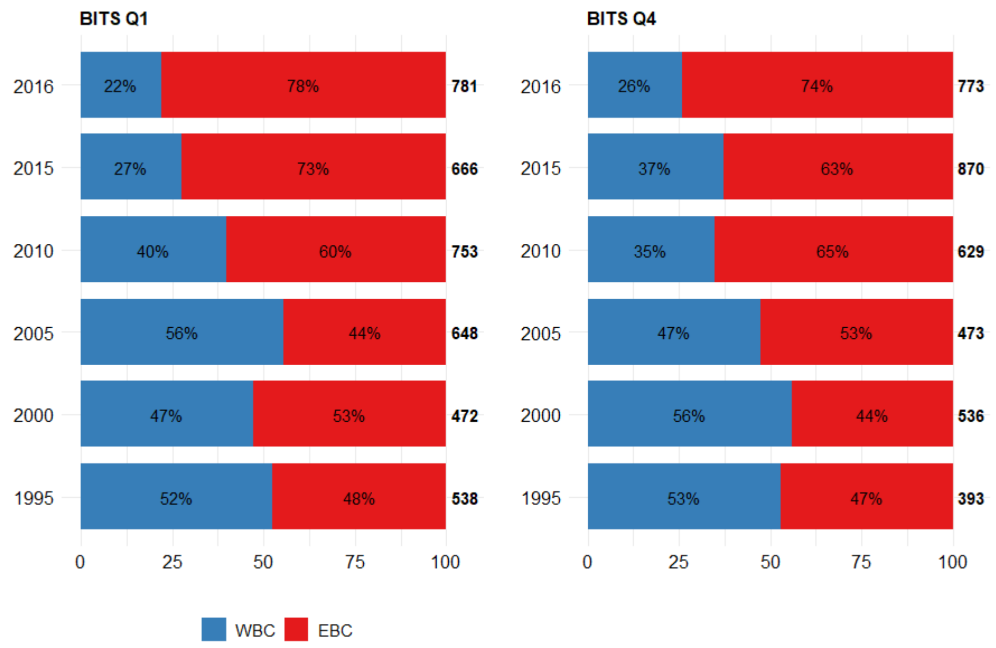

Figure 2.5. Mixing proportions of WBC and EBC in SD24 from samples based on the German BITS in 1st and 4th quarter between 1995 and 2016 (selected years, N=3858 otoliths). Stock assignment based on otolith shape analysis. Numbers of otoliths per year used in the shape analysis are given on the right side of each plot.

Conclusion

EBC occurs throughout SD24 and in all seasons. However, there is east-west gradient in stock mixing with lower proportion of EBC in the area west of 13°E (on average 47% EBC in the past 11 years), compared to the area east of 13°E (on average 78% EBC). This result is consistent between samples from commercial catches and research surveys. Survey data show intermediate proportion of EBC in the area between 13-14°E (on average 60% EBC, in the past 11 years).

2.1.2 Coastal-offshore gradient in stock mixing

Methods and data analyses

For this analysis, we used the mixing proportions of EBC and WBC in SD24 based on samples from German commercial catches (passive and active gear) in 2016, 2017 and 2018 and from the German Baltic International Trawl Survey (BITS; active gear) in the 4th quarter in 2018 (Table 2.2). A commercial sample usually is an unsorted catch sample, comprising the entire haul (passive gear) or a subsample (active gear) of 200 to 300 kg. For each sample, otoliths from 10 fish per 1 cm length class were taken. Within a given year, the commercial samples usually cover all quarters and the major fishing grounds of the German fleet in SD24. The samples from the BITS were taken according to the survey manual. Both German commercial and BITS data have a geographical position (latitude/longitude) for each sample, so that mixing proportion can be related to water depth. Data from other nations are not available on a similar spatial resolution (position and/or water depth).

Each cod otolith was assigned to the stock of origin using otolith shape analysis as described by Schade *et al.* (2019). In brief, images of entire and clean sagittal otoliths (N_{total} = 3538, Table 2.2) were taken with a stereomicroscope equipped with a digital microscope camera. Subsequent otolith shape analyses on high-contrast images were conducted using the ShapeR package (Libungan and Pálsson, 2015) in the R environment (R Core Team 2019). A baseline of stock-specific otolith shapes derived from genetically validated cod reference samples (Weist *et al.*,

2019) was used to assign otolith shapes from this study either to the EBC or WBC stock. The individual classification success of this approach is presently 83 to 85%.

Table 2.2. Number of individual cod otoliths and total fishing hauls (in brackets) used for otolith shape analysis grouped by gear type (passive/active), depth stratum (0-10m, 10-20m, >20m) and capture year (2016, 2017, 2018). Only hauls with ≥20 cod were used for the analysis. Samples originate from German commercial catches from 2016, 2017, and 2018 (passive and active gear) and from the German BITS in 4th quarter, 2018 (active gear) in SD24.

	Passive gear samples			Active gear samples		
Depth stratum (m)	0-10	10-20	>20	0-10	10-20	>20
2016	427 (3)	465 (4)	-	-	-	337 (2)
2017	147 (1)	298 (2)	-	-	206 (1)	149 (3)
2018	103 (1)		-	-	265 (2)	1141 (22)

For the analysis of coastal-offshore patterns in stock mixing, we calculated mixing proportions for each haul using the individual stock assignment of the cod samples, and grouped the data according to four alternative approaches:

1. Depth strata (0-10m, 10-20m, >20m),
2. “Distance to German baseline” strata (0-6nm, 6-12 nm, >12nm),
3. Gear types (passive commercial, active commercial, active survey/research),
4. Longitudinal sectors (12-14°E, 14-15°E).

The grouping by longitudinal sector combined the sectors 12-13°E and 13-14°E because the sample size from sector 12-13°E was too low.

Results

The proportion of EBC varied between samples, but showed a clear decreasing trend from east to west, and towards shallower waters and the coast/baseline (Figure 2.6).

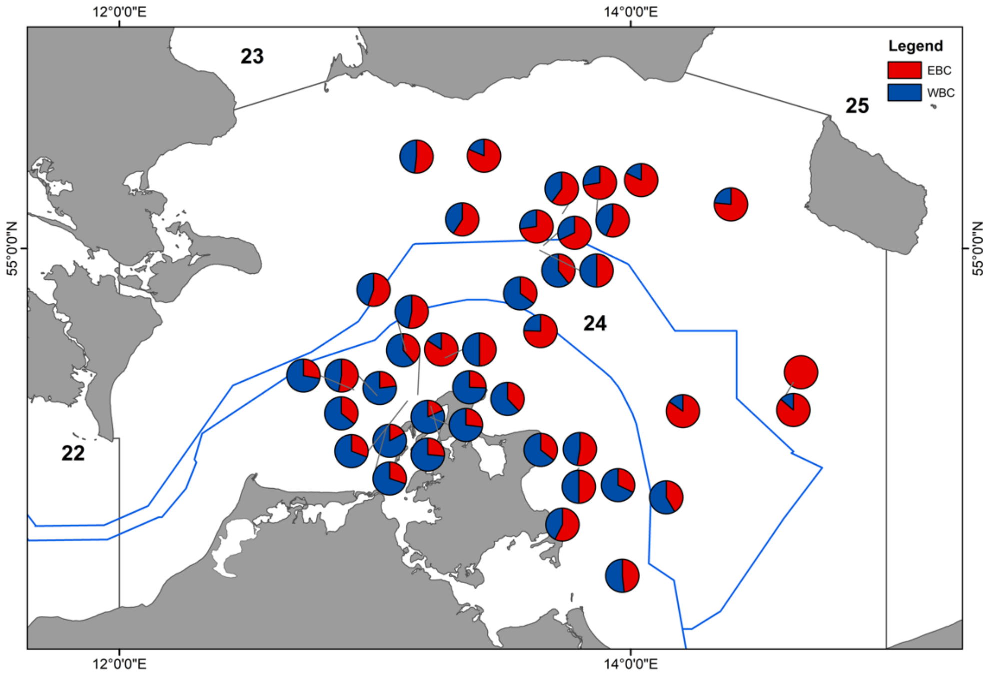

Figure 2.6. Mixing proportions of EBC and WBC in SD24 based on samples from German commercial catches from 2016, 2017 and 2018 (active and passive gear) and from the German BITS in the 4th quarter, 2018 (active fishing gear). Only hauls with ≥20 cod are shown. Blue lines delimit German territorial waters (*12*-nm *zone* from the baseline) and the German EEZ, respectively. Stock assignment based on otolith shape analysis (N_{total} = 3538 otoliths from 41 hauls).

There was a clear relationship between fishing gear type and the proportion of EBC in the catches, which reflects different fishing depths of the active and passive gear fleet. Passive gear catches had significantly lower proportions of EBC than active gear catches (Figure 2.7). Mean proportion of EBC in commercial passive fisheries was about 30%, while it was 50% in commercial active gear and even around 60% in research survey catches (using a scientific trawl). The proportion of EBC also decreased towards the (German) coast, and towards shallower waters. It appears likely that the same holds for most of the other coastlines along SD24, however probably not around Bornholm. The lowest proportions of EBC occurred in waters shallower than 10m (mean 27%; Figures 2.7 and 2.8).

While the active gear fleet usually operates in waters deeper than 20 m, the passive gear fleet sets gillnets in waters shallower than 20 m (see also Table 2.2). This responds to the fact that trawlers are not allowed to fish within the 3 nm zone and in shallower waters, while gillnetters mainly operate in shallower inshore waters, also to avoid disturbance of the set gillnets by trawlers. This depth effect (less EBC in water shallower than 20 m and 10 m) is evident in Figures 2.7 and 2.8.

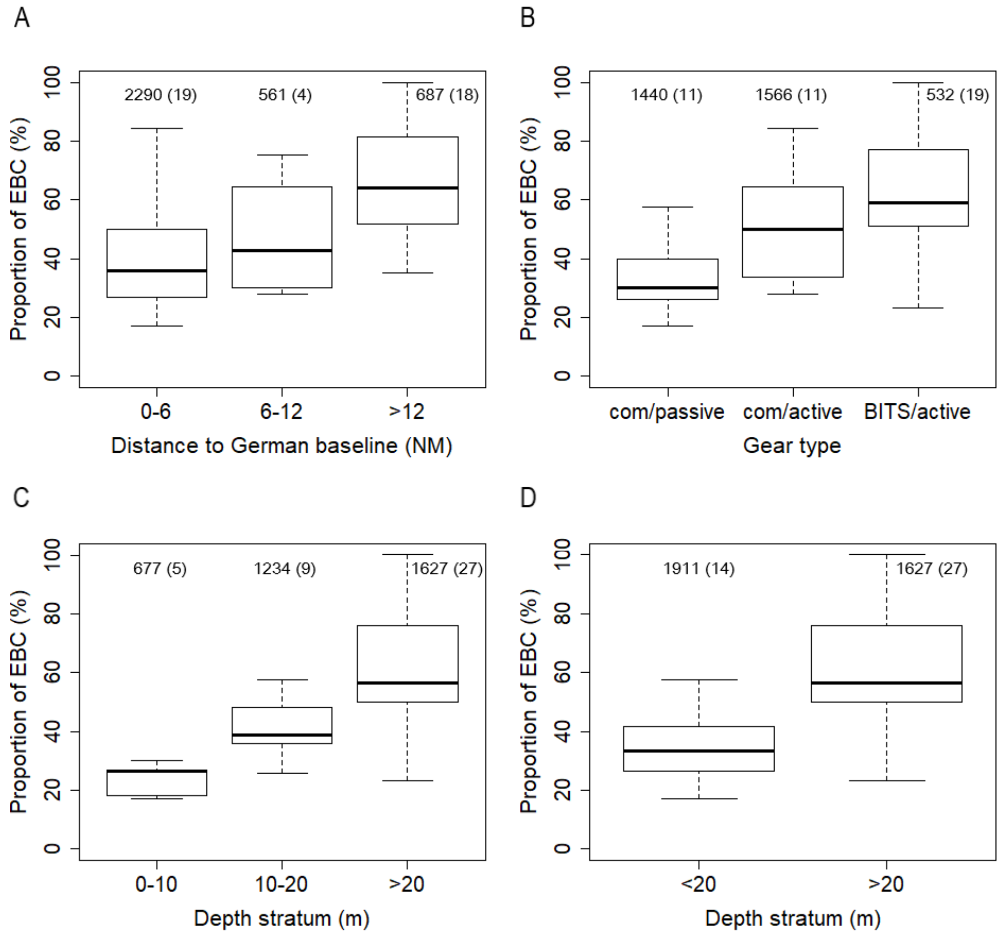

Figure 2.7. Proportion of (EBC) in catches in SD24 grouped by (A) distance to German sea baseline, (B) gear type (commercial passive, commercial active and BITS active gear), (C, D) depth strata (two different classifications). The box represent the interquartile range (IQR) with the median and the 1st and 3rd quantiles at the bottom and top of the box, respectively. Lower and upper whiskers are restricted to 1.5 x IQR. Numbers on top of each box plot correspond to the numbers of analysed otoliths and in brackets the numbers of sampled hauls. Stock assignment based on otolith shape analysis.

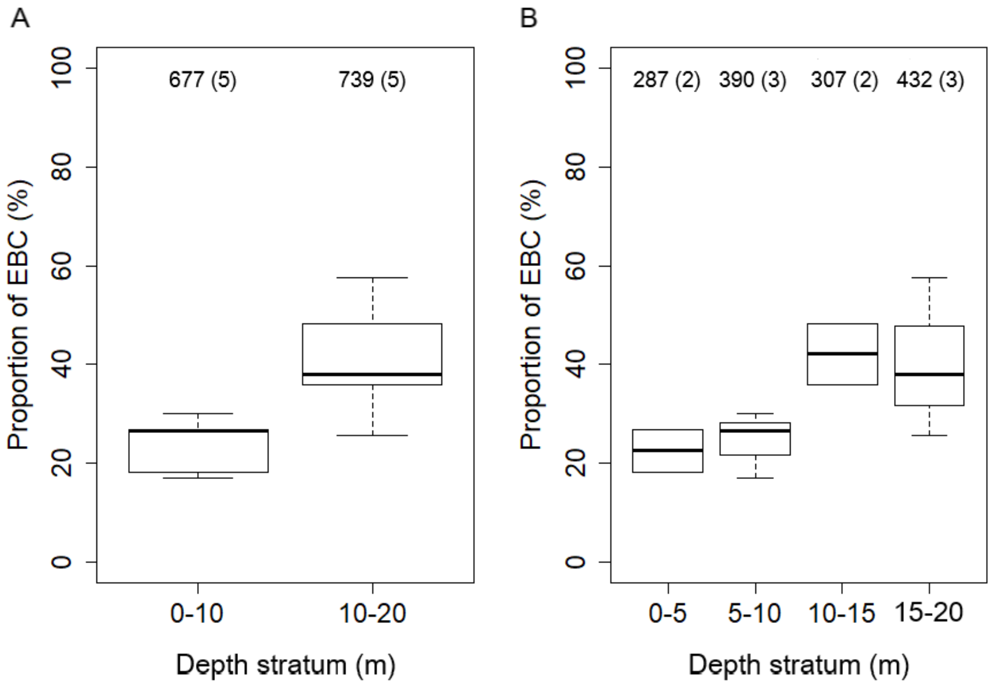

Figure 2.8. Proportion of EBC in SD24 based on commercial samples from passive gear fisheries close to the German sea baseline (0-6nm) grouped by different depth strata, shown at a lower (A) and higher depth resolution (B). Definition of box plot components and numbers on top of each box plot as in Figure 2.7. Stock assignment based on otolith shape analysis.

The data confirm the east-west gradient of EBC described in the previous section, which is present both in offshore and coastal areas (Figure 2.6). The proportion of EBC in commercial and survey catches was highest in the eastern areas of SD24 and lowest in the west (Figure 2.9). The mean proportions of EBC in passive and active gear catches were 83% in the longitudinal sector 14-15°E and 50% in the 12-14°E sector. This east-west gradient was also reflected when passive and active gear samples were analysed separately, even though passive gear samples from the 14-15°E sector originated from only one haul (Figure 2.9).

In the area close to the sea baseline (0-6 nm), the mean proportion of EBC was also around one third (36%). However, ”distance from the baseline” is probably not a useful category for management purposes. First, the 6nm is not an official line in legal nautical charts and is, hence, difficult to control; second, it has no ecological meaning regarding the distribution of cod.

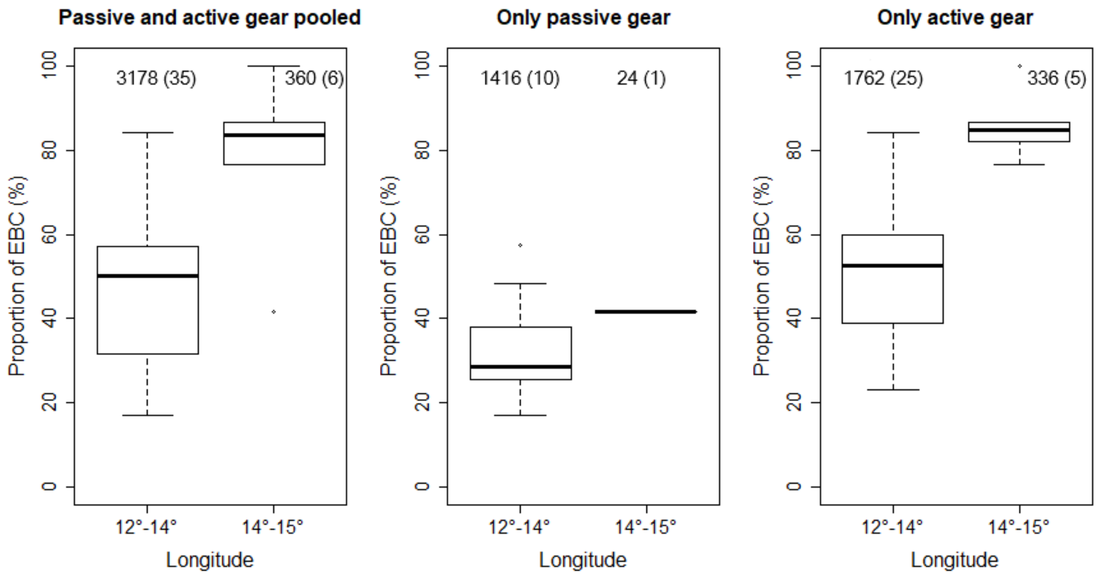

Figure 2.9. Proportion of EBC in SD24 in the longitudinal sectors 12-14°E and 14-15°E grouped by (A) passive and active gear pooled, (B) commercial passive gear only, and (C) active gear only (commercial and BITS). Definition of box plot components and numbers on top of each box plot as in Figure 2.7. Hollow circles in box plots represent outliers. Stock assignment based on otolith shape analysis.

This analysis suffers from the lack of international data, which are not available given the lack of spatial details in the data collected by other countries. It is assumed that the proportions of EBC presented here based on German data are similar along the Danish coast of Falster, Mön and Sealand (12-13°E or ICES rectangles 37G2, 38G2, 39G2), as well as southern Sweden, but are likely different around Bornholm (ICES rectangles 38G4, 39G4) due to the proximities to deeper waters dominated by EBC. However, no analyses are presently available for these areas to validate these hypotheses.

Conclusion

In addition to east-west gradient in stock mixing (see section 2.1.1), the proportion of EBC is lower in waters between 0-10m or 10[§]-20m deep (on average 27% or 39% EBC, respectively). This is assumed not to apply for the coastal waters around Bornholm.

2.2 Bycatch of eastern Baltic cod in fisheries targeting western Baltic cod in SD24

Bycatch of EB cod in fisheries targeting WB cod depends on:

i. Total catch/TAC of cod in the western Baltic management area (SDs 22-24);
ii. Distribution of fisheries targeting WB cod between subdivisions, i.e. what fraction of the WB cod catch is taken in SD24 compared to SDs 22-23;
iii. Distribution of the cod fishery within SD24, as there are both east-west and coast-offshore gradients in mixing of EB and WB cod (see Section 2.1 for more details).

[§] Modified following reviewers' comments.

Bycatch at status quo fishing patterns

Between 50 and 60% of total commercial cod catch (EBC+WBC) in the management area of SDs 22-24 has been taken in SD24 in later years (53% on average in the most recent three years) (ICES 2019a). Therefore, 53% of the cod TAC for SDs 22-24 management area could be expected to be taken in SD24 in 2020, at status quo fishing patterns.

74% of the cod caught in SD24 have been from the EB stock (on average in the most recent three years). This implies that catching 1 kg of WBC in SD24 is associated with a bycatch of 2.90 kg of EBC.

Assuming status quo fishing patterns, EBC bycatch in fisheries targeting WBC in SD24 in 2020 can be calculated as:

$$EBcod\_bycatch_{SD24} = TAC_{SD22-24} \times 0.53 \times 0.74$$

$TAC_{SD22-24}$ is the cod TAC for the management area of SDs 22-24;
0.53 is the fraction of total commercial cod catch in the management area of SDs 22-24 taken in SD24 (based on average in 2016-2018);
0.74 is the average proportion of cod in SD24 that belongs to the EBC stock (based on average in 2016-2018).
The commercial quota for cod in SDs 22-24 in 2020 at 3806 tonnes would correspond to 1493 tonnes EBC bycatch, at the fishing patterns observed in later years. However, due to additional restrictions for cod landings in SD24, the fraction of cod commercial catch taken in SD24 in 2020 will most likely reduce.

Possibilities to reduce bycatch of EBC in fisheries targeting WBC in SD24

Commercial fishing in subdivisions 22–23 will provide a catch of the WB cod stock only. Therefore, EBC bycatch in fisheries targeting WBC could be reduced by reducing the proportion of WBC catches taken in SD24. Furthermore, within SD24, bycatch of EB cod would be reduced by reducing fisheries in the eastern and offshore areas (with water depth deeper than 20 m) in SD24. This is because of lower proportion of EBC in the western part of SD24 (west from 13˚E) and in coastal shallow areas (see section 2.1 in this report for more details). In terms of gear types, the proportion of EBC is lower in fisheries by passive gears (e.g. gillnets) and higher in active gears (trawls), the latter have taken most of the cod landings (65-75%) in SD24 in latest years. This is due to passive gears fishing mostly in shallower coastal areas, where the proportion of EBC is lower.

Most of the commercial cod landings in SD24 (EBC+ WBC) have historically been taken in the area between 13-15˚E, i.e. in the area with higher proportions of EBC. 88% of the landings were taken in the area between 13-15˚E, while 12% were taken in the area between 12-13˚E, on average in the last 3 years (ICES 2019a). Consequently, only 1% of the total landings of eastern Baltic cod in last about 10 years has been taken in the area between 12-13˚E (Table 2.2.1). Therefore, fishing in the area west from 13 ˚E has had limited impacts on the eastern Baltic cod stock.

Table 2.3. Amount of eastern Baltic cod landings taken in the area west of 13 °E compared to total landings from the EBC stock.

Year	Amount (t) of eastern cod landings west of 13 degrees	Total landings of eastern Baltic cod (t) in SD24-32	% af eastern cod landings taken in the area west of 13 degrees
2009	677	56722	1.2
2010	647	56325	1.1
2011	668	57913	1.2
2012	527	59694	0.9
2013	430	36714	1.2
2014	618	34364	1.8
2015	552	43108	1.3
2016	289	33854	0.9
2017	111	27500	0.4
2018	224	18202	1.2

Conclusions

Bycatch of EBC in the WBC fishery, at status quo fishing patters, can be calculated as the TAC for the management area (SD22-24) multiplied with the proportion of the catch taken in SD24 (0.53 in last 3 years) and the proportion of cod in SD24 that belongs to the eastern stock (0.74 in last 3 years). Due to additional restrictions for cod landings in SD24, the fraction of commercial catch taken in SD24 in 2020 will most likely change compared to the pattern observed in last 3 years. Bycatch of EBC in fisheries targeting WBC in SD 24 can be reduced by reducing fisheries in deeper offshore areas in SD24, east from 13˚E (see section 2.1).

2.3 Impact of a potential closure of SD24 for western Baltic cod landings

Approximately half of the total cod landings (EBC+WBC) taken in the management area of SD22-24 have come from SD24 in the last 3 years (ICES 2019a). Cod landings in SD24 mainly originated from Denmark and Poland, followed by Sweden and Germany (Figure 2.10).

Most of the total cod landings in SD24 were taken by demersal trawls in 2018 (Figure 2.11). Cod landings in SD24 were distributed throughout the year, but with relatively lower landings in August-Sept (the low landings in February-March were due to a spawning closure) (Figure 2.12).

Denmark, Germany and Sweden had cod landings in other areas in the Western Baltic management area (i.e. in SD22-23), in addition to SD24. Polish cod landings in the western Baltic were only taken in SD24. In terms of vessel size, different vessel size groups contributed to cod landings in SD24 in 2018. However, the majority of the landings (70%) was taken by vessels above 12 m (Figure 2.13).

25% of the commercial landings of WBC stock have been taken in SD24 (on average in 2016-2018) (Figure 2.14). Therefore, a total closure of SD24 would result in corresponding proportional reduction in WBC commercial landings, at status quo fishing patterns. In case of a total closure in SD24, it is difficult to foresee to what extent the different countries would reallocate their fishery to SD22-23, especially in cases where a country has not been fishing in these areas earlier (e.g. Poland).

The ability to take the entire cod TAC set for the western Baltic management area in SDs 22-23 depends also on the level of that TAC. In 2018, 2885 tonnes of cod was landed from SDs 22-23, and 4319 and 3137 tonnes in 2016 and 2017, respectively (Figure 2.14). Considering the estimated increase in stock size of WBC from 2017 to 2020 (ICES 2019a), the cod TAC at 3806 tonnes for SDs 22-24 in 2020 would likely be possible to take in SDs 22-23.

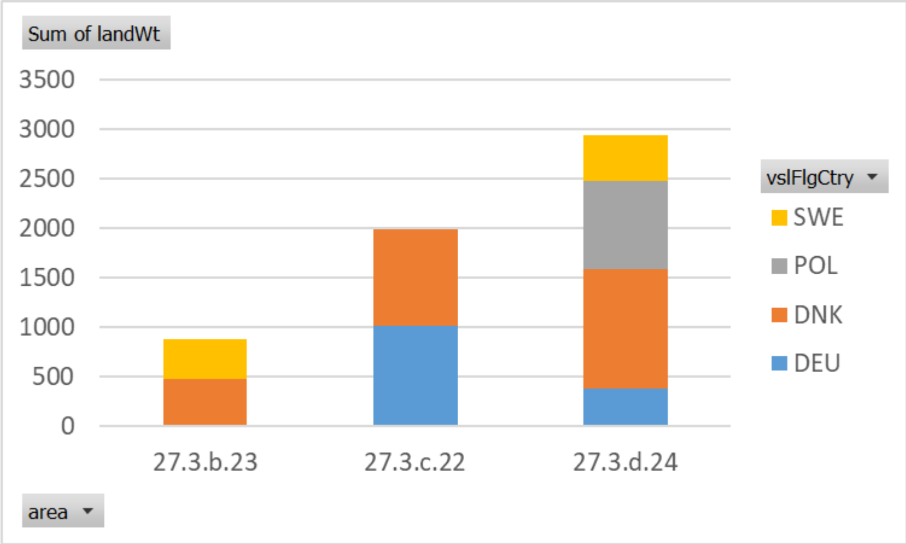

Figure 2.10. Cod landings (tonnes) in WB management area by country and SD, in 2018. Data provided to ICES in response to a data call in 2019.

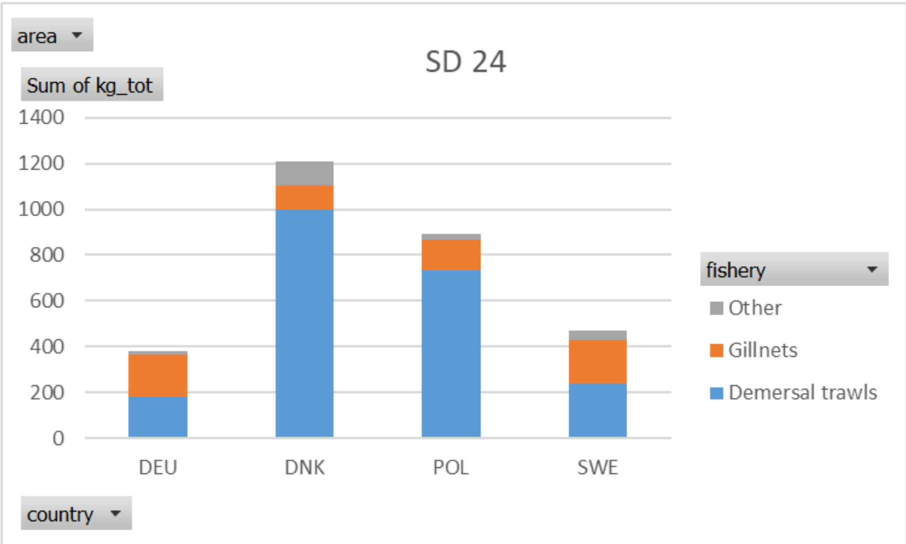

Figure 2.11. Total cod landings (tonnes) in SD24 in 2018, by country and gear type. Data provided to ICES in response to a data call in 2019.

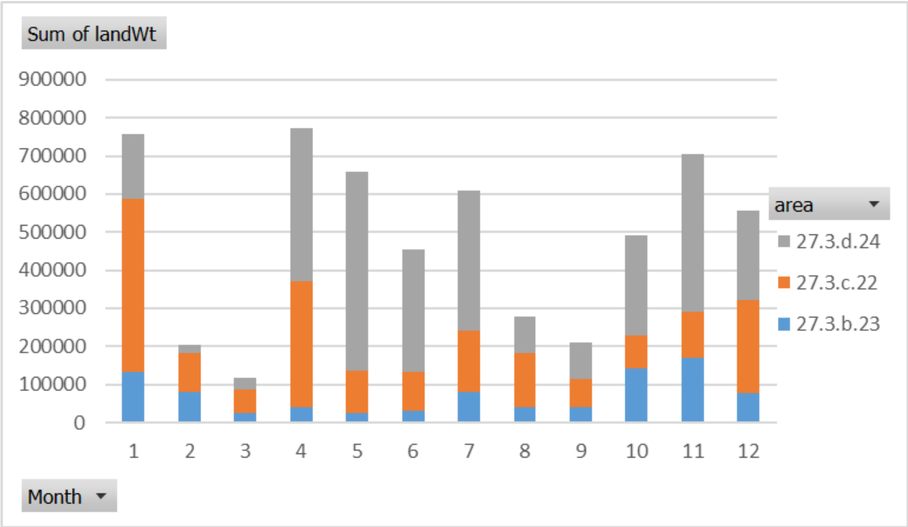

Figure 2.12. Total cod landings (tonnes) in 2018, by SD and month. Low landings in months 2-3 were due to a cod spawning closure, implemented with some exemptions. Data provided to ICES in response to a data call in 2019.

Figure 2.13. Cod landings (tonnes) in western Baltic management area (SD 22-24) by country and vessel size. Data provided to ICES in response to a data call in 2019.

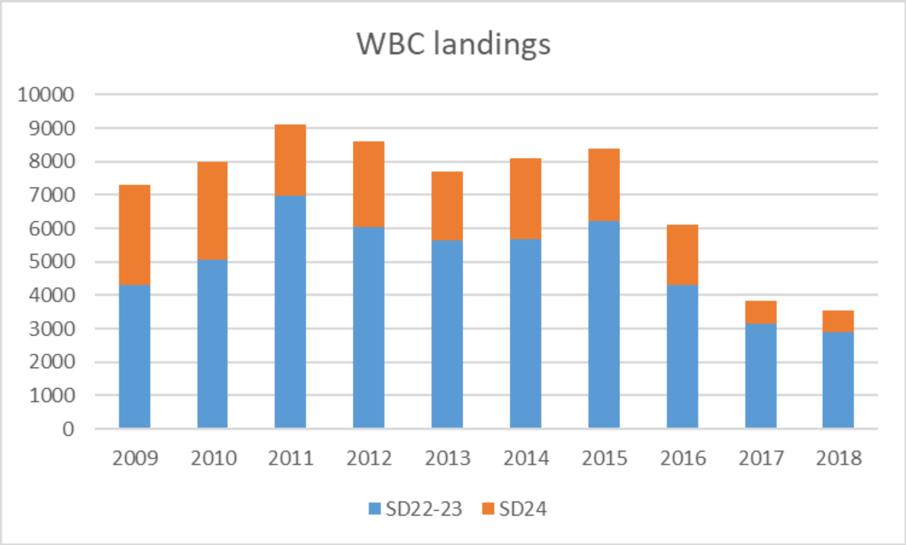

Figure 2.14. Commercial landings of WBC stock by SD. Data from ICES 2019a.

Conclusions

A closure of SD24 could result in up to 25% loss of WBC commercial landings, at the fishing patterns observed in latest years. It is difficult to foresee to what extent effort reallocation to SDs 22-23 would be possible for different fleets. The cod TAC at 3806 tonnes for the western Baltic management area in 2020 is close to the amount that has been taken in SD22-23 in later years. Thus, the TAC at 3806 tonnes would likely be possible to take in SD22-23.

3 Eastern Baltic cod in subdivisions 27-32

3.1 Eastern Baltic cod catches in SDs 27-32

Data

The time-series of catches in SDs 27-32 shown in this document are based on the data provided to the ICES Baltic Fisheries Assessment Working Group. This information is available by Active (e.g. trawls) and Passive (e.g. gillnets) gears. More specific information on the métiers contributing to the landings in SDs 27-32 was available for 2018, from Regional Database (RDB).

Results

Catches taken in SDs 27-32 have contributed less than 1% to the total catch from the eastern Baltic cod stock in 2010-2018, with the exception of 2017, when these areas contributed close to 3% of the total cod catches (Table 3.1). Eastern Baltic cod catches in SDs 27-32 were between 150 and 400 tonnes in the latest years (2010-2018), with the exception of 2017 when 883 tonnes were taken in this area (Table 3.2). This was due to relatively higher catches in SD28. Most of the cod catch within SDs 27-32 has been taken in SDs 27-29, with annually varying proportions of these SDs contributing to the cod catch.

The contributions of Active and Passive gears to cod catches in SDs 27-32 have been variable between years. In most years since 2010, both gear types have either contributed equally or Passive gears have dominated. An exception is 2017, when Active gears took most of the cod catch in SDs 27-32 (Table 3.3). Fishing pattern was much different in 2018, when Passive gears took 94 % of the cod catches in SDs 27-32. Most of the cod landings in SDs 27-32 in 2018 was taken by gillnets with 110-156 mm mesh size targeting demersal species.

Table 3.1. Relative contribution of catches in SDs 27-32 (in %) to the total catch of eastern Baltic cod (in SDs 24-32).

Year	BAL27	BAL28	BAL29	BAL30	BAL31	BAL32	Total
2010	0.08	0.10	0.08	0.00	0.00	0.00	0.27
2011	0.07	0.15	0.11	0.00	0.00	0.00	0.33
2012	0.04	0.30	0.11	0.00	0.00	0.00	0.45
2013	0.07	0.49	0.16	0.00	0.00	0.01	0.72
2014	0.06	0.56	0.27	0.00	0.00	0.01	0.90
2015	0.07	0.23	0.23	0.00	0.00	0.00	0.54
2016	0.18	0.31	0.40	0.00	0.00	0.00	0.89
2017	0.33	2.21	0.32	0.00	0.00	0.00	2.86
2018	0.20	0.18	0.40	0.00	0.00	0.00	0.78

Table 3.2. Commercial catch (tonnes) of eastern Baltic cod in SDs 27-32 in 2010-2018.

Year	BAL27	BAL28	BAL29	BAL30	BAL31	BAL32	Total
2010	47.9	63.9	50.6	1.1	0.0	2.6	166
2011	44.7	97.1	69.4	0.4	0.0	2.5	214
2012	26.3	208.2	75.5	0.5	0.6	2.0	313
2013	29.7	222.1	73.2	0.3		2.5	328
2014	27.5	251.5	123.1	1.2	0.1	3.7	407
2015	33.0	116.3	112.3	2.1	1.3	1.9	267
2016	66.4	114.4	149.8	1.0	0.0	1.0	333
2017	102.3	681.5	98.4	0.8	0.0	0.4	883
2018	42.1	37.9	86.8	0.4	0.1	0.3	168

Table 3.3. Relative contribution (in %) of Active and Passive gears to the eastern Baltic cod catch in SDs 27-32.

Year	Active	Passive
2010	25	75
2011	36	64
2012	52	48
2013	57	43
2014	36	64
2015	23	77
2016	34	66
2017	83	17
2018	6	94

Conclusions

Catches taken in SDs 27-32 have contributed less than 1% (150-400 tonnes) to the total catch from the eastern Baltic cod stock in 2010-2018, with the exception of 2017, when these areas contributed close to 3% (883 tonnes) of the total eastern Baltic cod catches. Most of the cod catch within SDs 27-32 has been taken in SDs 27-29. Active and passive gears have contributed to cod landings in varying proportions. In 2018, most of the cod landings in SDs 27-32 were taken by gillnets with 110-156mm mesh size targeting demersal species.

3.2 Effect of fishing at status quo level in SDs 27-32 on the biomass of eastern Baltic cod

Methods

To quantify the impact of continued fishing in SDs 27-32 at status quo level on cod biomass, two short-term forecast scenarios were run. The two scenarios differed in terms of the catch amount applied for 2020. In the baseline scenario (Scenario 0), catch from the entire eastern Baltic cod stock was set to zero in 2020. The results from Scenario 0 were compared to the scenario of status quo fishing effort in SDs 27-32 in 2020 (Scenario 1). *Status quo* fishing effort was assumed to correspond to the cod catch amount recorded in SDs 27-32 in 2018, i.e. 168 tonnes. In Scenario 1, total catch from the entire eastern Baltic cod stock in 2020 was set to 168 tonnes, i.e. assuming zero catches of eastern Baltic cod in other areas.

Total eastern Baltic cod catch in 2019 was set to 12 754 tonnes, in both scenarios 0 and 1. This catch amount was assumed to have been taken in Q1-Q2 in 2019, applying zero catch in Q3–Q4. Data on actual realized catches in 2019 are not yet available. Therefore, the assumption of 12 754 tonnes is based on assuming similar fishing mortality in 2019 Q1-Q2 as estimated for 2018 Q1-Q2. In both scenarios 0 and 1, the same assumptions were applied for recruitment (average of 2013–2017) and other biological parameters (latest estimates).

Results and conclusion

The results show little difference in the estimated SSB in 2021 between the two investigated scenarios (Table 3.4). Applying zero catch in 2020 for the entire eastern Baltic cod stock (Scenario 0) resulted in 0.08% higher SSB in 2021 compared to status quo fishing in SDs 27-32 (Scenario 1). The very small difference is due to a very low cod catch amount recorded in SDs 27-32 in 2018 (168 tonnes), applied in Scenario 1.

Table 3.4. Results of the short-term forecast scenarios. Weights are in tonnes.

Scenario	Total catch (2019)	F (2019)	Total catch (2020)	F (2020)	SSB (2019)	SSB (2020)	SSB (2021)
Scenario 0	12 754	0.13	0	0	66 353	71 578	79 122
Scenario 1	12 754	0.13	168	0.002	66 353	71 514	79 055

3.3 Potential impact of increased fisheries in SDs 27-32 on the biomass of eastern Baltic cod

Methods

It is not possible to reliably quantify how much the cod catches in SDs 27-32 could potentially increase as a result of effort reallocation to these areas. For this reason, maximum possible impact on the eastern Baltic cod biomass was evaluated, under an extreme scenario of fishing effort. The maximum theoretically possible impact on cod stock would be eradication of the fraction of the stock distributed in SDs 27-32. It is unrealistic that a commercial fishery could remove all cod present in this area. Thus, the realized impact on the stock biomass would likely be less than corresponding to the fraction of the stock in this area.

The data used includes catch per unit of effort (CPUE) in research surveys in 2018 and distribution of fisheries catch. The Baltic International Bottom trawl survey covers SDs 27-28 within the area of SDs 27-32. Fisheries catch data were available by SDs for the entire distribution area of the stock.

A rough approximation of relative stock distribution from survey catches was derived from area weighted CPUE values. The proportion of the stock in each SD was calculated as shown in the example of SD28:

$$Prop_{SD28} = \frac{CPUE_{SD28} \times W_{SD28}}{\sum_{n=25}^{28}(CPUE_{SDn} \times W_{SDn})}$$

where *W* is the size of the area of respective subdivision (SD).

Results and conclusions

Cod catch per unit of effort (CPUE) in research surveys in SDs 27-28 is substantially lower than in SDs 25-26 (Figure 3.1). The area weighted CPUE in SDs 27-28 was between 1 and 4% of the sum of area-weighted CPUEs in SDs 25-28, estimated both in terms of numbers and biomass and for 1st and 4th quarter. This can provide a rough proxy for stock distribution, and is in line with the spatial distribution of commercial catch observed in later years, where less than 3% of total catch from the stock has been taken in SDs 27-32 (Table 3.2). Thus, the survey information supports that the spatial distribution of commercial catches recorded in later years roughly represents the distribution of the stock.

Consequently, even at the scenario of extreme high fishing effort in SDs 27-32, less than 3% of the total biomass of eastern Baltic cod could be removed, i.e. even when removing the entire fraction of the cod stock distributed in SDs 27-32.

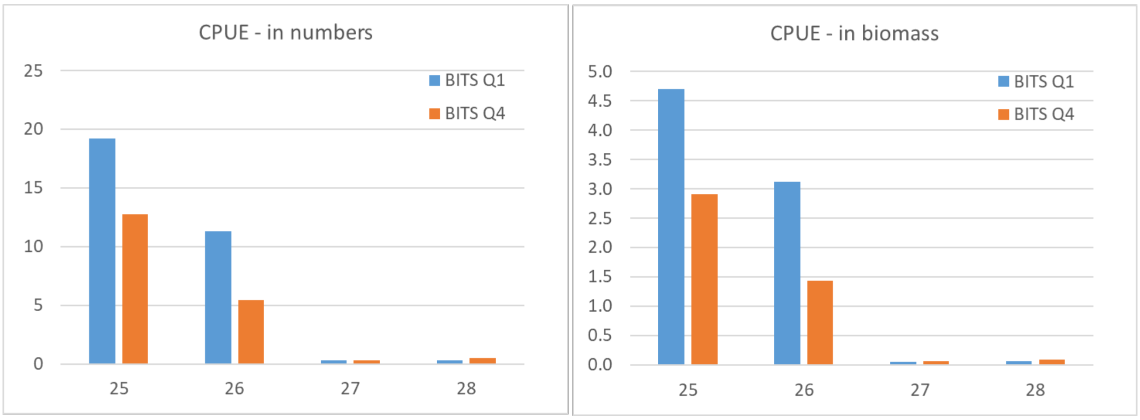

Figure 3.1. Catch per unit of effort of eastern Baltic cod in 1st and 4th quarter BITS surveys, by Subdivisions 25-28, weighted by the size of the area of the SD.

3.4 Size and condition of cod in SDs 27-32

The cod in SDs 27-32 is on average relatively larger than in SDs 25-26 in later years (since 2015) (Figure 3.2). In 2018, about half of the commercially caught cod in SDs27-32 were above 45 cm in length, while in SDs 25-26 only 30% of the cod were larger than 45 cm. This is based on data on length distributions of cod in commercial catches provided to ICES Baltic Fisheries Assessment Working Group.

The average body condition of cod in SDs 27-28 was better in years 2010-2015 compared to SDs 25-26, especially in 4th quarter (Figure 3.4.2). However, in latest years condition has further deteriorated in SDs 27-28, with a higher fraction of cod at a very poor condition than in SDs 25-26.

Cod condition was calculated based on total length and whole weight data from bottom trawl surveys (BITS) in the 1st and 4th quarter, which cover only SDs 27-28 within the area of SDs 27-32. We used Fulton's -K index to represent cod body condition, calculated as

$$Fultons\ K = \frac{Weight}{Length^3}$$

There are indications that cod at healthier condition occurs in Åland Sea (northern part of SD 29), in the deep trench between the northern Baltic Proper and the Bothnian Sea, at around 100-260 m depth (Figure 3.4). Cod caught in a small-scale commercial gillnet fishery in the area has a mean weight of 2.5 kg. The cod is indicated to grow fast, reaching a mean length of 50 cm at age 3 and 60 cm at age 4 (Bergström *et al.*, 2015). There are indications that body condition of cod in this area is better than in the main distribution area of the stock, however quantitative comparison is presently not available. There is hardly any infection with *Psuedoterranova decipiens*, while the liver parasite *Contracaecum sp.* is widespread (Lunneryd 2014, SVA 2019).

Given that the cod in SDs 27-32 are generally larger (Figure 3.2) and in some areas in better condition (Åland Sea), it would be relevant to know whether these individuals can contribute to recruitment. A large part of the cod caught in Åland Sea is in spawning condition. Even though the cod abundance in SDs 27-32 is low, the relatively larger and healthier individuals could still be valuable for reproduction, if their offspring can survive due to hydrographic conditions, but this is presently unclear.

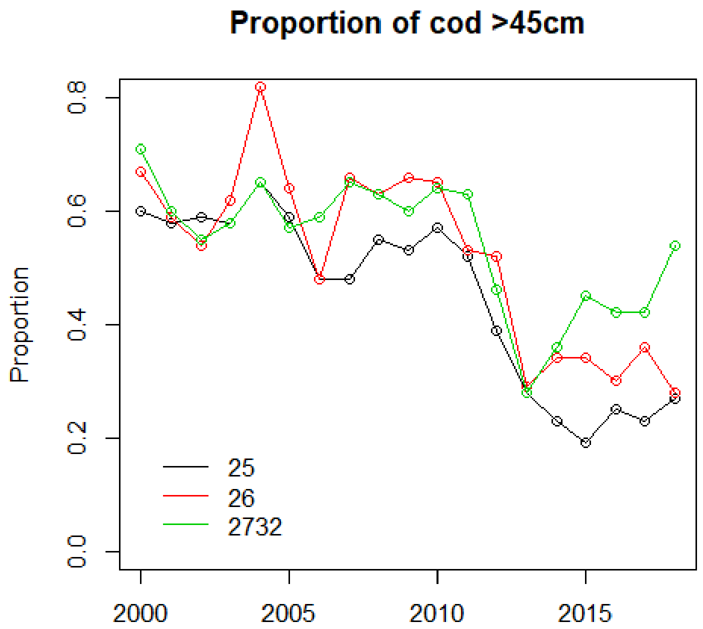

Figure 3.2. Proportion of larger cod (>45 cm) in commercial catches, by subdivision.

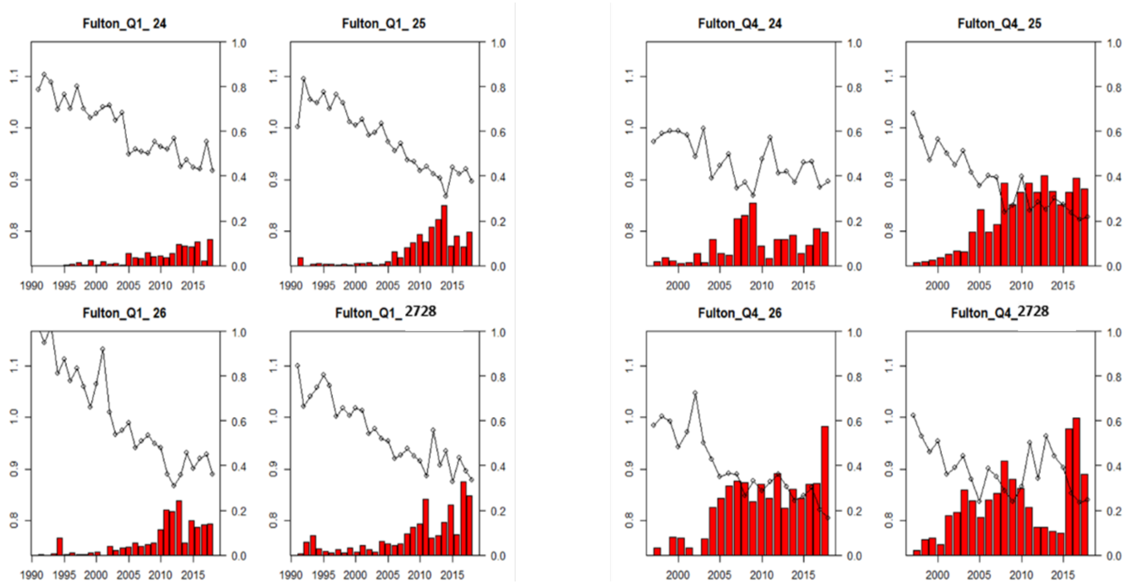

Figure 3.3. Fulton K condition factors for 40-60 cm cod in different SDs, by quarter. Data from BITS survey. The lines show mean values for Fulton K, the bars represent the proportion of cod at Fulton K <0.8.

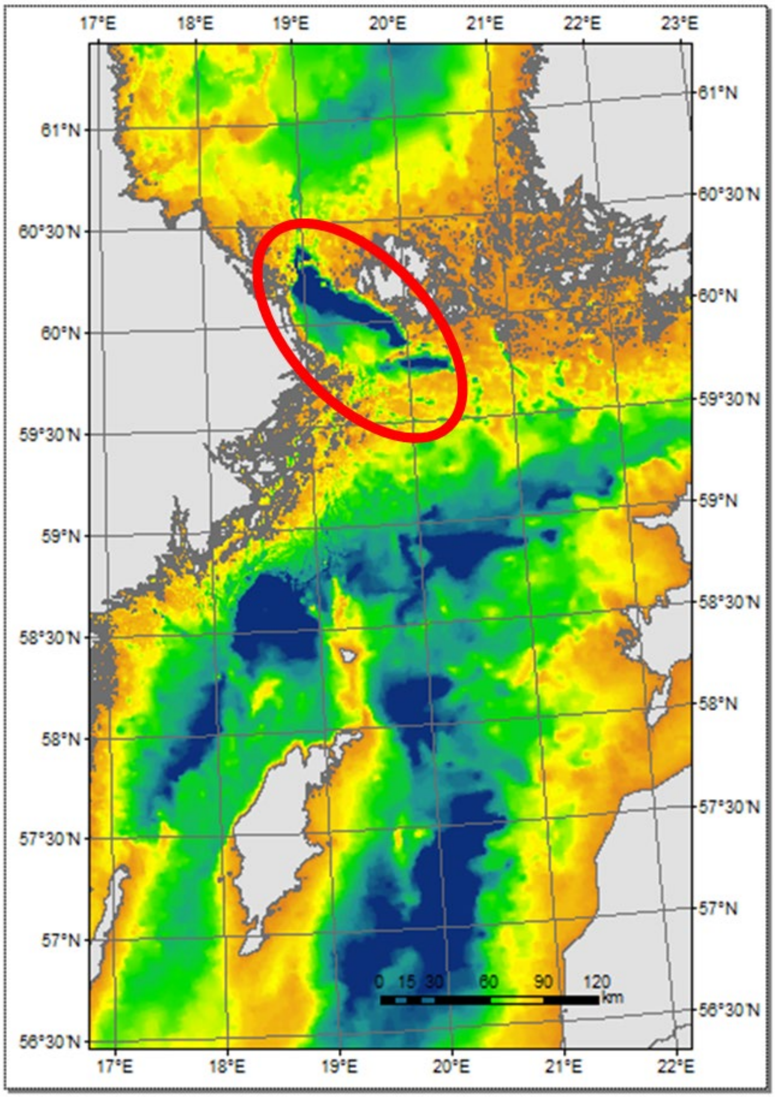

Figure 3.4. Location of small- scale cod fishery in the Åland Sea (marked in red), at 100-260 m depth.

Conclusions

The total biomass and abundance of cod in SDs 27-32 is low, however the cod found in this area are relatively larger than in SDs 25-26. The nutritional condition of the cod in SDs 27-28 (based on BITS survey) is poor in latest years, similar to SDs 25-26. However, indications exist that relatively larger cod at good condition occur in Åland Sea (northern part of SD 29). The importance of these few relatively larger and heathier individuals found in some areas within SDs 27-32 for the recovery potential of the stock is unclear.

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Annex 1: List of métiers by fishery and their total cod landings in 2018.

Fishery	Metier	Total cod landings (t)	Comments
Active_demersal	OTB_DEF_>=105_1_120	10369.1	
	OTB_DEF_>=115_0_0	740.8	
	OTB_DEF_>=120_0_0	658.2	
	OTB_DEF_90-104_0_0	0.0	
	OTM_DEF_>=105_1_120	4.7	
	OTT_DEF_>=105_1_120	165.6	
	OTT_DEF_>=115_0_0	58.4	
	OTT_DEF_>=120_0_0	0.9	
	PTB_DEF_>=105_1_120	16.6	
	PTB_DEF_90-104_0_0	0.1	
	SDN_DEF_>=105_1_120	42.2	
	SSC_DEF_>=105_1_120	0.4	
Coastal small scale	FPN_ANA_>0_0_0	0.1	
	FPN_CAT_>0_0_0	1.2	
	FPN_DEF_>0_0_0	8.9	
	FPN_FWS_>0_0_0	0.0	
	FPN_SPF_>0_0_0	3.4	
	FPO_ANA_>0_0_0	0.0	
	FPO_CAT_>0_0_0	0.0	
	FPO_DEF_>0_0_0	9.4	
	FPO_FWS_>0_0_0	0.1	
	FPO_SPF_>0_0_0	2.8	
	FYK_ANA_>0_0_0	0.0	
	FYK_CAT_>0_0_0	0.1	
	FYK_FWS_>0_0_0	0.3	
	FYK_SPF_>0_0_0	0.0	
	GNS_ANA_>=157_0_0	0.4	
	GNS_ANA_110-156_0_0	0.1	
	GNS_CAT_>0_0_0	1.4	
	GNS_CRU_>0_0_0	0.0	
	GNS_DEF_>=157_0_0	26.0	Vessels <10m
	GNS_DEF_110-156_0_0	680.4	Vessels <10m
	GNS_DEF_60-70_0_0	0.4	Vessels <10m
	GNS_DEF_90-109_0_0	31.9	Vessels <10m
	GNS_DEF_90-110_0_0	0.1	Vessels <10m
	GNS_FWS_>0_0_0	47.4	
	GNS_SPF_110-156_0_0	0.0	
	GNS_SPF_16-109_0_0	0.0	
	GNS_SPF_32-109_0_0	7.2	
	GTR_DEF_>=157_0_0	0.0	
	GTR_DEF_110-156_0_0	0.3	
	GTR_FWS_>0_0_0	0.0	
	GTR_SPF_32-109_0_0	0.0	
	LHP_FIF_0_0_0	2.0	
	LLD_ANA_0_0_0	0.2	
	LLS_ANA_0_0_0	0.0	
	LLS_CAT_0_0_0	0.1	
	LLS_DEF_0_0_0	201.0	Vessels <10m
	LLS_FWS_0_0_0	0.0	
	LLS_SPF_0_0_0	0.0	
	SB_FIF_>0_0_0	0.0	

Fishery	Metier	Total cod landings (t)	Comments
Passive_non_coastal	GNS_DEF_>=157_0_0	17.0	Vessels >=10m
	GNS_DEF_110_0_0	100.2	Vessels >=10m
	GNS_DEF_110-156_0_0	1622.1	Vessels >=10m
	GNS_DEF_90-109_0_0	7.2	Vessels >=10m
	GNS_DEF_90-110_0_0	0.0	Vessels >=10m
	GTR_DEF_>=157_0_0	0.5	Vessels >=10m
	GTR_DEF_110-156_0_0	1.3	Vessels >=10m
	LLS_DEF_0_0_0	408.9	Vessels >=10m
Active_pelagic	OTB_SPF_16-104_0_0	0.2	
	OTB_SPF_16-31_0_0	0.1	
	OTB_SPF_32-104_0_0	1.4	
	OTB_SPF_32-109_0_0	0.0	
	OTM_SPF_16_0_0	0.0	
	OTM_SPF_16_31_0_0	12.2	
	OTM_SPF_16-104_0_0	6.4	
	OTM_SPF_16-31_0_0	102.6	
	OTM_SPF_20_0_0	9.0	
	OTM_SPF_32-104_0_0	47.6	
	OTM_SPF_36_0_0	0.8	
	PS_SPF_16-31_0_0	0.0	
	PS_SPF_32-104_0_0	0.0	
	PTB_SPF_>=105_1_120	0.0	
	PTB_SPF_16-104_0_0	0.0	
	PTB_SPF_16-31_0_0	0.0	
	PTB_SPF_32-104_0_0	0.1	
	PTB_SPF_32-109_0_0	0.1	
	PTM_SPF_16_0_0	0.0	
	PTM_SPF_16-31_0_0	1.3	
	PTM_SPF_32-104_0_0	16.6	
	PTM_SPF_32-109_0_0	0.0	
	SDN_SPF_32-104_0_0	0.0	
Other	OTB_DEF_<16_0_0	12.1	
	OTB_FWS_>0_0_0	2.9	
	OTM_DEF_<16_0_0	5.6	
	PTB_FWS_>0_0_0	0.6	
	PTM_DEF_<16_0_0	0.2	

Annex 2: Reviewers' report

Reviewers; Mathieu Lundy (Agri-Food and Biosciences Institute, UK), Jon Elson (CEFAS, UK)
1 November 2019

In May 2019, ICES had insufficient data to provide advice to the commission on levels of a possible by-catch TAC in 2019 for Eastern Baltic cod. The mixing of Eastern Baltic and Western Baltic stocks in subdivision 24 complicates the management of the two stocks and further information is required to better inform management measures in that area.

The advice in May 2019 stated that abundance and catches in sub-divisions 27-32 are very low. The commission needs to consider the impact of any effort reallocation to this area when designing their management strategy for Eastern Baltic cod.

To that end the commission issued a further request to ICES

1. ICES is requested to estimate the levels of unavoidable by-catches of Eastern Baltic cod in fisheries not targeting Eastern Baltic cod (such as e.g. pelagic fisheries, flatfish fisheries, small-scale coastal fisheries when not targeting cod, and fisheries targeting Western Baltic cod in subdivision 24), where possible broken down by fishery and Member State, respectively in subdivisions 25-32 and subdivision 24.

- In that respect, ICES is requested to establish different scenarios and estimate their respective effect on the level of unavoidable by-catches: a baseline scenario which assumes unchanged fishing patterns in terms of effort and behaviour in fisheries not targeting Eastern Baltic cod; at least one, but preferably several, other scenarios in which by-catches are reduced by e.g. using more selective gears and/or closures. Such scenarios would be particularly important for demersal flatfish fisheries, which traditionally have been mixed fisheries of flatfish and cod.

2. ICES is requested to provide more details on the geographical distribution within subdivision 24 of the Western and the Eastern Baltic cod stock. For example:

- Are there areas or time periods where Eastern Baltic cod stock are more abundant which might be suitable for closure to minimise catches. What would be the impact of such closures on the Western Baltic cod catches.

3. ICES is requested to

- provide data about Eastern Baltic cod catches in subdivisions 27-32, where possible by subdivision and fishery.
- quantify the effect on the biomass of the Eastern Baltic cod stock if the fishing effort in subdivisions 27-32, ideally broken down by subdivision, remained at status quo levels.
- quantify the impact on the biomass of the Eastern stock of a potential effort reallocation to subdivisions 27-32 in case fisheries for the Eastern Baltic cod were closed in subdivisions 24-26 but remained open in subdivisions 27-32.

ICES proposed a solution to that request, sent out data calls and carried out the analysis and this is a review of that report. This review considers whether the detailed request was fulfilled, identifies errors and key points that might be missing, and if possible offers suggested improvements.

The report provides a comprehensive review of the known characteristics of the cod landings from mixed fisheries in subdivisions 24–32, Eastern Baltic stock (Eastern Baltic Sea). As proposed, by ICES, in the response to the Request 'Eastern Baltic cod 2020 – by-catch TAC, situation in subdivision 24, and in subdivisions 27-32' analysis of by-catch is restricted to analysis of logbook data form 2018. The report contains a review of existing relevant technical measures to reduced cod by-catch rates, a description of spatial distribution of cod catches and impact of management scenarios on stock biomass.

Although ICES commented in their initial response to the request, that observer data might be limited because of time scales and therefore insufficient to provide reliable estimates of by-catch for untargeted fisheries - there is no information provided on what discard rates are available. The latest advice sheet for Eastern Baltic Cod suggest current discard rates for Eastern Baltic Cod are in excess of 18%. These data might therefore be insufficient to conclude by-catch estimates on that basis but what discard data there is, could highlight the scale of any issue with this analysis. This analysis focuses on by-landings rather and therefore makes assumptions about by-catch.

1. ICES requested to estimate the levels of unavoidable by-catches of Eastern Baltic cod in fisheries not targeting Baltic cod.

Using 2018 logbook data cod by-catch is described from landings data by fishery and member state. Within the review an analysis is carried out which sets out to define when cod should be considered a by-catch within the landings of a fishery. This is done using arbitrary levels of catch composition – 'post hoc' in a mixed fishery context. It is unclear how this reflects the catch composition of the mixed fishery or the degree of targeting within the fishery. In the case that this reflects the catch composition with no fisher ability to target or avoid cod, the upper estimate is more likely to reflect the fishery characteristics.

The report details the factors which may lead to uncertainties in forecasting by-catch in 2020 including, and primarily relating to, using historic fishery characteristics to estimate future characteristics in a changing situation, such as, changing fisher behaviour; fishing opportunities for other species caught in the mixed fisheries; and potential technical measures to reduce by-catch. The caveats associated with the analysis of logbook data are identified. These include absences of discard estimates given the sampling levels are low, and potential under-representation from coastal/small scale fisheries which may not be registered in logbooks. It is also noted that a decline in cod stock size may result in lower catches. The report does not provide specific forecasts of likely unavoidable by-catch in 2020. It may be useful to have information on catch rates of cod compared to other TAC species within the mixed fishery as this may have allowed some estimate of unavoidable by-catch with the changing uptake of TAC for other species in the advice year. In order to incorporate changes in cod stock abundance a time series of catch rates may have shown changes due to the size of the cod stock.

A review of potential technical measures to reduce catch of cod is presented. The review covers a range of options and presents percentage reductions of by-catch and 'target' species catch that could be achieved. The implications of use of these gears on quantitative reduction in by-catch is not presented.

Reviewing catch distributions across the subdivisions 24-32 indicates that whilst cod are caught together with flatfish species, such as flounder and plaice, there may be limited impact on other fisheries if there was an area closure in subdivision 26. Cod landings from this area made up 50% of cod landings from the Eastern Baltic in 2018. It is unclear if this area closure would have disproportionate impact on other member states. Could the spatial distribution of catches of cod, flounder and plaice have been used to identify fishery records which were more likely to be 'unavoidable' (those areas with more spatial overlap in mixed species catches) compared to areas where cod comprised the 'main' species, such as in subdivision 26? At present, in section 1, the breakdown of catches is by subdivision 24 and subdivisions 25 – 32.

Specific comments:

Summary 1.a Overall estimates of by-catch. The numbers need to be checked - the by-catch ranges do not match the values in Table 1.2 and 1.3 from Section 1.1 in the main body of the report.

The analysis provides a baseline scenario for 2018. It is very thorough describing how each fishery is defined and provides by-catch estimates by fishery. The different thresholds for determining whether the species is targeted or not provides the range of by-catch expected as a reference for further analysis.

All EU Countries provided data – it may be useful to see the number of countries or who those countries are? The subsequent tables only list the relevant countries involved in those fisheries so an overall reference might be useful.

Proportion by value is often used as a threshold for determining whether a species is targeted or not. In this case landings were used – is that because value was not available for all species by MS?

This section provides a summary of the short comings and uncertainties which capture most of the issues with this analysis particularly the lack of discards information. Shortcomings are provided in the text for other sections.

The analysis of these data is based on 2018 data when the fishery was less restricted this will affect how these results should be interpreted. It is unlikely that if there is a ban on targeting cod that unless they are fishing in subdivision24 a fisherman will need to support landing any future cod with the landings of other fisheries. In this analysis, the figures show there are a significant number of trips which only caught cod.

Section 1.1 The values for the total cod by-catch ranges for all subdivisions need to be checked as they don't match the values in the tables (73-422 in the text is 65-417 in the table for subdivision 24). The proportion of cod landings taken in trips with maximum 50% cod by-catch are also slightly out from the values in the table (from the table - 14.2 and 10.4 for subdivision 24 and subdivisions 25-32) respectively.

***Summary 1.b Gear selectivity strategies*.** The main body of the report provides more detail but the different strategies <u>are</u> significantly effective, with the elimination or separation of between 80 and 100% of the cod. This could be included in the summary. The other factors considered in the main body of the report is the potential reduction of catches of other target species and the cost of modifying or replacing gear.

2. ICES is requested to provide more details on the geographical distribution within subdivision 24 of the Western and the Eastern Baltic cod stock.

A detailed review of stock mixing in subdivision 24 is presented. ICES provides a summary of the geographical distribution of cod but only a limited temporal summary possible because of the limited time frame. The main report concludes that a partial closure of subdivision 24 might be beneficial but it is not reported in the summary. The analysis is carried out using genetic and otolith assignment to Western Baltic cod and Eastern Baltic cod. Both commercial samples and samples for research cruises are presented. Potential for misallocation of commercial samples to ICES areas 1 (12° – 13°) & ICES area 2 (13° – 15°) with subdivision 24 is explored and methods used to minimise this potential data quality issue. In both areas of subdivision 24, across all seasons both Western and Eastern Baltic cod are present. The analysis does show an east – west gradient, ranging from 77% (14° – 15°) Eastern Baltic cod to 48% (12° – 13°) Eastern Baltic cod, on average (past 11 years). The Western extreme (12° – 13°) shows the greatest between year fluctuations the percentage composition in Eastern Baltic cod, this is argued to be as result of potentially low sampling. The report suggests that the 13 degree longitude and contour lines defining inshore and offshore areas might be used to limit the impact of management measures for Eastern Baltic cod on the fisheries for Western Baltic Cod. The report considers the impact of closing subdivision 24 on Western Baltic Cod but it would also be useful to consider relative the impact of the partial closure suggested earlier in section 2.2. Including the impact on other fisheries and member states.

The report highlights to likely factors that determine catches of Eastern Baltic cod in subdivision 24, these include the TAC of Western Baltic cod and distribution of fishing effort. Given a status quo assumption of fishery behaviour it is forecast that the catch of Eastern Baltic cod would be 1493 t. The analysis in the report suggest that the area closure of subdivision 24 would not impact the ability of fishers to fully take the Western Baltic cod TAC outside subdivision 24. An analysis to partition this to targeted fisheries and by-catch fisheries, as carried out under section 1 may be needed to allow the impacts on the mixed fisheries to be quantified.

Specific comment:

Cannot find a reference to 39% (or values that sum to 39%) or the 0-20m depth contour in the main body of the report apart from in the conclusion to 2.1.

3. Subdivisions 27-32

ICES to provide data on Eastern Baltic cod catches

A dataset of catches by subdivision is provided with annual estimates 2010 – 2018. The catches by fishery are aggregated for all subdivisions and partitioned between Active and passive gears. There is reference made to variation between passive and active gears across subdivisions but this is not presented. If the 2018 data used for section 1 was available by subdivision, then more detail on the fisheries in these subdivisions are available than has been reported.

Quantify the effect on the biomass of the Eastern Baltic cod stock in the subdivisions at status quo effort levels.

Results of a forecast are presented which adjust the catch levels in 2020 from two scenarios. 1. Zero Eastern Baltic cod catch; 2. Cod catch only originating from subdivisions 27-32. The assumptions of catch in subdivisions 27-32 are based on the observed landings in 2018. These catches may represent by-catch and targeted catches. Other intermediate year assumptions are described. It would be beneficial to have all forecast assumptions presented to ensure continuity with the forecast applied in other places (e.g. the ICES advice). It may have been useful to explore a scenario using likely unavoidable by-catch from mixed fisheries (in all areas or excluding closed areas) as an alternative scenario for catch estimates. The zero catch assumption is likely to be unfeasible in the mixed demersal fishery context. However, these unavoidable by-catch scenarios would have required the generation of unavoidable by-catch estimates for 2020.

The annual catches from this area over the last five years do not appear to be following any obvious trend. The landings last year were the lowest in eight years – the proportion of catches from this area relative to the total Eastern Baltic cod catch means that even without the analysis it was unlikely to show any significant impact on the SSB even if you used an average catch figure for the last 5 years.

Quantify the effect of increased fisheries in these subdivisions on the biomass of the Eastern Baltic cod stock if subdivisions 24-26 were closed.

To achieve, this the report applies an analysis to explore the stock biomass distribution and contribution of subdivisions 27-32 to the total stock biomass. The analysis makes two assumptions with regard to the estimate of stock biomass; the survey area (subdivisions 27-28) can be raised to the management area (subdivisions 27-32) and the selectivity of the fishing gear used in the survey has a catchability similar to that of the vulnerable biomass. The authors suggest that, in the case of ‘extremely high’ effort in subdivisions 27-32, 3% of the total stock biomass would be removed. Different scenarios of effort reallocation are not quantified. Although the report suggests that under the high effort scenario only 3% of cod biomass would be vulnerable this is not translated to by-catch levels of cod.

It is unclear from this analysis what fisheries in this area would attract and support the relocation of large scale effort from other areas – especially if directed cod fishing is not allowed.

Annex 3: Fact sheets

MESH

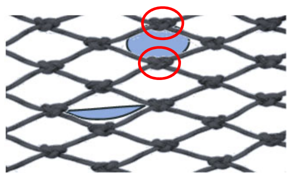
(MESH configuration)

STRATEGY 1: MECHANICAL SELECTION

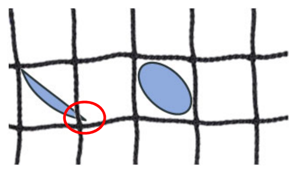
Information	Conditions	Target investigation		
Theoretical	-			
Experimental	Research	35(1)		
	Commercial			

Different morphologies (especially body cross section) of cod and flatfish can be utilized to adjust species specific selectivity. While flatfish fit more easily through netting in standard configuration (diamond or T0 meshes), square meshes (as applied in the BACOMA design) or diamond meshes, which are turned by 90° (T90) (Wienbeck et al. (2014)) are suitable for cod escapement.

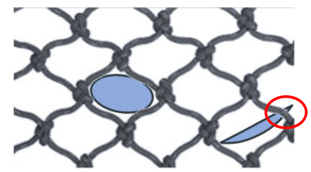
T0

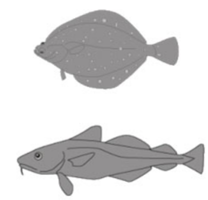


Square



T90

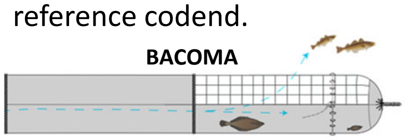




Test

Setup: The fishery selectivity indicators presented here were calculated from a fishery simulation. For the analysis, two simultaneously fishing trawls with different codend design, thus different selective properties, were used. One of the trawls used a standard BACOMA codend (132 mm, reference), with selectivity properties experimentally obtained by Wienbeck et al (2014), while the other trawl used one of nine test designs considered. Selectivity parameters estimated experimentally were obtained by Wienbeck et al. (2014), while theoretical estimations were obtained from predictions showed in Herrmann et al. (2008) and Herrmann et al. (2009), based on the FISHSELECT framework. The populations of plaice and cod fished by the trawls consisted of 100.000 fish, with length distributions based on empirical population structures for cod and plaice in the Baltic (ICES SD 24, 2018, Quarter 4). Finally, the resulting catch share among trawls was used to estimate the ratio of catches in a given test codend relative to catches in the BACOMA 132 mm reference codend.

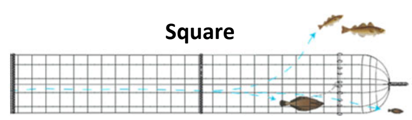
BACOMA



BACOMA codends with different mesh sizes in square mesh panel

Mesh size	Cod		Plaice		Esti-mation	Source
	L50	SR	L50	SR		
132 mm	38.7	8.0	21.4	2.0	Exp (ref)	1
146 mm	45.2	10.3	24.9	4.3	Exp	1

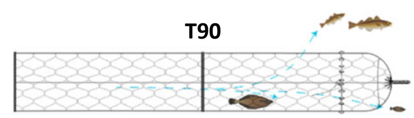
Square



Codends entirely made of knotless square mesh netting in different mesh sizes

Mesh size	Cod		Plaice		Esti-mation	Source
	L50	SR	L50	SR		
120 mm	42.3	6.7*	24.3	2.1*	Theo**	2,3
127 mm	43.4	6.7*	24.7	2.1	Exp	1
130 mm	44.5	6.7*	26	2.1*	Theo**	2,3
140 mm	48	6.7*	29	2.1*	Theo**	2,3

T90



T90 codends with different mesh sizes

Mesh size	Cod		Plaice		Esti-mation	Source
	L50	SR	L50	SR		
120 mm	42.4	7.2*	20.8	3*	Theo**	1
127 mm	45.6	7.2	20.2	3	Exp	1
130 mm	46.1	7.2*	22.3	3*	Theo***	2,3
140 mm	50.0	7.2*	24.4	3*	Theo***	2,3

Tables: L50 and SR values in cm. exp: experimental. theo: theoretical.*SR fixed to the same values obtained experimentally from codends with similar design. **Opening angle of the mesh assumed to be 100°. ***Opening angle of the mesh assumed to be 90°.

Legal status and commercial adoption

- **Legal status:**
  - BACOMA: legal
  - Square: needs clarification
  - T90: legal
- **Commercial use:**
  BACOMA and T90 are in common use, but most fishers stick to the minimum legal mesh sizes.

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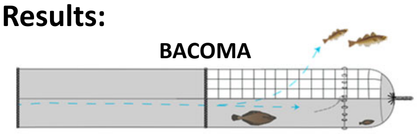
MESH

(MESH configuration)

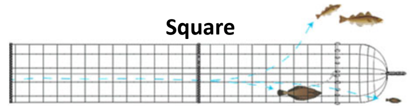
Results:

BACOMA

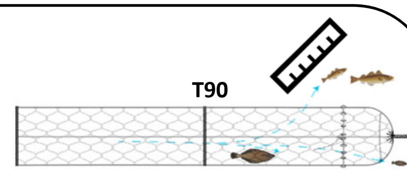


(only experimental data (*exp) given)

Square



T90



Catch ratio (100% indicates equal catch efficiency of test codend relative to reference codend)

BACOMA

Mesh		Cod	Plaice
120 mm	calculation not possible due to dual selection caused by use of two different mesh types		
127 mm	calculation not possible due to dual selection caused by use of two different mesh types		
132 mm (*exp, *reference*)		100.0% / 100.0 %	100.0 % / 100.0 %
146 mm (*exp)		46.9% / 32.5%	98.9% / 56.2%

Square

Mesh		Cod	Plaice
120 mm	*theo	71.7% / 115.3%	99.9% / 101.8%
127 mm	*exp	47.5% / 68.7%	99.9% / 106.5%
130 mm	*theo	44.4% / 63.4%	99.9% / 87.0%
140 mm	*theo	25.4% / 33.5%	99.8% / 61.3%

T90

Mesh		Cod	Plaice
120 mm	*theo	63.0% / 26.6%	100.0% / 65.5%
127 mm	*exp	52.5% / 15.7%	100.0% / 60.1%
130 mm	*theo	43.2% / 8.8%	100.0% / 43.4%
140 mm	*theo	21.5% / 1.0%	99.9% / 17.0%

BACOMA:
- Good release of cod
- Reductions in catches of plaice
- Poor selectivity (due to the use of small diamond mesh netting)

Square:
- Good release of cod
- Similar catch efficiency for plaice
- Hydrodynamical/handling issues

T90:
- Very good release of cod
- Reductions in catches of plaice
- Effect depends on yarn/opening

Caution: **1. Results of some designs (*theo) based solely on theoretical estimations!**
2. Mesh sizes for BACOMA (132, 146 mm) differ from simulated mesh sizes used for Square and T90 (130, 140 mm)!

Conclusion

☺ Easy handling
☺ Easy implementation
☺ Possibility to further improve escapement of cod:
- **combine with strategy 2** (selection by behaviour) → **see strategy 3**
- **adapt mesh size or mesh configuration**

😐 Design potentially sensitive to external factors (handling, catch volume, etc.)
☹ All options: problematic if meshes blocked by flatfish
consider strategy 3 (better control when cod is separated)

More information

www.thünen.de/mesh/

✗ Technical drawing
✓ Multimedia
✓ Report

1. Herrmann, B., Krag, L. A., Frandsen, R., Lundgren, B., Madsen, N., & Stæhr, K-J. (2008). Simulering af selektivitet i fiskeredskaber. Charlottenlund: DTU Aqua.
2. Herrmann, B., Krag, L. A., Frandsen, R. P., Madsen, N., Lundgren, B., & Stæhr, K.-J. (2009). Prediction of selectivity from morphological conditions: Methodology and a case study on cod (*Gadus morhua*). Fisheries Research, 97(1–2), 59-71. doi: 10.1016/j.fishres.2009.01.002
3. Wienbeck, H., Herrmann, B., Feekings, J. P., Stepputtis, D., & Moderhak, W. (2014). A comparative analysis of legislated and modified Baltic Sea trawl codends for simultaneously improving the size selection of cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*). Fisheries Research, 150(0), 28-37. doi: 10.1016/j.fishres.2013.10.007

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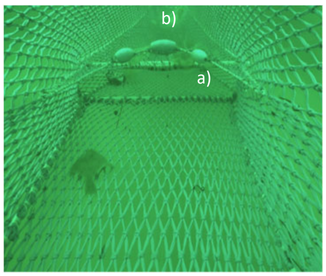
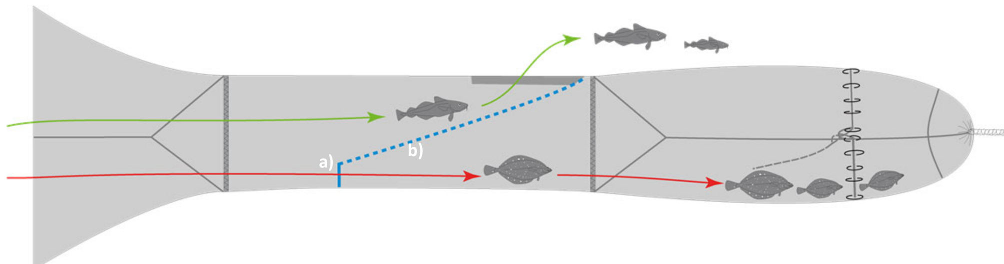
CODEX

(COD EXcluder)

Information	Conditions	Target investigation (gear)	Target investigation (fish)	Target investigation (gear + fish)
Theoretical	-			
Experimental	Research			
	Commercial		5(1)	

CODEX is based on a discussion when SORTEX was presented to the fishery. Similarly to the concept of SORTEX, CODEX intends to separate cod and flatfish in the extension section of the trawl, whereas CODEX involves only one codend. Flatfish are being guided into the codend through a rather flexible entry in the lower part of the tunnel (a). By a panel (b), cod are guided towards the escapement opening in the upper part of the extension section.





Legal status and commercial adoption

- **Legal status:** in accordance with EU2019/1241
- **Commercial use:** none

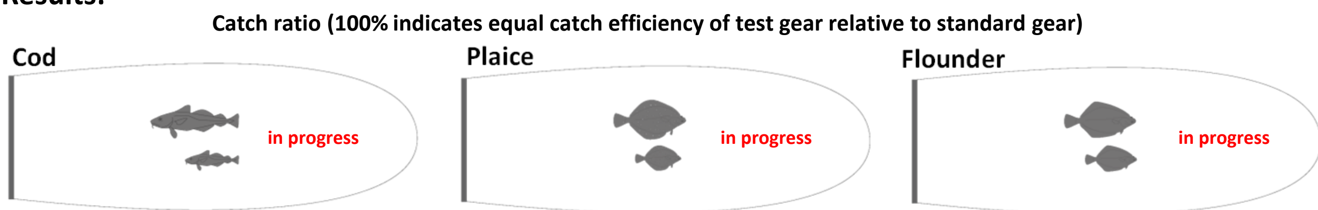
There is a high interest by the fishery. First trials conducted in 09/2019 (analysis in progress) and upcoming commercial trials planned for 10-12/2019 mainly in ICES SD 22-24 onboard German vessels.

Test

Period: Autumn 2019
Area: ICES SD 24 (German fishing grounds)
Vessel: SAS 107 "Crampas" (5 hauls)
Aim: Evaluating **release efficiency of cod**

Setup: Twin trawl – Catches from a control trawl (standard 115 mm T90 codend) were compared with catches from a test trawl mounted with CODEX (115 mm T90 codend).

Results:



- Significant reduction in cod catches
- Slightly reduced catch efficiency for flatfish

➜ **high potential to minimize cod catches while catching flatfish**

Conclusion

- ☺ Indications of strong catch separation
- ☺ Similar catches of flounder in test and control gear
- ☺ Possibility to further improve escapement of cod:
  - **combine with strategy 1** (use of selective codend) ➜ **see strategy 3**
- 😐 Additional trials advisable
- ☹ Catches of plaice reduced in test gear (might change after design modification planned for upcoming trials)

More information

www.thünen.de/codex/

- ✔ Technical drawing
- ✔ Multimedia
- (✔) Report (available 12/2019)

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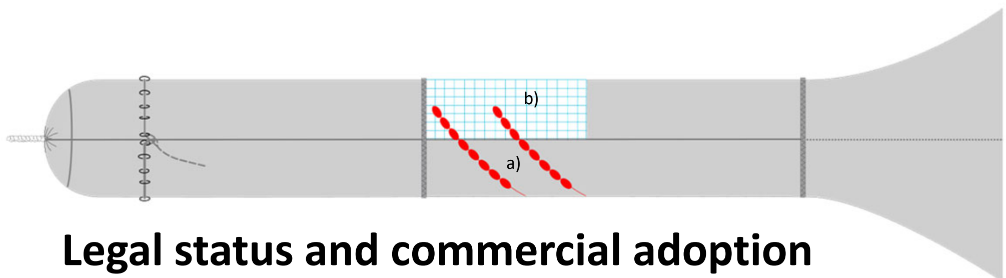
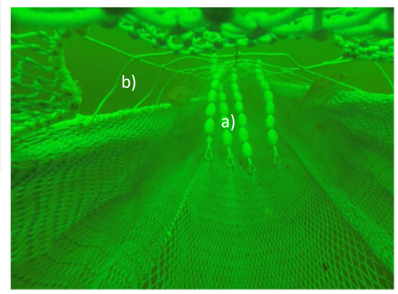
STIPED

(STImulation Excluder Device)

Information	Conditions	Target investigation		
Theoretical	-			
Experimental	Research		16(1)	
	Commercial			

As roundfish tend to stay clear off any netting during the fishing process, several studies have reported the effectiveness of escape windows in the upper panel of the extension of a trawl to be very limited. The idea of STIPED is to use ropes with floats (a) to stimulate roundfish to perform upwards escaping reactions in the vicinity of the escape window (b). The device raises the escapement rate while keeping catches of flatfish. In addition to the study presented below, aiming at an avoidance of all cod, Herrmann et al. (2015) were able to proof the efficiency of STIPED for releasing undersized cod.





Legal status and commercial adoption

- **Legal status:** clarification needed
- **Commercial use:** none

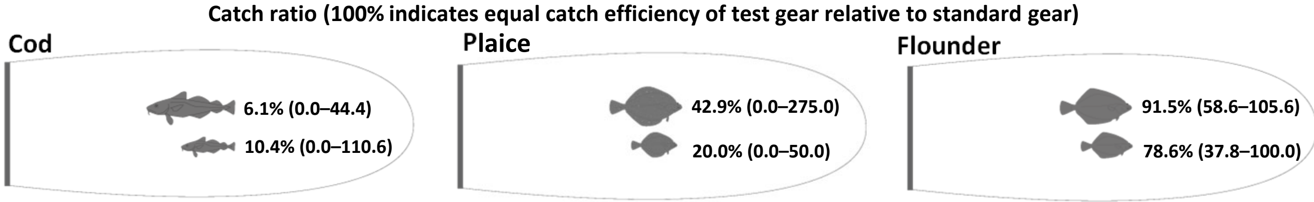
Test

Period: Autumn 2013
Area: ICES SD 24 (German fishing grounds)
Vessel: FRV "Clupea" (16 hauls)
Aim: Evaluating **release efficiency of cod**

Setup: Twin trawl – Catches from a control trawl (60 mm T0 codend) were compared with catches from a test trawl mounted with STIPED (60 mm T0 codend; 400 mm T45 window).

Results: (from setup 2 as per definition from report)

Catch ratio (100% indicates equal catch efficiency of test gear relative to standard gear)



- High reduction in cod catches
- Reduction of plaice (results uncertain due to poor catches of plaice during trials)
- Similar catch efficiency for flounder

➜ **high potential to minimize cod catches**

Conclusion

- ☺ High flexibility in way of mounting stimulation devices
- ☺ Promising release efficiency for cod
- ☺ Possibility to further improve escapement of cod:
  - **combine with strategy 1** (use of selective codend) ➜ **see strategy 3**
  - **use of "topless" extension**
- ☺ Similar catches of flounder in test and control gear
- 😐 Weak data ➜ Additional trials advisable
- 😐 Design potentially sensitive to external factors (construction, towing speed, fish behavior, etc.)

More information

www.thünen.de/stiped/

- ✔ Technical drawing
- ✔ Multimedia
- ✔ Report

Herrmann, B., Wienbeck, H., Karlsen, J. D., Stepputtis, D., Dahm, E., & Moderhak, W. (2015). Understanding the release efficiency of Atlantic cod (*Gadus morhua*) from trawls with a square mesh panel: effects of panel area, panel position, and stimulation of escape response. ICES Journal of Marine Science 72(2), 686-696. doi:10.1093/icesjms/fsu124

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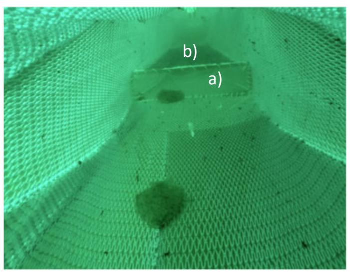
STRATEGY 3: COMBINED SELECTION

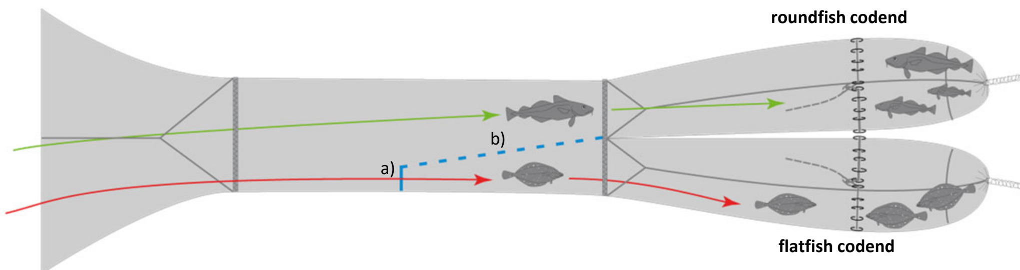
SORTEX

(SORTing EXtension)

Information	Conditions	Target investigation		
				+
Theoretical	-			
Experimental	Research		41/1	15/1
	Commercial			(Nov. 2019)

SORTEX was originally designed to sort flatfish and cod into separated codends, with size selection characteristics of the individual codends adjusted accordingly to the species. The inlet to the lower (flatfish) codend is defined by a rigid frame (a), while the path to the upper (roundfish) codend is defined by an oblique panel (b). In addition to a better utilization of available quotas, a proper separation of flatfish from roundfish could improve the quality of cod catches, as they are not subjected to damages caused by contact to species with a rougher skin (e.g. Flounder). To drastically reduce cod catches as required under the current management regime, fishers could mount an upper codend made of very large square mesh/T90 netting to retain only the largest individuals available. Cod catches might be totally avoided by opening the upper codend during the fishing process.





Legal status and commercial adoption

- **Legal status:** clarification needed
- **Commercial use:** none

The use of two codends with different nettings needs clarification (legal status according to EU2019/1241). Increasing interest by the fishery led to upcoming commercial trials planned for Autumn/Winter 2019/20 mainly in ICES SD 22-24 onboard German vessels.

Test

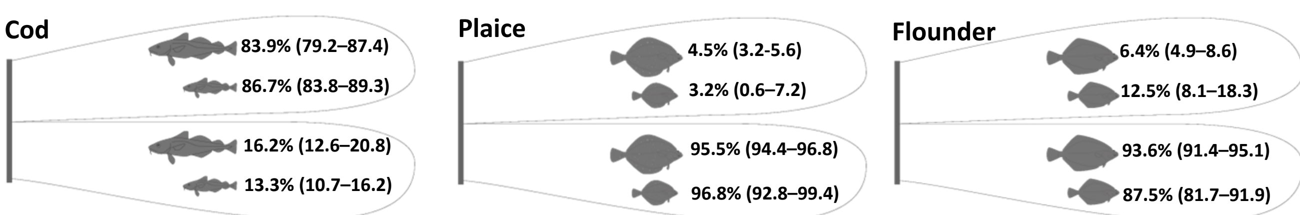
Experiment 1:

Period: Autumn 2016
Area: ICES SD 24 (German fishing grounds)
Vessel: FRV “Solea” (41 hauls)
Aim: Evaluating **sorting efficiency of cod and flatfish**

Setup: Small-mesh codends were used to avoid size selection that might compromise a proper description of the device´s sorting efficiency.

Results:

Catch ratio (50% indicates even catch share among codends)



- Most cod in upper (roundfish) codend
- Most flatfish in lower (flatfish) codend

Very good species separation

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SORTEX

(SORTing EXtension)

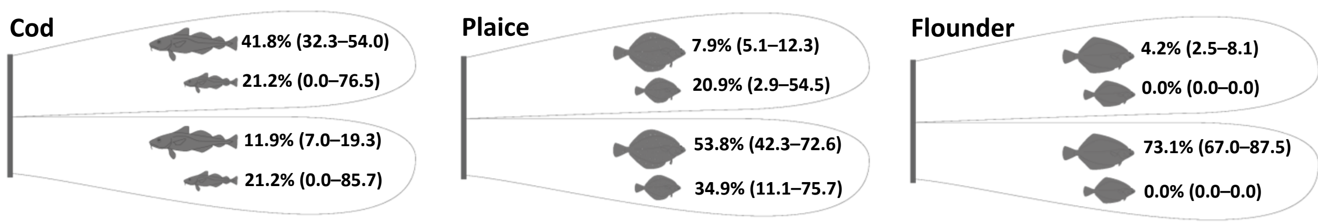
Experiment 2:

Period: Winter 2018
Area: ICES SD 24 (German fishing grounds)
Vessel: FRV "Clupea" (15 hauls)
Aim: Evaluating the **combined effect of sorting and size selection** for specific codends

Setup: Twin trawl – Catches from a control trawl (standard 120 mm T90 codend) were compared with catches from a test trawl mounted with SORTEX (roundfish codend: standard 120 mm T90; flatfish codend: 135 mm diamond).

Results:

Catch ratio (100% indicates equal catch efficiency of test gear relative to standard gear)



- Strong catch separation confirmed
- High reduction of flatfish catches due to 135 mm codend

Selection of different species can be controlled by modifying codend characteristics (see strategy 1)

Caution: Tests of this experiment were not specifically designed to avoid cod catches!

Conclusion

- ☺ Consistently strong catch separation
- ☺ High adaptability of SORTEX to achieve management goals
- ☺ Interest by fishery
- 😐 Catch separation relies on fish swimming behaviour, which might vary depending on fish traits and/or environmental conditions
- 😐 Clarification required concerning legal status (EU2019/1241)
- ☹ Double codend solutions might not be usable by all types of vessels

More information

www.thünen.de/sortex/

- ✔ Technical drawing
- ✔ Multimedia
- ✔ Report

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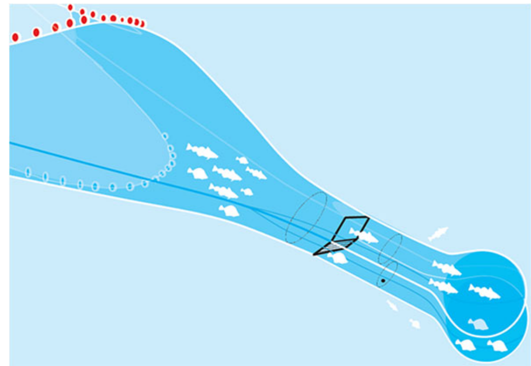
ADEM-4

(Trawl separating flat- and round fish)

ADEM-4 was designed to separate round- and flatfish into different codends and to select for large round fish (adaptation to limiting cod quota by the landing obligation). The experimental trawl divides the catch going through the grid (a) vertically into two codends. The upper part of the grid is open and attached to the upper codend. The lower part of the grid has horizontal slots and is attached to the lower codend. In the experiment, a large diamond mesh was used in the upper codend but cod catches could be minimized by opening the upper codend during fishing.



Legal status and commercial adoption

- **Legal status:** Clarification needed
- **Commercial use:** 3a (limited)

The vessel involved in the development are using the gear to adapt to fish- and quota availability. During the fall of 2019 a number of codends are available for lending so that more fishermen can test the gear for free.

Test results

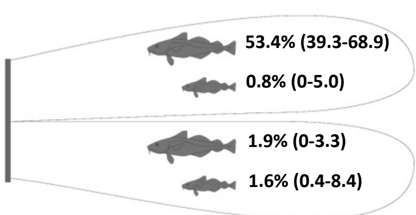
Period: May 2017 (target: plaice and large cod)
Area: Skagerrak and Kattegat
Platform: GG 840 Svanen av Rörö (22 Hauls)
Aim: Evaluating the **combined effect** of sorting and size selection of ADEM-4 for specific codends

Setup: Catches from a control trawl (120 mm diamond codend) were compared with catches from a test trawl mounted with ADEM-4 (upper: 200 mm diamond, 50 cm grid opening; lower: 120 mm diamond, 5 cm slot width).

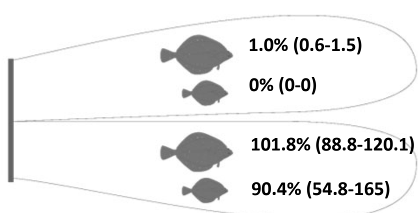
Results:

Catch ratio (100% indicates equal catch efficiency of test compartment relative to control codend)

Cod



Plaice



- most cod in the upper codend
- most plaice in the lower codend
- no loss of plaice >MCRS
- loss of cod >MCRS in the upper codend depends on the large mesh size (200 mm)

➔ **very good species separation**

Conclusion

- ☺ Flatfish primarily caught in lower codend; opposite for roundfish
- ☺ Less than 2% of the cod catch in the lower codend
- ☺ Similar catches of plaice in test and control gear
- 😐 Not specifically designed to entirely avoid cod catches (but upper codend can be removed/opened)
- 😐 Experiments conducted in the Skagerrak / Kattegat

More information

www.slu.se/selective-fishing/en

- ✔ Technical drawing
- ✘ Multimedia
- ✔ Report (Swedish)

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