ICES Ad hoc REPORT 2018

ICES Advisory Committee

ICES CM 2018/ACOM: 65

Ad hoc Report on the Special Request on further development of ICES mixed fisheries considerations and biological interactions

November- December 2018

Claire Moore, Youen Vermard, Clara Ulrich, Marc Taylor, Thomas Brunel, Paul Dolder, Katja Ringdahl, Kirsten Birch Håkansson and Johan Lövgren

ICES
International Council for the Exploration of the Sea
CIEM
Conseil International pour l'Exploration de la Mer

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Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

Ad hoc Report on the Special Request on further development of ICES mixed fisheries considerations and biological interactions, Nov-Dec 2018, Claire Moore, Youen Vermard, Clara Ulrich, Marc Taylor, Thomas Brunel, Paul Dolder, Katja Ringdahl, Kirsten Birch Håkansson and Johan Lövgren. ICES CM 2018/ACOM: 65. 82 pp.

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Executive summary

In June 2018, ICES accepted a special request from the European Commission to develop mixed fisheries considerations. This report was primarily prepared using work by members of WGBFAS and WGMIXFISH, ACOM, experts at DTU-AQUA, Denmark, and the ICES secretariat.

Work on furthering the mixed fisheries analysis in the fisheries overviews was completed and published as part of the Baltic Fisheries Overviews and new Celtic Seas fisheries overviews in November 2018. There were also minor updates to the mixed fisheries section of the North Sea fisheries overview in November 2018.

In 2017, a subgroup of the Regional Coordination Group for the Baltic (RCG Baltic) generated regional and national overviews of the Baltic fisheries, including spatial and temporal distribution of fishing effort and landings of relevant stocks. Preliminary analysis of this data, on sprat and herring mixing and maps showing the mixing by statistical rectangle and by month, are now available.

Current information shows variation in the degree of mixing, in catches from the pelagic as well as from the demersal fisheries in the Baltic Sea. Control data also indicate that species misreporting may occur in pelagic fisheries, which could imply that quotas of bycatch are potentially limiting. Development of a mixed-fisheries model for these fisheries therefore appears to be justified.

In May 2018 ICES issued advice on the Gulf of Riga herring, advising that the evidence is insufficient to justify an application of the upper F_{MSY} range based on the condition; “to avoid serious harm to a stock caused by intra- or inter-species stock dynamics”, set out in the MAP.”

ICES has identified ten additional species (21 stocks) that could be included in the Celtic Seas mixed-fisheries analysis in the near future. The feasibility of including stocks was assessed and stocks were prioritized, based on their relative importance to the Celtic Sea landings (in terms of weight and values), the degree of mixing, and the availability of data.

ICES considers that the separation of what would constitute a round- or a flatfish fishery is not clear and distinct enough to justify splitting the current Fcube model. Splitting the model raises difficulties regarding where to draw boundaries, and which gears and fleets to include in each sub-model. The model would also lose the ability to account for the diverse sources of revenue and the recognition of the ability of the fleet to switch target species. Splitting the model would also reverse the efforts made over recent years to increase the number of stocks in the model, including several important bycatch stocks.

The report concludes with recommendations for further work to advance the mixed fisheries considerations in the Baltic, Celtic Seas, North Sea and Iberian waters. Specifically, this will include a designated workshop in 2019 to address issues of pelagic and demersal mixing in the Baltic.

1 Request

Mixed fisheries considerations and biological interactions are important for the decision process for fishing opportunities as well as the development and implementation of regional multi annual plans (MAPs).

ICES mixed fisheries considerations evaluate the potential implications of single stock (TAC and Effort) management on the catches of multiple stocks caught together in mixed fisheries. Based on recent observed fishing patterns, catchability of the different fleets and ICES single stock advice on fishing opportunities it presents catch composition under different management scenarios. ICES mixed fisheries work is also exploring the level of mixing with the aim of identifying target stocks and bycatch stocks.

The ecosystem approach is being implemented incrementally in the advice on fishing opportunities and will be supported by information and advice provided in Fisheries Overviews and Ecosystem Overviews.

In this context ICES is requested to further develop advice on mixed fisheries and on biological interactions for the North Sea, Baltic Sea and the Atlantic.

This work should include:

1. A description of the main mixed fisheries technical interactions and biological interactions known in the Baltic Sea, the North Sea and the Atlantic. These can be in either the Fisheries Overviews or the Ecosystem overviews (such as those already developed for the Baltic Sea and the North Sea) or alternatively in the single stock advice. ICES is requested to:
    a. Describe the species caught together in mixed fisheries taking account of spatial, gear, fleet and temporal dimensions as appropriate (e.g. it is known that in the flatfish fishery sole, plaice, witch, lemon sole and turbot are often caught together. It is known that cod, haddock, saithe and whiting are caught together in the North Sea. In the Atlantic it is known that hake, megrim and anglerfish are caught together and that this fishery can have important bycatches of cod and haddock. In the Baltic Sea it is known that sprat and herring are caught together. ICES is asked to confirm these and all other cases of stocks caught together).
    b. ICES is requested to identify if intra-specific density dependence is known to occur for Gulf of Riga herring based on existing, updated scientific evidence.

2. Expanding the number of stocks included in the Celtic Sea mixed fisheries considerations. Priority should be given to target species of high economic interest, such as megrims and anglerfish.

3. Analyze the existing mixed-fisheries model for the North Sea with a view to develop broken-down models and scenarios for the flatfish fisheries/fleets and for the roundfish fisheries/fleets

4. Developing mixed-fisheries considerations and understanding on biological interactions for stocks in the Baltic Sea. According to the EU multiannual plan for Baltic Sea stocks fishing opportunities may be fixed in accordance with the upper fishing mortality ranges specified in the plan provided that the stock concerned is above the minimum spawning stock biomass reference point.

a. ICES is requested to describe the mixed sprat and herring fisheries in the Baltic Sea and to develop a mixed fisheries model for these fisheries, which can be used to assess the likely consequences on the stocks and fisheries of different management scenarios.
b. Developing biological interaction knowledge on Gulf of Riga herring

5. ICES is also requested to inform the Commission on the tasks and timeline to further develop knowledge necessary to advise on mixed fisheries and biological interactions in the Baltic Sea, the North Sea and the Atlantic.

2 A description of the main mixed fisheries technical interactions and biological interactions known in the Baltic Sea, the North Sea and the Atlantic.

2.1 Baltic Sea

The following text was released as part of the Fisheries Overviews in August 2018:

Many fishing gears catch more than one species at the same time, so 'technical interactions' occur between stocks when multiple species are captured in the same gear during fishing operations. Because these interactions may vary through time and space (e.g. interactions might vary between day and night, or between different times of year, or between different areas), it would be ideal for them to be quantified at the scale of the fishing operation. However, most fisheries data, including those submitted to STECF, are aggregated based on species, gear, mesh size range, ICES square, and calendar quarter which may create perceived interactions that do not occur in real life, and some subtle interactions are missed.

ICES has evaluated technical interactions between species captured together in demersal fisheries by examining their co-occurrence in the landings at the scale of the gear, mesh size range, ICES statistical rectangle and quarter (hereafter called strata). The percentage of landings of species A where species B is also landed and constitutes more than 5% of the total landings in that stratum has been computed for each pair of species. Cases in which species B accounts for less than 5% of the total landings in a stratum were ignored.

To illustrate the extent of the technical interactions between pairs of species, a qualitative scale was applied to each interaction (Figure 1). In this figure, the rows represent the share of each species A that was caught in fisheries where species B accounted for at least 5% of the total landing of the fisheries. A high proportion of the catches of herring was for example taken in fisheries where herring landings where at least 5% of the total landings while the amount of herring in fisheries where sprat accounts for at least 5% of the total landings was medium. The amounts of sprat were high in both the fisheries where herring or sprat accounted for at least 5% of the total catch.

The columns illustrates the degree of mixing and can be used to identify the main fisheries. Fisheries where herring (species B) constitute 5% or more of the total landings account for a high share (red cells) of the total landings of herring and sprat, while the amount of herring in the fisheries where sprat constitute at least 5% of the total catch was medium (orange cells).

In the Baltic Sea, cod fisheries often capture flounder (and occasionally take plaice and whiting). Occasional fisheries for flounder frequently harvest cod. The Baltic herring fisheries often land also sprat and vice versa.

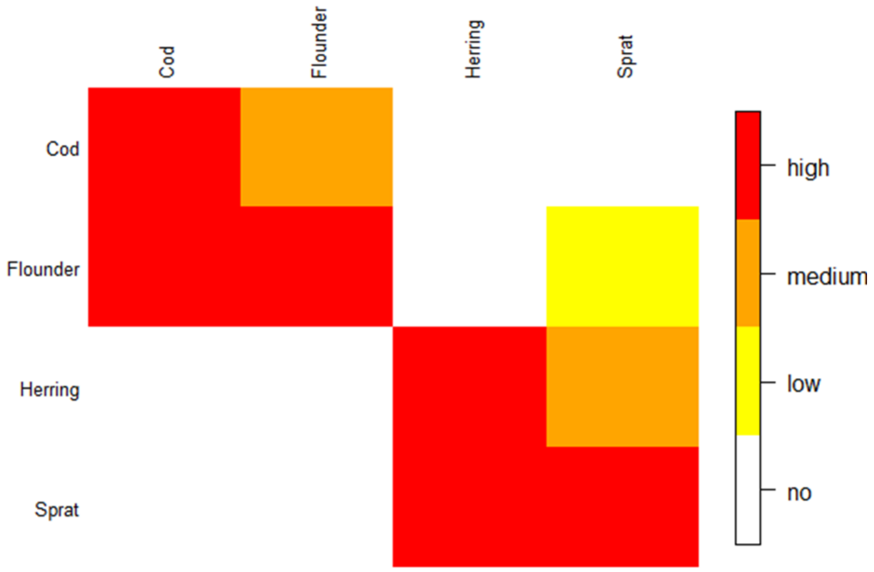


Figure 1 Technical interactions between the four most important stocks in the Baltic Sea. The rows of the figure illustrate the fisheries where the species A was caught. Red cells indicate the species B which the A species are frequently caught together with. Orange cells indicate medium interactions and yellow cells indicate weak interactions. The column shows the degree of mixing in fisheries where species B account for at least 5% of the total landings. A more detailed explained of the figure is provided in the text.

The technical interaction in the Baltic pelagic fishery differs between fisheries. The majority of herring and sprat are caught with pelagic trawls. The pelagic trawlers performing a directed fishery for either sprat or herring have a very variable degree of mixing in the catches of sprat and herring. The degree of mixing varies on a spatial scale (Figure 2). According to logbooks and sales slips, the mixing can vary between <5% to 40% although these percentages are not quantifiable at this stage. Given that the information available on the mixing in the directed single species pelagic fishery is based on logbooks and sales slips and thus on a trip basis, the actual mixing in the individual hauls is at present unknown. The directed herring fishery close to Bornholm in SD 23–25 is reported to have less sprat in the catches than further north in the Baltic (SD 27–29). Mixing of herring and sprat in the directed herring trawl fishery is highest in SD 32, decreasing further north in SDs 30–31.The vast majority of the total herring landings in SDs 30–31 are not for human consumption and these tend to be mixed. The majority of the landings in the directed herring trawl fishery are for human consumption but there are also landings for industrial purposes. Herring is caught as a bycatch in the directed sprat fishery which is mainly in the central part of the Baltic. Landings in this fishery are mainly for industrial purposes, but there are also landings for human consumption. The directed sprat fishery shows the same spatial variation in mixture of herring and sprat as the directed herring fishery. There is, however, a low spatial overlap of the directed herring and sprat fishery reported.

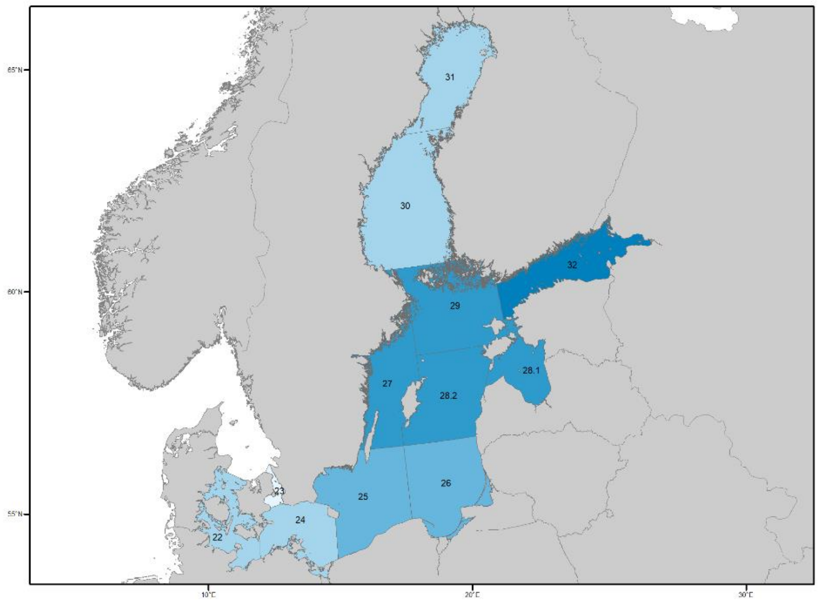


Figure 2 Spatial variation in reported mixing of herring and sprat in trawl fishery in the Baltic. Darker colour indicates higher mixing.

The species composition in trawl hauls in these directed fisheries is also reported to vary on a seasonal scale. Reporting from sales slips and logbooks show that there are higher concentrations of sprat in the directed herring trawl fishery in the 1st and the 4th year quarters, in particular in the northern Baltic Sea; 1st and 4th quarter are also the main fishing seasons.

The coastal fisheries with smaller vessels targeting herring with gillnets and trap-nets have a low degree of actual mixing in the catches and are predominantly clean herring fisheries with less than 5% mixing of sprat in the catches. If sprat is caught as bycatch, mixing is less than 5%.

In addition to the directed single species pelagic fishery there is a small meshed fishery for industrial purposes which has quite a high degree of mixing of herring and sprat.

Cod and flounder account for the highest landings of demersal species in the Baltic. The majority of the landings are made with demersal trawls but there are also significant landings with gill nets. The otter trawlers and gill netters also land other demersal species; dab, plaice, and whiting.

There is no mixed fisheries advice developed yet for the Baltic Sea.

2.2 North Sea

There are updates to the mixed fisheries section of the Fisheries Overview.

2.3 Celtic Seas

The Celtic Seas fisheries overview was released on the 30th November 2018 with a full mixed fisheries section.

3 Intra-specific density dependence in Gulf of Riga herring

See Annex 1.

3.1 Introduction

The impact of intra-specific density dependence on Gulf of Riga herring was assessed by reference to a 2018 Working Document and Working Document Annex by Tiit Raid Estonia and Georgs Kornilovs, Latvia, on applying the higher range fishing mortalities for the Gulf of Riga herring stocks in 2018. This was then reviewed by an external expert. The main conclusions from the WD and the main comments from the reviewer are presented here.

3.2 Working Document main conclusions

The authors state that whilst there is no interaction of the Gulf of Riga herring stock with other commercial fish species in the area, there are intra-species dynamics and feeding conditions that are heavily influenced by the size of the stock.

The Gulf of Riga herring analytical assessment is based on Estonian and Latvian catch data, CPUE series and hydro-acoustic survey. The hydro-acoustic survey is undertaken at the end of July and beginning of August by Estonia and Latvia. For the forecast of the stock, the recruitment at age 1 is taken as the average value from 1989 onwards.

The preliminary results of the hydro-acoustic survey performed in summer 2017 indicate that the 2016 year class could be of average strength corresponding to the value used for this year class in the prediction.

This stock is presently considered to be harvested within safe biological limits and has been since the beginning of 1990s. The number of 1-year old herring after 1990 is more than double that in the period before. The fluctuation of the spawning stock size is by a fluctuating recruitment. In recent years the spawning stock has decreased due to the weak year class of 2013 although it is still close to the long-term average of the favourable reproduction period. The short-term forecast predicts an increase in the spawning stock size.

The authors argue that the lower level of TAC and corresponding fishing mortality rate (F=0.32) could create a situation where the SSB will increase considerably, causing high feeding competition, slower growth, lower condition factor and quality of the fishes and lower income for the fishermen. With a catch reduction, the stock could continue to grow, affecting growth and the medium weight of age groups, which could decline. As the SSB in 2018 will be well above MSY $B_{trigger}$, the authors argue it is possible to use fishing mortalities in the upper range of F_{msy} without detriment to the stock in the long-term.

Based on this, Estonia and Latvia argued for the application of the F range principles described in Baltic Sea multispecies multiannual plan Regulation 1139/2016 Article 4 paragraph 4. b (justified by intra- or inter-species stock dynamics), setting the TAC for the Gulf of Riga herring in 2018 by using the applicable range provided in the Annex I column B, corresponding to the moderate MSY fishing mortality F = 0.347 (roll-over of the TAC for 2017 = 31121 t) while not advising application of $F_{msy\ upper}$=0.38.

3.3 Reviewer comments

The central part of the argument presented in the WD is the strength of the 2015 year class, however, the WD is based on the 2017 assessment i.e. only data up to and including 2016. The ICES stock assessment is based on data from the commercial fishery and two stock indices: trapnet catch rates and an acoustic abundance survey. The commercial fishery is largely exploiting ages 2+ and therefore there is little information on the 2015 year class in these 2016 data; the trapnet catch rates are only used for ages 2 and older.

The document would have benefitted from an update including the 2017 data, even if it was only as preliminary data. There is a brief mention of the results of the 2017 acoustic data on the 2016 year class. The fishery in 2017 is claimed to show high catch rates for the 2015 year class but this is not documented. Also, data for the trapnet fishery (catch rates are used as tuning fleet) would have been useful.

The strength of the 2015 year class is argued based on a projection of the acoustic data. The approach to the prediction - plotting the age 1 estimate from the assessment against the proportion of age 1 - should be investigated further as it provides significantly higher estimates than the XSA output.

It is likely that any prediction based on age 1 acoustic data is subject to substantial prediction error. The selection for age 1 in the acoustic survey is less than for the older age groups suggesting that the survey is not fully covering the age 1 herring.

The reviewer concluded that the high estimate for year class 2015 is not satisfactory substantiated based on the data presented.

The study (presented in 2017 based on 2016 data) concludes that the lower level of TAC and corresponding fishing mortality rate (F = 0.32) could create a situation where the SSB would increase considerably. However, considering that in recent years the spawning stock has decreased due to the weak year class of 2013, the uncertainty of the strength of the 2015 year class, and that biomass seems unlikely to reach a level for which there is no precedent, the reviewer did not agree with the conclusions.

Additionally the Annex argues that the high proportion of the 2015 year class in the catches will diminish the fishing pressure on older year classes, therefore, the resulting fishing mortality will be much lower than predicted and even below F_{msy} level. Apparently, the assumption is that the fishing pressure will concentrate on the most abundant age groups. This implies that it is possible to fish age groups selectively. However, this is presented without evidence; that the selection pattern changes with the strength of the year class and should be judged as merely speculative at this stage.

Concerning the criteria laid down in Article 4 (4) the reviewer finds:

1. **Mixed fishery**: The Gulf of Riga fishery is rather clean with little bycatch and hence (a) does not apply
2. **Inter species interaction**: The stock has been declining in recent years and the direct and indirect effects on other stocks are therefore within that observed in previous years without documenting significant detrimental effects. The stock is not expected to increase to biomasses outside the range for which there is experience in recent years.
3. **Intra species interaction**: The Gulf of Riga Herring is known to be strongly dependent on environmental factors e.g. growth and the recruitment. The growth of Gulf of Riga herring is dependent on the strength of the year class but also on general environmental conditions such as zooplankton abundance in the

Gulf. It is likely that growth may, as for other fish stocks, be slower with high herring abundance than in years with less herring. This is not threatening the stock in terms of recruitment based on past experience.

4 Expansion of the number of stocks included in the Celtic Sea mixed fisheries considerations

4.1 Basis

ICES was requested to assess the possibility of expanding the number of stocks included in the Celtic Sea mixed fisheries considerations, where priority should be given to target species of high economic interest, such as megrims and anglerfish. This request was further broken down by ACOM into three main task:

To describe and evaluate the species mixing in Celtic Sea demersal fisheries and identify the stocks for which information and data are sufficient to include in the mixed fisheries analysis for Celtic Sea. Review the current mixed fisheries scenarios provided for the Celtic Sea, evaluate if it is possible to include additional stocks in the mixed fishery and suggest possible process.

If required develop and issue a data call for data needed to incorporate the stocks identified under a) in the mixed fisheries analysis for Celtic Sea.

Expand the mixed fisheries model for Celtic Sea to include the species identified in a).

4.2 Identify the species to include

An analysis was conducted to identify candidate species for possible inclusion in Celtic Seas mixed fisheries considerations. Eleven species were considered: monkfish (MON, *Lophius piscatorius* and *Lophius budegasa*), cod (COD, *Gadus morhua*), haddock (HAD, *Melanogrammus aeglefinus*), hake (HKE, *Merluccius merluccius*), megrim (MEG, *Lepidorhombus whiffiagonis* and *Lepidorhombus boscii*), Nephrops (NEP, *Nephrops norvegicus*), plaice (PLE, *Pleuronectes platessa*), pollack (POL, *Pollachius pollachius*), sole (SOL, *Solea solea*) and whiting (WHG, *Merlangius merlangus*). The aims of the analysis were to determine:

1) the relative contributions of each species to the overall weight and value of landings in the Celtic Seas
2) to assess the level of mixing among these species within the fisheries executed within the area.
3) Are the single species stocks assessments for candidate species suitable for inclusion in FCube?

This analysis was conducted on retained catch data which was submitted to the WGMIXFISH accessions, focusing on an average of the last three years (2015–2017). Four Member States (MS) are responsible for the majority of the landings in this area and so were the focus of this analysis. Using a three year average the total landings (tonnes) for each of the species was plotted. The species which accounted for the largest landings were monkfish and hake (Fig 4.1). These species were mostly landed by the French fleet (Fig 4.2). Each member state exhibited differences in fishing behaviour, with French fleets targeting mainly monkfish and hake, English fleets targeting monkfish and megrim, and Irish fleets targeting whiting and *Nephrops.*

Fishing is an economic activity, therefore monetary value can be used as an indicator of fisher intent and targeting behaviour. Overall, the most valuable and most targeted species in the Celtic Sea during this time period were monkfish, *Nephrops*, hake and megrim (Fig 4.3), although the highest price is for sole (Table 4.1). There is variation in how member states target these species (Fig 4.4) and in the price per kilogram for each species (Table 4.2)

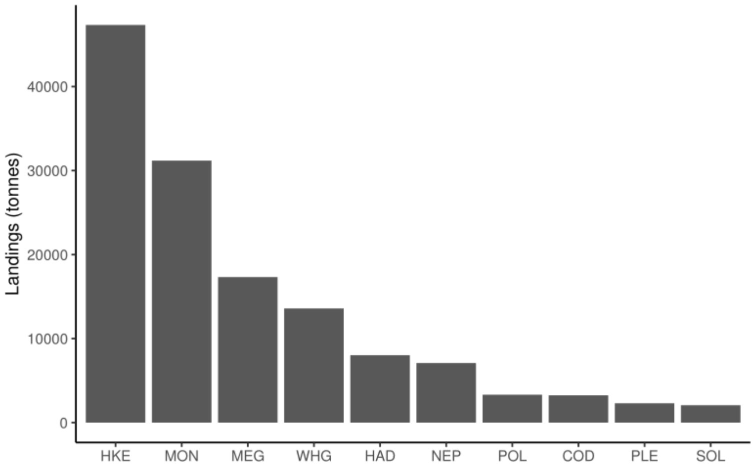


Figure 4.1 Distribution of landings weight per species using a three year average (2015–2017).

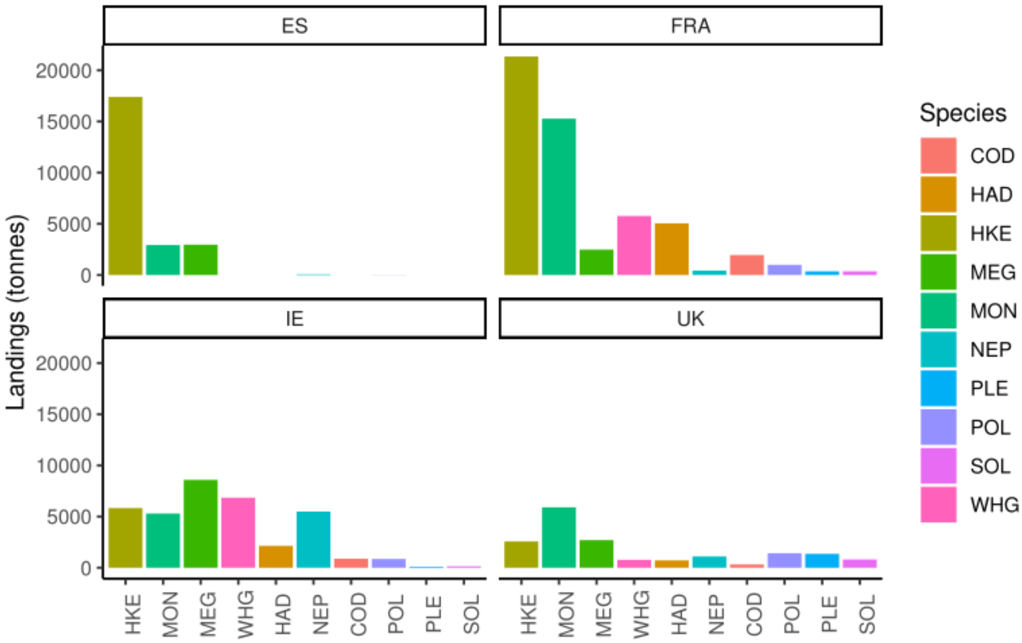


Figure 4.2 Distribution of landings weight per species using a three year (2015–2017), per country

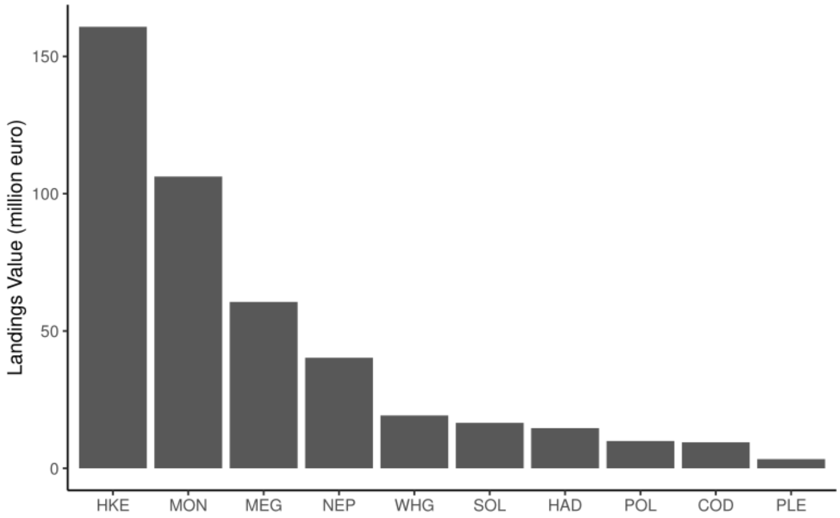


Figure 4.3 Average value Celtic Sea Landings from 2015 – 2017

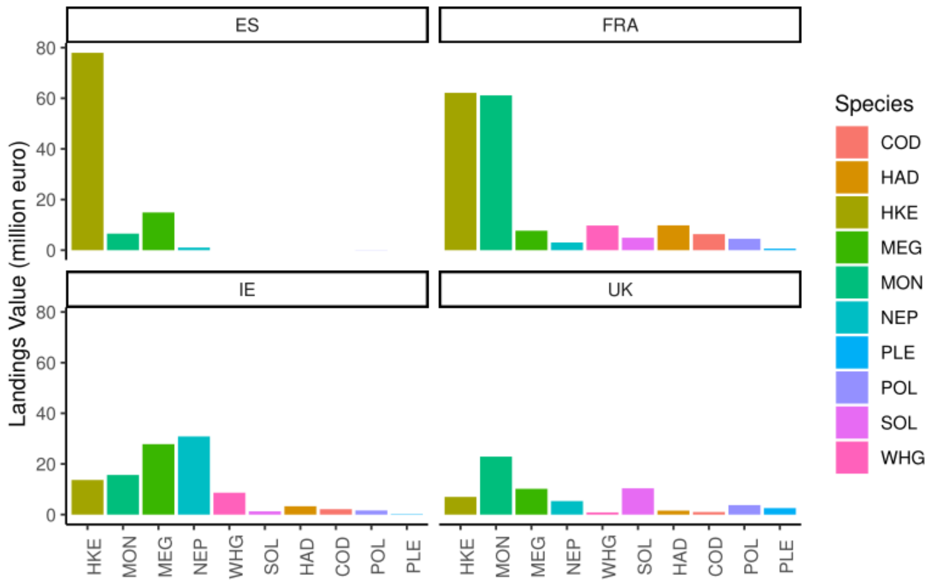


Figure 4.4 Average value Celtic Sea Landings from 2015 – 2017 for the four main member states operating in the Celtic Sea.

Table 4.1 Summary of the average price (Euro/kg) of species landed in the Celtic Sea from 2015–2017

Species	price_euro_kg
SOL	12.62
NEP	5.68
MEG	3.62
MON	3.61
HKE	3.41
POL	3.02
COD	3.01
HAD	1.85
PLE	1.83
WHG	1.44

Table 4.2 Summary of the average price (Euro/kg) of species landed in the Celtic Sea per member state from 2015–2016

Country	COD	HAD	HKE	MEG	MON	NEP	PLE	POL	SOL	WHG
ES	NA	2.01	4.48	5.02	2.24	14.89	NA	2.96	10.67	NA
FRA	3.26	1.94	2.91	3.10	4.00	7.07	1.67	4.55	13.53	1.69
IE	2.40	1.54	2.34	3.24	2.96	5.62	1.77	1.90	8.96	1.26
UK	3.14	2.16	2.72	3.78	3.88	4.85	1.88	2.62	12.86	1.13

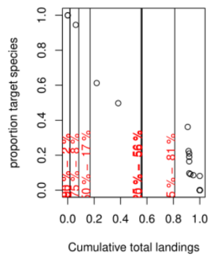
Each of these 11 species were examined to determine the extent of mixing within the Celtic Sea. This species interaction in, terms of landings, was described using two plots and a summary table (Table 4.3). Combined, these two plots allow us to make some inferences about the extent of mixing in relation to each of species included. The plot on the left-hand side shows the cumulative landings, ordered by the proportion of the species landed by each unique level 4 métier. This plot indicates to what extent a species is being targeted and whether or not they are part of a mixed fishery. A clean fishery will have all the points along the top of the plot, while a by-catch species will quickly drop down to a low proportion. The pie-chart on the right shows overall species composition of the métiers which landed relevant species. Finally, a summary table shows the proportion of the species of interest, per metier being executed in the Celtic Sea.

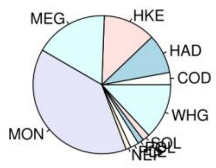
From this analysis it can be concluded that the priority species to include in the Celtic Sea FCube are monkfish, hake, megrim and *Nephrops*. These four species constitute the bulk of the weight (tonnage) and value (euros) of retained catch in the Celtic Sea (Figures 4.1 and 4.3). Additionally, these four species are caught as part of mixed fisheries executed by many of the Celtic Seas métiers, resulting in mixed fisheries interactions with each other, and interactions with the three species currently assessed by WGMIXFISH for the Celtic Sea (cod, haddock and whiting) (Table 4.2).

Table 4.3 Summary species mixing in the Celtic Sea. (i) Cumulative landings, ordered by the proportion of the species landed by each unique level 4 métier, indicating to what extent a species is being targeted. (ii) Species composition, identifying the species with which this species is typically landed. (iii) Total proportions of the species, demonstrates to what extent a metier targets this species, and how clean the fishery is.

Species	(i) Cumulative Landings	(ii) Species Composition	(iii) Total proportions per métier	Summary

MON

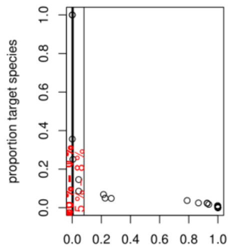


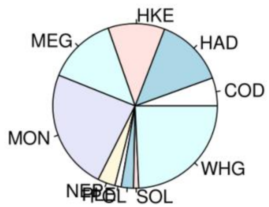


	Métier (lvl 4)	MON Landings (tonnes)	Total Landings (tonnes)	Proportion of MON per métier %
3	GTR_DEF	1889.78	2042.74	93
4	OTT_DEF	4937.61	8369.40	59
5	TBB_DEF	5086.08	11894.82	43
6	OTB_DEF	16411.76	55758.22	29
7	OTT_CRU	196.39	888.41	22
10	MIS_MIS	150.17	1318.12	11
11	OTB_CRU	688.91	8211.08	8
12	GNS_DEF	1531.89	18988.83	8
13	OTM_DEF	19.64	263.78	7
14	SSC_DEF	259.07	4928.95	5

Monkfish is directly targeted by a number of métiers (GTR, OTT & TBB)(iii), with 40% of the of monkfish landings occurring from métiers where they comprise of >50% of total landings (i). Monkfish occurs in mixes with slope species (MEG) and gadoids (HKE, HAD, COD, WHG), and NEP(ii)

COD



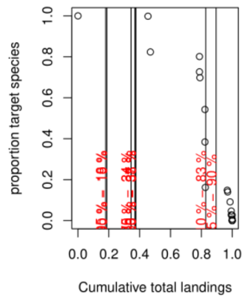


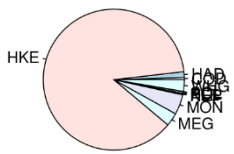
	Métier (lvl 5)	COD Landings (tonnes)	Total Landings (tonnes)	Proportion of COD per métier %
3	SDN_DEF	13.42	53.50	25
4	OTT_CRU	128.00	888.41	14
6	OTT_DEF	553.34	8369.40	7
7	OTB_DEF	1692.57	55758.22	3
8	SSC_DEF	137.32	4928.95	3
9	MIS_MIS	35.56	1318.12	3
10	OTB_CRU	192.41	8211.08	2
11	TBB_DEF	252.20	11894.82	2
13	GTR_DEF	34.01	2042.74	2
15	GNS_DEF	193.49	18988.83	1

Cod is not directly targeted by any métier in the Celtic Sea (iii), with almost 100% of the landings occurring in métiers where cod comprises of less than 20% of the landings (i). Cod is landed in mixes with slope species (MON & MEG), and other gadoids (HAD, HKE & WHG), and NEP(ii)

SPECIES	(I) CUMULATIVE LANDINGS	(II) SPECIES COMPOSITION	(III) TOTAL PROPORTIONS PER MÉTIER	SUMMARY

HKE

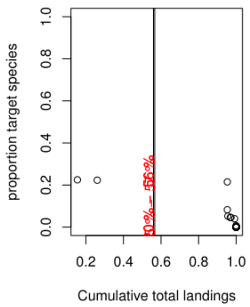


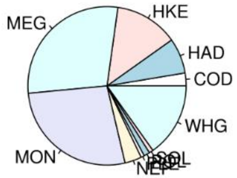


	Métier (lvl 5)	HKE Landings (tonnes)	Total Landings (tonnes)	Proportion of HKE per métier %
2	LLS_DEF	21479.19	21525.00	100
3	LLS_FIF	741.35	908.96	82
4	GNS_DEF	15054.00	18988.83	79
6	OTM_DEF	141.58	263.78	54
7	SSC_DEF	1535.05	4928.95	31
8	OTT_CRU	122.84	888.41	14
9	OTB_DEF	6732.11	55758.22	12
10	MIS_MIS	116.03	1318.12	9
11	OTT_DEF	736.12	8369.40	9
13	OTB_CRU	373.99	8211.08	5
14	TBB_DEF	272.44	11894.82	2
16	GTR_DEF	15.79	2042.74	1

Hake is directly targeted, with around 80% of landings occurring in métiers where hake comprises of >50% of the landings (i). Hake is targeted by a variety of gear types including long lines which demonstrate a clean fishery with a 100% HKE bring landed (ii). Small mixes of mixes of gadoids (COD, HAD, WHG), slope species (MON & MEG) , and NEP (ii).

MEG

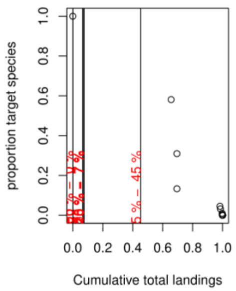


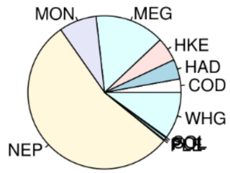


	Métier (lvl 4)	MEG Landings (tonnes)	Total Landings (tonnes)	Proportion of MEG per métier %
1	TBB_DEF	2676.70	11894.82	23
2	OTB_CRU	1831.94	8211.08	22
3	OTB_DEF	11993.72	55758.22	22
5	OTT_CRU	46.50	888.41	5
6	SSC_DEF	227.42	4928.95	5
7	MIS_MIS	59.94	1318.12	5
8	OTT_DEF	335.78	8369.40	4
9	GNS_DEF	142.12	18988.83	1

Megrim is not a targeted species, with 100% of landings occurring in métiers where Megrim comprises of <30% of the landings (i). Megrim is mostly landed by trawler (iii), in mixes with gadoids (HAD, HKE, COD & WHG), slope species (MON), and NEP (ii).

NEP



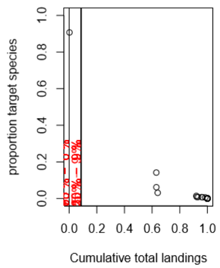


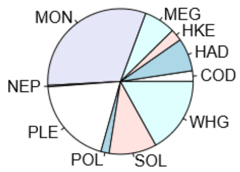
	Métier (lvl 5)	NEP Landings (tonnes)	Total Landings (tonnes)	Proportion of NEP per métier %
2	OTB_CRU	4655.21	8211.08	57
3	OTT_CRU	271.49	888.41	31
5	OTB_DEF	2039.13	55758.22	4
6	MIS_MIS	22.62	1318.12	2
7	OTT_DEF	79.51	8369.40	1
8	TBB_DEF	17.65	11894.82	0

Nephrops is a targeted species, >60% of landings occurring in métiers where *Nephrops* comprises of >60% of the landings (i). *Nephrops* are targeted by trawler (OTB & OTT)(iii), along with mixes of gadoids (HAD, HKE, COD & WHG) slope species (MON & MEG) (ii).

SPECIES | (I) CUMULATIVE LANDINGS | (II) SPECIES COMPOSITION | (III) TOTAL PROPORTIONS PER MÉTIER | SUMMARY

PLE

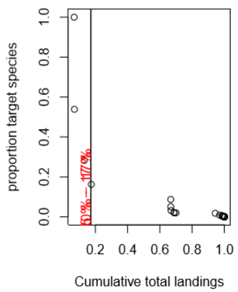


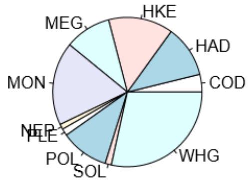


	Métier (lvl 5)	PLE Landings (tonnes)	Total Landings (tonnes)	Proportion of PLE per métier %
2	TBB_DEF	1447.53	11894.82	12
4	MIS_MIS	22.27	1318.12	2
5	OTB_DEF	643.96	55758.22	1
7	OTT_DEF	60.57	8369.40	1
8	GTR_DEF	13.34	2042.74	1
9	OTB_CRU	45.80	8211.08	1
10	SSC_DEF	22.70	4928.95	0
11	GNS_DEF	35.15	18988.83	0

Plaice are not a targeted, with just under 100% of landings occurring in métiers where Plaice comprise of <15% of the landings (i). Plaice is mostly landed by beam trawlers (iii), in mixes with gadoids (HAD, HKE, COD & WHG), slope species (MON, MEG), and NEP (ii).

POL

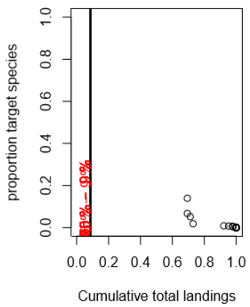


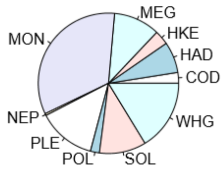


	Métier (lvl 5)	POL Landings (tonnes)	Total Landings (tonnes)	Proportion of POL per métier %
1	LHM_DEF	227.43	227.43	100
3	LLS_FIF	146.42	908.96	16
4	MIS_MIS	202.18	1318.12	15
5	GNS_DEF	1633.50	18988.83	9
7	GTR_DEF	39.31	2042.74	2
9	OTB_DEF	807.74	55758.22	1
10	SSC_DEF	61.83	4928.95	1
11	TBB_DEF	88.61	11894.82	1
12	OTT_DEF	52.10	8369.40	1
15	OTB_CRU	16.85	8211.08	0
16	LLS_DEF	28.19	21525.00	0

Pollack are targeted by hand and pole lines, which demonstrate a clean fishery (i, ii). The remaining landing occur in mixes with gadoids (HAD, HKE, COD, POL & WHG), slope species (MON, MEG), NEP, and SOL (ii).

SOL



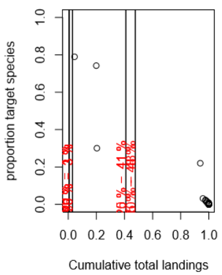


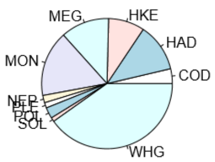
	Métier (lvl 5)	SOL Landings (tonnes)	Total Landings (tonnes)	Proportion of SOL per métier %
1	DRB_MOL	11.41	17.10	67
2	TBB_DEF	1425.94	11894.82	12
4	MIS_MIS	37.27	1318.12	3
5	GTR_DEF	37.24	2042.74	2
6	OTB_CRU	62.57	8211.08	1
7	OTB_DEF	398.62	55758.22	1
8	OTT_DEF	50.26	8369.40	1
10	GNS_DEF	42.35	18988.83	0

Sole mostly a non-target, with just under >80% of landings occurring in métiers where Sole comprise of <15% of the landings (i). Sole is mostly landed by beam trawlers (iii), in mixes with gadoids (HAD, HKE, COD & WHG), slope species (MON, MEG), PLE, and NEP (ii). One métier (DRB_MOL) appears to target sole (>50%)(iii), however this refers to very low tonnage and will not be considered for the purposes of this analysis.

SPECIES | (I) CUMULATIVE LANDINGS | (II) SPECIES COMPOSITION | (III) TOTAL PROPORTIONS PER MÉTIER | SUMMARY

WHG

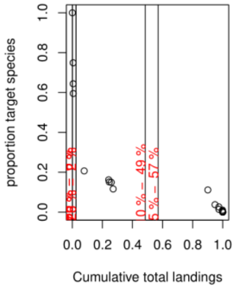


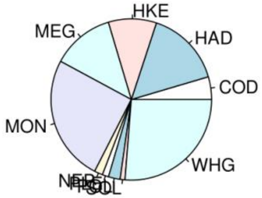


	Métier (lvl 5)	WHG Landings (tonnes)	Total Landings (tonnes)	Proportion of WHG per métier %
2	OTM_SPF	42.65	51.50	83
3	MIS_MIS	565.17	1318.12	43
4	SSC_DEF	2099.73	4928.95	43
5	OTM_DEF	60.95	263.78	23
6	OTB_DEF	9989.89	55758.22	18
7	OTT_DEF	256.77	8369.40	3
8	TBB_DEF	245.32	11894.82	2
10	OTB_CRU	137.02	8211.08	2
12	GNS_DEF	161.55	18988.83	1

Whiting are an increasingly targeted species in the Celtic Sea, with approximately 20% of landings occurring in métiers where whiting comprise of >80% of the landings (i). Whiting is mostly landed by beam trawlers (iii), in mixes with gadoids (HAD, HKE, COD & WHG), slope species (MON & MEG), flatfish (PLE & SOL), and NEP (ii). One métier (OTM_SPF) targets whiting (83%)(iii).

HAD





	Métier (lvl 5)	HAD Landings (tonnes)	Total Landings (tonnes)	Proportion of HAD per métier %
2	SDN_DEF	40.07	53.50	75
4	OTT_DEF	1307.34	8369.40	16
5	SSC_DEF	584.66	4928.95	12
6	OTM_DEF	30.62	263.78	12
7	OTT_CRU	101.80	888.41	11
9	OTB_DEF	5048.71	55758.22	9
10	MIS_MIS	106.92	1318.12	8
11	TBB_DEF	382.35	11894.82	3
12	OTB_CRU	206.39	8211.08	3
14	GNS_DEF	192.94	18988.83	1

Sole are not a targeted, with just under >80% of landings occurring in métiers where Sole comprise of <15% of the landings (i). Plaice is mostly landed by beam trawlers (iii), in mixes with gadoids (HAD, HKE, COD & WHG), slope species (MON & MEG), flatfish (PLE and SOL), and NEP (ii).

4.3 Impacts on the fleet characterisation

With the addition of new species, a number of challenges will arise in how the fleets targeting these species are conditioned. With the addition of new species comes the addition of new metiers and new fleets, thereby increasing the FCube model complexity. This complexity could impact the quality of the model which relies on accurate identification of the technical interactions between fleets, gears and the resulting composition of species in the retained catch. The spatiotemporal heterogeneity of the conditioned fleets needs to be considered. Recent work by this group (Moore *et al*. in press) demonstrates that a fairly simplistic structure of fishing units (country of provenance, fishing location, gear & target species) can effectively describe the complex mixed fisheries scenarios being executed within the Celtic Sea consistently across multiple years. It is recommended that during the next WGMIXFISH-Methods meeting this group explores whether these findings hold true with the addition of new species.

4.4 Species suitability for inclusion in FCube

The 10 species considered for inclusion in the Celtic Sea FCube model can be further divided into 21 stocks, all of which vary in their suitability for inclusion in FCube. These stocks vary in their single species assessment model, framework, quality, and intermediate year assumptions (Table 4.4). It was decided that only category 1 stocks, with full quantitative assessments, would be tested in FCube, as there is currently no method for the inclusion of data poor stocks in FCube. Many of these category 3 flat fish stocks, which were initially considered for inclusions are due to be benchmarked by ICES in 2020, after which, if they progress to category 1 stocks, it will be easier to incorporate them into FCube.

Table 4.4 List of candidate stocks for inclusion, the details of their assessment availability, ICES assessment category describing available knowledge, model type, short term forecast availability.

Species	Stock	Assessment	Category	Model Type	STF
mon	**27.7b-k & 8a-b,k**	yes	1	a4a	yes
cod	**27.7ek**	yes	1	XSA	yes
had	**27.7bk**	yes	1	ASAP	yes
hke	**27.3a46-8abd**	yes	1	ss3	yes
meg	**27.7b-k8abd**	yes	1	Bayesian statistical catch at age	yes
ple	**27.7bc**	no	6	none	none
ple	**27.7e**	yes	3	XSA	yes
ple	**27.7fg**	yes	3	SPiCT	yes
ple	**27.7hk**	yes	3	XSA	yes
pol	**27.767**	yes	4	ss3	yes
sol	**27.7bc**	no	6	none	none
sol	**27.7e**	yes	1	XSA	yes
sol	**27.7fg**	yes	1	XSA	yes
sol	**27.7hk**	yes	3	XSA	yes

Species	Stock	Assessment	Category	Model Type	STF
whg	**27.b-c &e-k**	yes	1	XSA	yes
nep	**16**	yes	1	Analytical model	yes
nep	**17**	yes	1	Analytical model	yes
nep	**19**	yes	1	Analytical model	yes
nep	**2021**	yes	1	Analytical model	yes
nep	**22**	yes	1	Analytical model	yes
nep	**7OTH**	no	6	none	none

However, the principal challenge to the incorporation of new species into the Celtic Sea FCube is the alignment of single species stock assessment, with some stocks distributed across several TAC units, while for others (plaice and sole) there are several stocks within the Celtic Seas, which is further complicated by varying assumptions of species mixing within individual stocks. Although there is agreement between the TAC and assessment area of hake, megrim and anglerfish, all three stocks expand well beyond the boundaries of the Celtic Sea (Fig.4. 5). This can be rectified by using proportions of catch, effort and TAC for the subset of the Celtic Sea but requires an assumption about the catch coming from other areas; this is handled in the model by assuming constant fishing effort/fishing mortality from areas not explicitly modelled for each scenario. This effectively neutralises the effect of the other areas on the overall stock F under the scenarios (allowing their side-by-side comparison of the effects in the modelled fleets), though care is required in interpreting the overall catches, as this assumption indirectly affects the catch by the modelled fleets due to the fact a constant F for other areas under a 'min' FCube scenario would reduce catches for the modelled fleets more than a constant F under the 'max' scenario under the Baranov catch forecast. Other spatial resolution issues arise with the incorporation of *Nephrops* which are assessed at the spatial resolution of Functional Unit (FU), and are based on ICES Statistical Rectangle boundaries. However, *Nephrop*s management, specifically TAC allocation, is at the level of ICES area, with a TAC being provided for all of area 7 (except FU16). Additionally only some of these FU's receive an abundance estimate (necessary to calculate a catchability).

It should be noted that the largest obstacle to the inclusion of *Nephrops* is the mismatch between the timing of mixed fisheries advice (WGMIXFISH-Advice, June) and the *Nephrops* single species advice (WGNEPS, October) which incorporates the latest underwater TV surveys.

Assumptions around species mixing pose an additional challenge. Both monkfish and megrim have designated TACs for groups of both species, however, they are assessed as a single species. Monkfish species, *Lophius piscatorius* and *Lophius budegassa*, mix within the Celtic Sea. Levels of mixing appear to be variable over the time, ranging annually from 10 – 30 % of *L. budegassa*. Both stocks were benchmarked in 2018. As a result, *L. piscatorius* now has an accepted category 1 analytical assessment, with reference points, and a short term forecast. *L. budegassa*, however, remains a category 3 assessment based on survey trends. Yet the issue of species mixing within fisheries was not addressed at benchmark. Instead the benchmark recommended that this issue be reviewed in more detail with the intention of developing an appropriate species split for a future benchmark (ICES 2018).

Megrim (*Lepidorhombus whiffiagonis*) and four-spot megrim (*Lepidorhombus boscii*) are two closely related flatfish species, which mix within the Celtic Sea. The TACs covers both megrim species, although there is no catch advice for four-spot megrim, as it is considered to constitute less than 5% of total landings based on historical sampling of the Scottish and Irish megrim catch (ICES 2016). However, to successfully incorporate this economically valuable species into FCube, WGMIXFISH would need clear guidelines from the single species assessment as to how species splits should be applied.

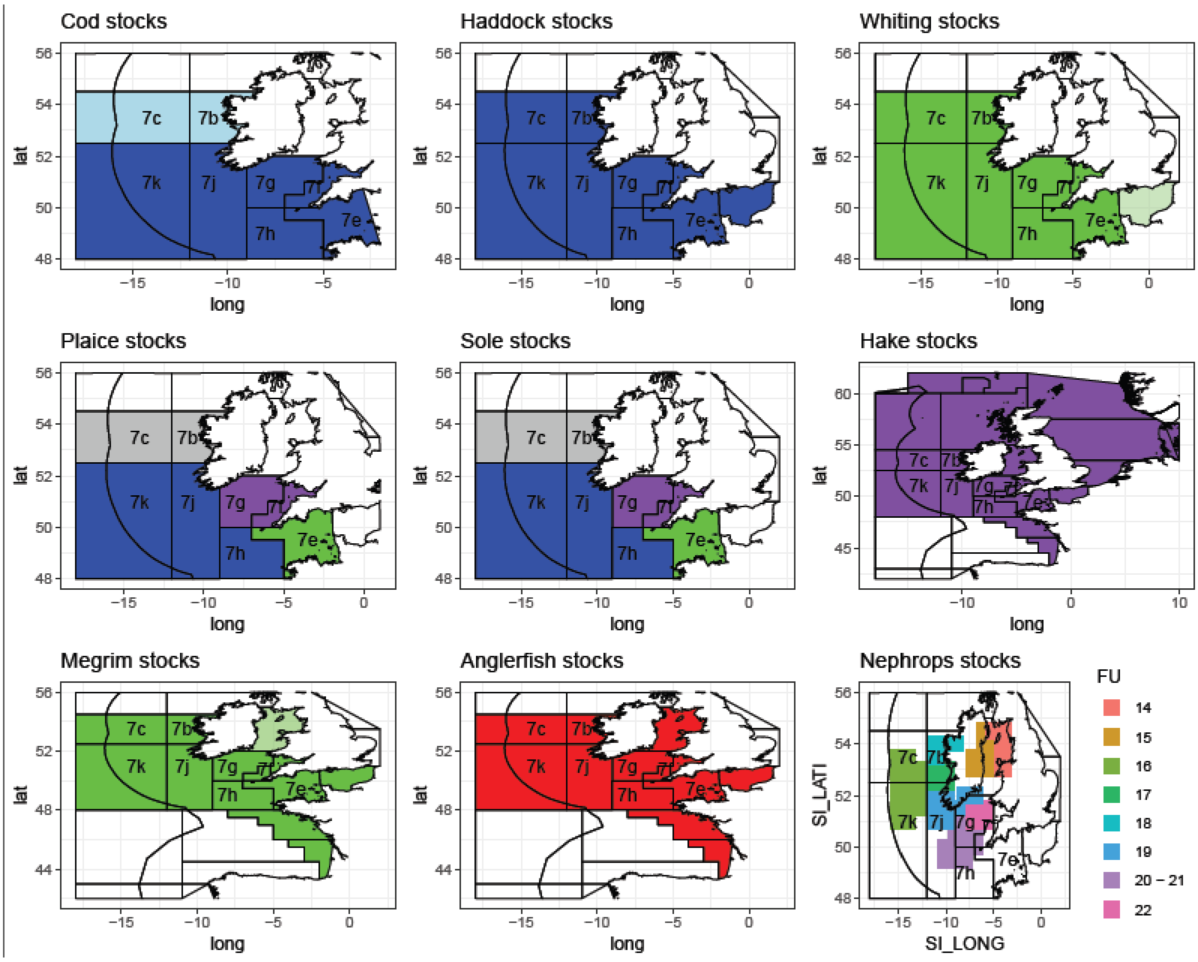


Figure 4. 5: Stock and TAC boundary overlaps for the different species considered. For each panel (species) a different colour shading indicates a different stock unit, while only the area modelled has ICES division labels (the "Celtic Sea")

4.4 Improve data and workflow

If additional species are to be successfully incorporated into WGMIXFISH-Advice there needs to be a number of improvements to data sources and workflow, to ensure quality, transparency, and accessibility of an advice product. Currently three data sources are used to produce mixed fisheries advice for the Celtic Sea: ICES Accession, InterCatch, and single species FLR stock objects. A disproportionate amount of time is spent by WGMIXFISH-Advice in cleaning and matching these three data sources. This wastage of time has resulted in insufficient discussion on the quality and outcomes of the models. This working group have identified possible solutions to this problem, all of which would require intersessional work and support from ICES secretariat.

- **Datacall:** Data submitted through ICES Accessions currently contains a high number of errors in naming terminology. ICES provides a prescriptive format for these naming systems, however, some aspects of the datacall require clarification to reduce the chance of submission errors. This working group will supply ICES Secretariat with a list of datacall improvements.

- **Screening:** Data needs to be screened by ICES at the point of submission. A recommendation of this group is to work intersessionally with the ICES Secretariat to develop an R script which can check the individual country submission for quality and send a quality report back to the user. This will provide a QA process on the data submitted, such as that used for the VMS datacall - https://github.com/ices-eg/VMS-datacall. This screening process will improve our ability to merge the three data sources and estimate consistent parameters for métier catchability and effort used in the model.
- **Stock co-ordinators:** Expert input from the single species stock co-ordinators is required to improve the current procedure. This group will develop a short form to be completed by stock co-ordinators. This form will outline the information and data required by WGMIXFISH, therefore avoiding any issues in version control of assessments or misinterpretation of data in reports and stock annexes. This form should also include a description of the InterCatch allocation system applied for the stock.
- **Transparent Assessment Framework (TAF):** Work has already begun on the transfer of the mixed fisheries code to reproducible Rmarkdown documents which are being moved to TAF.

4.5 Expand the mixed fisheries model

Finally, priority species which were identified as suitable for inclusion in the production of mixed fisheries advice were grouped into tiers, based on their data quality and priority (Table 4.5). These tiers were systematically tested for their performance in FCube and their interaction with each other. This framework is divided into three main stages:

i) Reproduce the single species advice
ii) Conditioning the fleet
iii) FCube forecast

The outcomes of these trial runs were then discussed in the context of what intersessional work should be to support next year's advice drafting process.

Table 4.5: A description of the tiers, the stocks and the logic behind their grouping.

TIER	STOCK	DETAIL
Tier 1	**cod 7ek,** **had 7bk** **whg 7b-c &e-k**	These are the stocks in the original analysis, all are category 1 assessments with deterministic short term forecasts which can be performed accurately in FLR.
Tier 2	**hke 3a46-8abd** **meg 7b-k8abd,** **mon 7b-k & 8a-b,k**	These were identified as the first priority demersal stocks to include, but were also the most challenging due to the range of assessment and forecasting methods. The following summarises the issues encountered: Northern hake: The single stock assessment is a length-based SS3 model, where the output from the assessment is converted to an age-based approximation to allow a forecast in FLR. Similarly, to the forecasts performed for the Bay of Biscay model, we were able to forecast catches

		close to the single stock advice (< 2 % difference in 2018, ~ 5 % difference in 2019) but difference in SSB were very difference (~ 33 % higher in 2020). Megrim: The single stock assessment is an age-based Bayesian model where the median output from the assessment was used as input to deterministic forecasts in FLR. There was some difficulty reproducing close to the advice (a catch difference of 16 % in 2018) which we could not explain. This is being further investigated with the stock coordinator as there is no clear reason why a large difference should be found (a small difference from a deterministic forecast of the median assessment outputs might be expected from the median of a stochastic forecast). Also, we are required to make an assumption concerning the split of the TAC that's belongs to each species based on the landings split, which is uncertain/unclear. Monkfish: The single stock assessment is a statistical catch-at-age model with forecasts undertaken in the FLR framework. There is no problem in recreating the forecasts (I think, it's not right, and I need to spend time next week to see if I can fix it or not. May be it's a stochastic forecast..
Tier 3	**sol 7e** **sol 7fg**	While not considered immediate priority stocks for inclusion they are category 1 stocks with full analytical assessments and forecasts. As the assessments are XSA with deterministic short term forecasts we could replicate them perfectly with FLR.
Tier 4	**ple 7bc** **ple 7e** **ple 7fg** **ple 7hjk** **pol** **sol 7bc** **sol 7hjk**	These stocks do not have full analytical assessments and as such there iso currently accepted method for producing forecasts for inclusion in FCube. While approaches for including stocks with only trends based advice was discussed during the meeting, it was considered this required further testing before it could be used for advice. In addition, some stocks (ple 7hjk , sol 7hjk, ple 7fg) were due to be benchmarked in the coming year, where their inclusion in FCube could be reconsidered.
Nephrops **New**	**FU16** **FU17** **FU19** **FU2021** **FU22** **NEP7OTH**	In order to understand the impact of these different approaches we run two versions of the code, i) with the latest stock abundances, ii) with the data truncated to use the previous year abundance estimates (as if we were undertaking the advice process in May). Handing of the dead discards v live discards needs to be addressed – currently dealt with wrong.
Nephrops **Old**	**FU16** **FU17** **FU19** **FU2021** **FU22**	The biggest challenges remain: The assumption that the share of the Area VII TAC in b-k is the same as observed in previous years (with only ~ 42 % of the quota caught outside of VIIa, which is not included in the model). The timing of the advice for *Nephrops*, where because the surveys take place in the summer the advice is not released until October. This means that we have either to incor-

NEP7OTH	porate *Nephrops* using the previous years abundance estimates (which will be inconsistent with the single stock advice) or cannot released the mixed fisheries advice until October/November.

4.5.1 Reproducing the advice

It was generally possible to reproduce the single species advice for all the additional stocks within a reasonable tolerance given the range of forecasting methods (≤5 % difference in catches) except for megrim in the intermediate year, where the difference was much larger (~ 16 %). In addition, for hake the SSB forecasts in the TAC year + 1 were very difference (~ 33 %). Both these issues will need investigating going forward to try and reduce the inconsistencies when presented in the mixed fisheries scenarios as advice. Individual stock details can be seen in Figure 4.6.

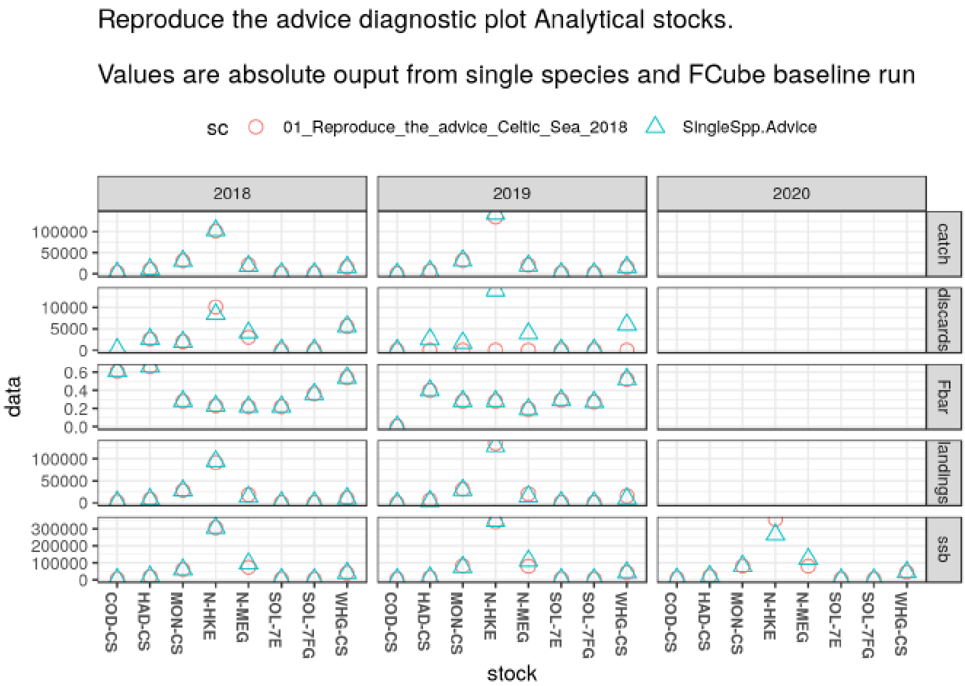


Figure 4.6 Difference between FCube baseline run and Single Species advice for finfish stocks, showing Fbar (2018–2019), catch, discards and landings (2018–2019) and SSB (2018–2020).

4.5.2 Conditioning the fleets

Conditioning the fleets is a vital component of this framework. This is the stage of the FCube assessment process where the most time is spent correcting the errors of data submissions to account for the various errors in coding when data are submitted, where all fleets and metiers are aggregated and filtered. Therefore, this process has to deal with all the issues related to the data submission through accession and InterCatch. The whole process takes a very long time despite the progressive implementation of smarter algorithms to partly correct and recode species name, country, areas, fleets, metiers. A major part of the script still requires manual recoding. This script has nearly 2000 lines of R code, representing nearly two thirds of the code.

No major issues were spotted regarding the inclusion of new stocks, assuming a careful partitioning of areas and species for stocks where boundaries expand further than the

Celtic sea itself. New species that were represented over several stocks (e.g sole and *Nephrops*) were recorded in all effort, landings and InterCatch files with a special code mixing FAO species code and stock boundaries (eg SOL-7FG) with names matching the assessment stock object. For *Nephrops*, Functional units needs to be converted back into ICES division. This is easily overcome if data submission follows the same rule, i.e. for example *Nephrops* in FU22 becomes NEP-FU22 and rather than providing FU22 as area, ICES division are provided so that the catches are naturally splitting for each FU as ICES division. This works needs to be done prior to data submission. When data was missing, FU areas were converted to the ICES division within that FU with the highest proportion of catches.

While processing the data, it was unclear for monkfish and megrim, because of various FAO codes in the accession files, if the splits between species has already been done prior submission of data to accession. Comparing the landings and discards in accessions with the available advice sheets led to the understanding that the splitting was done before data were submitted to accessions. However, this aspect is not documented at all in the data submission considering several FAO codes for those species, and mixing of those species were found. Some coefficients were found in the latest ICES benchmark reports to allow some splitting of the catches between species. This option was implemented for megrim and monkfish but disabled for this exercise.

Apart from the recoding task, the allocation of discards rates based on InterCatch data showed, because of different sorting habits and on-board data collection, some local area exhibit relatively high discard quantities in comparison to nearby areas and somehow induce substantially higher estimates than actually reported. Some basis rules reject discards rates above 98% but depending on the behaviour of some fleets for some species, that threshold might need to be modulated at the stock or local level to take account of the possibility that discards above 98% might occasionally happen. It also appears that some stocks were not fully uploaded into InterCatch (monkfish, sole) and therefore it is unknown if this affects the estimates of discard rates. Overall, the estimates and allocation of discards rates would probably benefit from an improved allocation of discard rates.

4.5.3 FCube runs

A trial run was undertaken with combinations of stocks as described above, in order to better understand any likely consequences on the dynamics of the mixed fisheries advice. Little time was available to evaluate these runs, as the complexities of including a large number of additional stocks meant work had to continue beyond the meeting. A summary of the outcome of these trial runs can be found in Table 4.6. Table 4.6 summaries the catch projections, and choke species for each of the combinations of stocks. Immediately it can be seen that the addition of any new species alter the perception of gadoid projection (tier 1) in 2019. There are many complicated dynamics at play here, and much intersessional work needs to be done to describe and understand these dynamics. For example, the inclusion of *Nephrops* alongside the tier 1 stocks changes the dynamics for the 'max' scenario where NEP2021 becomes a significant driver of effort for the fleets. This was also the case for the NEP Old Tier 1 scenario (where we approximated the advice given the previous years abundance estimates for *Nephrops* from the UWTV survey). The major difference here is the higher TAC for *Nephrops* and catches under the scenario than with the most recent UWTV surveys (which revised down significantly abundance estimates for some of the key FUs).

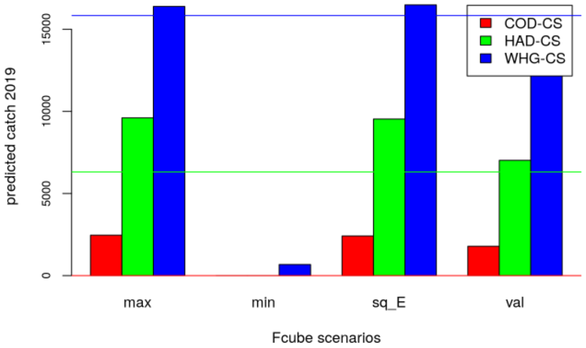
Including the Tier 2 stocks also resulted in changed dynamics, with monkfish and megrim both limiting effort of fleets under the 'min' scenario, and northern hake and monkfish being the least limiting stocks under the 'max' scenario. Further including sole 7e and sole7fg changed the dynamics again in that sole 7fg become limiting for 1 fleet, while Sole 7e was least limiting for 17 stocks. In reality, sole 7fg would not limit fleet catches of the other stocks due to the limited geographical bounds of the stock, where other stocks could be caught by fleets moving elsewhere when their sole7fg quota was exhausted. Similarly, its likely fleets could change their spatial effort distribution to change their proportion of sole7e in their catch, and it's important we consider the nature of these effort dynamics in including more geographically restricted stocks in the model.

Including all stocks together (Nep New Tier 123) led to a much more dynamic system, with more stocks being the limit for fleets under the 'min' scenario.

Table 4.6 : Summary of FCube runs with varying stock/tier combinations

	FCUBE 2019 PROJECTION'S	CHOKE SPECIES

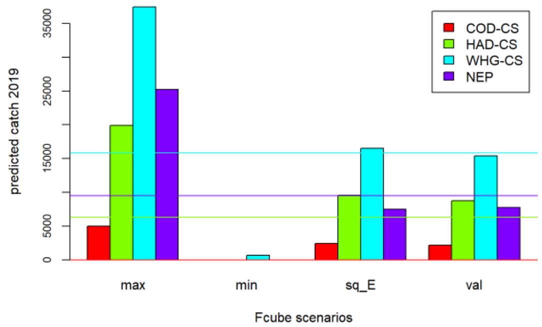
Tier 1



	CHOKE SPECIES		LEAST LIMITING SPECIES	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.801	10		
HAD-CS	0.162	1	0.039	2
WHG-CS	0.038	2	0.961	10

Tier 1

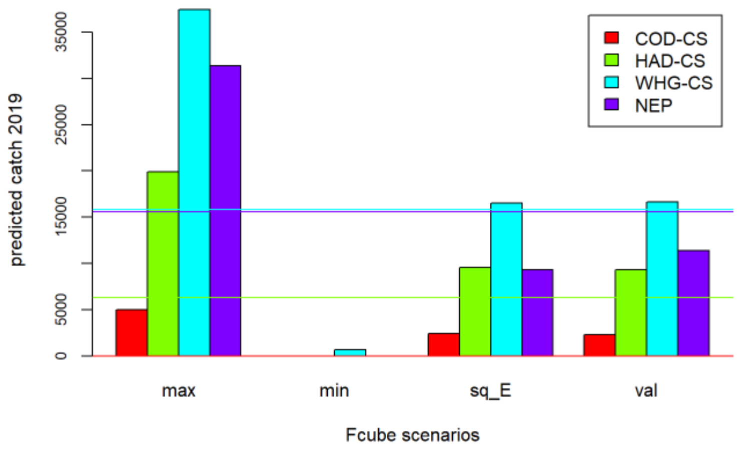
NEP New



	Choke species		Least limiting species	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.858	11		
HAD-CS	0.114	1	0.173	2
NEP16	0.000	1		
NEP 17	0.000			
NEP 19	0.000			9
NEP 2021	0.552		0.552	
NEP 22	0.000			
NEP7OTH	0.000	2		3
WHG-CS	0.275		0.275	

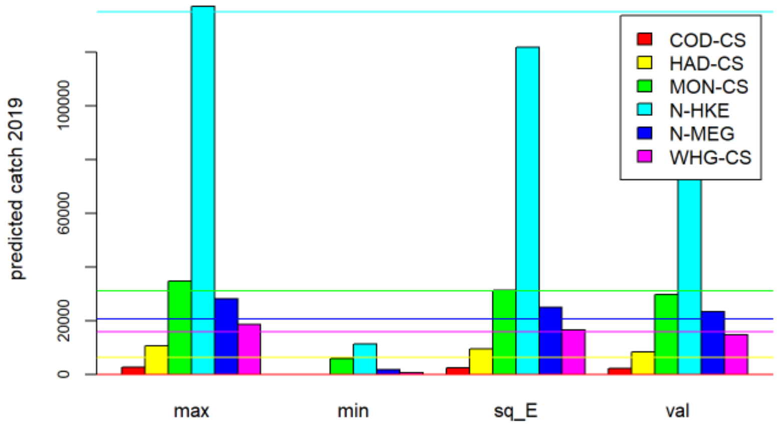
Tier 1

NEP Old



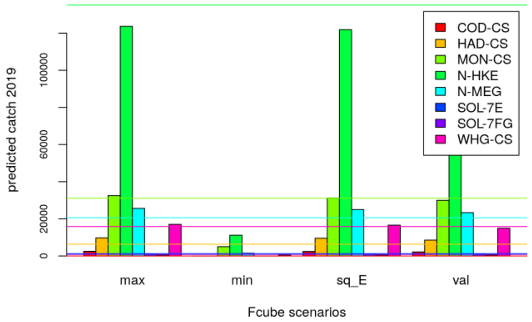
	Choke species		Least limiting species	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.858	11		
HAD-CS	0.114	1	0.173	1
NEP16	0.000	1		
NEP 17	0.000			
NEP 19	0.000			9
NEP 2021	0.000		0.552	
NEP 22	0.000			
NEP7OTH	0.000	2		3
WHG-CS	0.275		0.275	

Tier 1,2



	CHOKE SPECIES		LEAST LIMITING SPECIES	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.851	13	0	
HAD-CS	0.109	2	0	
MON-CS	0.011	1	0.290	3
N-HKE	0.000	0	0.509	10
N-MEG	0.025	1	0.000	
WHG-CS	0.004	1	0.201	4

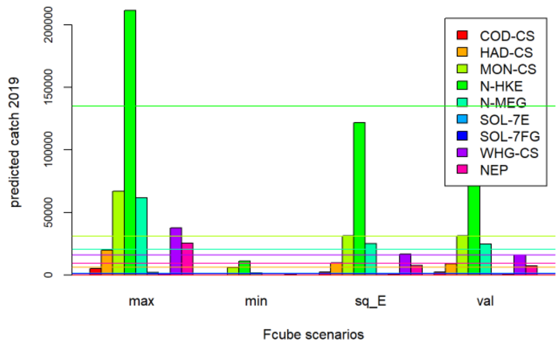
Tier 1, 2, 3



	Choke species		Least limiting species	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.928	17		
HAD-CS	0.034	2		
MON-CS	0.010	1		
N-HKE			0.014	2
N-MEG				
SOL-7E			0.842	17
SOL-7FG	0.024	1		
WHG-CS	0.004	1	0.144	2

Tier 1,2,3

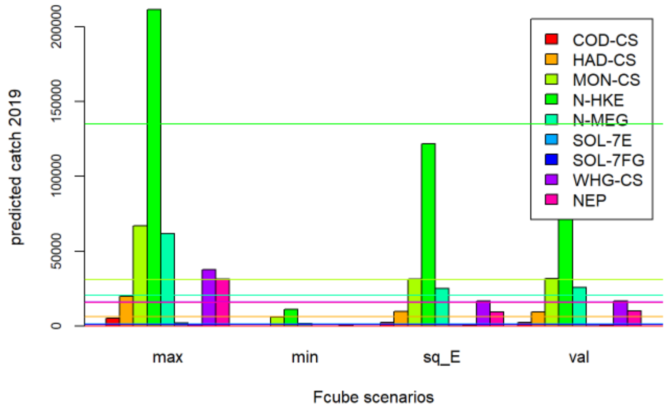
NEP New



	Choke species		Least limiting species	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.928	17		
HAD-CS	0.034	2		
MON-CS	0.004	2		
N-HKE	0.000		0.014	2
N-MEG	0.000			
SOL-7E	0.000		0.473	
SOL-7FG	0.024	1		
NEP16	0.000			10
NEP 17	0.010			
NEP 19	0.000			
NEP 2021	0.000		0.514	9
NEP 22	0.000	1		
NEP7OTH	0.000	1		
WHG-CS	0.000			

Tier 1,2,3

NEP Old



	CHOKE SPECIES		LEAST LIMITING SPECIES	
	% of 2017 effort limited by each spp in 2019	No. of Fleets	% of 2017 effort limited by each spp in 2019	No. of Fleets
COD-CS	0.928	17		
HAD-CS	0.034	2		
MON-CS	0.004	2		
N-HKE	0.000		0.014	2
N-MEG	0.000			
SOL-7E	0.000		0.473	
SOL-7FG	0.024	1		
NEP16	0.000			10
NEP 17	0.010			
NEP 19	0.000			
NEP 2021	0.000		0.514	9
NEP 22	0.000	1		
NEP7OTH	0.000	1		
WHG-CS	0.000			

4.6 Conclusion

This working group has identified 11 new stocks for inclusion in the Celtic Seas FCube. The challenges and possible pitfalls associated with their inclusion have been identified and tested. This working group would recommend the inclusion of *Nephrops* and all tier 1 species (monkfish, hake, and megrim) in next year's advice drafting. However, there is much intersessional work that needs to be done to ensure that usable advice can be produced in a transparent manner. This group needs to consider some of the dynamics this induces (stock boundaries, different TAC areas), which should be a ToR for next year's WGMIXFISH-Methods meeting which we recommend is held in May.

4.7 Recommendation:

The recommendations of this working group are:

1) Request that ACOM swap the timing of WGMIXFISH-Advice meeting with the WGMIXFISH-Methods meeting to allow for the incorporation of updated *Nephrops* advice.
2) Work with ICES Secretariat to clarify datacall.
3) Work with ICES Secretariat to create a screening system for data submission.
4) Provide single species stock coordinators (WGCSE, WGBIE and WGNSSK) with a form requesting clearly what WGMIXFISH requires.
5) Continue work to transfer code to TAF framework.
6) Analysis the outcomes of the FCube runs to determine the drives of the scenarios produced.

5 Analysis of the existing mixed-fisheries model for the North Sea: broken-down models and scenarios for the flatfish fisheries/fleets and for the roundfish fisheries/fleets

5.1 Introduction to the issue

In terms of single-stock assessments, the North Sea has always been considered as a single area (ICES Subarea 4), without further spatial division. This is different from most other areas, where stocks can be defined at the level of the subdivision (including for some of the Greater North Sea area, e.g. subdivisions 7d, 3a20 and 6a). Additionally, the DCF does not consider the spatial structure of the North Sea either, and sampling strata and metiers definitions are defined over the entire area 4. As a consequence, the mixed-fisheries model has also been accordingly designed considering area 4 as a unique area.

Nevertheless, this is a well-known fact that the fish populations are not homogeneously defined throughout the North Sea. And in particular, the main flatfish species (sole and plaice) are mainly caught in the southern part by the southern fisheries (from e.g. Netherlands and Belgium), and the main roundfish species (cod, haddock and saithe) are mainly caught in the northern part by the northern fisheries (from e.g. Scotland and Norway).

Since the fisheries are defined by country, differences in catch composition are nevertheless already accounted for to some extent in the model. However, not distinguishing between sub-areas or other spatial divisions can lead to assuming that different species can be caught together whether they are not. A second problem is that some fleets can be considered to be limited in the FCube "min" scenario (or, contrarily, not limited in the "max" scenario) by a given stock, whereas in reality this stock can represent only a very small portion of the catch.

The WGMIXFISH group was therefore requested to reflect on the potential need, added value and impact of splitting the current model setup into two sub-models, one flatfish- and one roundfish-oriented. To answer this MIXFISH investigated in some details the spatial distribution of the various species, and their occurrence in the various métiers of the various countries.

5.2 Spatial overlap and mixing of roundfish and flatfish landings

WGMIXFISH-ADVICE relies on INTERCATCH data as a source of stock landings and discards at various levels of disaggregation (e.g. country, area, métier, age). As the database does not contain information at finer spatial scales than ICES management areas, the STECF FDI database[1] was used to show spatial patterns in landings by ICES rectangle (0.5° x 1.0° resolution). Since that data is for landings only (i.e. excluding discards), it offers a more conservative perspective of the true overlap between flatfish and roundfish. Nevertheless, the data provides information on the general spatial extraction patterns of wanted catch, including the degree of mixing between flatfish and roundfish landings.

[1] https://stecf.jrc.ec.europa.eu/dd/effort/graphs-quarter

Data analysis

FDI data of landings from 2016, areas 3B1-3 (Annex 2A), were included in the exploration. Countries and gears most important to North Sea demersal mixed fisheries were included, as well as the most important stocks. For a full list of data levels included, see Table 5.2.1.

Table 5.2.1. FDI landings data used in the analysis.

CATEGORY	*LEVELS INCLUDED*
Years	2016
Areas	3B1 (=ICES Subdivision 3a20, Skagerrak), 3B2 (=ICES Subarea 4, North Sea), 3B3 (=ICES Division 7d, Eastern Channel)
Countries	BEL = Belgium, DEU = Germany, DNK = Denmark, ENG = England, FRA = France, NLD = Netherlands, SCO = Scotland, SWE = Sweden
Gears	BEAM = beam trawl, BT1 = beam trawl >=120 mm, BT2 = beam trawl 80–119 mm, GT1 = trammel nets-, GN1 = gill net, LL1 = long line, TR1 = otter trawl >= 100 mm, TR2 = otter trawl 70–99 mm
Roundfish stocks*	ANF = anglerfish, **COD** = cod, **HAD** = haddock, HKE = hake, **POK** = saithe, **WHG** = whiting
Flatfish stocks*	BLL = brill, DAB = dab, FLE = flounder, LEM = lemon sole, **PLE** = plaice, **SOL** = sole, TUR = turbot, WIT = witch sole

* Bold text indicates stocks, or their sub-stocks, that are presently included in North Sea MIXFISH-Advice

Maps were created to show the overall distribution of landings by stock, In addition landings by stock aggregates (roundfish and flatfish) were created that summarize both relative and absolute landings, and aided in illustrating the degree of overlap.

An index of mixing between roundfish and flatfish landings was calculated using the following approach. Pielou's evenness index was first calculated for each ICES rectangle:

$$J = H'/\log S\ ,$$

where H' is the Shannon-Weaver diversity index, $H' = \sum_i^S p_i \log p_i$, S is the total number of species (i.e. richness; S=2), and p_i is the proportion of individuals belonging to the ith species (*i.e.* flatfish or roundfish). Landings weight was used in place of abundance. For example, when a given area's landings are comprised entirely of roundfish or flatfish, the result is $J = 0$, while equal proportions result in $J = 1$. A single mixing index (J_w, i.e. 'weighted evenness') was calculated as the mean of all ICES rectangles, r, weighted by landings, L_r:

$$J_w = \frac{\sum_r^n J_r L_r}{\sum_r^n L_r}\ .$$

Overall distribution patterns

Figure 5.2.1 shows the general spatial landings distribution across all gears and countries for the main roundfish (red hues) and flatfish (blue hues) stocks. The patterns show a majority of flatfish landings being derived from the shallower areas of the southern and eastern sections of the North Sea, while roundfish landings are more from the deeper areas to the northwest and along the Norwegian trench. There is nevertheless a degree of overlap, mainly around the Northwest of Denmark.

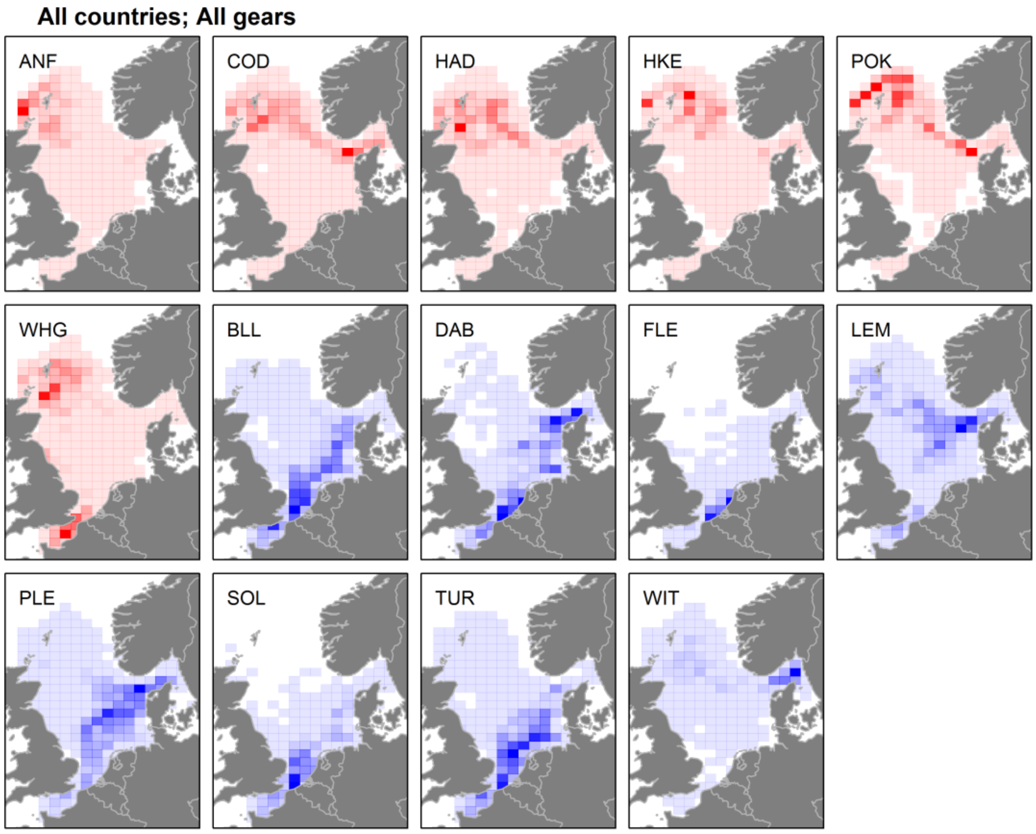


Figure 5.2.1. Landings by ICES rectangle and stock for 2016. Roundfish and flatfish stocks are coloured in red and blue, respectively. Darker colours indicate higher landings. ANF=Anglerfish, COD=Cod, HAD=Haddock, HKE=Hake, POK=Saithe, WHG=Whiting, BLL=Brill, DAB = Dab, FLE=Flounder, LEM=Lemon sole, PLE=Plaice, SOL=Sole, TUR=Turbot, WIT=Witch flounder.

The results of the overall landings patterns by stock aggregate is shown in Figure 5.2.2. Again, the separation of areas dominated by flatfish and roundfish landings patterns is observed, with most mixing occurring along the Norwegian trench, near the north-eastern boundary of ICES area 4b, and areas near the English Channel. The overall mixing index is $J_w = 0.36$.

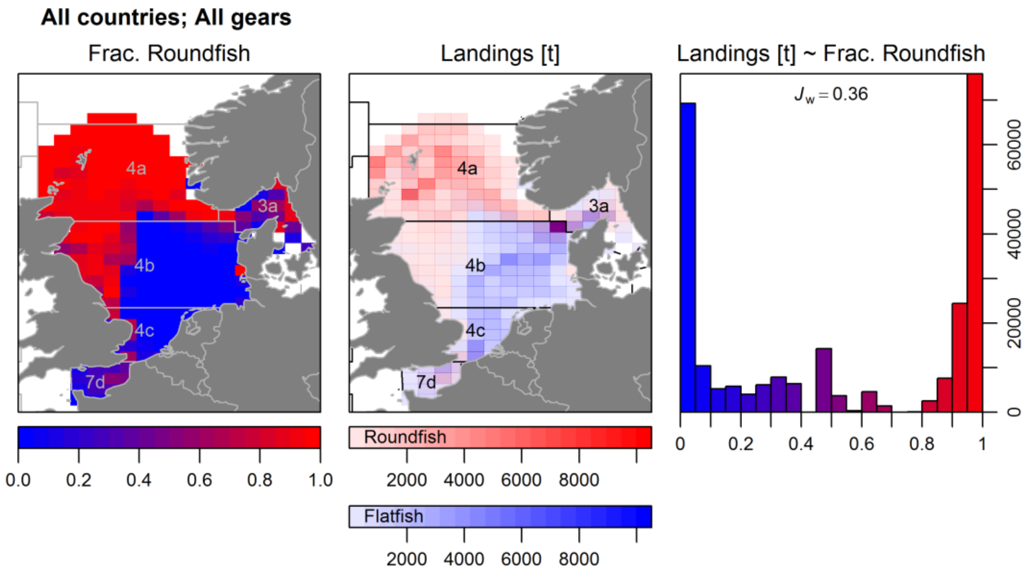


Figure 5.2.2. Landings by ICES rectangle and stock aggregates for 2016 across all countries and gears. The left panel shows the fraction of roundfish in landings by ICES rectangle. The middle panel scales colour transparency with landings to emphasize areas with highest values. Colour scale legend illustrate colour intensities for non-mixed landings, although purple hues would indicate mixing of roundfish and flatfish, as in the left panel. The right panel shows total landings by mixing category (i.e. fraction roundfish), with the overall mixing index (Jw) shown at the top.

Mixing indices by country can be seen in Figure 5.2.3, showing significant variation among countries. Countries with lower values (e.g. England, Germany and Netherlands) avoid areas of stronger mixing. Germany also shows less mixing in areas of the Norwegian trench than seen in other countries. Differences in gear or higher discard rates may be responsible for this deviation. The highest index was observed for Denmark, which shows much higher landings from the main mixing areas of the Norwegian trench. The higher index of Belgium is due to higher landings derived from the northeast extent of ICES area 4b and near the English Channel (areas 4c, 7d). Figures showing mixing of stock aggregates for each country can be seen in Annex 3 (Figures A3-10)

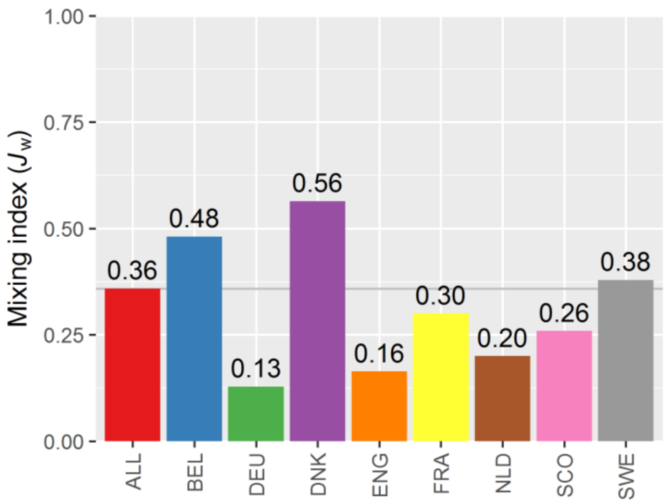


Figure 5.2.3. Mixing indices by country for all gears. Horizontal grey line references the overall mixing index. ALL=Overall, BEL=Belgium, DEU=Germany, DNK=Denmark, ENG=England, FRA=France, NLD=Netherlands, SCO=Scotland, SWE=Sweden.

Distribution patterns of main trawl gears

Distribution patterns in landings from the main trawl gears alone were also explored in order to further identify degrees of mixing for the most mixed gears. These included gears "TR1" and "TR2" (categories of otter trawl or demersal seine), which are gears likely to have mixing of roundfish and flatfish catches. They differ in terms of their mesh size, with TR1 ≥100 mm and TR2 ≥70 mm and <100 mm.

The patterns in landings derived from the larger mesh-sized TR1 gear (Figure 5.2.4) shows less mixing of roundfish and flatfish landings than the TR2 gear (Figure 5.2.5) (J_w of 0.31 vs 0.66, respectively). TR1 is more associated with roundfish landings derived from the more northern areas of North Sea (4a), while TR2 is more associated with mixed roundfish and flatfish landings from shallower depths of the eastern North Sea (4b), English Channel (7d) the Skagerrak (3a20). The pattern of higher mixing indices associated with the TR2 gear is observed for all countries (Figure 5.2.6).

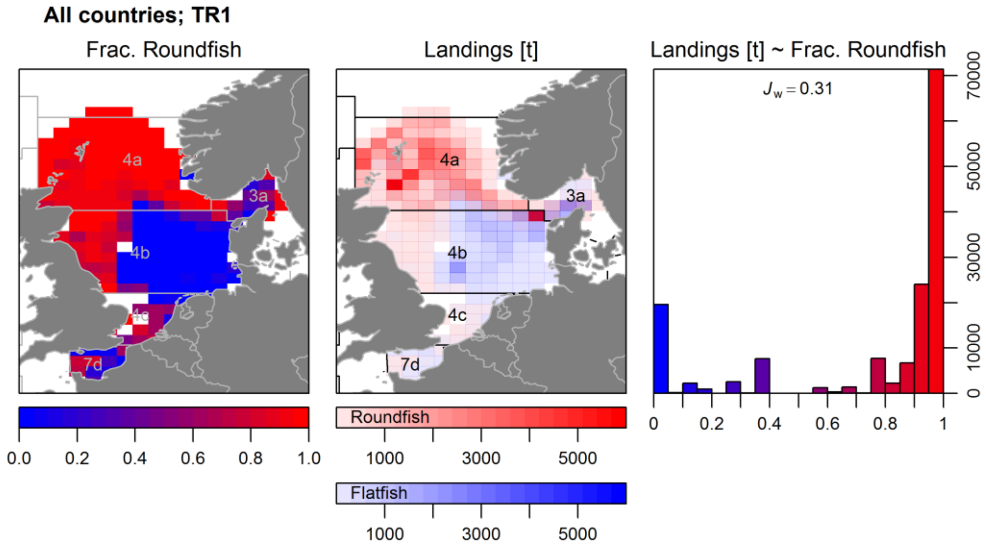


Figure 5.2.4. Landings for TR1 gear by ICES rectangle and stock aggregates for 2016. See Figure 5.2.2 for details.

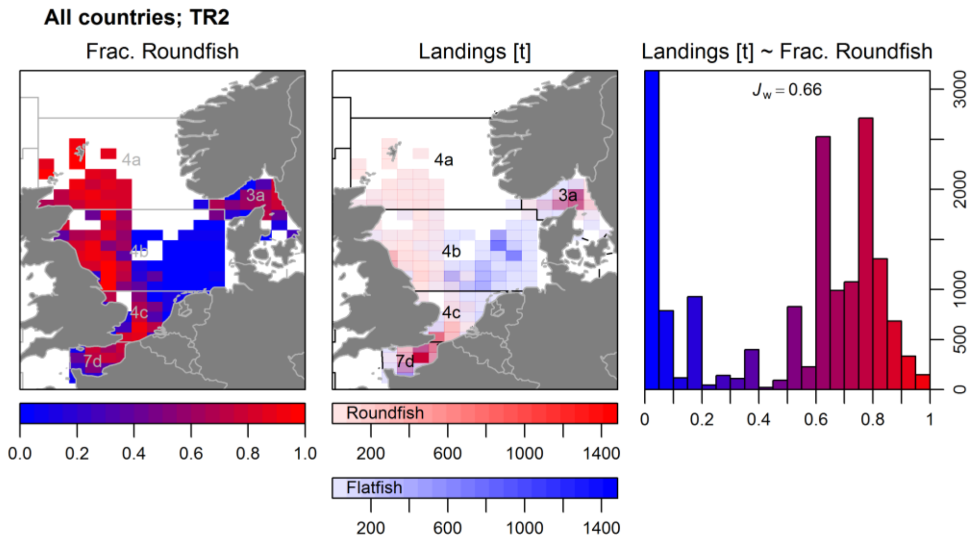


Figure 5.2.5. Landings for TR2 gear by ICES rectangle and stock aggregates for 2016. See Figure 5.2.2 for details.

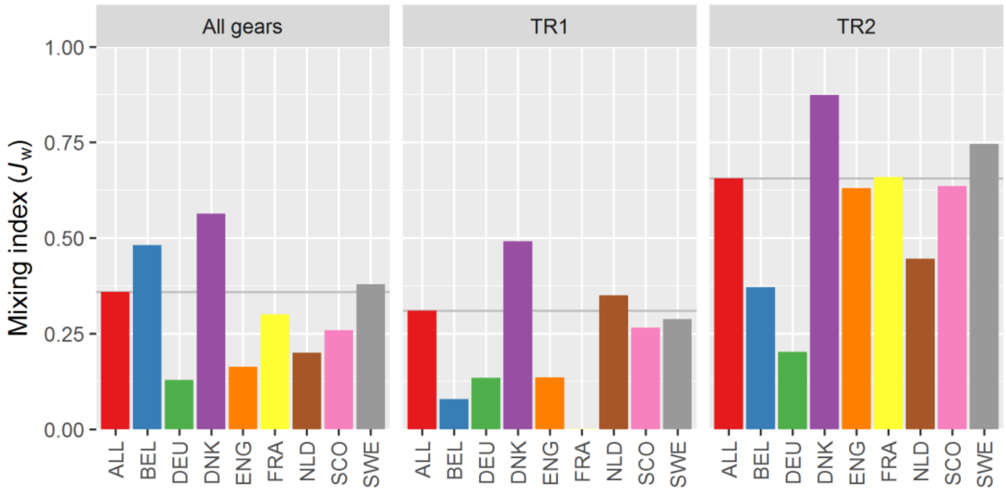


Figure 5.2.6. Mixing indices by country and gear. Horizontal grey line references the overall mixing index. ALL=Overall, BEL=Belgium, DEU=Germany, DNK=Denmark, ENG=England, FRA=France, NLD=Netherlands, SCO=Scotland, SWE=Sweden.

5.3 Are flatfish and roundfish exploited by different fleets?

The development of separate mixed fisheries models for roundfish and for flatfish would be justified if there was only little interaction between flatfish and roundfish species in most of the North Sea fleets. In order to investigate if this is the case, and to supplement the mapping by country above, the MIXFISH dataset was investigated in more details. The main fleets responsible for the majority of the catches were identified for a selection of stocks (2 roundfish: cod and whiting and 2 flatfish stocks: sole and plaice).

In the case of North Sea sole (Figure 5.3.1), 80% of the 2017 landings are taken by 4 beam trawler fleets (Dutch and Belgian) and the fleet OTH (which is a grouping of smaller fleets+ Norwegian data). This stock therefore appears to be caught mainly by flatfish specialist fleets (the landings of these 4 beam trawler fleets are composed almost exclusively of plaice or sole).

North Sea plaice, on the other hand, is caught by a large number and a greater diversity of fleets (10 fleets are responsible for 80% of the landings, Figure 5.3.2). Some of these fleets are flatfish specialists, in which plaice and sole represent most of the landings (i.e. Dutch, English and Belgian beam trawlers), but for others (mainly Danish fleets) plaice is caught with a mix of gadoids, and in one instance (Scottish otter trawlers larger than 24 m), plaice represents only a minor part of the landings dominated by roundfish.

North Sea cod is also caught by a large number of fleets (9 fleets to reach 80% of the landings, Figure 5.3.3). Most of these fleets have their landings dominated by roundfish (EN_FDF, Scottish otter trawls), but catch also flatfish (plaice) in small proportion. About 20% of cod landings are also taken by the Danish fleets, targeting both plaice and different gadoids.

Finally, the bulk of the whiting is landings is also taken by a small number of fleets (5, Figure 5.3.4). Whiting is the main target stock for one of them (French otter trawlers) which also catches Eastern channel plaice and sole in smaller proportion. However, the large majority of whiting landings are taken by fleets for which this stock represents only a small percentage.

This analysis shows that there is not a clear separation between flatfish and roundfish fisheries. While sole is indeed exclusively caught by beam trawlers, plaice is also targeted by Danish fleets which also targets roundfish. Plaice is also an abundant bycatch in roundfish fisheries. Roundfish stocks are mainly taken by fleets targeting those stocks, but potentially also with flatfish (e.g. French otter trawl for whiting, Danish fleets for cod). Furthermore, this analysis does not look into details of the stocks representing a smaller percentage of the landings; thus, there is probably additional overlap for stocks caught by flatfish and roundfish fisheries.

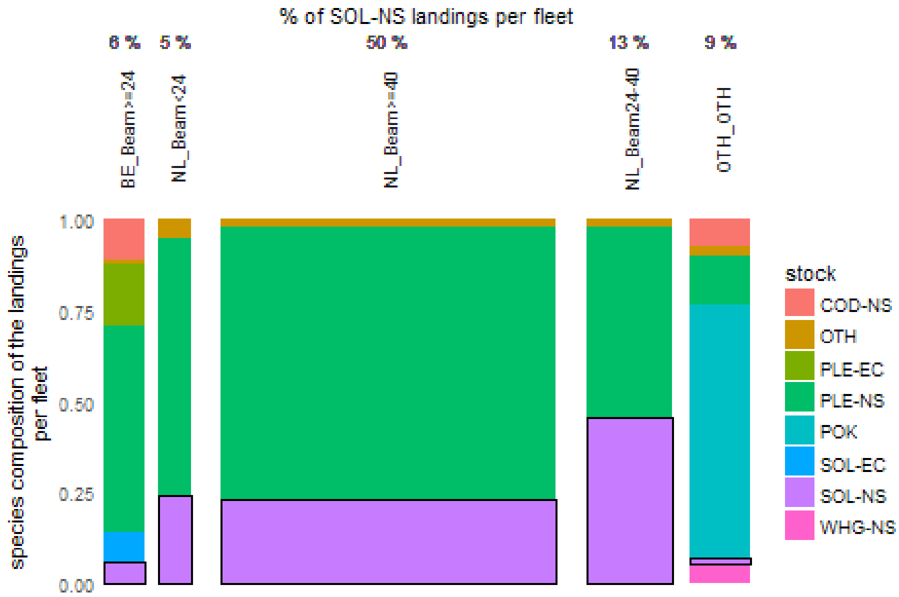


Figure 5.3.1 : main fleets contributing to 80% for the landings for North Sea sole (bar width proportional to the percentage of the 2017 sole landings taken by each fleet) and landing composition of each of these fleets (colouring of the bar indicating the percentage of each stock in the 2017 landings for each fleet, with sole highlighted).

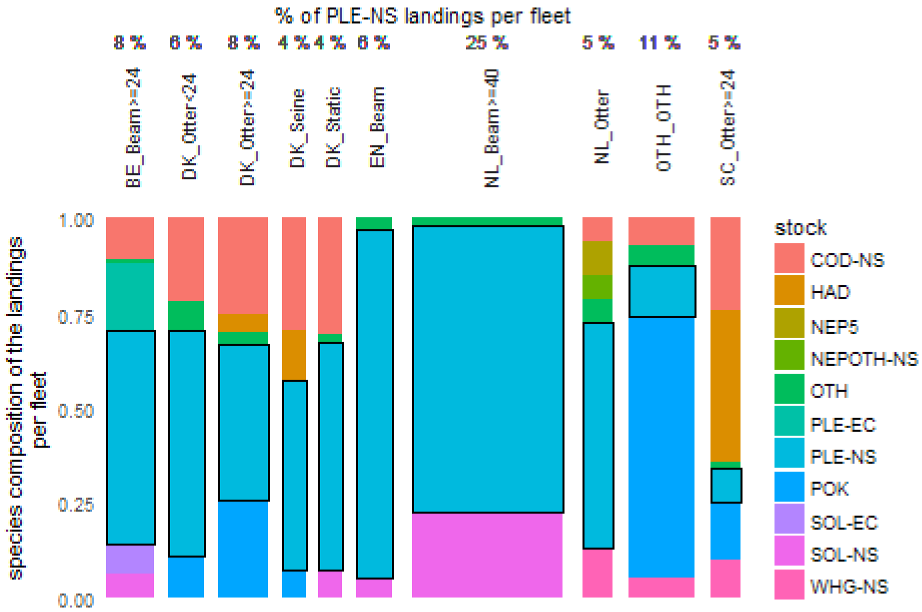


Figure 5.3.2. Main fleets contributing to 80% for the landings for North Sea plaice (bar width proportional to the percentage of the 2017 plaice landings taken by each fleet) and landing composition of each of these fleets (colouring of the bar indicating the percentage of each stock in the 2017 landings for each fleet, with plaice highlighted).

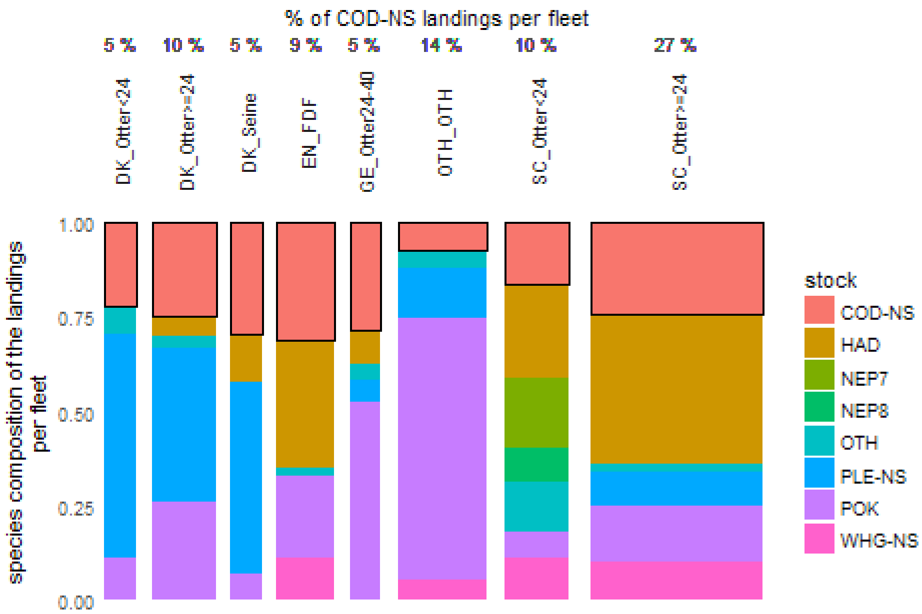


Figure 5.3.3. Main fleets contributing to 80% for the landings for North Sea cod (bar width proportional to the percentage of the 2017 cod landings taken by each fleet) and landing composition of each of these fleets (colouring of the bar indicating the percentage of each stock in the 2017 landings for each fleet, with cod highlighted).

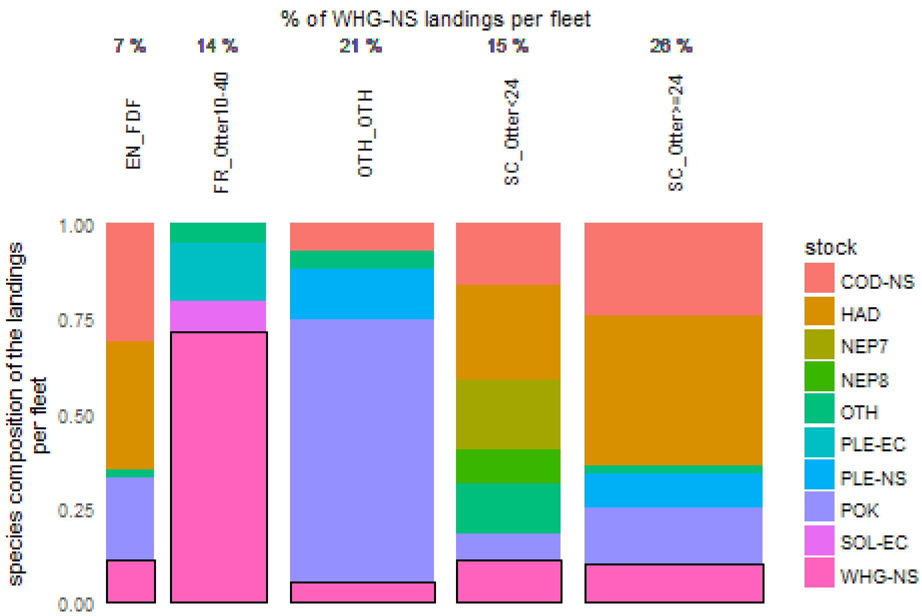


Figure 5.3.4. Main fleets contributing to 80% for the landings for North Sea whiting (bar width proportional to the percentage of the 2017 whiting landings taken by each fleet) and landing composition of each of these fleets (colouring of the bar indicating the percentage of each stock in the 2017 landings for each fleet, with whiting highlighted).

5.4 Potential choke effect of roundfish stocks in the flatfish targeting fisheries

The outcome of the latest North Sea mixed fisheries forecast (ICES, 2018) can be used to investigate the importance of the roundfish stocks for fleets targeting flatfish. The case of the 4 Dutch fleets included in the model (3 beam trawl fleets and 1 otter trawl fleet, all catching mainly flatfish) is taken here as example.

The mixed fisheries forecast produces an estimate of the effort needed by each fleet to catch its quotas for the different stocks. Comparing these efforts indicates which stocks are the least limiting and most limiting stocks.

For these flatfish targeting fleets, the most limiting species will be whiting (in red on Figure 5.4.1). The effort needed to catch the whiting quota, especially for the beam trawlers, is very small compared to the effort corresponding to the quota of the main target species of these fleets (plaice and sole). This indicates that whiting is likely to be a choke species for the Dutch demersal fisheries in 2019. For these 4 fleets, the second most limiting stock is cod.

The current North Sea model therefore shows that these flatfish targeting fleets are likely to be limited by their limited roundfish quotas. This indicates that important constraints in the system would be completely eluded if the mixed fisheries advice was to be given based on separate models for flatfish and roundfish fisheries

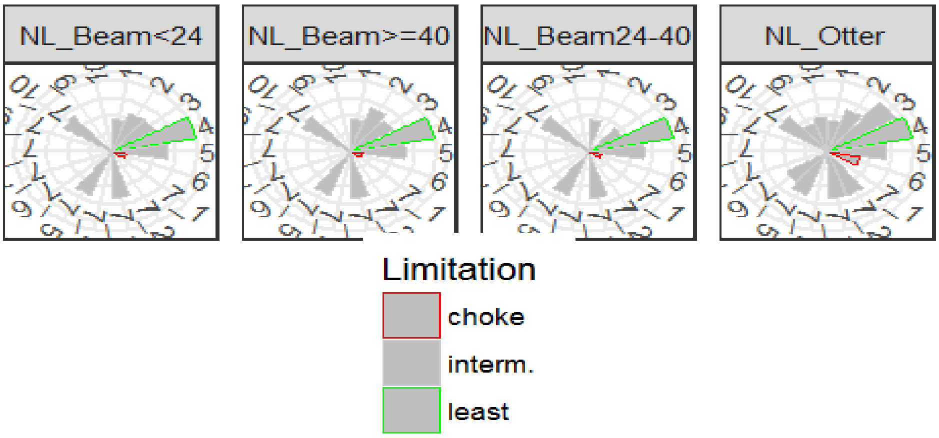


Figure 5.4.1. Estimates of effort by fleet needed to reach the single-stock advices. Red triangles highlight the most limiting species for that fleet in 2019 ("choke species"), whereas the green triangles highlight the least limiting species. (1: cod 27.47d20; 2: had 27.46a20; 3: Plaice 27.420; 4: pok 27.3a46; 5: sol 27.a; 6: whg 27.47d; 7_1: NEP10; 7_2: NEP32; 7_3: NEP33; 7_4: NEP34; 7_5: NEP35; 7_6: NEP6; 7_7: NEP7; 7_8: NEP8; 7_9: NEP9; 7_10: NEPOTH; 9: ple 27.7d; 10: sol 27.7d).

5.5 Economic aspects

The demersal mixed fishery model for the North Sea defines fleets by vessels with similar length class and predominant fishing gear, while further segmentation into métiers is based on fishing operations with a similar exploitation pattern (e.g. based on similar target species, gear, area). Presently, WGMIXFISH-ADVICE uses the FCube model (Ulrich et al., 2011) to provide advice on quota uptake under a variety of scenarios, helping to identify incompatibilities between single species advice (TACs) in a mixed fisheries context. The group has also been advancing towards supplementing this advice with additional economic information. Towards this goal, a parallel version of the North Sea model has been implemented in FLBEIA (Garcia *et al.*, 2017, 2012), which allows for the integration of economic data (e.g. fixed and variable costs, price). A preliminary version of model has already been used in medium-term scenarios that address the economic consequences of strict Common Fishery Policy implementation (e.g. fishing at MSY levels, discard ban) (Taylor *et al.*, 2018). Although some of the fleets are likely to primarily target a single stock aggregate, there are also fleets that show a more mixed pattern due to their métier allocations (e.g. see Section 5.4). Disaggregating fleet capacity and fishing effort into separate roundfish and flatfish models would likely undermine the ability to address economic questions in a clear and realistic manner, since some economic variables (e.g. fixed costs) are more relevant at the fleet level.

5.6 Conclusions and ways forward

The analyses above have provided a very detailed picture of the level of mixing between roundfish and flatfish in the North Sea demersal fisheries.

While it is undeniable that a majority of the fisheries, in terms of overall tonnage, can be considered as displaying low levels of mixing between flat- and roundfish, the analyses presented here have also shown that the mixing is far from negligible. This is mainly true in some specific areas (e.g. centre-East of the North Sea), some specific gears (e.g. TR2) and for some specific countries (e.g. Denmark). But ultimately, most fleets have a degree of mixing, and no country lands exclusively one of the two types of fish, not even the Netherlands or Scotland, All together, the MIXFISH WG considers that the separation of what would constitute a round- or a flatfish fishery is not clear and distinct enough to justify splitting the model. Splitting the model would raise a lot of questions and create a lot of difficulties regarding where to draw the border lines, and which gears and fleets to include in each sub-model. It would also lose the ability to account for the diverse sources of revenue and the recognition of the ability of the fleet to switch target species if one stock becomes in a poorer state. Such ongoing adaptation to e.g. targeting saithe to targeting plaice following quota availability has been documented for a Danish demersal trawler by Mortensen *et al.* (2018). Splitting the model would also go against the efforts made over the last few years to increase the number of stocks in the model, including several important bycatch stocks.

Instead, the MIXFISH WG considers more appropriate to improve the analysis of the actual quota limitations in the fishing fleets, to define whether a stock could be truly limiting in the “min” scenario”. The first step of this was developed in ToR d) of the 2018 Working Group, where quota limitations within a country were investigated using the FIDES TAC database and the Choke Mitigation Tool (CMT) developed by the North Western Water Advisory Council (Rihan, 2018).

5.7 Future development

The North Sea MIXFISH model is continually being updated in response to the changing stock status as determined within WGNSSK. In addition, the involvement of group members in various EU projects with mixed fisheries components has resulted in adaptations in the model structure to allow for a more flexible framework. One such example is the incorporation of data-limited stocks for which only biomass dynamics are modelled (e.g. SPiCT model, Pedersen and Berg, 2017). With these adaptations in place, the working group is presently considering the inclusion of several stocks (Table 5.7.1), many of which are data-limited flatfish stocks (e.g. turbot, flounder, brill, which flounder, dab, lemon sole). It is of note that the FDI data shows that several of these stocks have substantial landings derived from areas of high mixing.

Turbot is likely to be recognized as a Category 1 stock starting next year, and will most certainly be included in future advice. Other likely candidates for inclusion are brill and witch founder, for which TAC advice is given and SPiCT models are accepted and used in defining MSY proxy reference points. While not currently used for advice, the addition of non-TAC stocks (e.g. flounder, grey gurnard, dab, etc.) is also of interest in addressing the effects of mixed fisheries on bycatch species, and the case study members are likely to address these aspects in ongoing projects.

Table 5.7.1. Prospective stocks for MIXFISH-Advice inclusion

Stock	Common name	Cat.	Bench-marks	Advice frequency (Next)	Remarks
tur.27.4	turbot	3 (1)	2017, 2018, 2020	Biennial (2019)	SAM assessment since 2015, with 2 over 3 HCR based on SSB output; Survey data and commercial LPUE indices are used; Likely moving to Cat. 1 in 2019; Combined TAC with brill.
fle.27.3a4	flounder	3	2018	None	No advice given from 2017 onwards; advice based on 2 over 3 HCR using survey trends. LBI and SPiCT assessment available for MSY proxy reference points. Combined TAC with dab until 2016; none since.
brill.27.3a47de	brill	3	2020	Biennial (2019)	Biennial advice is provided based on the LPUE trends of the Dutch beam trawl fleet. Length-based indicators and SPiCT model provide MSY proxies. Combined TAC with turbot.
wit.27.3a47d	witch flounder	3	2018	Biennial (2020)	SAM and SPiCT assessment, but SAM is used for stock status; IBTS CPUE indices used; biennial advice; Currently, lemon sole and witch flounder are managed under a combined species TAC
gug.27.3a47d	grey gurnard	3	None	None	2 over 3 rule; Length based methods were tested in order to define MSY proxy reference points for this stock; Given that the catch data are highly uncertain and only available for a short time period, the SPiCT model was not considered as an option for MSY proxies. Grey gurnard in Subarea 4, Divisions 7.d and 3.a is a non-target stock with no TAC. ICES has not been requested to provide advice on fishing opportunities for this stock
dab.27.3a4	dab	3	2016	None	2 over 3 rule based on SSB from IBTS–Q1 ; SURBAR used to derive evaluate stock status; SPiCT used for MSY proxy reference points - showing reference FMSY proxy and the relative biomass is above the reference BMSY proxy; non-target species with no TAC
ang.27.3a46	anglerfish	3	2018	Annual	SPiCT assessment exists, but not used. 2 over 3 rule used for advice (based on survey index).
lem.27.3a47d	lemon sole	3	2018	Biennial (2020)	SPiCT assessment for this stock was rejected; Age-structured survey indices with deltaGAM; advice based on the 2 over 3 rule, applied to relative SSB estimates from SURBAR; Stock status in relation to Fmsy proxies was to be evaluated using a suite of length-based indicators (LBIs); biennial advice

6 Mixed-fisheries considerations and understanding of biological interactions for stocks in the Baltic Sea.

6.1 Description of the mixed sprat and herring fisheries in the Baltic Sea

6.1.1 Introduction

ICES was asked to describe the mixed sprat and herring fisheries in the Baltic Sea and to develop a mixed fisheries model for these fisheries. To meet these requirements it was decided that a data call should be issued to all Baltic countries to get an understanding of the degree of mixing. In preparation for the formulation of this data call, it was decided that an overview of the sampling scheme and description of the fishery should be produced by each country. The following text summarises the different countries fishery, sampling program and available data.

6.1.2 Information by country

Poland

Fishery

Vessels between 12–35 m length (mainly offshore fisheries). The larger vessels (>18.5 m) use mainly pelagic trawls (OTM, PTM) for fishing sprat and herring, destined for both human consumption and industrial purposes. Sprat have dominated by weight in the landings since 1997. Cutters with the length range 20 to 27 m, and a small number of larger vessels (up to 35 m) are involved in the pelagic catches of sprat (partly mixed with herring and to some extent with cod) for both human consumption and industrial purposes.

In the period 2015–2017, 89.5% of annual herring catches were designated for human consumption and 10.5% for industrial purposes.

The Polish total annual landings of sprat (bycatch of herring excluded) in the most recent three years was 62 229, 59 258 and 68 430 tonnes respectively. The bycatch of herring in the Polish landings of sprat in 2015–2017 was 1944, 1220 and 1541 tonnes respectively. In the above-mentioned years the mean share (by weight) of herring in the Polish annual catches of Baltic sprat was 3.0; 2.0 and 2.2% respectively.

Possible misreporting

The main tools to estimate the official landing statistics in Poland are logbooks (in paper and electronic format) and sales slips.

Species misreporting may occur in the Polish pelagic fishery. Misreporting is mostly from the industrial sprat trawl fishery. Only a part of this fishery is monitored by the NMFRI (Gdynia) scientific observers, in consequence the data on herring bycatch in the sprat fishery are limited spatially and temporally. Sampling may be insufficient in some areas (e.g. ICES subdivisions 27, 28, 29) and for cutters not regularly entering Polish ports.

Clupeids landings for industrial purposes are mixed catches, using trawl with sprat codend mesh size, and are not sorted by species. These are recorded in logbooks as sprat species. Proportions of herring and sprat are only estimated in a few logbooks.

Results of sampling are used to correct official landings on the ICES subdivision and quarter level.

Latvia

Fishery

In Latvia the TAC for pelagic species is utilized above 90% and in some years is fully utilized. In 2017 the catches taken in the economic zones of other EU countries was below 10%.

In the Baltic Proper the pelagic fishes are mainly caught by pelagic trawls and this is mainly a sprat directed fishery with some bycatch of herring. In the Gulf of Riga there are two main fisheries – herring directed trawl fishery in which some bycatch of sprat occurs and a trap-net fishery in the coastal zone which has only herring catches. The proportion of the latter is around 15–20% of the total herring catches in the Gulf of Riga.

The major part of the landings is used for human consumption although the utilization of pelagic fishes for industrial purposes has increased in recent years.

There are regular checks of pelagic landings by control inspectors that estimate the proportion of herring and sprat in the landings and compare it with the records in the logbooks. The Fisheries Data Collection Program at the Institute of Food Safety, Animal Health and Environment BIOR, performs monthly random onboard sampling of pelagic fisheries in the Baltic Proper where a mainly sprat targeted fishery takes place. During sampling the proportion of herring and sprat is estimated in the catches and biological samples of both species are taken.

Possible misreporting

The proportion of herring and sprat in the trawl fishery that is estimated in onboard sampling is similar to the proportion of the total landings of these two species. All boats in the pelagic fishery have quotas for both species, thus misreporting by species is likely only when quota for one of the species is utilized. There is no information as to whether the results of the sampling are used to correct official landings on the ICES subdivision and quarter level.

Germany

Fishery

The German herring fisheries mostly follow the corresponding TAC/quota system, where the fishing fleet tries to compensate quota restrictions of herring by means of quota transfer with other countries in the Baltic Sea.

The main fleet is a cutter fleet with boats between 12 m and 40 m. The fishing is mainly carried out with pelagic trawls (pair trawlers) catching herring (minimum mesh-size >32 mm in SDs 22–27 and >16 mm in SDs 28–32) and sprat (minimum mesh-size >16 mm).

Catches and landings are monitored at sea, by control vessels of the federal and state governments of Schleswig-Holstein and Mecklenburg-Vorpommern (fishery board, customs, marine police) In harbors, the control is carried out by the port control of the state fishery board (13 check points along the Baltic coast) and by the fishmaster. All catches taken with gillnet and trapnet are exclusively catching herring with no bycatch of sprat. The landings in the herring fishery are mainly taken in SD 24 (2014–2016), but there is some spatial overlap with the fishing activities for sprat, which is mainly conducted in SDs 25–26 and 28–29.

Information on the German fishery is derived from sales slips and logbooks. This information is sent to the fishery department of the corresponding federal states (countries). After checking the reported catch and landing data, they are forwarded to the national state authority (Federal Centre for Agriculture and Food, BLE).

Possible misreporting

The logbooks are cross-checked and, when necessary, corrected by the BLE using information from the corresponding sales slips. Landing data based on sales slips are fairly reliable because it is based on the sorting and weighing process carried out in the factories with standardized equipment. The product weight is also used for cross-checking, by applying a correction factor, to get an estimate of the original landing figure. The quota is charged for the final landing species composition of a trip.

The German quota for herring and sprat from the Baltic was almost fully taken during the most recent years. This may have resulted in incentives for misreporting. However, the low spatial overlap of the herring and sprat fishery - where herring is mainly caught in SD 24 and sprat in SDs 25–26 and 28–29 - is not supporting the incentives of misreporting on a larger scale.

The scientific self-sampling program for sprat, which covers the two major pelagic trawlers catching herring and sprat in SDs 25–29, involves 1 unsorted catch sample (5 kg) per trip since their entire catches are landed abroad. However, the analysis of species composition of these sampled sprat landings, which contained only a minor proportion of herring, suggests that no correction of the official landings statistics of sprat is needed.

Since most herring landings are used for human consumption, the trawl fishery intends to catch pure samples of herring with minor bycatch of sprat. This also guarantees the highest landing prices.

Sweden

Fishery

The Swedish logbook for fishing information conforms to the EU fishing logbook. It also provides information on hauls, positions, effort and applied gear on a more detailed basis.

In 2017 the total annual landings from the metier was 2 443 tonnes. The landings constitutes exclusively (>96%) of the target species herring and sprat (89 and 6%, respectively according to the logbooks). The majority of the landings are for human consumption but there are also landings for industrial purposes. The fishery is nationally managed by transferable individual quotas, limiting the allowed landing by vessel.

A gillnet fishery targeting herring is carried out in SD 23 and in 2017 the total landing from the métier was 356 tonnes. The landings consist of more than 99% of herring. Discard rate is assumed to be low. Catch composition is achieved through logbooks and monthly fishing journals. It is not considered cost-effective to sample this fishery.

In 2017 the total annual landing from the metier was 89 585 tonnes. The landings constitutes exclusively (>99%) of the target species herring and sprat (53 and 47%, respectively according to the logbooks). The majority of the landings are for industrial purposes, in which herring is caught as a bycatch, but there are also landings for human consumption. Discard rates are estimated to be below 10%. The fisheries are conducted all year around but are much less intense during summer. The fishery is nationally managed by transferable individual quotas, limiting the allowed landing by vessel. The majority of the catches (79% in 2017) were taken by midwater trawlers using a mesh size of 16–31, and 10–104 mm. However, to some extent other trawls and mesh sizes are used within the fisheries.

Sampling

For herring and sprat from SD 22–32 except SD 30–31, the metier was included in the sea sampling programme 1996-2001. The metier is sampled concurrently in harbours/at markets by purchasing unsorted samples. The sampling is stratified by quarter and subdivision. The assumption for the planned number of trips is that the fishery is conducted all year around in all the main SDs (25–29). All samples are transported to SLU for analysis. Information on age, length, weight, and sex is collected routinely from each individual sampled. Gonadal maturity is recorded for all individuals of herring, while for sprat, maturity is collected in 1st and 2nd quarter due to the typical spawning activity of Baltic sprat in the 2nd quarter. The samples are too small to provide information on the species composition of the catch.

Possible misreporting

For herring from SD 30–31 samples are collected by purchasing a random sample of about 20 kg of the unsorted catch, including bycatches and discard, directly from the fishing vessel. Samples are taken from three different vessels in each quarter (1–4) from trawls, and in quarters 2–3 from gill nets. Samples are analyzed in Öregrund.

A seasonal small-meshed trawl fishery targeting vendace (*Coregonus albula*) with small-sized pair-trawlers is conducted in SD 31 (Bothnian Bay). The fishery occurs within the Swedish territorial zone and is nationally regulated by effort (license permits), area closures and technical measures (selective grids). The fishery is only allowed during six weeks each autumn. The overall landing consisted of ~80% vendace. The major bycatch is herring (*Clupea harengus*) (17% in weight) but minor catches of whitefish (*Coregonus lavaretus*) and other fresh-water species occur. Catches, including bycatches, are landed unsorted and recorded by census methods (logbooks and specific fishing journals). Self-sampling of the catches occur after each fishing day at which juvenile and mature vendace are counted, as well as bycatch species. Unsorted samples (10 litres) are also taken by authorities of the catch in 5 areas, 3 times, during the fishing season (first, third and fifth week).

Finland

Fishery

The Finnish offshore fleet comprises around 60 vessels between 12–40 m in the Baltic Sea main basin, the Archipelago Sea, the Gulf of Bothnia and the Gulf of Finland. The main target is Baltic herring stocks (with sprat taken usually as bycatch) with pelagic trawls.

The catch statistics in Finland are based on log-books. The catches are reported to coastal Centres for Economic Development, Transport and the Environment (ELY-Centres), who are also responsible for the monitoring of the catch compositions. These catches are not, however, monitored regularly, and only in cases when there is some reason to suspect misreporting. Intentional misreporting has not been shown to be prevalent, and misreporting as such is not considered to be a problem in the Finnish fisheries.

The species composition in catches varies between subdivisions with the share of sprat being highest in the Gulf of Finland (SD 32), and lowest in the Bothnian bay (SD 31). Most of the Finnish herring catches (70–75%) are fished from the Bothnian Sea (SD 30) where there are low bycatches of sprat (on average 22%). In SD 30 the share of sprat in annual catches has been 4% on average. The annual share of pelagic catches in the Finnish fishery from SD's 25–28 is only a few per cents at its highest, and therefore they are not considered here.

Possible misreporting

The Finnish sprat quota is only 5.87% of the Baltic sprat TAC, which has caused restrictions to the trawl fishery in SD's 29 and 32 in recent years, in order to help fully utilize the SD 30 herring quota.

Estonia

Fishery

The Estonian fishing fleet in the Baltic consists of two parts: a coastal fleet with vessels ≤ 10 m and engine power ≤ 100 HP. The fishing is mostly conducted with passive gears (gillnet and trapnet, which are exclusively catching herring). Trawlers of lengths between 12 m and 40 m, fish mainly with pelagic trawls (single or pair trawlers) catching mixture of herring and sprat (minimum mesh-size 17–20 mm). On average, 25% of herring catches are taken with coastal fixed gears and 75% with trawls in 2015–2017.

Most herring catches originated from SD 28.1 (40–52%) and from SD 32 (26%) in 2015–2017. Sprat catches have shown a slight increase in 2017 compared to the two previous years due to an increase in TAC.

Possible misreporting

No discarding takes place in the Estonian herring and sprat fishery. All catches taken with gillnet and trapnet are exclusively catching herring with no bycatch of sprat.

Some misreporting can occur in the trawl fishery only, with the exception of the Gulf of Riga (SD 28.1) where there is a very low abundance of sprat.

The logbooks information are cross-checked and, when necessary, corrected on the basis of information from fisheries inspectors and the corresponding sales slips. Landing data based on sales slips are fairly reliable because it is based on the sorting and weighing process carried out in the factories with standardized equipment.

The scientific sampling program for herring and sprat covers all pelagic trawlers, (randomly chosen) catching herring and sprat and covers the unsorted catch sample (10 kg) per trip. Approximately 3–5 trips are sampled per month and SD.

Logbook information is cross-checked and, when necessary, corrected on the basis of information from fisheries inspectors and the corresponding sales slips. Landing data based on sales slips are fairly reliable because it is based on the sorting and weighing process carried out in the factories with standardized equipment.

Denmark

Fishery

The logbooks from the directed herring fishery in the Baltic show that more than 80% of the trips are catching herring without any bycatch of sprat. Denmark has presently a high utilization of the sprat quota, however. Of the 271 Danish trips registered in the Baltic in 2015 with more than 70% herring in the logbook, 20% had registered sprat in the logbook accounting to 9% of the total catch in the directed herring fishery. In 2016 in the directed herring fishery, 18% of the trips had registered sprat in the logbook accounting for 4% of the total catch.

Although herring and sprat is fished within the same area there is a tendency towards more sprat being caught in the northern part of the Baltic and a large part of the herring caught close to Bornholm in SD 23–25.

In 2015 and 2016, close to 95% of the Danish sprat quota was fished in the Baltic and in 2015, 86% of the Danish herring quota was utilized in the western Baltic (SD 22–24) and 14 % in eastern Baltic (SD 25–32). In 2016 this picture changed and a larger part of the Danish herring quotas were utilized. For herring, 92% of the Danish quota was utilized in the western Baltic (SD 22–24) and 90 % in the eastern Baltic (SD 25–32).

The calculation of bycatches is only done on the fishery for correction of the species composition in the catch according to biological samples collected in the harbors. Landings are reported with precise quantities for all species. To determine the quantities, both the logbooks and the sales notes are used. The logbooks contain information on ICES rectangles, whereas the sales notes contain information on the sold species.

The procedure is divided into two parts:

1. A species distribution is calculated for each ICES rectangle using a 9 square technique on all available samples. The species distribution is used to calculate the bycatches
2. This figure is adjusted with figures from the sales notes on the fishery. In this calculation, the Baltic Sea is divided into the Eastern and Western Baltic Sea.

Possible misreporting

The procedure above adjusts landings declarations but does not include all catches.

Lithuania

Fishery

The Lithuania fishing fleet in the Baltic consists of two parts. Firstly a coastal fleet with boats ≤ 8 m and small vessels 12–15 m. A small pelagic fishery is conducted with passive gears (gillnets and trapnets), which are exclusively catching herring. Secondly, trawlers with total lengths between 24 m and 40 m which are fishing exclusively on herring or sprat or a mixture of both in different proportions (mesh-size varies from 16 to 32 mm). Nearly 60% of herring and 52% of sprat are caught by OTM. Landings of herring and sprat from the demersal fishery (OTB) comes as a bycatch. Only 28% of herring and 12% of sprat are used for human consumption. The major part of the landings are utilized for industrial purposes (fish meal).

Information on the Lithuanian fishery is derived from logbooks and sales slips. The data includes information on fishing effort, monitoring system, sales, catches, etc. In the Baltic region, Lithuanian fishing both vessel groups below and above 8 m are obliged to fill in a logbook.

Catches and landings of trawlers are permanently monitored (including the species composition), in all landing harbours by inspectors of Fisheries Service. This information is compared with the logbooks. The logbook information is cross-checked and, when necessary, corrected on the basis of information from fisheries inspectors and the corresponding sales slips.

Possible misreporting

NA

Russia

Fishery

The main fleet operates mainly within the 12-nm limit over the year. The main fleet, targeting sprat for the human consumption, during all quarters, has on average by-catches of herring between 13 – 64% in SD 26. Russia utilized their sprat (in 26 SD) and herring (in SD 26+32) quotas 90.8% and 75.7% respectively. There is a fishery in the Vistula Lagoon (SD 26) targeting herring. The herring catch in this area was about 12% in 2017 compared to the total Russian catch (SD 26+32). There are vessels that operate in SD32 which are targeting herring. The herring catch in SD 32 from the total Russian catch (SD 26+32) in 2017 was about 39%.

Possible misreporting

NA

6.1.3 Conclusions

The work conducted by experts from WGBFAS found that at the scale of the Baltic Sea, the majority of the catches are being taken by pelagic trawlers performing a directed fishery for either sprat or herring, in which bycatch of the other species also occurs. Most of the countries also have fisheries using fixed gears (gillnets or traps) which exclusively catch herring (accounting for up to 20% of the total national herring catches, depending on the country). Part of the catches come from industrial fisheries using small mesh sizes and are likely to catch both species. Catches are often not sorted by species.

Catch statistics at the national level indicate that all countries catch both sprat and herring, but proportions vary across countries (from 90% herring in Finland to 76% sprat in Lithuania).

At the métier level (trawl fishery targeting herring or trawl fishery targeting sprat), all countries reported that bycatch occurred, but only part of the countries provided estimates of the bycatch percentages (based on logbooks and sale slips). Disparities are observed between countries: for instance the bycatch of herring in the Polish sprat fishery in under 3% while Russia reports bycatch rates varying between 13 and 64%. Likewise, for herring, the directed herring fishery close to Bornholm in SD 23–25 is reported to have less sprat in the catches than further north in the Baltic (SD 27– 29). Mixing of herring and sprat in the directed herring trawl fishery is highest in SD 32, decreasing further north in SDs 30–31.

The catch-species composition in these directed fisheries is reported to vary on a seasonal scale with higher concentrations of sprat in the directed herring trawl fishery in the 1st and the 4th quarters (which correspond to the main fishing seasons), in particular in the northern Baltic Sea.

The information available mainly comes from logbooks and sales slips and therefore is collected at a scale that does not allow the assessment of the degree of actual mixing at the scale of a trawl haul. It is therefore not currently clear if the two species actually occur in mixed catches in a given trawl haul (actual technical interaction), or if they occur through occasional hauls with rather clean catches of the bycatch species (taken intentionally or not).

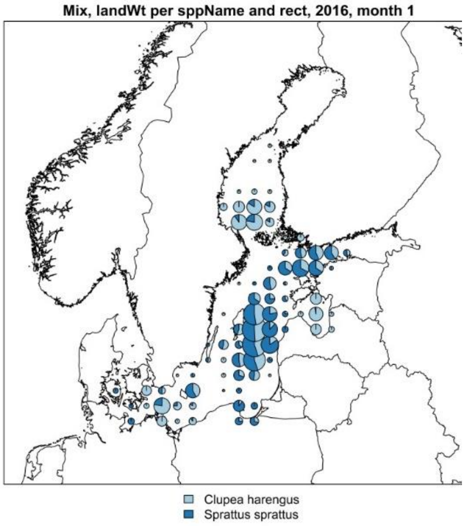
There was some concern raised by the WGBFAS group about the accuracy of the landing-species composition data. The fact that most countries consistently utilize their quota of sprat and herring almost to 100%, even though the stock development for sprat and herring has changed dramatically, is taken by WGBFAS as an indication of potential species misreporting. In the different countries, information on catches species composition are also collected during control operations. The extent to which scientific institutes can access this data, and to which this data is used to correct for potential misreporting varies across countries. WGBFAS indicated that control data for all Baltic Sea countries could be requested to the European Fisheries Control Agency in order to get a better overview of the extend of misreporting. It is important to assess the magnitude of misreporting problems, and when possible correct the fisheries statistics, before using them as the basis for mixed fisheries models.

6.2 Recent work on the Regional Database

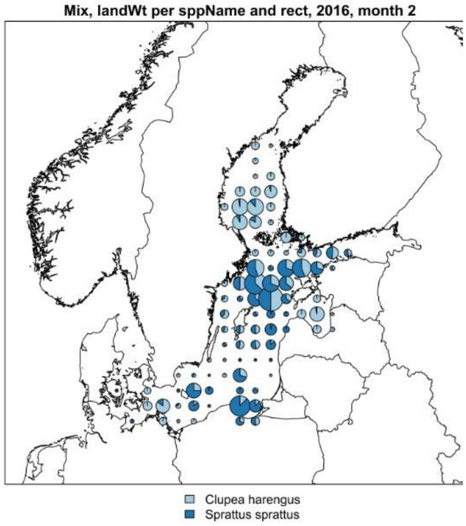
The Regional Coordination Group for data collection in the Baltic (RCG Baltic) decided in 2017 to establish a subgroup on how a regional sampling programme for small pelagics in the Baltic can be designed and implemented. The first task for that subgroup was to generate regional and national overviews of fisheries including spatial and temporal distribution of fishing effort and landings of relevant stocks. The data used for this analysis is data uploaded to the regional database (RDB) in response to the yearly RCG data call.

The subgroup presented initial results at the 2018 RCG meeting. A part of this analysis was the spatial and temporal distribution of the herring and sprat catches and when and where mixture of herring and sprat landings occur. Summaries of regional (EU countries) reported sprat and herring catches by rectangle and month from 2016 are shown in Figure 6.2.1.

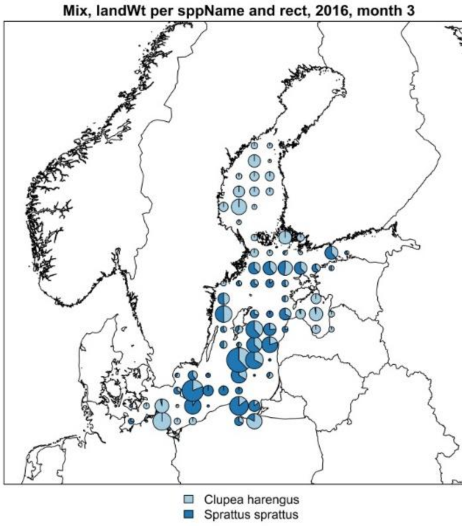
Mix, landWt per sppName and rect, 2016, month 1



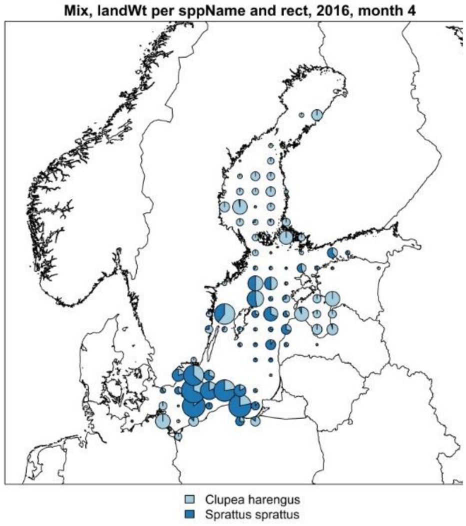
Mix, landWt per sppName and rect, 2016, month 2



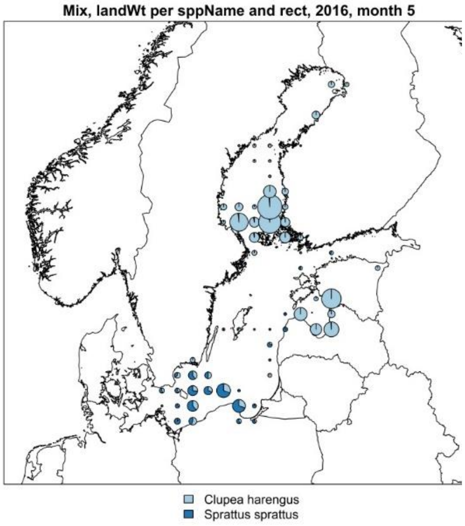
Mix, landWt per sppName and rect, 2016, month 3



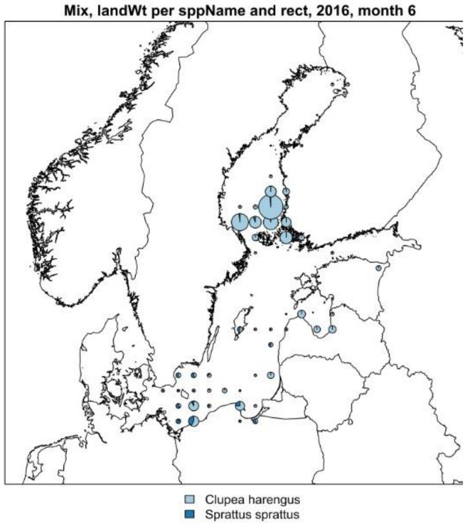
Mix, landWt per sppName and rect, 2016, month 4



Mix, landWt per sppName and rect, 2016, month 5



Mix, landWt per sppName and rect, 2016, month 6



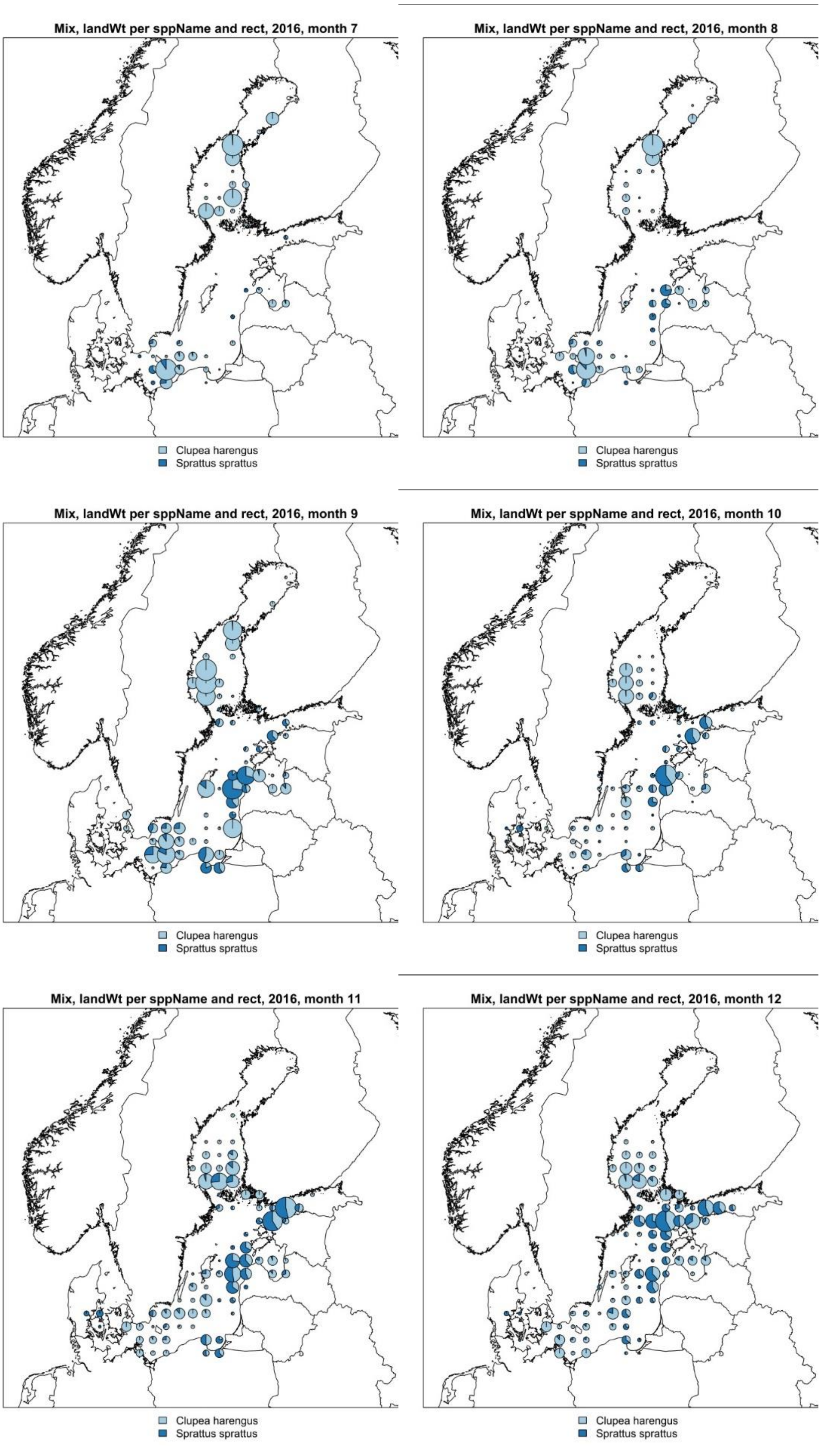


Figure 6.2.1. Summary of regional (EU countries) reported sprat and herring landings by rectangle and month from 2016.

6.3 Development of a mixed fisheries model for these fisheries, which can be used to assess the likely consequences on the stocks and fisheries of different management scenarios.

6.3.1 Effort measure

The models used in WGMIXFISH (FCube and FLBEIA) are based on the relationship between fishing mortality (based on stock assessment output) and the fishing effort (based on fisheries statistics), at the fleet level. For the demersal fisheries (dominated by bottom trawl), the nominal effort measured as number of kW.days (vessel power times sum of trips duration) is broadly accepted as a fair measure of the effective effort. For pelagic fisheries, it is less likely that a nominal effort in kW.days is an accurate measure of effective effort.

A fishing trip for a pelagic trawler is typically divided in a succession of activities (Vermard *et al*, 2010), some focusing on targeting the fish (searching suitable fish aggregations using acoustic equipment, trawling) more than others (steaming to fishing grounds, pumping the fish out of the net and processing the catch). The proportion of time dedicated to these different activities depends on the characteristics of the spatial distribution of the resource and its degree of aggregation. For migratory stocks, the location of the fishing ground may depend on the time of the year, resulting in different proportion of the trip represented by steaming time in different months. The proportion of time spent fishing compared to searching is also higher for highly aggregated species (e.g. blue whiting) than for more scattered ones (e.g. horse mackerel, Fässler *et al*. 2016). It is also not straightforward to which extend these different activities contribute to the effective fishing effort, depending on the degree of targeting of the species that they imply. Estimating a fishing effort can be further complicated in situations where vessels communicate their fishing positions, where some vessels can benefit from the searching time from others. Finally, vessel power is a poor descriptor of fishing power for pelagic trawlers (Reid *et al*. 2011) for which excess engine capacity can be used for other purposes than towing the net (seawater refrigeration, faster cruising, allowing for larger size and increased storage).

The link between nominal and effective effort in the Baltic Pelagic fisheries should be investigated to assess whether simple and easily available measures of effort – such as kW.days as used in demersal fisheries – can be used in a potential pelagic mixed fisheries model. Quantifying the proportion of the time actually dedicated to targeting the fish (based on analyses of vessel tracks for instance, combined with acoustic information), and describing how this proportion varies at different scales (trips, season, year), could help establish whether the trip duration is a good proxy for effective effort.

6.3.2 Assumptions made on catchability

The catchability– expressed as the ratio between the partial fishing mortality of a given fishing fleet for a given stock and the effort of this fleet - is a central parameter in the mixed fisheries models used to provide advice on mixed fisheries. Catchability coefficients are calculated - for each of the stocks appearing in the catches of each of the fleets -based on the catch and effort data, and the stock assessment output for the most recent year in the data (usually the year prior to the current year). These coefficients are then assumed to be constant in the mixed fisheries short term projections, and are used to convert future quota shares of the different stocks for each fleet into a fishing effort. Different scenarios (“min”, “max”, ...) are then applied to define which effort will be deployed by each fleet, and catchabilities are used again to compute the corresponding partial fishing mortalities and landings. A central assumption in the mixed fisheries models is therefore that fleets have constant catchabilities for the different stocks over the period for which the projections are made (i.e. current year -1 to current year +1).

For pelagic species, the assumption of constant catchability is more likely to be challenged. First, pelagic species tend to remain aggregated in schools and fishermen are often very efficient at finding these aggregations (knowledge, use of acoustic equipment, sharing information). The catch per unit of effort can remain constant even if stock size is declining (described as hyperstability by Hilborn and Walters, 1992). It is therefore likely that catchability becomes higher as the stock size decreases. Another potential issue with pelagic fish is the dependency of their habitat to environmental conditions. Environmental variability can cause changes their distribution -extend of the distribution, vertical distribution, degree of aggregation and schools characteristics – which affect the catchability of the different fleet for these stocks. In case of strong environmental anomaly, the year-to –year change in catchability can be substantial (Maunder *et al.*, 2006). Although such effects can potentially happen for any species (e.g. Erisman *et al*., 2011), they are likely to be more pronounced for pelagic species, such that the assumption of constant catchability might not be realistic.

6.3.3 Spatial and temporal issues

The models used in WGMIXFISH are not spatially or temporally explicit. This comes down to assuming that stock distribution (and overlap between stock) is constant, both at the seasonal and at the interannual scales. The differences in local abundances are implicitly accounted for in the difference in the catchability estimated for the fleets of different countries, exploiting the stocks in different areas.

Pelagic stocks have a more variable distribution than demersal stocks, and often undertake more extensive migrations. Their availability to a given fleet, and degree of spatial overlap between target and bycatch is therefore susceptible to vary between seasons and between years, which would hamper the application of the type of models used in WGMIXFISH and call for the use of spatial/temporal explicit models.

Analysis of spatial and temporal data on species distribution (surveys or fisheries data) could provide some insight in the variability in the distribution of herring and sprat, and on the extent of their overlap.

6.3.4 Conclusions and recommendations

The information presented by the WGBFAS indicates that there is a moderate degree of mixing in the catches of the Baltic Sea pelagic fisheries. There are also some indications from the control data that species misreporting may occur, which could be, if that is intentional, an indication that quotas of bycatch are potentially limiting. Therefore, there appears to be enough justification for developing a mixed fisheries model for these fisheries.

However, a number of conceptual questions have to be addressed to assess whether the tools currently used by WGMIXFISH can be applied in the case of these fisheries, or if alternative approaches should be envisaged instead.

The WGMIXFISH group recommends that a series of analyses should be carried out to better describe the quality of the data available, the extend of the species mixing in the landings and variability of the catchability of the different fleets. The following road map is suggested:

- Assess the reliability of the catch composition declared in the log book using control data from the European control agency.

- Based on detailed logbook data, and possible observer data, describe in detail how the mixed fisheries interactions occur (in terms of geographical location, period of the year, and fleets involved). Data collected from acoustic surveys can also be used to inform on the degree of spatial overlap between herring and sprat, and the degree of mixing of the 2 species at the school (or group of schools) level.

- Make a mixed fisheries data call to assemble a landing and effort database for the pelagic fisheries in the Baltic Sea

- Based on catches and effort per fleet data, time series of catchabilities for herring and sprat could be calculated for the different fleets. Any large variation in the catchabilities (especially if not correlated between the two species) would indicate that the mixed fisheries models used at WGMIXFISH are not suitable to describe the Baltic Sea pelagic fisheries.

7 Tasks and timeline to further develop knowledge necessary to advise on mixed fisheries and biological interactions in the Baltic Sea

7.1 Introduction

The Landing Obligation in the Baltic means that from 2019 discarding will no longer be allowed, however, the Baltic MAP has an option for using the upper-range of F_{MSY} if issues regarding mixed fisheries, inter-or intra-specific issues (density-dependence growth, species interactions), or limits to inter-annual variability in the TACs, are fulfilled.

Mixed fisheries for the Baltic are not yet established: data needs and research needs must be outlined.

Some advice on spatial overlap/mixed fishery exists (also in the FO); however, much more is needed in order to fully reply to future advice needs.

Stock-mixing is very variable. Currently there is a mismatch between the catch composition and quota availability. Data on the degree of mixing per haul is needed.

7.2 Roadmap development

Final product must be a mixed fisheries advice for the Baltic – not necessarily matching the current advice for the North Sea or Celtic Sea, however, with tools for management to deal with issues of spatial/temporal overlap. The end product should be a spatially resolved multispecies model, with process-studies for validation, e.g. growth models, stomach content results, distribution pattern analyses.

For this Special Request advice an Issue list is required. Setting up the roadmap would imply the following steps:

1. Identify issues necessary for management needs
    a. Mixed Fishery
    b. Inter species interactions
    c. Intra species interactions
2. How to address the needs in terms of
    a. Research
    b. Data: use of acoustic survey data and ground-truthing may be a way forward. Maps already exist. Data also in the RDB. May be useful for describing spatial distribution of different species.
    c. Expertise

Managers need to be included in the scoping process for the roadmap (5-year process). Need to know exactly what the policy makers want to achieve.

7.3 Suggested format for producing the necessary advice

A SCICOM-approach to a workshop series of 3-year periodicity with assigned tasks progressing through the 'Issue list'.

7.4 Immediate way forward

1. A workshop will be established for the scoping formed of Baltic ACOM members and managers. Needs to be a transparent process. This to be formalised at

the November ACOM meeting (Workshop on the Ecosystem Based Management of the Baltic Sea?)

2. A process by correspondence between all members of this group/wk will take place in order to outline the issue list. Included will be further work looking into the quality of the catch data in the RDB.

7.5 Longer term

- A Data call is needed.
- Need to include the Integrated Assessment Working Group for the Baltic Sea (WGIAB) and the multi-species WG (WGSAM).
- Need data by fishery not by species. Control agencies?
- Separate density dependence from environmental forcing. Could also be done for clupeids using stomach data (available in different places around the Baltic and the zooplankton database developed in BONUS-INSPIRE)
- Include density-dependence in a spatially explicit new multispecies model. Current work ongoing on producing a multispecies expansion of SAM. Needs testing with independent data.
- Analyse the BIAS acoustic and trawl data for co-occurrence of herring and sprat in May and September (as a starting point).
- Talk to fishermen about self-sampling.

7.6 Draft ToRs for a meeting:

The **Workshop on the Ecosystem Based Management of the Baltic Sea** (WKBALTIC), chaired by XXX, XXX, will be established and will meet in XXX, XX 2019 to:

a) With stakeholders, identify issues necessary for management needs regarding mixed-fisheries interactions, ecosystem drivers of fisheries productivity and inter- and intra-specific interactions;

b) Prioritize recommendations for future improvements to mixed-fishery methodology, particularly in regards to a new models for pelagic species;

c) Expand on preliminary work exploring data in the Regional Database (RDB) on the mixing of pelagic species in the Baltic, and mixed demersal species in particular evaluating the quality of catch data,

d) Consider and potentially adapt existing mixed fisheries methodology for application in the Baltic, and prioritise recommendations for a new mixed fisheries model for pelagic species

e) Develop a roadmap for the delivery of future research needs for EBM and mixed fisheries management of Baltic Sea fisheries.

WKBALTIC will report by DATE for the attention of ACOM/SCICOM.

Supporting information

Priority	
Scientific justification	
Resource requirements	

Participants	10-15 people. Experts on integrated assessment, fish stock assessment models, Baltic Sea ecosystem, stakeholders (industry, administrations, NGOs).
Secretariat facilities	Professional assisstance by the ICES secretariat
Financial	No financial implications
Linkages to advisory committees	There are close links with ACOM and SCICOM
Linkages to other committees or groups	This work requires collaboaration with WGSAM, WGMIXFISH and WGIAB. The work should also feed into the Fisheries Overviews.
Linkages to other organizations	

8 References

Erisman, B.E., L.G. Allen, J.T. Claisse, D.J. Pondella II, E.F. Miller, and J.H. Murray. 2011. The illusion of plenty: hyperstability masks collapses in two recreational fisheries that target fish spawning aggregations. Canadian Journal of Fisheries and Aquatic Sciences 68:1705-1716.

Fässler, S.M.M.; Brunel, T.; Gastauer, S.; Burggraaf, D. (2016) Acoustic data collected on pelagic fishing vessels throughout an annual cycle: operational framework, interpretation of observations, and future perspective. Fisheries Research 178, p. 39-46

Garcia, D., Sánchez, S., Prellezo, R., Urtizberea, A., Andrés, M., 2017. FLBEIA : A simulation model to conduct Bio-Economic evaluation of fisheries management strategies. SoftwareX 6, 141–147. https://doi.org/10.1016/j.softx.2017.06.001

Hilborn, R. and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty. Chapman Hall

Maunder, M. N., Sibert, J. R. Fonteneau, A., Hampton, J., Kleiber, P., and Harley, S. J. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. e ICES Journal of Marine Science, 63: 1373e1385

Mortensen, L.O., Ulrich, C., Hansen, J., Hald, R., 2018. Identifying choke species challenges for an individual demersal trawler in the North Sea, lessons from conversations and data analysis. Mar. Policy 87, 1–11. https://doi.org/10.1016/j.marpol.2017.09.031

North Western Waters Choke Species Analysis, n.d. , NWW Member States & NWW Advisory Council.

Pedersen, M.W., Berg, C.W., 2017. A stochastic surplus production model in continuous time. Fish Fish. https://doi.org/10.1111/faf.12174

Reid, D. G., Graham, N., Rihan, D. J., Kelly, E., Gatt, I. R., Griffin, F., Gerritsen, H. D., and Kynoch, R. J. 2011. Do big boats tow big nets? – ICES Journal of Marine Science, 68: 1663–1669

Taylor, M.H., Kempf, A., Brunel, T., Ulrich, C., Vermard, Y., Garcia, D., 2018. Estimating the impacts of common fisheries policy implementation to North Sea demersal fisheries using a bioeconomic mixed fisheries model. Presented at the ICES Annual Science Conference, Hamburg, Germany.

Ulrich, C., Reeves, S.A., Vermard, Y., Holmes, S.J., Vanhee, W., 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. ICES J. Mar. Sci. J. Cons. 68, 1535–1547. https://doi.org/10.1093/icesjms/fsr060

Vermard, Y., Rivot, E., Mahevas, S., Marchal, P. and Gascuel. D. 2010. Identifying fishing trip behaviour and estimating fishing effort from VMS data using Bayesian Hidden Markov Models Ecol. Model., 221 (15) , p. 1757-1769.

ICES. 2018. Report of the Benchmark Workshop on Anglerfish Stocks in the ICES Area (WKANGLER), 12–16 February 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:31. 177 pp.

ICES. 2016. Inter-Benchmark Protocol Workshop Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b–k and 8.a, 8.b, and 8.d (West and Southwest of Ireland, Bay of Biscay) (IBP Megrim 2016), July 2015–March 2016, by correspondence. ICES CM 2016/ACOM:32. 124 pp.

Annex 1. Working Document: Justification of possibility for applying higher range fishing mortality level for the Gulf of Riga (ICES subd.28.1) herring stocks in 2018.

A1. 1. Justification of possibility for applying higher range fishing mortality level for the Gulf of Riga (ICES subd.28.1) herring stocks in 2018.

Tiit Raid, Estonian Marine Institute, Estonia, Georgs Kornilovs, Institute of Food Safety, Animal Health and Environment BIOR, Latvia

The Gulf of Riga is inhabited by local herring population which is the main commercial fish species in this area. There is no interaction of this herring stock with other commercial fish species. However intra-species dynamics and feeding conditions in this relatively small sea area are very much influenced by the size of the stock.

The state of the Gulf of Riga herring stock is assessed at the Baltic Fisheries Assessment Working Group of ICES. Analytical assessment is based on Estonian and Latvian catch data, CPUE series and results of the hydro-acoustic survey. The hydro-acoustic survey is performed in the end of July- beginning of August jointly by Estonia and Latvia. For the prediction of the Gulf of Riga herring stock, the recruitment at age 1 is taken as the average value from 1989 onwards.

The preliminary results of the hydro-acoustic survey performed in summer 2017 indicate that the 2016 year class could be of average strength corresponding to the value used for this year class in the prediction.

This stock is at present considered to be harvested within safe biological limits. The Gulf of Riga herring stock is in a good state since the beginning of 1990s. The average spawning stock biomass in 1992–2016 was 1.6 times higher than in years 1977–1991, respectively 94.3 thousand tonnes and 57.9 thousand tonnes. The increase of the stock size was promoted by global warming and significant increase in the number of mild winters which are favourable for the reproduction of the Gulf of Riga herring. Thus the number of 1-year old herring (recruitment) in period after 1990 is 2.4 times higher than in the period before. The fluctuation of the spawning stock size is mainly determined by the appearance of strong and weak year classes since the recruitment is rather variable. In recent years the spawning stock has decreased due to the weak year class of 2013 although it still shows very close figures to the long-term average of the favourable reproduction period. The prediction shows that in the following years the spawning stock size will increase.

Also the joint assessment of Estonian and Latvian scientists performed in the Gulf of Riga in 2016 and presented to the EU Council last year in the paper,, Preliminary estimate of the Gulf of Riga (ICES subd.28.1) herring stock 2015 year class and its influence on the prediction and fishing mortality levels in 2017'' (Tiit Raid, Estonian Marine Institute, Estonia, Georgs Kornilovs, Institute of Food Safety, Animal Health and Environment BIOR, Latvia) (Attached to this paper as an Annex) brings to one of the main conclusions that the lower level of TAC and corresponding fishing mortality rate ($F = 0.32$) could create situation that the SSB will increase more considerably causing high feeding competition, slower growth, lower condition factor and quality of the fishes and finally lower income for the fishermen.

As it was mentioned above the stock size of the Gulf of Riga herring is stable and staying at a high level for very long period. Therefore situation is not changed very much from one described in the scientific paper last year. It should be stressed that the increase of the stock size in the following years would be associated with slower growth and poorer feeding condition of herring. With the catch reduction (-7%) recommended by the Commission the stock will rise further on, and this will affect the growth of herring and the medium weight of age groups will follow to decline. For relatively small sea area like the Gulf of Riga the food competition and negative stock dynamic tendencies will appear more rapidly. Also the SSB in 2018 will be well above MSY $B_{trigger}$ therefore it is possible to use fishing mortalities in the upper range of F_{msy} without doing any harm to a long term healthy stock.

Based on this argumentation, scientific data and conclusions from Estonian and Latvian joint stock assessment Estonia and Latvia arguing for application of the F range principles described in Baltic Sea multispecies multiannual plan Regulation 1139/2016 Article 4 paragraph 4. b (justified by intra- or inter-species stock dynamics) and invites the Commission to set the TAC for the Gulf of Riga herring in 2018 by using the applicable range provided in the Annex I column B, corresponding to the moderate MSY fishing mortality F = 0.347 (roll-over of the TAC for 2017- 31 121 t) while not advising application of $F_{msyupper}$ = 0.38.

Then taking into consideration the state and predicted development of the stock - the SSB in 2019 will still be higher than in 2018 and the diference with the SSB when using F = 0.347 instead of F_{msy} = 0.32 will be only 2.5%.

It should be also taken into account that the Gulf of Riga herring TAC has been significantly decreased in the previous two years and the TAC in 2017 was already 20% lower than in 2015.

Therefore when setting the TAC for the Gulf of Riga herring the socio-economic consequences should be seriously taken into account. The Gulf of Riga herring is caught by the fleet of trawlers and by coastal fishermen using trap-nets. For both fleets herring is the main target species constituting 90–100% of the total catch. In such situation further decrease of the fishing possibilities will have a negative influence on their economic situation especially in the sector of coastal fishery in which Common Fishery Policy has defined a target to provide good economic situation.

A1.2 Annex to paper: Justification of possibility for applying higher range fishing mortality level for the Gulf of Riga (ICES subd.28.1) herring stock in 2018.

Preliminary estimate of the Gulf of Riga (ICES subd.28.1) herring stock 2015 year class and its influence on the prediction and fishing mortality levels in 2017

The assessment of the Gulf of Riga herring is performed in the ICES Baltic fisheries assessment working group. For the assessment the results of the hydro-acoustic survey are used as tuning fleet. The hydro-acoustic survey is performed in the end of July-beginning of August jointly by Estonia (EE) and Latvia (LV) and since 1999 and since 2005 the results are used for the assessment of the Gulf of Riga herring. For the prediction of the Gulf of Riga herring stock, the recruitment at age 1 is taken as the average value from 1989 onwards.

For the data analysis the average age composition of the trawl catches performed during the hydro-acoustic survey was available and it has not been combined with the acoustic recordings (Table 1). However, results of the hydro-acoustic surveys indicate that there is a significant correlation between the percentage of the age group 1 in the hydro-acoustic survey and the estimate of this age group which is performed next spring after the hydro-acoustic survey takes place (Figure 1, Table 2).

Table 1: Average age composition of herring in the trawl catches of the hydro-acoustic surveys in the Gulf of Riga, (%). 1999–2015 data from the WGBFAS report and data of 2016 obtained from the age determination of trawl samples performed during hydro-acoustic survey.

	Age							
Year	1	2	3	4	5	6	7	8+
1999	40.1	33.0	10.2	8.8	3.5	2.4	1.6	0.5
2000	36.7	32.8	14.7	5.0	5.6	2.8	1.2	1.2
2001	61.0	16.1	11.7	6.2	1.7	2.4	0.5	0.5
2002	33.1	49.6	8.8	4.3	1.8	0.7	1.4	0.3
2003	71.3	9.3	12.9	2.4	1.5	1.5	0.3	0.8
2004	19.3	65.1	4.1	8.2	1.3	1.2	0.5	0.2
2005	52.7	10.1	29.2	2.2	4.4	0.6	0.5	0.4
2006	77.3	12.7	1.4	6.0	0.7	1.4	0.2	0.2
2007	19.0	47.2	16.3	1.8	12.5	1.5	1.3	0.3
2008	54.0	12.3	25.7	4.8	0.8	2.1	0.1	0.1
2009	45.1	33.0	6.1	12.0	2.0	0.2	1.6	0.1
2010	50.3	22.8	17.0	2.4	5.8	1.0	0.1	0.5
2011	20.3	33.9	16.1	18.9	3.8	5.5	1.0	0.4
2012	54.8	7.0	14.1	7.1	9.5	3.4	2.8	1.2
2013	50.6	29.8	3.2	6.7	2.6	4.4	1.0	1.7
2014	12.4	42.7	24.9	3.1	6.3	4.9	5.2	0.5
2015	41.6	7.0	24.5	14.3	3.3	4.5	2.3	2.5
2016	67.0	9.1	3.0	10.3	6.1	1.1	1.8	1.6

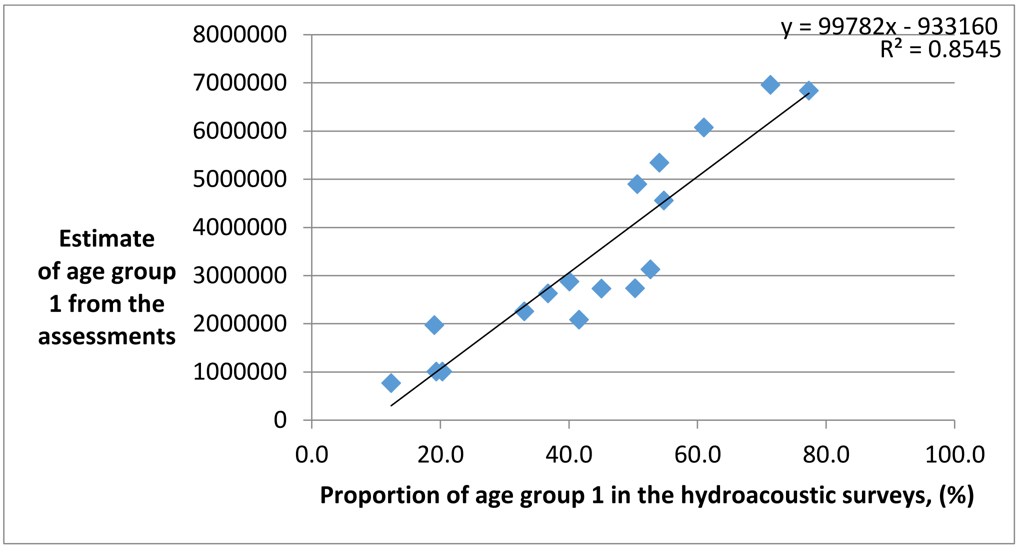


Figure 1. Relationship between proportion of age group 1 herring in the hydro-acoustic surveys and the age group 1 estimate from the assessment performed at ICES WGBFAS.

Table 2. Data used for the relationship

	Percentage of age group 1 in the surveys	Estimate of age group 1 from the assessments, thou
1999	40.1	2881773
2000	36.7	2637417
2001	61.0	6075974
2002	33.1	2262487
2003	71.3	6959875
2004	19.3	1014777
2005	52.7	3132862
2006	77.3	6839933
2007	19.0	1973385
2008	54.0	5344126
2009	45.1	2733762
2010	50.3	2738980
2011	20.3	1013508
2012	54.8	4559331
2013	50.6	4904046
2014	12.4	774679
2015	41.6	2088033

The equation from the relationship was used for the calculation of the possible number of age group 1 herring in the beginning of 2016 and the resulting value was 5752 234 thousand indicating that 2015 year class is rich. Y = 99782*67-933160 = 5752234. Although in the assessment of the Gulf of Riga herring that will be performed next spring the recruitment estimate for 2016 could differ from the value that EE and LV institutes have obtained from the observed relationship it could be declared with high confidence that the 2015 year class is rich and well above the average level. This is also confirmed by the high abundance of this year class in the commercial fishery.

The obtained value of the 2015 year class was used in the prediction for the Gulf of Riga herring stock as the number of age group 1 in 2016. The results of the prediction are presented in Table 2. Other input variables of the prediction were not changed. The results show that the SSB in 2017 will considerably increase because the 2015 year class will add to the spawning stock. Besides also the catches in 2017 are predicted to be higher at similar fishing mortality levels. Since the proportion of this age group in the catches will be higher than predicted it will decrease the fishing pressure on older age groups therefore the resulting fishing mortality could be lower than predicted previously. The fishing mortality for the Gulf of Riga herring within ICES is calculated as the average for age groups 3–7. Therefore the catch level of the Gulf of Riga herring as it proposed for fishing opportunities in 2017 by EE and LV – 26 770 t (without exchange with the Baltic Sea area), in practice corresponds to much lower fishing mortality than F = 0,38 as it was based on previous prediction data and would be below F = 0.3 while the F_{msy} = 0.32.

Table 2. Prediction of the Gulf of Riga herring with the calculated new recruitment value for age group 1 in 2016.

2016						
Biomass	SSB	FMult	FBar	Landings		
146446	78936	1.1021	0.3671	30515		
2017					2018	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
148852	109226	0	0	0	181043	140043
.	108597	0.1	0.0333	3413	177329	135818
.	107972	0.2	0.0666	6734	173715	131732
.	107351	0.3	0.0999	9967	170197	127778
.	106734	0.4	0.1333	13114	166774	123953
.	106120	0.5	0.1666	16177	163442	120253
.	105510	0.6	0.1999	19159	160198	116672
.	104903	0.7	0.2332	22062	157041	113206
.	104301	0.8	0.2665	24888	153968	109852
.	103701	0.9	0.2998	27640	150976	106606
.	103106	1	0.3331	30320	148063	103464
.	102513	1.1	0.3665	32930	145227	100423
.	101925	1.2	0.3998	35472	142466	97479
.	101340	1.3	0.4331	37947	139776	94628
.	100758	1.4	0.4664	40358	137158	91869
.	100180	1.5	0.4997	42706	134608	89196
.	99605	1.6	0.533	44994	132124	86609
.	99034	1.7	0.5663	47223	129705	84102
.	98466	1.8	0.5997	49394	127348	81675
.	97901	1.9	0.633	51510	125053	79324
.	97340	2	0.6663	53572	122817	77047

The prediction also shows that if the TAC will be set according to ICES advice (23 078 t) the SSB in 2018 will be above 110 thousand tonnes that will considerably increase the feeding competition, will cause slower growth, lower condition factor and quality of the fishes and finally lower income for the fishermen. The predicted SSB will be 37.5% higher than the long-term average value of SSB. The data analysis show that there is a negative correlation (r = 0.75) between SSB and average weight of herring in age groups 2–7 (Figure 2). The density dependent growth of Clupeids in the Baltic Sea has been described in several publications (Casini *et al* ., 2006; Casini *et al* ., 2011).

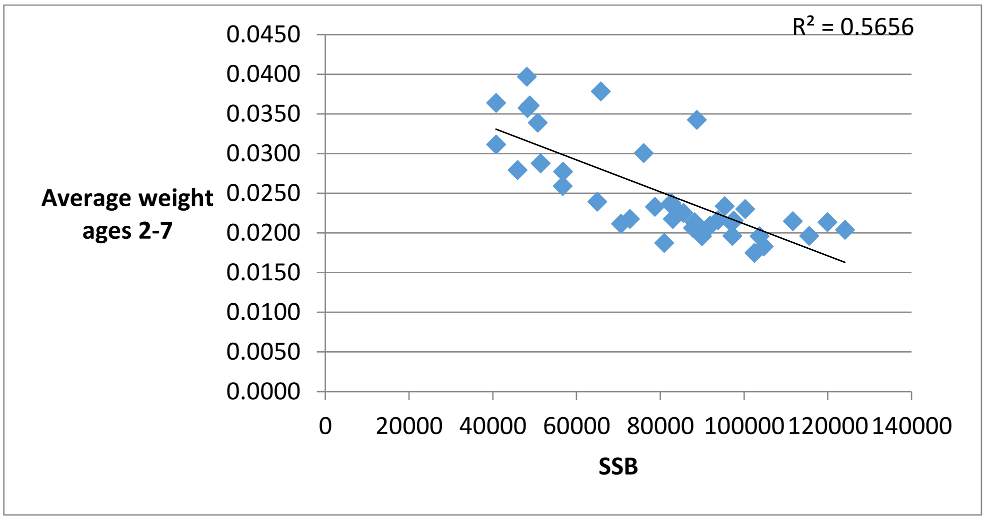


Figure 2. Relationship between average weight of 2–7 years old herring and spawning stock biomass in the Gulf of Riga

Main conclusions:

1. The results of the Gulf of Riga herring hydro-acoustic survey indicate that the 2015 year class is very strong and it will define significant increase of SSB in 2017–2018.

2. The high proportion of this year class in the catches will diminish the fishing pressure on older year classes therefore the resulting fishing mortality will be much lower than predicted and even below F_{msy} level.

3. If the TAC is adopted at the level proposed by the European Commission the SSB will increase more considerably causing high feeding competition, slower growth, lower condition factor and quality of the fishes and finally lower income for the fishermen.

4. The TAC proposed by EE and LV at a level F = 0,38 is based on the data from ICES advice released on May 2016. However, the new prediction that used the data from the latest EE and LV joint hydro-acoustic survey (August 2016) shows that the real level of F in 2017 with a high probability would not exceed F = 0,30 that is below the F_{msy} level.

The data analysis and prediction were performed by Tiit Raid from Estonian Marine Institute, Estonia and Georgs Kornilovs from Institute of Food Safety, Animal Health and Environment BIOR, Latvia. Both scientists would like to underline that the ICES advice was the best possible with the available data at the moment when advice was elaborated. The present data analysis and prediction have included the data from hydro-acoustic survey which was performed after the release of ICES advice.

References

Casini, M., Cardinale, M. and Hjelm, J. (2006). Inter-annual variation in herring (Clupea harengus) and sprat (Sprattus sprattus) condition in the central Baltic Sea: what gives the tune? Oikos, 112: 638-650.

Casini, M., Kornilovs, G., Cardinale, M., Möllmann, M., Grygiel, W., Jonsson, P., Raid, T., Flinkman, J. and Feldman, V. (2011). Spatial and temporal density-dependence regulates the condition of central Baltic Sea clupeids: compelling evidence using an extensive international acoustic survey. Population Ecology, 53: 511-523.

A1.3 Review: Justification of possibility for applying higher range fishing mortality level for the Gulf of Riga (ICES subd.28.1) herring stock in 2018.

The background for the paper explained as

Based on scientific data and conclusions from Estonian and Latvian joint stock assessement, Estonia and Latvia is arguing for application of the F range principles described in Baltic Sea multispecies multiannual plan Regulation 1139/2016 Article 4 paragraph 4. b (justified by intra- or inter-species stock dynamics) and invites the Commission to set the TAC for the Gulf of Riga herring in 2018 by using the applicable range provided in the Annex I column B, corresponding to the moderate MSY fishing mortality F = 0.347 (roll-over of the TAC for 2017- 31121 t) while not advising application of Fmsyupper=0.38.

The paragraph referred to is

4. Notwithstanding paragraphs 2 and 3, [fishing mortality range 0.24–0.32] fishing opportunities for a stock may be fixed in accordance with the fishing mortality ranges set out in Annex I, column B, provided that the stock concerned is above the minimum spawning stock biomass reference point set out in Annex II, column A [60 000 t, current estimate is ~88 000 t]:

(a) if, on the basis of scientific advice or evidence, it is necessary for the achievement of the objectives laid down in Article 3 in the case of mixed fisheries;

(b) if, on the basis of scientific advice or evidence, it is necessary to avoid serious harm to a stock caused by intra- or inter-species stock dynamics; or

(c) in order to limit variations in fishing opportunities between consecutive years to not more than 20 %.

The application of this paragraph shall be explained by a reference to one or more of the conditions set out in points (a) to (c) of the first subparagraph.

Comments

The central part of the argument presented is the strength of the 2015 year class. The annex is based on the 2017 assessment i.e. only data including 2016. The ICES stock assessment is based on data from the commercial fishery and two stock indices trapnet catch rates and an acoustic abundance survey. The commercial fishery is largely exploiting ages 2+ and therefore there is little information on the 2015 year class in these 2016 data; the trapnet catch rates are only used for ages 2 and older. The document had benefitted from an update including the 2017 data even only as preliminary data. There is a brief mention of the results of the 2017 acoustic data on the 2016 year class. The fishery in 2017 is claimed to show high catch rates for the 2015 year class but this is not documented. Also, data for the trapnet fishery (catch rates are used as tuning fleet) would be appreciated.

The strength of the 2015 year class is argued based on a projection of the acoustic data

The approach to the prediction, plotting the age 1 estimate from the assessment against the proportion of age 1 should be reflected upon as it provides significantly higher estimates than the XSA output, see Table 4.3.10 WGBFAS 2017.

The acoustic data for age 1 are used in the stock assessment where the fit with the final solution is subject to considerable error s.e. on the log(q) about 0.35. Also, the selection for age 1 in the acoustic survey is less than for the older age groups suggesting that the survey is not fully covering the age 1 herring. It is likely that any prediction based on age 1 acoustic data is subject to substantial prediction error

Table 4.3.10 WGBFAS 2017 provides an analysis between the acoustic estimate and the tuning fleet (acoustic survey) i.e. an analysis of the residuals based on an estimate of age group 1 at 1 922 198 thousand individuals rather than the ~5 700 000 thousand individuals suggested by the Fig 1 in the Annex. The value used in the prediction by ICES 2017 is in-between at 3 000 000 thousand. The 2016 yearclass is assessed to be of average strength in spring 2017.

The reviewer therefore concludes that the high estimate for year class 2015 is not satisfactory substantiated based on the data presented.

The study (presented in 2017 based on 2016 data) has as one of the main conclusions that the lower level of TAC and corresponding fishing mortality rate (F = 0.32) could create a situation that the SSB will increase more considerably causing high feeding competition, slower growth, lower condition factor and quality of the fishes and finally lower income for the fishermen. However, considering that in recent years the spawning stock has decreased due to the weak year class of 2013 the uncertainty of the strength of the 2015 year class and that the biomass seems unlikely to reach level for which there is no experience (SSB and total biomass have been above the current level) the reviewer finds that the strength of this argument appears to be weak.

The Annex argues (Conclusion 2 of the annex)

> *The high proportion of this year class in the catches will diminish the fishing pressure on older year classes therefore the resulting fishing mortality will be much lower than predicted and even below Fmsy level.*

Apparently, the assumption is that the fishing pressure will concentrate on the most abundant age groups. This implies that it is possible to fish age groups selectively. However, this is presented without evidence; that the selection pattern changes with the strength of the year class and should be judged as merely speculative at this stage.

Concerning the criteria laid down in Article 4 (4) the reviewer finds:

4. **Mixed fishery**: The Gulf of Riga fishery is rather clean with little bycatch and hence (a) does not apply
5. **Inter species interaction**: The stock has been declining in recent years and the direct and indirect effects on other stocks are therefore within what have been observed in previous years without documenting significant detrimental effects. The stock is not expected to increase to biomasses outside the range for which there is experience in recent years.
6. **Intra species interaction**: The Gulf of Riga Herring is known to be strongly dependent on environmental factor e.g. growth and the recruitment, this is documented in the Annex. The growth of Gulf herring, see annex for references dependent on the strength of the year class but also on the general environmental conditions, zooplankton abundance in the Gulf. It is likely that growth may as for other fish stocks be slower with high herring abundance than in years with less herring. This is not threatening the stock in terms of recruitment based on past experience.

Annex 2 Landings plots for roundfish and flatfish

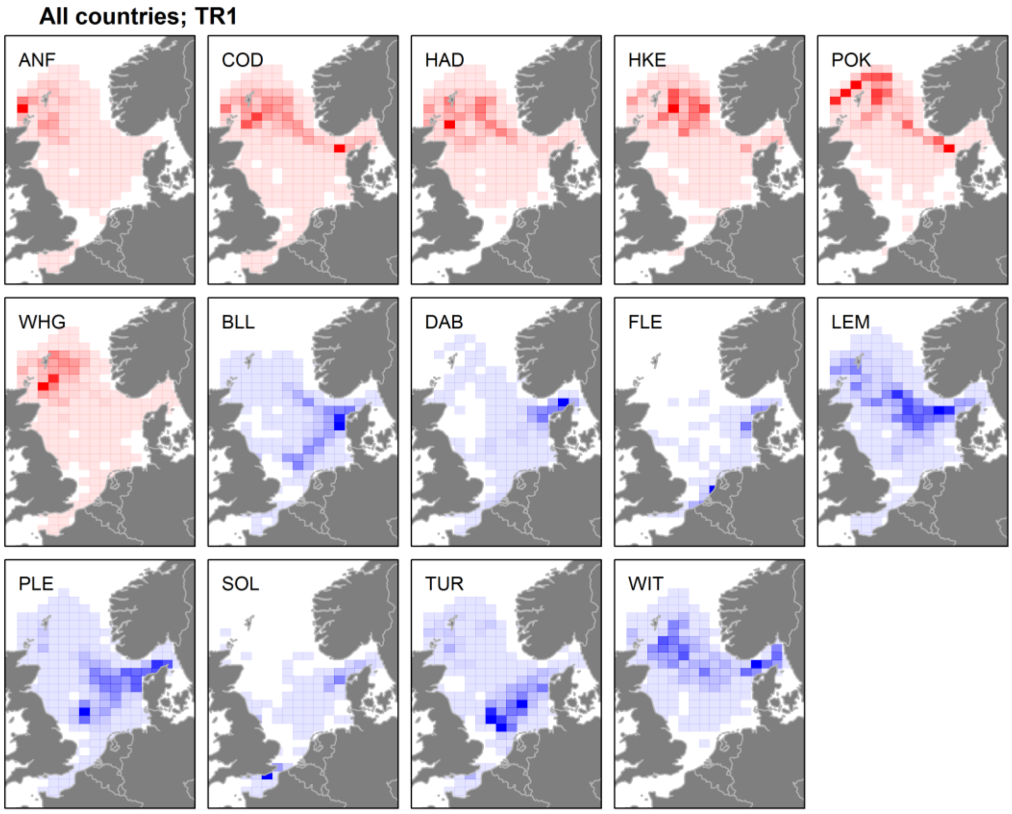


Figure A1. Total landings for TR1 gear by ICES rectangle and stock for 2016. Roundfish and flatfish stocks are coloured in red and blue, respectively. Darker colours indicate higher landings.

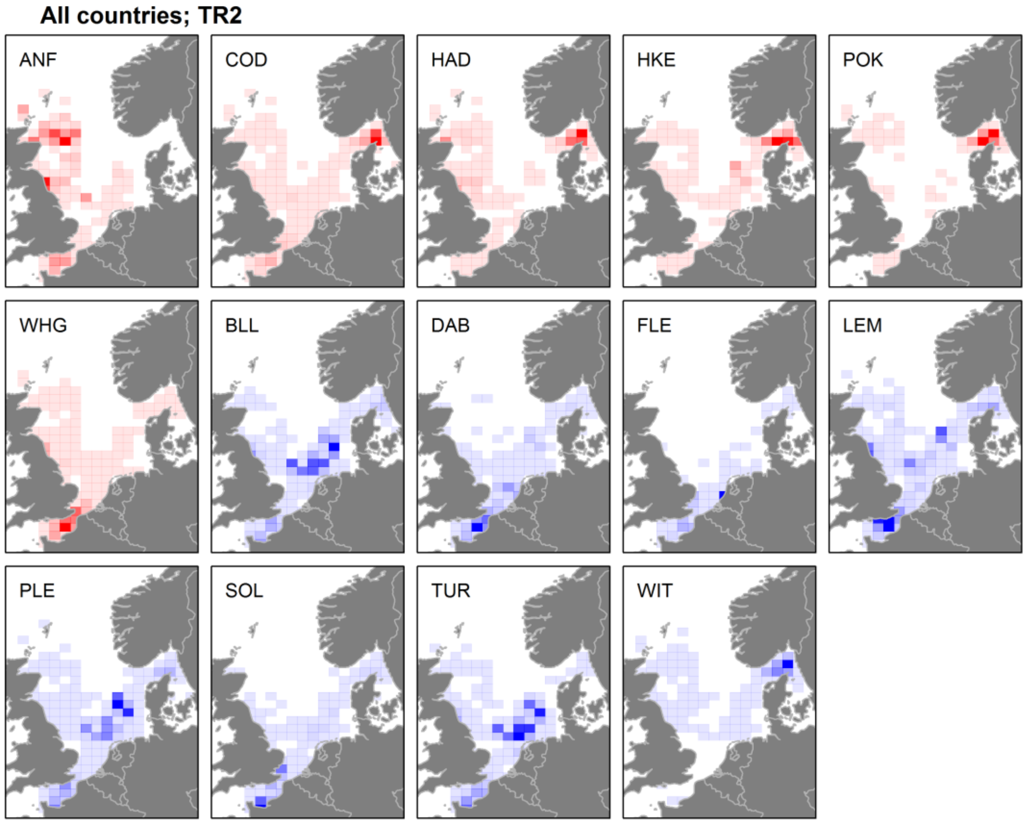


Figure A2. Total landings for TR2 gear by ICES rectangle and stock for 2016. Roundfish and flatfish stocks are coloured in red and blue, respectively. Darker colours indicate higher landings.

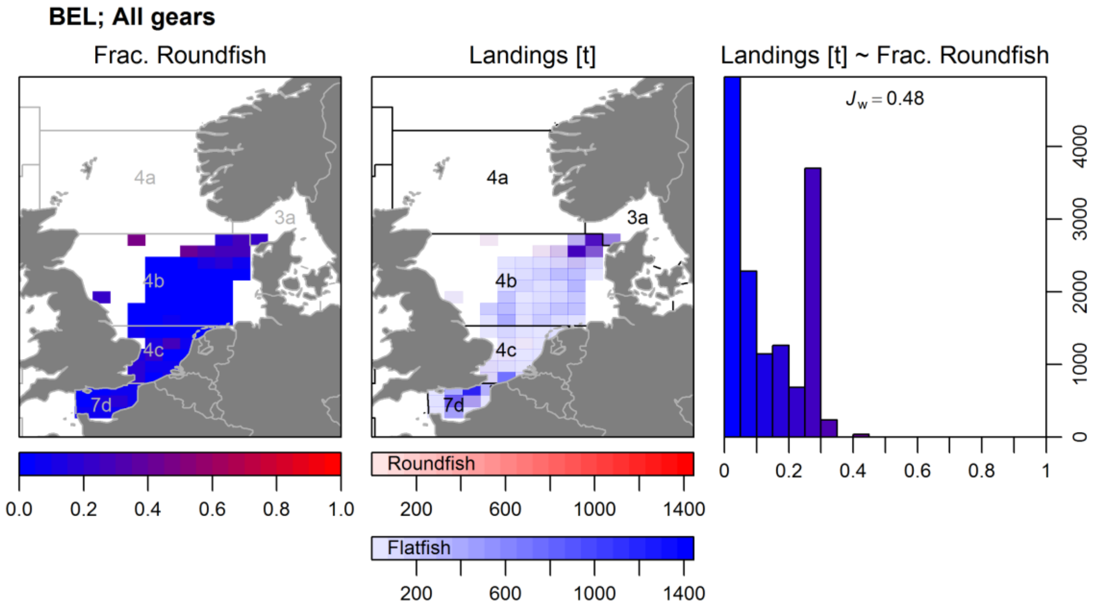


Figure A3. Landings for Belgium by ICES rectangle and stock aggregates for 2016. See Figure. A2 for details.

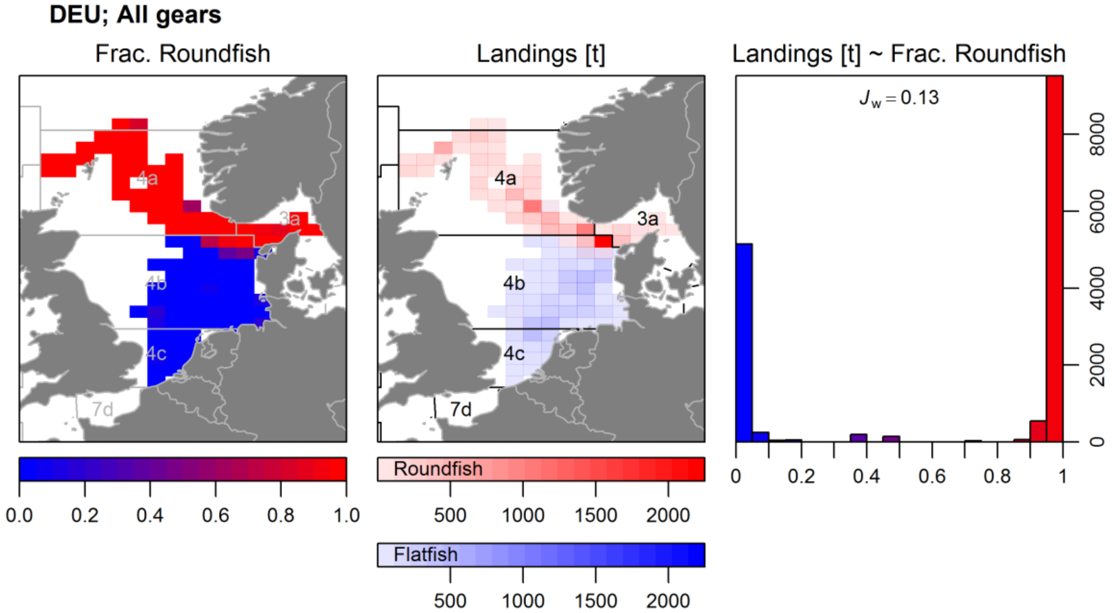


Figure A4. Landings for Germany by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

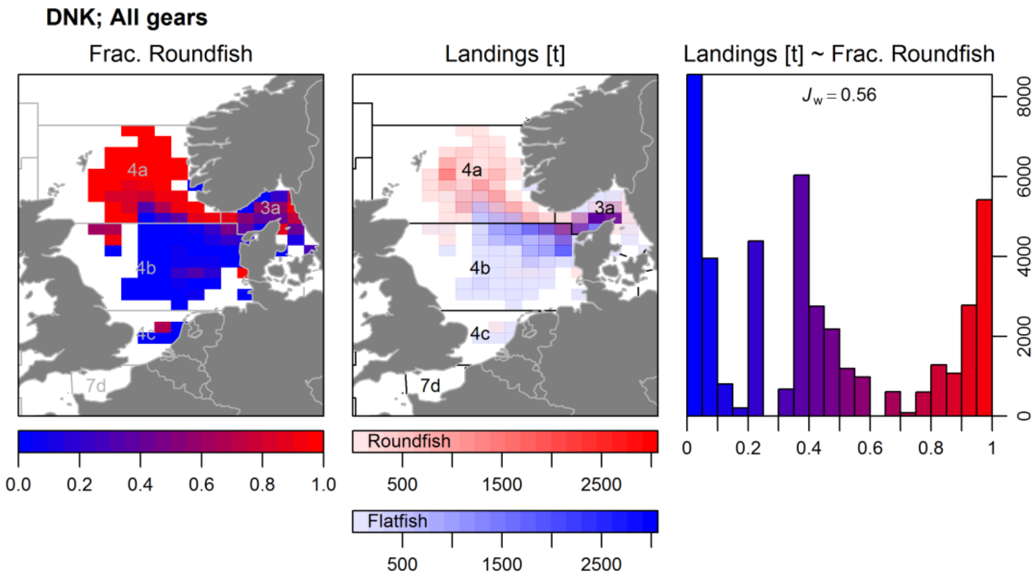


Figure A5. Landings for Denmark by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

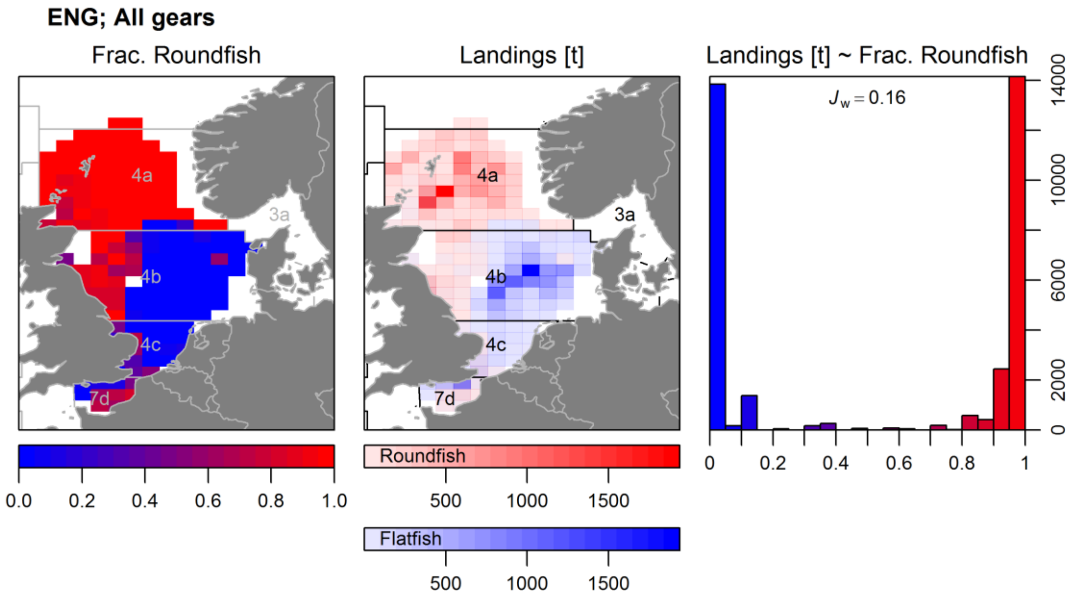


Figure A6. Landings for England by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

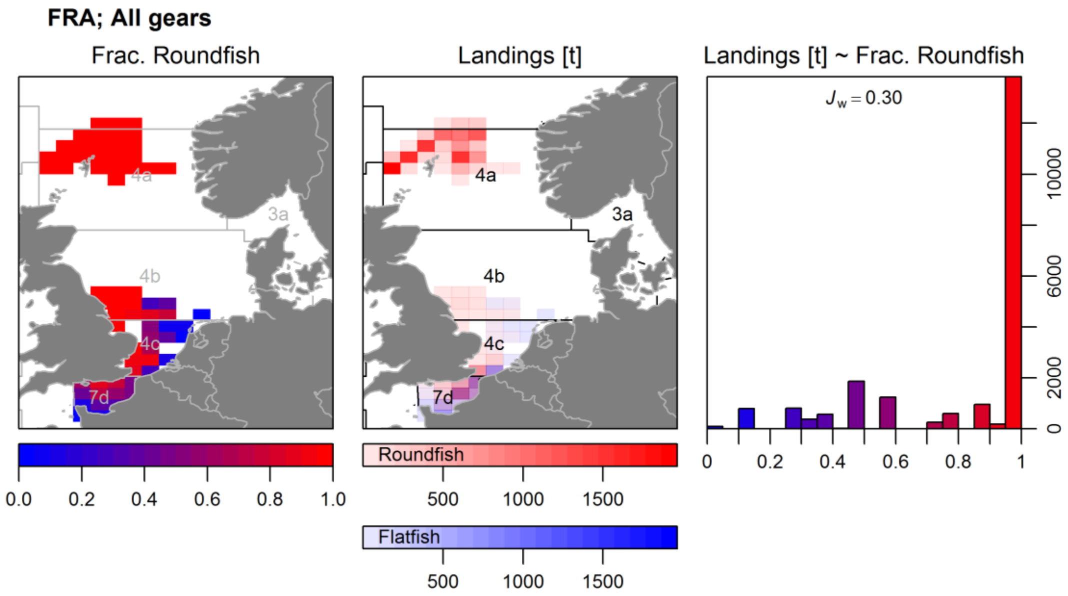


Figure A7. Landings for France by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

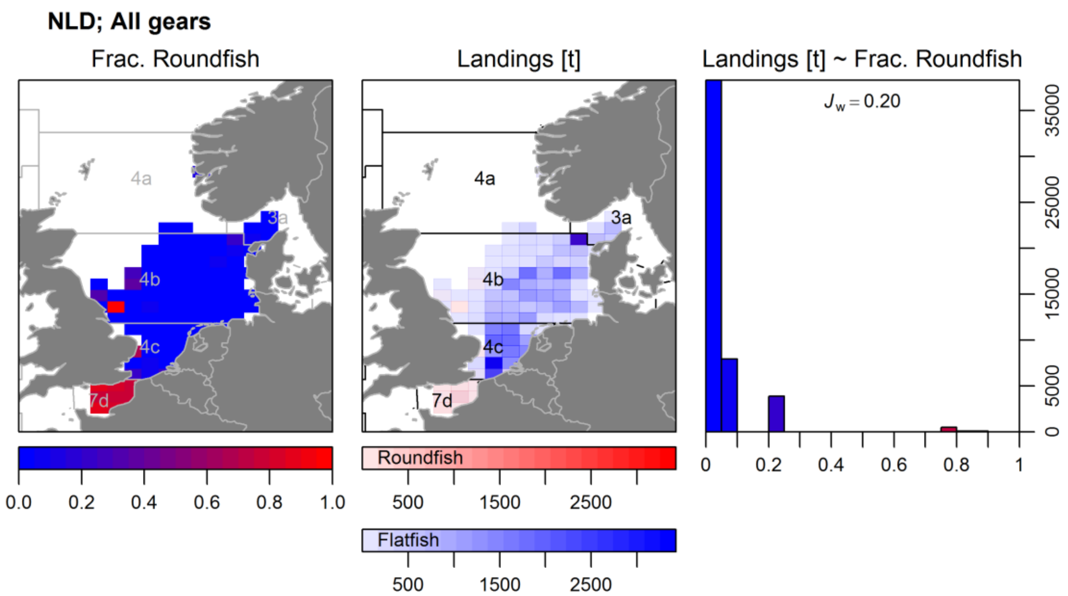


Figure A8. Landings for Netherlands by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

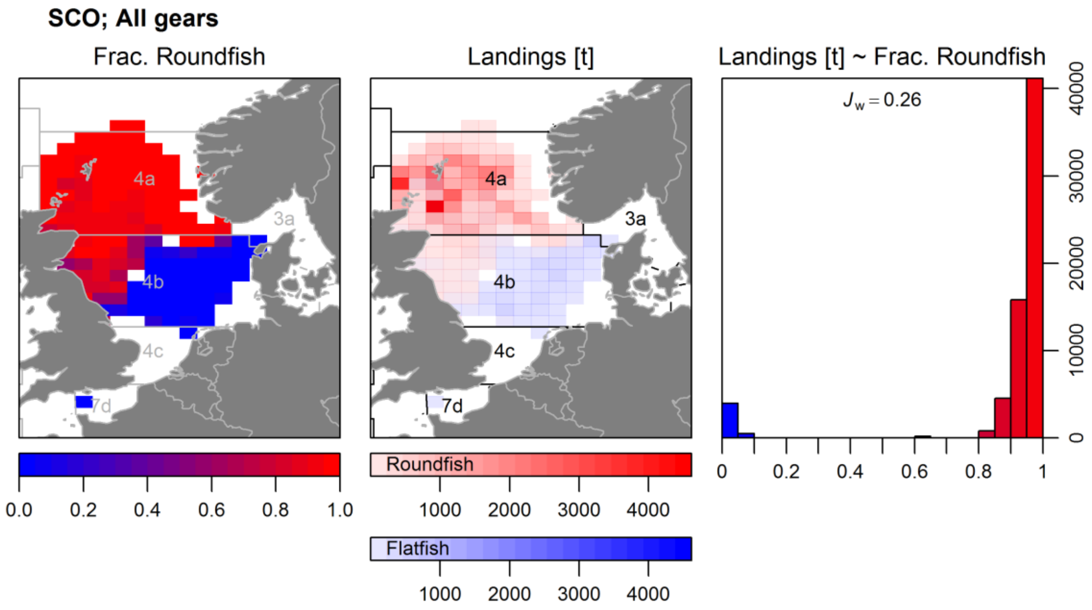


Figure A9. Landings for Scotland by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.

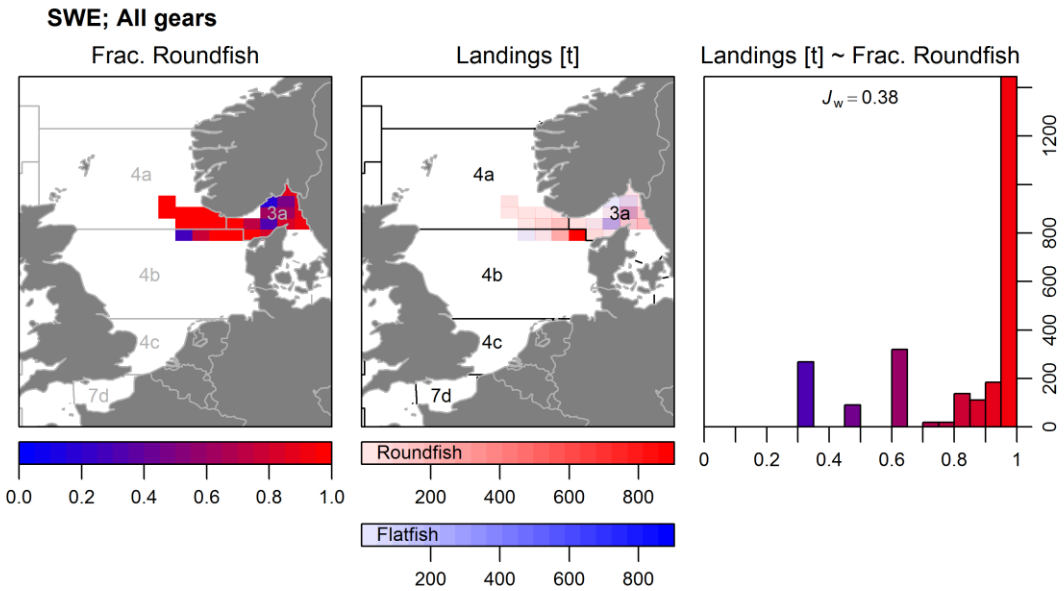


Figure A10. Landings for Sweden by ICES rectangle and stock aggregates for 2016. See Figure A2 for details.