WORKING GROUP ON MIXED FISHERIES ADVICE (WGMIXFISH-ADVICE; outputs from 2020 meeting)

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

Contents

i Executive summary

The ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) met remotely to produce mixed fisheries forecasts for the Bay of Biscay, Celtic Sea, Iberian Waters and North Sea. Mixed fisheries advice highlights the potential implications of single-stock (total allowable catch and effort) management on the catches of multiple stocks caught together in mixed fisheries. It takes into account past fishing patterns and catchability of the different fleets, and the TAC advice produced by the single-stock advice groups, to provide quantitative forecast of over- and under-exploitation of the different stocks given mixed fishery interactions. The mixed fisheries forecasts were produced using the "FCube" (Fleet and Fishery Forecasts) methodology for the Celtic Sea and North Sea, and on the "FLBEIA" (Fisheries Library Bio-Economic ImpaPrct Assessment) methodology for the Bay of Biscay and Iberian Waters.

The Bay of Biscay mixed fisheries projections consider the single-species advice of 14 demersal stocks (ank.27.78abd, bss.27.8ab, hke.27.3a46-8abd, hom.27.2a4a5b6a7a-ce-k8, mac.27.nea, meg.27.7b-k8abd, mon.27.78abd, nep.fu.2324, rjc.27.8, rjn.27.678abd, rju.27.8ab, sdv.27.nea, sol.27.8ab and whg.27.89a. Mixed-fisheries projections for 2021 indicate that there is no single stock that restricts all fleets. Smooth-hound (sdv.27.nea), Norway lobster (nep.fu.2324) and both anglerfishes (ank.27.78abd and mon.27.78abd) are the least limiting stocks, resulting in an overshoot of the advised catch for the other considered stocks.

The Celtic Sea mixed fisheries projections consider the single-species advice for 12 demersal stocks (cod.27.7e–k, had.27.7b–k, whg.27.7bce–k, nep.fu.16, 17, 19, 20–21, 22, and outside FUs, sol.27.7fg, mon.27.78abd, and meg.27.7b–k8abd). The results of the mixed fisheries projections show that cod (cod.27.7e–k) limits all fleets due to the zero catch advice for cod and that all fleets catch cod to a greater or lesser extent. Sole (sol.27.7fg) and Norway lobster (nep.fu.16, 17, 19, 20–21, 22) are the least limiting stocks corresponding to an overshoot of the advised catch for the other considered stocks.

The Iberian waters mixed fisheries projections consider the single-species advice for 5 demersal stocks (ank.27.8c9a, hke.27.8c9a, lbd.27.8c9a, meg.27.8c9a and mon.27.8c9a). The result of the mixed fisheries projections indicate that hake (hke.27.8c9a) will be the most limiting stock, corresponding to an undershoot of the advised catch for the other stocks. Anglerfish stocks (ank.27.8c9a and mon.27.8c9a) are the least limiting stocks, corresponding to an overshoot of the advised catch for the other considered stocks.

The North Sea demersal mixed fisheries projections consider the single-species advice for 15 demersal stocks (cod.27.47d20, had.27.46a20, whg.27.47d, pok.27.3a46, ple.27.420, ple.27.7d, sol.27.4, tur 27.4, wit.27.3a47d, nep.fu.5–10, 32, 33, 34, and 4 outFU). The results of the projections indicate that cod (cod.27.47d20) will be the most limiting stock for certain fleets, corresponding to an undershoot for the advised catch for the other stocks considered in the mixed-fisheries analysis. The "range" scenario suggests that the potential for mixed-fisheries mismatch would be lowered with a 2021 TAC in the lower part of the F_{MSY} range for North Sea plaice (ple.27.420), saithe (pok.27.3a46), and sole (sol.27.4), and at the highest possible value for cod (cod.27.47d20) in accordance with the MSY approach and the EU multiannual plan.

ii Expert group information

Expert group name	Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Claire Moore, Ireland
Meeting venue and dates	26-30 October 2020, by correspondence (26 participants)

1 Introduction

This report documents WGMIXFISH-ADVICE 2020 meeting outputs

This report documents WGMIXFISH-ADVICE 2020 meeting outputs. The ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) chaired by Claire Moore, Ireland, met by correspondence on 26–30 October 2020 to apply mixed fisheries forecasts to the 2020 single-species advice for the Bay of Biscay, Celtic Sea, Iberian waters, and North Sea. Progress was made on the development of mixed fisheries advice for two additional regions, Irish Sea and Kattegat. This working group also contributed to the fisheries overviews for a number of regions and a technical request.

Within Europe, most fisheries management is undertaken on a stock-by-stock basis, using tools such as total allowable catch (TAC). This form of management does not reflect the reality of most mixed fisheries where multiple species are caught together. Particularly in the case of demersal fisheries where fishers have limited flexibility to discriminate between species caught during fishing operations. This mismatch between the multispecies outcomes of fishing operations and the single-species catch advice can produce a number of challenges for management, including discarding, the emergence of choke species, and missed fishing opportunities.

Within a European context, the need for mixed fisheries advice arose in 2002, when the conflicting states of the various demersal stocks in the North Sea made the limitations of the traditional, single-species approach to advice particularly apparent. These circumstances led to the introduction of management measures, such as effort restrictions and single-species multiannual management plans. The 2014 revision of the CFP-Common Fisheries Policy (EU, 2013), further highlighted the limitation of the single-species advice structure, with the introduction of two additional management measures: the landings obligation and the regional multiannual management plans for mixed fisheries. The introduction of these management measures fundamentally changed how fisheries were managed. Therefore, since 2016 the ICES advice on fishing opportunities have been provided in the context of catch, rather than landings. As mixed fisheries objectives are still are under development, they cannot be incorporated in the mixed fisheries forecasts, which must build on the existing legal and management system.

ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) produces management advice and options that take into account the consequences of technical interactions in multi-stock, multi-gear fisheries. This advice is produced using two different models, depending on the advice region, FCube and FLBIEA. Mixed fishery advice is based on the Common Fisheries Policy (CFP) TAC regime and is consistent with relative stability.

1.1 Definitions

Two key descriptive terms form the foundation of mixed fisheries advice, the fleet (or fleet segment), and the métier. Their definition has evolved over time, but the most recent official definitions are provided by the CEC's Data Collection Framework (DCF, Reg. (EC) No 949/2008 and Commission Decision 2010/93/UE), and are adopted here:

- A fleet segment is a group of vessels with the same length class and predominant fishing gear during the year. Vessels may have different fishing activities during the reference period, but might be classified in only one fleet segment. A métier is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area, and characterised by a similar exploitation pattern.

Since 2012, WGMIXFISH has requested catch and effort data from countries data according to aggregations based on the definitions of the EU Data Collection Framework (DCF). The data call allowed merging across DCF métiers and as such national data entries were sometimes not by métier in the strict sense. Merging of métiers to reduce to a manageable number going forwards in the forecasts further leads to the formation of combined or 'supra-métiers'.

1.2 Terms of reference

The Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE), chaired by Claire Moore (Ireland) met at ICES Headquarters 26 October–30 October 2020 to:

a) Carry out mixed demersal fisheries projections for the North Sea taking into account the single species advice and the management measures in place for 2020 for cod, haddock, whiting, saithe, plaice, sole, turbot, *Nephrops norvegicus*, sole 7.d and plaice 7.d that is produced by WGNSSK in May 2020;

b) Carry out mixed demersal fisheries projections for the Celtic Sea taking into account the single species advice and the management measures in place for 2020 for cod, haddock, whiting, hake, megrim, monkfish, and *Nephrops norvegicus* that is produced by WGCSE and WGBIE in 2020.

c) Carry out mixed fisheries projections for the Bay of Biscay and for the Iberian waters taking into account the single species advice and the management measures in place for 2019 for hake, four-spot megrim, megrim and white anglerfish that is produced by WGBIE in May 2020, and further develop mixed fisheries analyses for the region;

d) Produce draft mixed-fisheries sections for the ICES advisory report 2020 that includes a dissemination of the fleet and fisheries data and forecasts for the North Sea, Celtic Sea, Bay of Biscay, and Iberian waters;

WGMIXFISH-Advice will report by 30 November 2020 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group.

Supporting Information

Priority:	The work is essential to ICES to progress in the development of its capacity to provide advice on multispecies fisheries. Such advice is necessary to fulfil the requirements stipulated in the MoUs between ICES and its client commissions.
Scientific justification and relation to action plan:	The issue of providing advice for mixed fisheries remains an important one for ICES. The Aframe project, which started on 1 April 2007 and finished on 31 march 2009 developed further methodologies for mixed fisheries forecasts. The work under this project included the development and testing of the FCube approach to modelling and forecasts. In 2008, SGMIXMAN produced an outline of a possible advisory format that included mixed fisheries forecasts. Subsequently, WKMIXFISH was tasked with investigating the application of this to North Sea advice for 2010. AGMIXNS further developed the approach when it met in November 2009 and produced a draft template for mixed fisheries advice. WGMIXFISH has continued this work since 2010.
Resource requirements:	No specific resource requirements, beyond the need for members to prepare for and participate in the meeting.

Participants:	Experts with qualifications regarding mixed fisheries aspects, fisheries management and modelling based on limited and uncertain data.
Secretariat facilities:	Meeting facilities, production of report.
Financial:	None
Linkages to advisory committee:	ACOM
Linkages to other committees or groups:	SCICOM through the WGMG. Strong link to STECF.
Linkages to other organizations:	This work serves as a mechanism in fulfilment of the MoU with EC and fisheries commissions. It is also linked with STECF work on mixed fisheries.

2 Bay of Biscay

2.1 Background

2.1.1 The fishery

The Bay of Biscay covers ICES divisions 27.8a, b and d. Fisheries executed in this area are highly mixed targeting a variety of species, using a number of different gears. The trawlers form a major component of this fishery, and use otter, beam and pelagic gears.

Otter trawls are the main gear type used in demersal fisheries, and the resulting catch composition of species caught is strong influenced by the mesh size range, location and depth fished. The main species caught in these fisheries are hake, anglerfishes, megrims, Norway lobster, sole, horse mackerel, mackerel, blue whiting, sea bass, pollack, and red mullet as well as cephalopods (cuttlefish and squid). Net fisheries target sole, hake, pollack, seabass, anglerfishes as well as some crustacean species while a longline fishery targets hake with bycatch of other deep-water species. The fisheries are mainly carried out by French and Spanish vessels with the addition of some vessels from Ireland, UK and Belgium.

For some stocks, such as hake and megrim, the stock area extends outside of the study area of the Bay of Biscay. These stocks are full accounted for in the mixed fisheries forecasts. Any fishing operations that have occur outside the study area (i.e. hake in ICES Division 3.a and Subareas 4, 6 and 7 and megrim and anglerfish in Subarea 7) but are still important for these stocks area also included in the current analysis, as "other" fleets, to ensure that all fishing mortality for these stocks is accounted for. Fishing operation in those areas are carried out mainly by vessels from Spain, France, Ireland and UK.

2.1.2 Management measures

Fisheries within the Bay of Biscay are currently managed under the new CFP, and the EU multi-annual management plan (MAP) for the management of the Western Waters demersal mixed fisheries, which has been in force since 2019[1], and replacing the former single-stock long term management plans with a unique framework defining objectives and constraints for both target and bycatch demersal species. Among the stocks with analytical assessment included in the Bay of Biscay mixed fisheries analysis, several are either shared between the EU and non EU member states (which are not involved in the EU MAP) or not included in the EU-MAP. In those cases ICES gives advice based on the ICES MSY approach.

As of 1 January 2016, a European demersal species landings obligation was introduced (Commission Delegated Regulation (EU) 2015/2438). This regulation prevents the discarding of certain species on a fishery by fishery approach. From 1 January 2019, catches of all quota species in the Bay of Biscay are subject to the EU landings obligation rule, except if an exemption is in place.

[1] EU. 2019. Regulation (EU) 2019/472 of the European Parliament and of the Council of 19 March 2019 establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008. Official Journal of the European Union, L 83. 17 pp. http://data.europa.eu/eli/reg/2019/472/oj

2.2 FLBEIA

2.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.,* 2007); www.flr-pro-ject.org; FLCore 2.6.13; FLAssess 2.6.3) running with R 3.6 (R Development Core Team, 2018). All forecasts were projected using the FLBEIA Package (v1.15.5) (García *et al.,* 2017). FLBEIA is an FLR package that facilitates the bio-economic evaluation of management strategies in a multi-stock and multi-fleet framework. It can be used to produce both short and long-term simulations. A total of 14 stocks was considered in the present analysis. 8 stocks are assessed as an ICES category 1 (with one *Nephrops* stock assessed based on UWTV survey) and the six remaining stocks are assessed as ICES category 3 and 5.

The list of species considered and the software used in the single-species assessments and forecasts was as outlined in the table below:

Stocks	Assessment	Forecast
WHITE ANGLERFISH 7, 8.a–b and 8.d	A4A	FLR-STF
HAKE 3.a, 4, 6, 7 and 8.a,b,d	SS3	SS3 (ad hoc R code)
SOLE 8ab	FLR-XSA	FLR STF
MEGRIM 7b-k8abd	Bayesian statistical catch at age model	ad hoc R code
SEA BASS 8ab	SS3	SS3 (ad hoc R code)
NEPHROPS 8ab	UWTV survey	Ad-hoc (excel sheet)
HORSE MACKEREL in the Northeast Atlantic	SS3	FLR-STF
MACKEREL in the Northeast Atlantic and adjacent waters	SAM	SAM
BLACK ANGLERFISH 78abd	Survey trend (Category 3)	No
THORNBACK RAY 8	Survey trend (Category 3)	No
CUCKOO RAY 6, 7, 8.a–b and 8.d	Survey trend (Category 3)	No
UNDULATE RAY 8a-b	None (Category 5)	No
SMOOTH-HOUND in the Northeast Atlantic and adjacent waters	Survey trend (Category 3)	No
WHITING 8 and 9a	None (Category 5)	No

2.2.2 Scenarios

The basis of the model is to estimate the potential future levels of effort by a fleet corresponding to the fishing opportunities (TACs by stock and/or effort allocations by fleet) available to that fleet, based on fleet effort distribution and catchability by métier. This level of effort was used to estimate landings and catches by fleet and stock, using standard forecasting procedures.

In 2020 and for the stocks with analytical assessments, single-stock ICES advices were given according to either the EU multiannual plan (MAP) for Western Waters when it is applicable or, alternatively, according to MSY approach (for the stocks shared with non EU members for instance). For the stocks with no analytical assessments (Category 3 and 5 stocks), the advices were given based on the precautionary approach. Alternative scenarios were conducted for a selection of stocks only, leading to the following 17 scenarios:

	Scenario
max	**"Maximum":** For each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares *. This option causes overfishing of the single-stock advice possibilities for most stocks.
min	**"Minimum":** For each fleet, fishing stops when the catch for any one of the stocks meets the fleet's stock share *. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks.
ank	**"Black anglerfish PA approach":** All fleets set their effort corresponding to their black anglerfish quota share, regardless of other catches.
bss	**"Sea bass MSY approach":** All fleets set their effort corresponding to their hake quota share, regardless of other catches.
hke	**"Hake MSY approach":** All fleets set their effort corresponding to their hake quota share, regardless of other catches.
hom	**"Horse mackerel MSY approach":** All fleets set their effort corresponding to their horse mackerel quota share, regardless of other catches.
mac	**"Mackerel MSY approach":** All fleets set their effort corresponding to their horse mackerel quota share, regardless of other catches
meg	**"Megrim MSY approach":** All fleets set their effort corresponding to their horse mackerel quota share, regardless of other catches
mon	**"White anglerfish MSY approach":** All fleets set their effort corresponding to their white anglerfish quota share, regardless of other catches.
nep	**"Norway lobster MSY approach":** All fleets set their effort corresponding to their Norway lobster quota share, regardless of other catches.
rjc	**"Thornback ray PA approach":** All fleets set their effort corresponding to their undulate ray quota share, regardless of other catches.
rjn	**"Cuckoo ray PA approach":** All fleets set their effort corresponding to their undulate ray quota share, regardless of other catches.
rju	**"Undulate ray PA approach":** All fleets set their effort corresponding to their undulate ray quota share, regardless of other catches.
sdv	**"Smooth-hound PA approach":** All fleets set their effort corresponding to their smooth-hound quota share, regardless of other catches.
sol	**"Sole MSY approach":** All fleets set their effort corresponding to their undulate ray quota share, regardless of other catches.
whg	**"Whiting PA approach":** All fleets set their effort corresponding to their undulate ray quota share, regardless of other catches.
sq_E	**"*Status quo* effort":** The effort is set equal to the average effort in the most recent three years recorded for which landings and discard data are available (2017-2019).

2.3 Stock input data and recent trends

2.3.1 Stocks

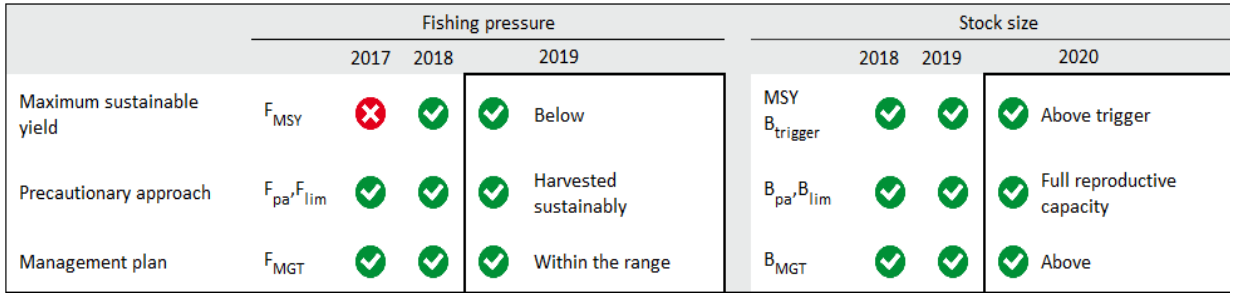
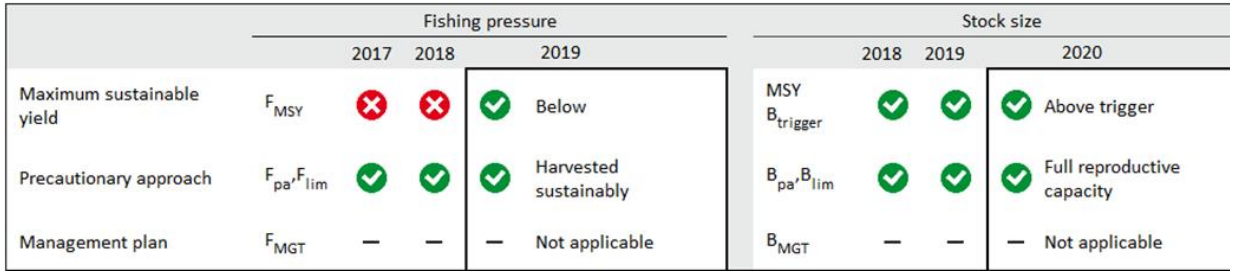
2.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGBIE (ICES 2020a), ICES WGEF (ICES 2020b) and ICES WGWIDE (ICES 2020c). Several of the stocks considered here are being assessed using statistical assessments: SS3 for the stock of sea bass in the Bay of Biscay, the northern hake stock and the stock of horse mackerel in the Northeast Atlantic, SAM for the stock of mackerel in the Northeast Atlantic and adjacent waters, a Bayesian statistical catch at age model for the stock of megrim in the west and southwest of Ireland and the Bay of Biscay and A4A for the stock of white anglerfish in the southern Celtic Seas and the Bay of Biscay. Some of those assessments are length based and/or seasonal and for some of these stocks the advice is based on stochastic projections. All this cannot currently be fully replicated in the deterministic FLBEIA software. However, the projections carried out with FLBEIA are routinely compared to those carried out in the single-species assessment working group to assess the potential impact of using different approaches and results are reasonably similar (see Section 2.4.2.1 below); as such, WGMIXFISH does not consider that the difference impacts significantly the mixed fisheries advice and the projections.

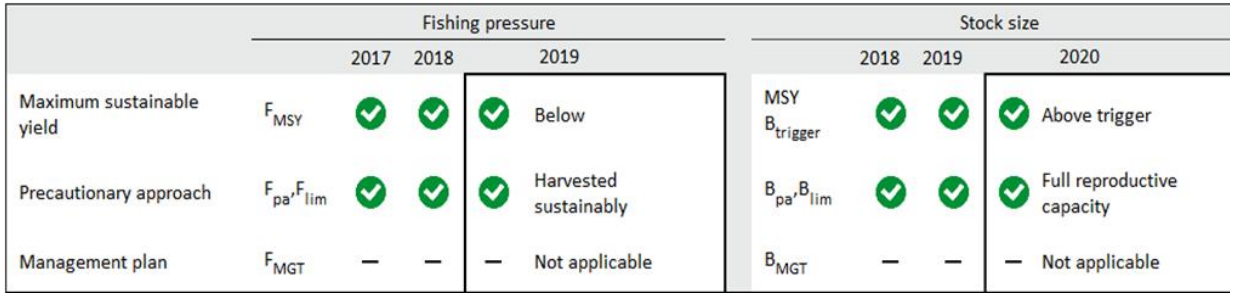
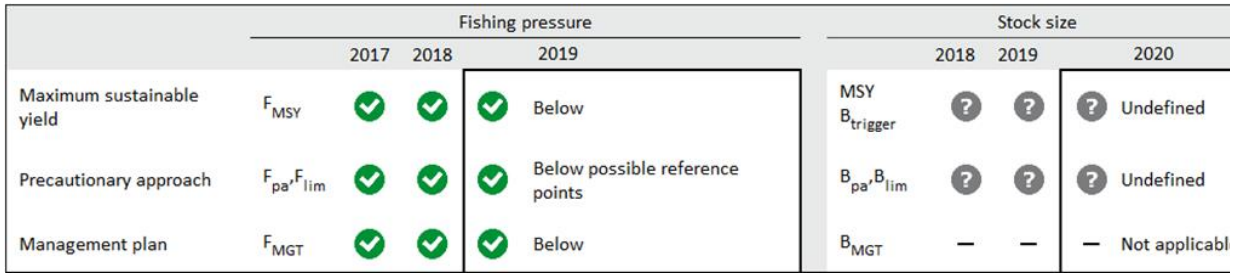
2.3.1.2 Trends and advice

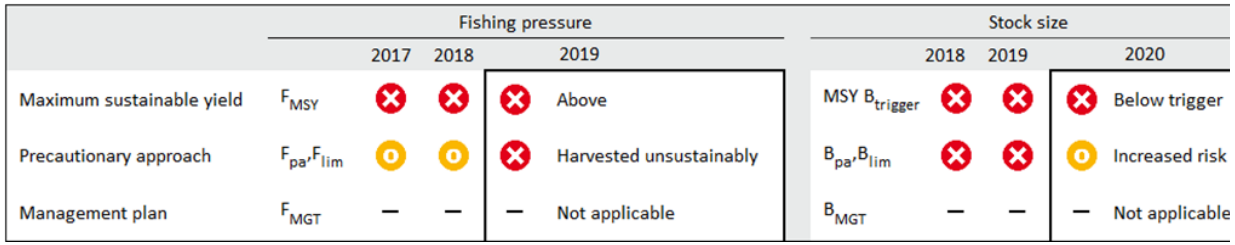
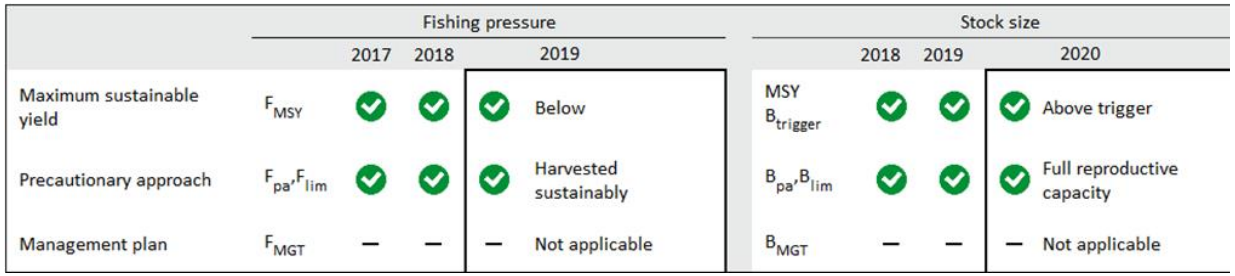
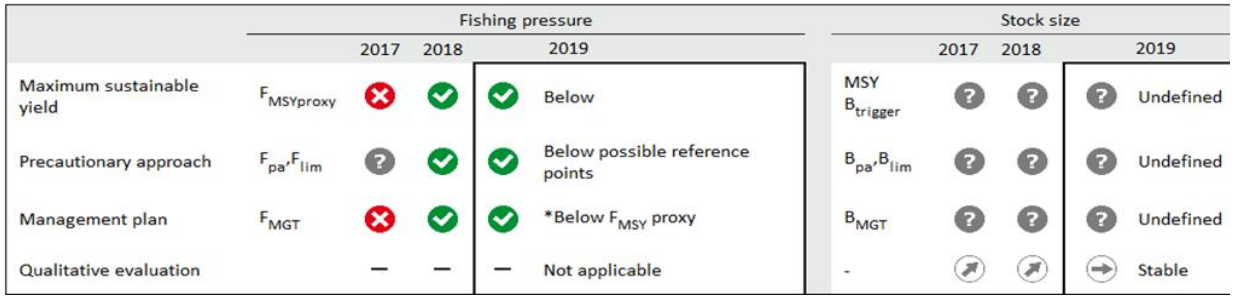
The advice for these stocks is drafted by the WGBIE 2020, WGEF 2020, and WGWIDE 2020 under considerations by ACOM. Recent trends in SSB, F and recruitment are described on a stock-by-stock basis in ICES (2020 a,b,c), and latest advice by stock is available on the ICES website. In order to give a global overview of all Bay of Biscay demersal stocks of interest to this analysis, this information is summarised in the table below. Table 2.1 lists the final advised TACs for 2021 and expected SSBs in 2022.

Stock status and ICES 2021 advice for the stocks included in the mixed fishery analysis

Species	Area	Stock status	Advice 2021
mon.27.78abd White anglerfish	Subarea 7 and divisions 8.a–b and 8.d		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 23 320 tonnes and 45 996 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (34 579 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.
hke.27.3a46-8abd (Hake)	subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d		ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 98 657 tonnes. ICES notes the existence of a precautionary management plan developed and adopted by one of the relevant management authorities for this stock.

sol.27.8ab (sole)	divisions 8.a–b (northern and central Bay of Biscay)	Fishing pressure				Stock size						ICES advises that when the EU multiannual plan (MAP) for the Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the plan are between 2036 tonnes and 4814 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (3483 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.
			2017	2018	2019		2018	2019	2020			
		Maximum sustainable yield	F_{MSY}	✓	✗	✗ Above	MSY $B_{trigger}$	✓	✓	✓ Above trigger		
		Precautionary approach	F_{pa},F_{lim}	✓	✓	✓ Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓ Full reproductive capacity		
		Management plan	F_{MGT}	✓	✓	✓ Within the range	B_{MGT}	✓	✓	✓ Above		
meg.27.7b-k8abd (megrim)	divisions 7.b–k, 8.a–b, and 8.d (west and southwest of Ireland, Bay of Biscay)	Fishing pressure				Stock size						ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 12 706 tonnes and 27 748 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (19 184 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range
			2017	2018	2019		2018	2019	2020			
		Maximum sustainable yield	F_{MSY}	✗	✗	✓ Below	MSY $B_{trigger}$	✓	✓	✓ Above trigger		
		Precautionary approach	F_{pa},F_{lim}	✓	✓	✓ Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓ Full reproductive capacity		
		Management plan	F_{MGT}	✓	✓	✓ Within the range	B_{MGT}	✓	✓	✓ Above		

			is considered precautionary when applying the ICES advice rule.
bss.27.8ab (sea bass)	divisions 8.a–b (northern and central Bay of Biscay)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 2966 tonnes and 3770 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (3108 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.
nep.fu.2324 (*Nephrops*)	divisions 8.a and 8.b, functional units 23–24 (northern and central Bay of Biscay)		ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 6105 tonnes, assuming recent discard rates.

hom.27.2a4a5b6a7a-ce-k8 (Horse mackerel)	Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic)		ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 81 376 tonnes.
mac.27.nea (Mackerel)	subareas 1–8 and 14, and in Division 9.a (the Northeast Atlantic and adjacent waters)		ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 852 284 tonnes
ank.27.78abd (Black anglerfish)	Subarea 7 and divisions 8.a–b and 8.d (Celtic Seas, Bay of Biscay)		ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 15 551 tonnes. Management of catches of the two anglerfish species, *Lophius budegassa* and *L. piscatorius*, under a combined species total allowable catch (TAC), prevents effective control of the single species exploitation rates and could lead to the overexploitation of either species.

rjc.27.8 (Thornback ray)

Subarea 8 (Bay of Biscay)

		Fishing pressure				Stock size			
		2017	2018	2019		2017	2018	2019	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable
Qualitative evaluation	-	?	?	?	Unknown	-	↗	↘	↘	Decreasing

ICES advises that when the precautionary approach is applied, landings should be no more than 389 tonnes in each of the years 2021 and 2022. ICES cannot quantify the corresponding catches.

rjn.27.678abd (Cuckoo ray)

subareas 6 and 7, and in divisions 8.a–b and 8.d (West of Scotland, southern Celtic Seas, and western English Channel, Bay of Biscay)

		Fishing pressure				Stock size			
		2017	2018	2019		2017	2018	2019	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable
Qualitative evaluation	-	?	?	?	Unknown	-	↗	→	↗	Increasing

ICES advises that when the precautionary approach is applied, landings should be no more than 3150 tonnes in each of the years 2021 and 2022. ICES cannot quantify the corresponding catches.

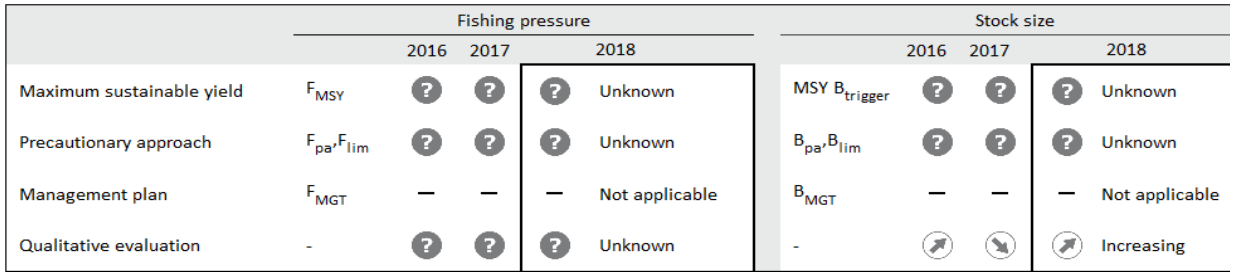
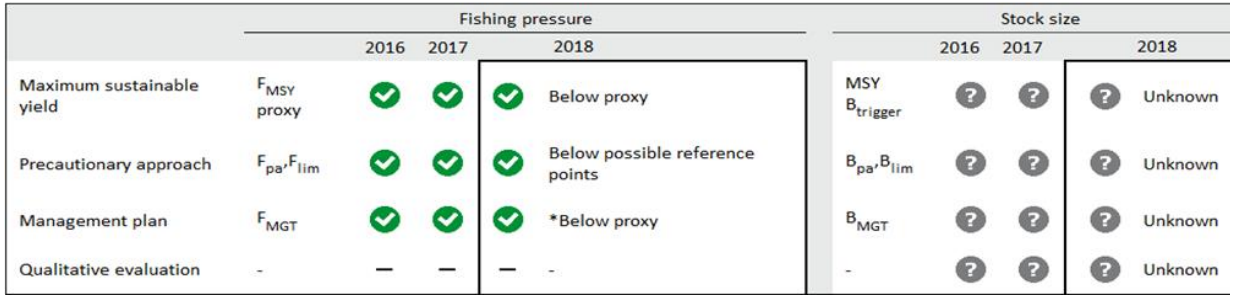
rju.27.8ab (Undulate ray)

divisions 8.a–b (northern and central Bay of Biscay)

		Fishing pressure				Stock size			
		2017	2018	2019		2017	2018	2019	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable
Qualitative evaluation	-	?	?	?	Unknown	-	?	?	?	Unknown

ICES advises that when the precautionary approach is applied, catches should be no more than 202 tonnes in each of the years 2021 and 2022. If discard rates do not change from the average of the last five years (2015–2019), this implies landings of no more than 13 tonnes.

ICES advises that the restriction in the amount of landings indicated

			above is due to the assumed high survival of discards and that landing a higher share of the catches would result in an increase in fishing mortality for the stock. ICES is not in a position to evaluate if such an increase in fishing mortality is sustainable.
sdv.27.nea (Smoothhound)	subareas 1–10, 12, and 14 (the Northeast Atlantic and adjacent waters)		ICES advises that when the precautionary approach is applied, landings should be no more than 4626 tonnes in each of the years 2020 and 2021. ICES cannot quantify the corresponding catches.
whg.27.89a (Whiting)	Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, catches in each of the years 2019, 2020, and 2021 should be no more than 2276 tonnes.

2.4 Fleets and métiers

2.4.1 Catch and effort data

Landings and effort data were requested consistent with the definition of DCF métiers and with data submitted to InterCatch (though with additional vessel length disaggregation), as specified by WGMIXFISH data call.

The WGMIXFISH information was requested with the same DCF métier-based definitions as those to InterCatch, but separated into vessel length categories.

Discard data were not requested by vessel length categories, as national observer sampling programmes do not distinguish between vessel lengths, so discard ratios for the various métiers aggregated across all vessel lengths could be extracted from InterCatch and applied to the landings of the corresponding métiers in the vessel length specific data.

Age distribution by métier and area is now available in InterCatch and was integrated in the MIXFISH data. The relative size of catches of the stocks incorporated in the mixed fisheries projections is shown in Figure 2.1.

The final dataset extracted from InterCatch includes discards estimates (either imported or raised) for all stocks and métiers. These Intercatch estimates have been used to estimate a discard ratio by métier, which allows allocating discards for all WGMIXFISH fleets and métiers with matching names, such that:

$$d* = \frac{Dl}{L}$$

Where $d*$ is the discard value for the métier used by FLBEIA, l is the weight of landings for the métier used by FLBEIA and L and D are the weight of landings and discards entered for the (vessel length aggregated) métier in InterCatch.

2.4.2 Definitions of fleets and métiers

The procedure to define the fleets and métier in the model are the following:

- Fleets were defined by aggregating landing and effort across country, gear group and vessel length (where applicable).
  - Fleet landing small amount of any of the stocks included in the analysis was binned into another ("OT") fleet together with fleets from country fishing outside the Bay of Biscay to reduce the dimensions of the model.
  - Effort and landing files were matched to ensure consistency, métiers with effort and no landing were aggregated to the "Other fleet".
- Within a fleet, métiers were defined as a combination of gear, target species (e.g. demersal fish, DEF, or crustaceans, CRU) and country.

The final data used contained 24 fleets, covering landing and effort for the years 2009 to 2019. These fleets engage in one or several different métiers, among a total of 22 métiers (Table 2.2). Several fleets still represent a small amount of catches and could be combined in order to reduce the total number of fleets. The distribution of landings by stock and métiers is presented in Figure 2.2.

2.4.3 Trends

Analyses of trends by fleet were carried out on 2015–2019 data. A number of exploratory graphs were produced to aid quality checking of the data once compiled into the final fleets object for catches, effort and catchability. Catchability plots by stock, fleet and métier are presented in figures 2.3 to 2.15.

2.5 Mixed fisheries forecasts

2.5.1 Description of scenarios

2.5.1.1 Baseline runs

The objectives of the single-species stock baseline runs were to:

- reproduce as closely as possible the single-species advice produced by ACOM, and
- act as the reference scenario for subsequent mixed fisheries analyses.

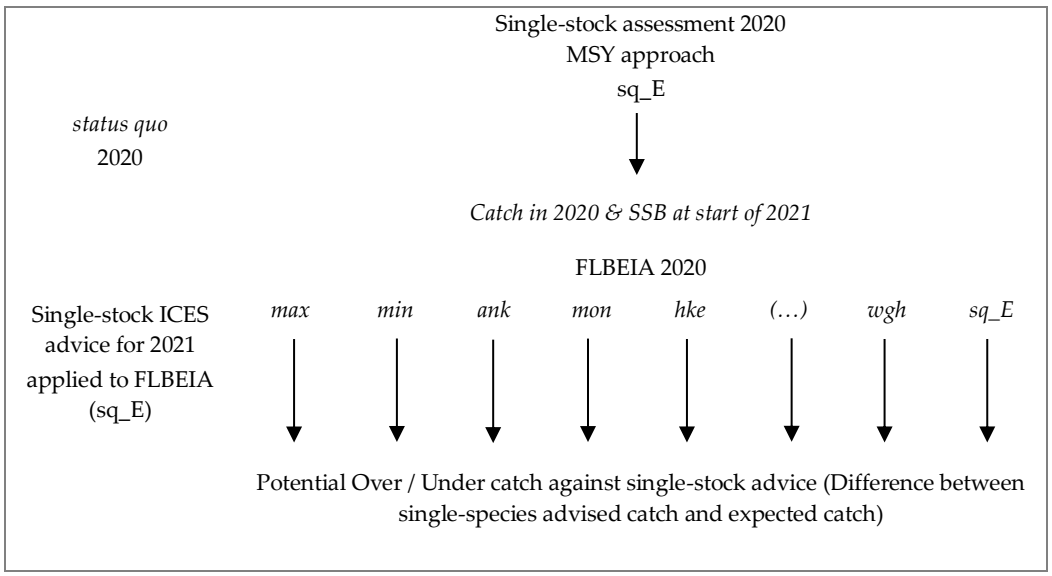
The various single-stock forecasts presented by WGBIE are performed using different software and setups (see 2.2.1 above). However, for the purposes of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the "FLBEIA" library (García *et al*., 2017). The same forecast settings as in WGBIE are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY approach).

2.5.1.2 Mixed fisheries runs

The mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2020), with the FLBEIA scenarios used for the TAC year (2021). The *status quo* effort assumption for the intermediate year is considered a plausible assumption because is in line with the standard single-stock short-term forecasting approach.

The projections were run assuming a full and perfect implementation of a discard ban (i.e. all quota species caught must be landed, with no exemptions, *de minimis* or inter-species flexibilities).

In summary, the FLBEIA runs followed the scheme below:



2.5.2 Results of FLBEIA runs

2.5.2.1 Baseline runs

As for some stocks, the population dynamics model used for the assessment differs from the one used in FLBEIA, some discrepancies were found between the FLBEIA baseline runs and the single-stock forecasts (tables 2.3, 2.4, and 2.5). Discrepancies in catches were larger for horse mackerel, mackerel and black anglerfish. The reasons of such large discrepancies are unknown and need to be investigated further.

2.5.2.2 Mixed fisheries analyses

The full overview of the FLBEIA projections to 2021 is presented in Table 2., figures 2.15 and 2.16. The results for 2021 can be compared to each other as in a single-species option table. For ease of comparison, the landings relative to the single-stock advice are also presented (Figure 4.16).

Mixed-fisheries advice considers the implications of mixed fisheries operating under single-stock catch limits, taking into account the fishing pattern and catchability of the various fleets in recent years (2017-2019). The scenarios, therefore, do not assume any amount of quota balancing through adaptation of fishing behaviour. Scenarios that result in under- or overutilization are useful in identifying the main mismatches between the fishing opportunities of the various stocks. They indicate the direction in which fleets may have to adapt to fully utilize their catch opportunities.

The "min" scenario is based on the assumption that the fishery stops for a fleet when any of the stock quotas is exhausted, representing a full implementation of the landings obligation. For 2021, the results in none of the scenarios are similar to the "min" scenario, indicating that the limiting stock varies from fleet to fleet. Horse mackerel, undulate ray and whiting are restrictive for 15 fleets out of 24, corresponding to an undershoot of the advised catch for the other stocks considered in the mixed-fisheries analysis. They lead the largest loss of fishing opportunities, indicating that they are the most limiting stocks.

The "max" scenario is included to highlight the upper bound of potential fleet effort and stock catches, because it assumes all fleets continue fishing until all their stock shares are exhausted, irrespective of any economic viability or the violation of the landings obligation. For 2021, the results in none of the scenarios are similar to the "max" scenario, indicating that the least limiting stock varies from fleet to fleet. Smooth-hound, *Nephrops* and both anglerfishes are the least limiting stocks, corresponding to an overshoot of the advised catch for the other considered stocks. Although *Nephrops* only restricts the activity of four fleets the overall impact is higher than that of smooth hound that restricts the activity of eight fleets (Figure 2.17). The reason is that the difference between recent catch of Norway lobster and catch advice for 2021 is high, comparing to the difference for smooth hound were catch advice is similar to the catch in recent years.

The *status quo* "SQ_E sets the effort of each fleet in 2020 and in 2021 equal to the average of the effort in the most recently recorded three years for which data are available (2017-2019). This scenario investigates the mixed-fisheries outcomes if the situation remains the same in terms of total effort and effort allocation among métiers. This situation presents a potential 2021 TAC overshoot for hake, horse mackerel, megrim, thornback and undulate rays and whiting.

Table 2.1. Bay of Biscay: Summary of the 2021 landings and target Fs, resulting from the Advice Approaches considered by ICES.

Stock	Total catch advice 2021	F 2021	SSB 2022	Rational
White anglerfish 7, 8.a–b and 8.d	34 579	0.22	80 416	MAP
Hake 3.a, 4, 6, 7 and 8.a,b,d	98 657	0.26	249 402	MSY
Sole 8ab	3483	0.33	12 759	MAP
Megrim 7b-k8abd	19 184	0.191	115 734	MAP
Sea Bass 8ab	3108	0.123	16 964	MAP
Horse mackerel in the Northeast Atlantic	81 376	0.061	1 037 631	MSY
Mackerel in the Northeast Atlantic and adjacent waters	852 284	0.26	3 625 357	MSY

Table 2.2. Métier categories used in the Bay of Biscay mixed fisheries analysis.

Acronym	Definition
FR_LHM	Handline
FR_PTM	Twin otter trawl directed to demersal fish
GNS_DEF	Set gillnet targeting demersal fish
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm
GNS_DEF_100-119_0_0_all	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm
GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range of 60–79 mm
GNS_DEF_all_0_0_all	Set gillnet targeting demersal fish
GTR_DEF_100-119_0_0_all	Trammelnet targeting demersal fish with mesh sizes larger than 100 mm
GTR_DEF_all_0_0_all	Trammelnet targeting demersal fish
LLS_DEF	Set longline targeting demersal fish
LLS_DEF_0_0_0	Set longline targeting demersal fish
OTB_CRU_>=70_0_0	*Nephrops* bottom otter trawl (at least 70 mm)
OTB_DEF	Bottom otter trawl directed to demersal fish
OTB_DEF_>=70_0_0	Bottom otter trawl directed to demersal fish (at least 70 mm)
OTB_MCF_>=70_0_0	Bottom otter trawl directed to mixed cephalopods and demersal fish (at least 70 mm)
OTB_MPD_>=70_0_0	Bottom otter trawl directed to mixed pelagic and demersal fish (at least 70 mm)
OTM_DEF_70-99_0_0_all	Medium water otter trawl directed to demersal fish (mesh sizes between 70 and 99 mm)
OTT_CRU	*Nephrops* twin otter trawl

Acronym	Definition
OTT_DEF	Twin otter trawl directed to demersal fish
SP_GTR	Spanish trammel net
SP_PTB	Spanish bottom pair trawl directed to demersal fish (at least 70 mm)
SSC_DEF_All_0_0_All	Fly shooting seine

Table 2.3. Bay of Biscay: Baseline run outputs from the FLBEIA package.

	ANK	BSS	HKE	HOM	MAC	MEG	MON	NEP	RJC	RJN	RJU	SDV	WHG	SOL
2020_Fbar	NA	115	263	56	0.32	0.21	0.22	NA	NA	NA	NA	NA	NA	0.36
2020_Fmult	NA	1	1	1	1	1	1	NA	NA	NA	NA	NA	NA	1
2020_Landings	10540	2785	93285	69527	834140	17176	22351	2550	417	2985	202	3456	1620	3214
2020_SSB	0	18369	237830	808971	3959736	99119	63222	0	0	0	0	0	0	11487
2021_Fbar	NA	123	0.26	61	0.26	191	0.28	NA	NA	NA	NA	NA	NA	0.33
2021_Fmult	NA	1	1	1	1	1	1	NA	NA	NA	NA	NA	NA	1
2021_Landings	13212	3108	91028	81376	852284	17646	33821	6105	389	3150	202	4626	1627	3483
2021_SSB	0	17886	269768	920574	4153788	112532	66137	0	0	0	0	0	0	12435
SSB_2022	0	17733	259519	994212	4190889	116914	69827	0	0	0	0	0	0	13001

Table 2.4. Bay of Biscay: Comparison between baseline run and ICES advice. Figures for 2020 compare results from the baseline run - that use the same assumptions for F in the intermediate year as the forecasts leading to ICES advice–to the ICES intermediate year results.

	ANK	BSS	HKE	HOM	MAC	MEG	MON	NEP	RJC	RJN	RJU	SDV	WHG	SOL
2020_Catch Baseline	11697	2961	101869	114789	834611	18795	30084	2552	471	2985	307	3456	2356	3214
2020_Catch ICES	NA	2785	103027	69527	1090879	20350	24343	NA	NA	NA	NA	NA	NA	3524
2020_% diff	NA	1.06	0.99	1.65	0.77	0.92	1.24	NA	NA	NA	NA	NA	NA	0.91
2021_Catch Baseline	14662	3108	98657	81376	852284	19184	35977	6105	389	3150	202	4626	2276	3483
2021_Catch ICES	14662	3108	98657	81376	852284	19184	35977	6105	389	3150	202	4626	2276	3483
2021_% diff	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 2.5. Bay of Biscay: FLBEIA baseline run outputs for SSB and F relative to ICES advice.

Stocks	SSB_2020	SSB_2021	SSB_2022	F_2019	F_2020	F_2021
BSS	1	1.05	1.05	1	1	1.04
HKE	1.01	1.05	1.04	1.03	0.99	0.95
HOM	1	1	1	1	1	1
MAC	1.08	1.09	1.1	1.03	1.01	1
MEG	0.99	1	1	0.99	1	0.97
MON	1.01	1.03	1.03	1	0.93	0.98
SOL	1	1.01	1	1.01	0.98	1.02

Table 2.6. Results of running FLBEIA scenarios on the TAC year (2021). Comparison of the single-stock ICES advice and potential landings in the various FLBEIA scenarios.

Stock	Single-stock catch advice 2021	max	min	ANK	BSS	HKE	HOM	MAC	MEG	MON	NEP	RJC	RJN	RJU	SDV	SOL	WHG	sq_E
ANK	14662	1.2	0.82	1	0.94	0.93	0.86	0.9	0.93	0.97	1.17	0.93	0.94	0.86	1.03	0.94	0.93	0.8
BSS	3108	1.31	0.76	1.07	1	0.97	0.86	0.97	0.97	1.02	1.16	0.97	0.97	0.77	1.16	0.97	0.95	0.95
HKE	98657	1.24	0.87	1.08	1.01	1	0.95	0.99	1	1.05	1.15	1.01	1.01	0.91	1.07	1.01	0.98	1.03
HOM	81376	1.01	1	1	1	1	1	1	1	1	1.01	1	1	1	1	1	1	1.47
MAC	852284	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.98
MEG	19184	1.2	0.92	1.05	1.01	1	0.95	0.97	1	1.03	1.18	1	1.01	0.96	1.07	1.01	1	1.05
MON	35977	1.08	0.95	1.01	0.99	0.99	0.97	0.98	0.98	1	1.07	0.99	0.99	0.95	1.02	0.99	0.98	0.87
NEP	6105	1	0.25	0.52	0.42	0.42	0.28	0.42	0.41	0.48	1	0.42	0.42	0.25	0.56	0.42	0.39	0.42
RJC	389	1.05	0.96	1.03	1.01	1.01	0.99	0.97	1.01	1.02	1.01	1	1.02	1.01	1.04	1.01	1.01	1.21
RJN	3150	1.01	0.98	1.01	1	1	0.99	0.98	1	1	1	0.99	1	1	1.01	1	1	0.95
RJU	202	1.09	1	1.05	1.04	1.03	1.02	1.03	1.03	1.04	1.07	1.03	1.03	1	1.06	1.03	1.03	1.52
SDV	4626	1.1	0.91	0.99	0.96	0.96	0.93	0.96	0.96	0.98	1.09	0.96	0.96	0.91	1	0.96	0.95	0.75
WHG	2276	1.68	0.72	1.18	1.08	1.04	0.82	1.04	1.04	1.11	1.49	1.04	1.04	0.75	1.34	1.04	1	1.03
SOL	3483	1.57	0.67	1.23	0.99	0.98	0.92	0.99	0.99	1.08	1.31	0.99	0.99	0.68	1.34	1	0.98	0.99

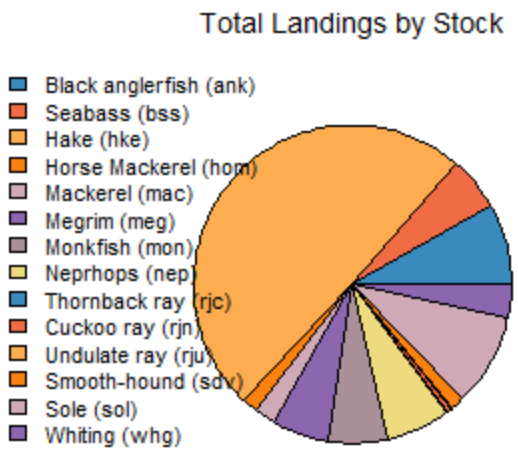


Figure 2.1. Bay of Biscay: Distribution of landings of the stocks included in the mixed fisheries projections.

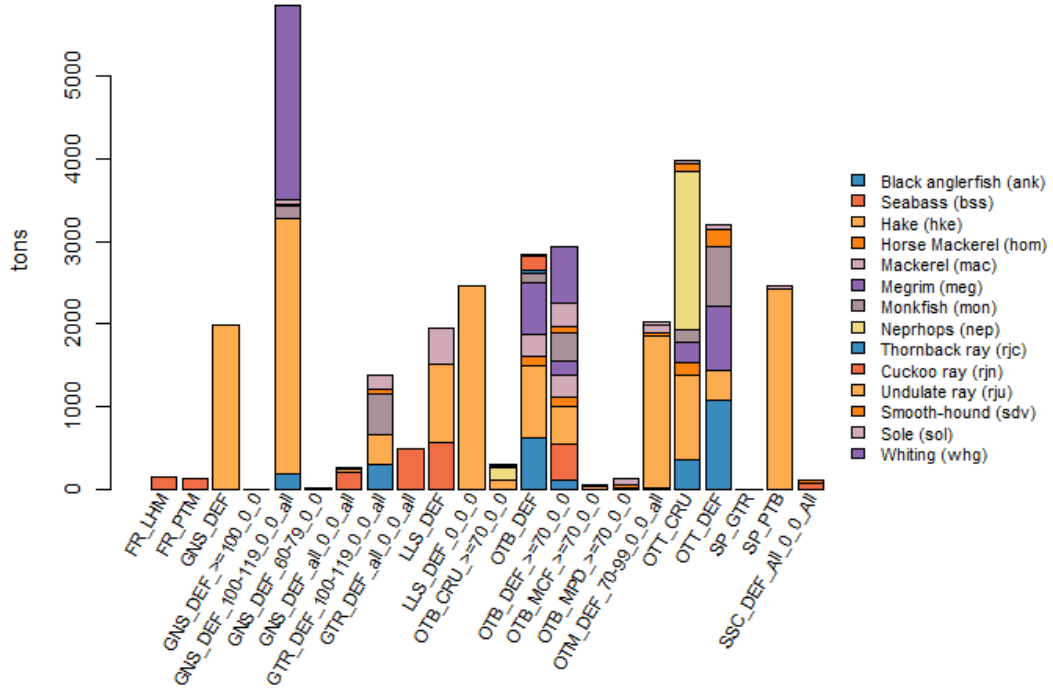


Figure 2.2. Bay of Biscay: Landings distribution of species by metier

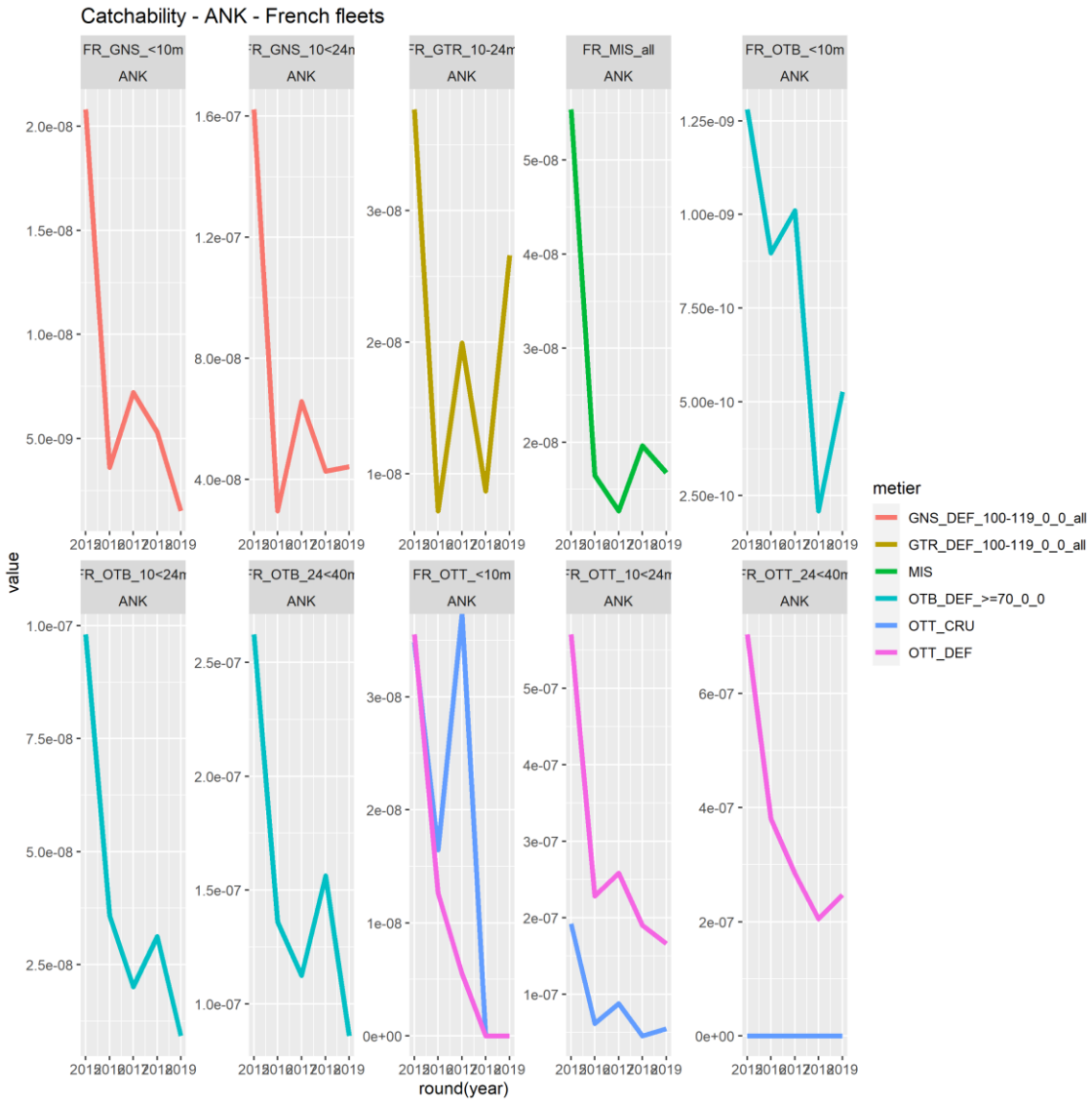


Figure 2.3. Bay of Biscay: trends of French catchability for black anglerfish (ank) by fleet and métier.

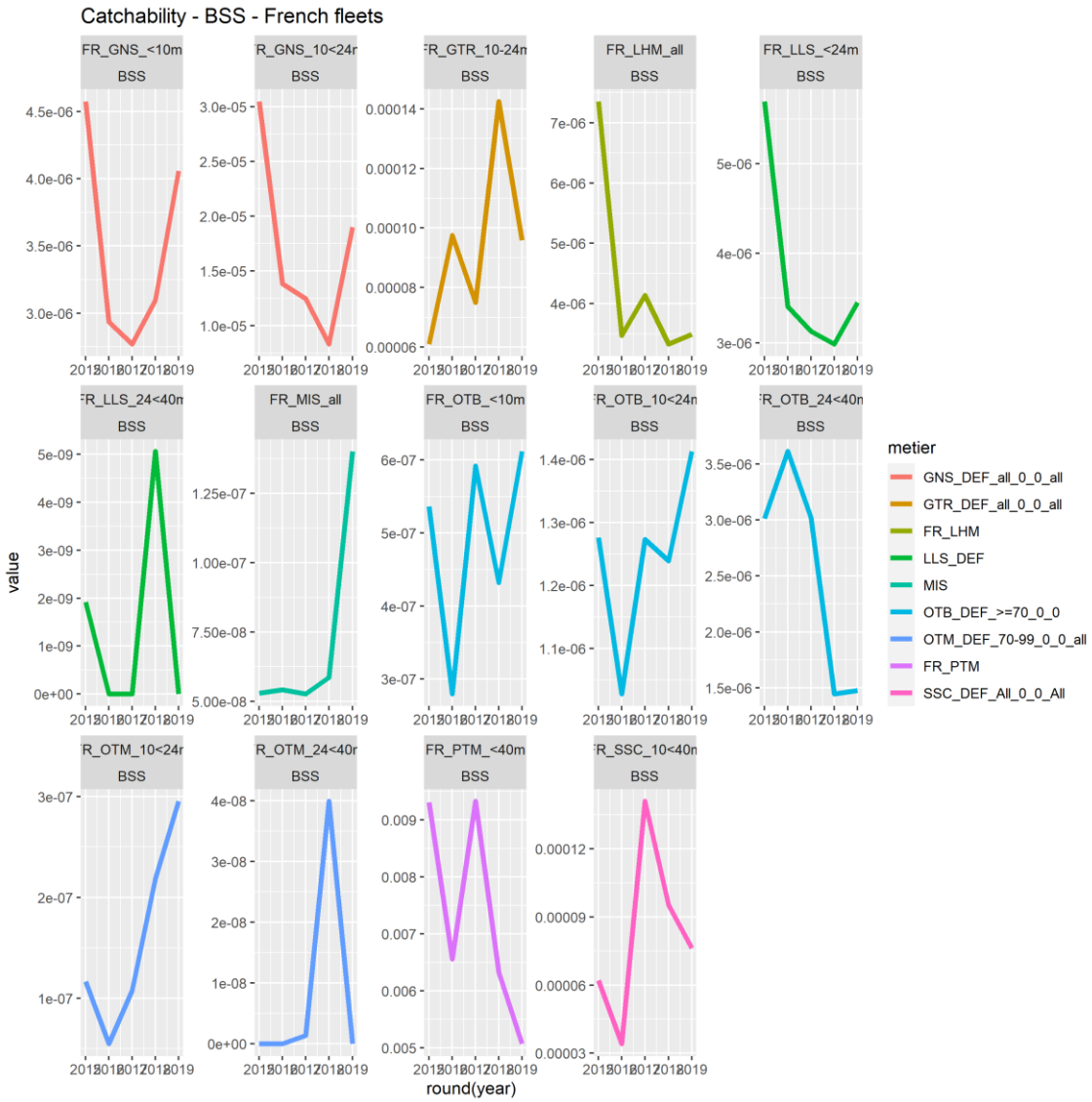


Figure 2.4. Bay of Biscay: trends of French catchability for seabass (bss) by fleet and métier.

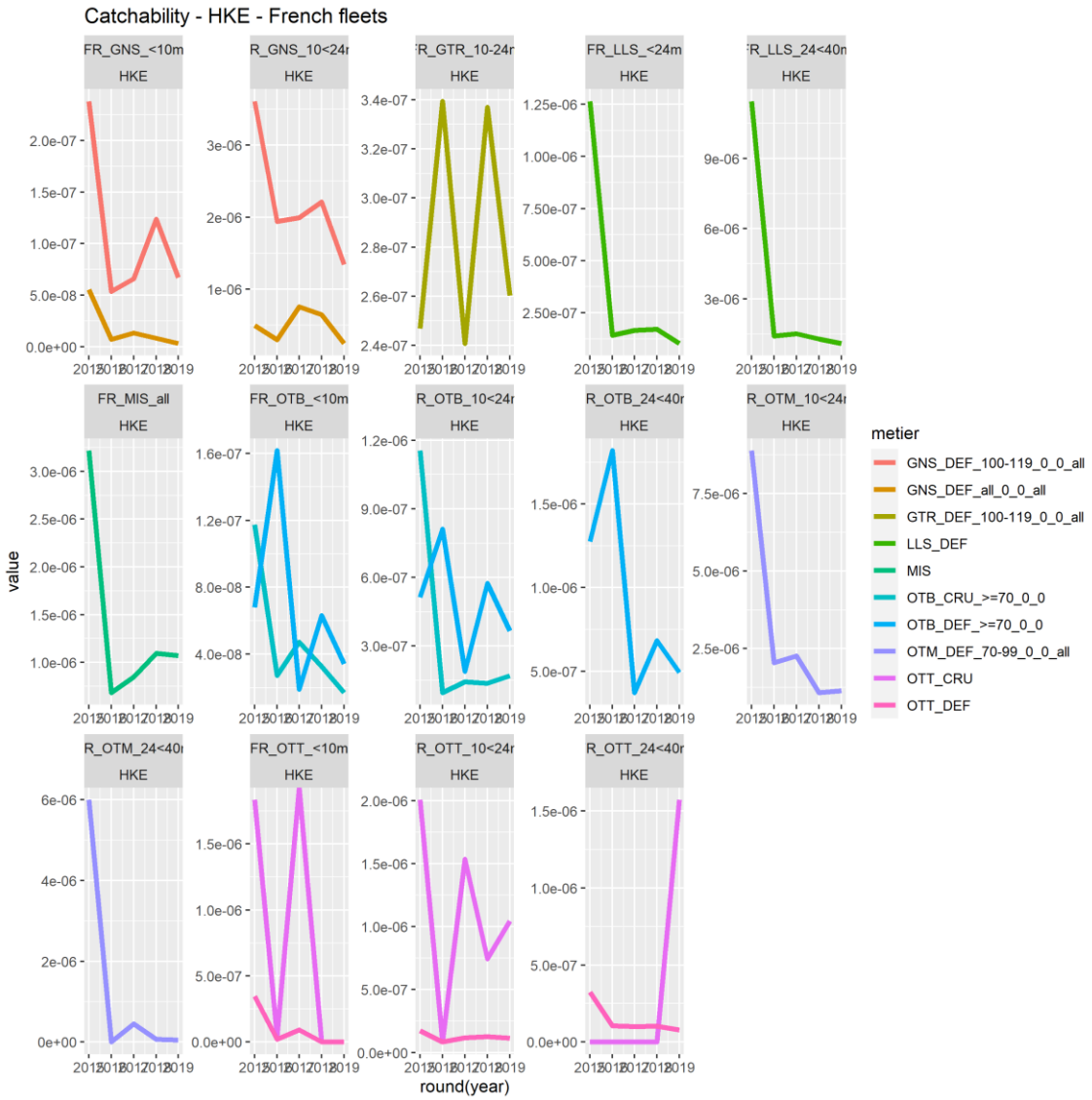


Figure 2.5. Bay of Biscay: trends of French catchability for hake (hke) by fleet and métier.

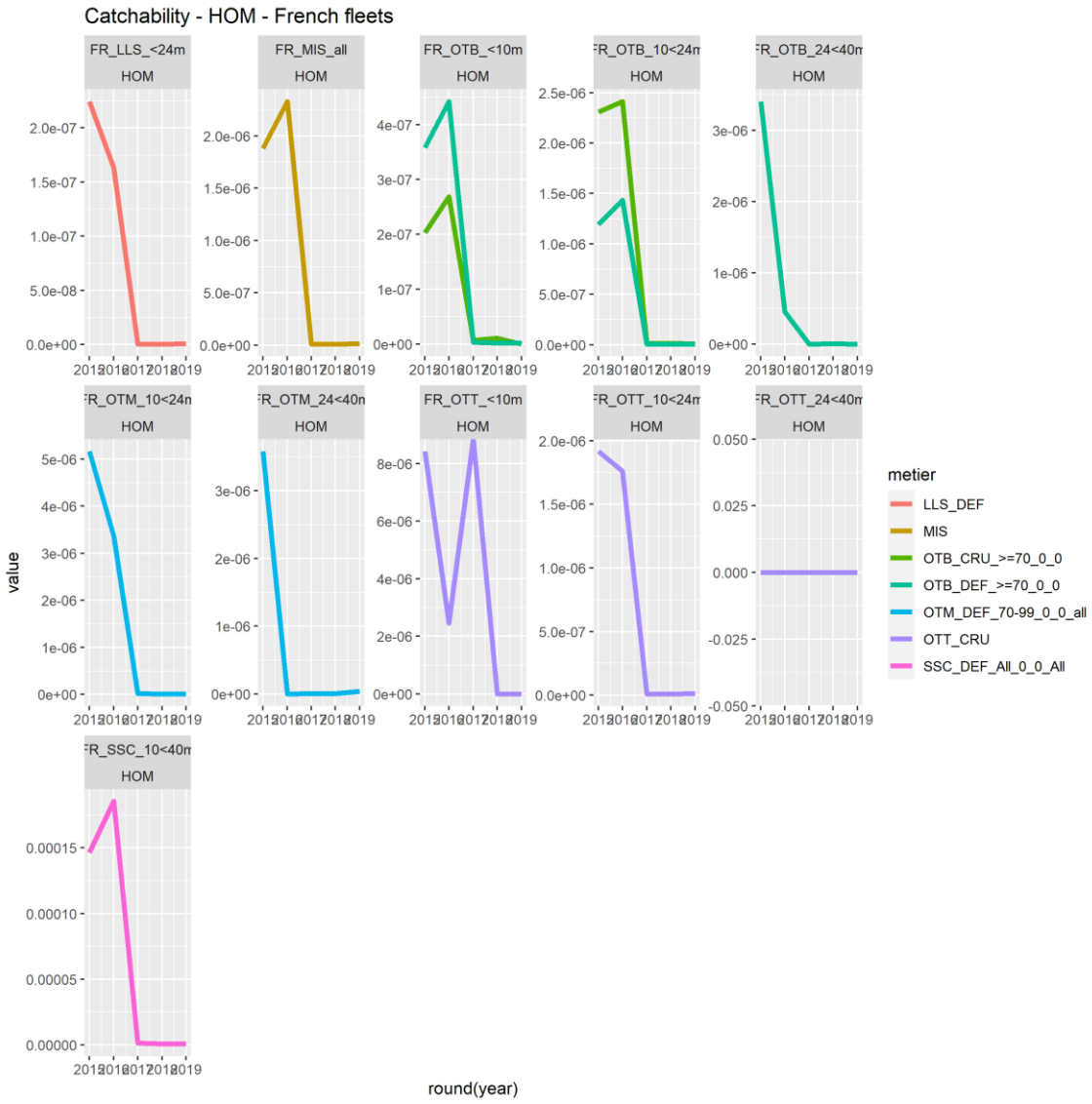


Figure 2.6. Bay of Biscay: trends of French catchability for horse mackerel (hom) by fleet and métier.

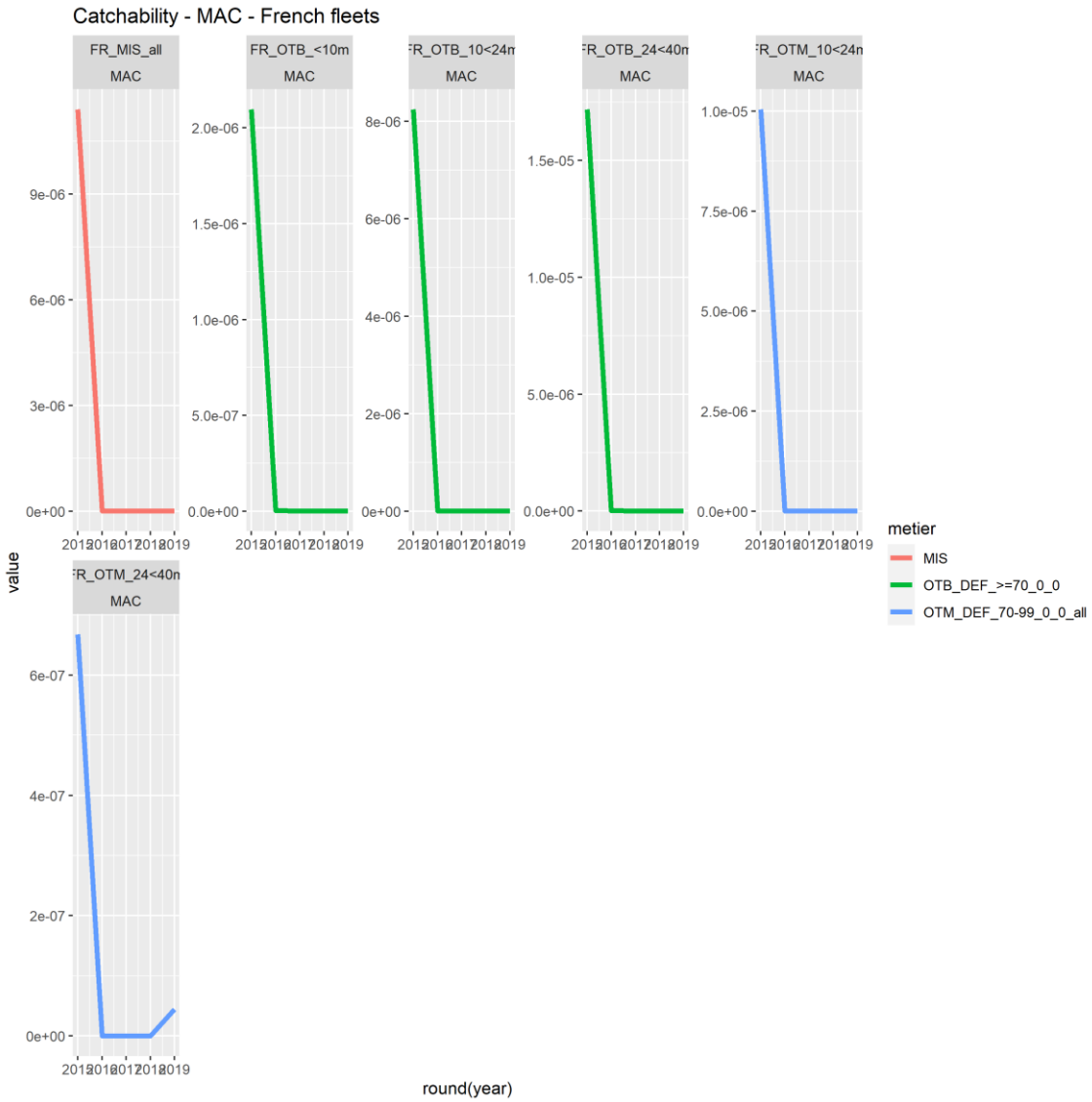


Figure 2.7. Bay of Biscay: trends of French catchability for mackerel (mac) by fleet and métier.

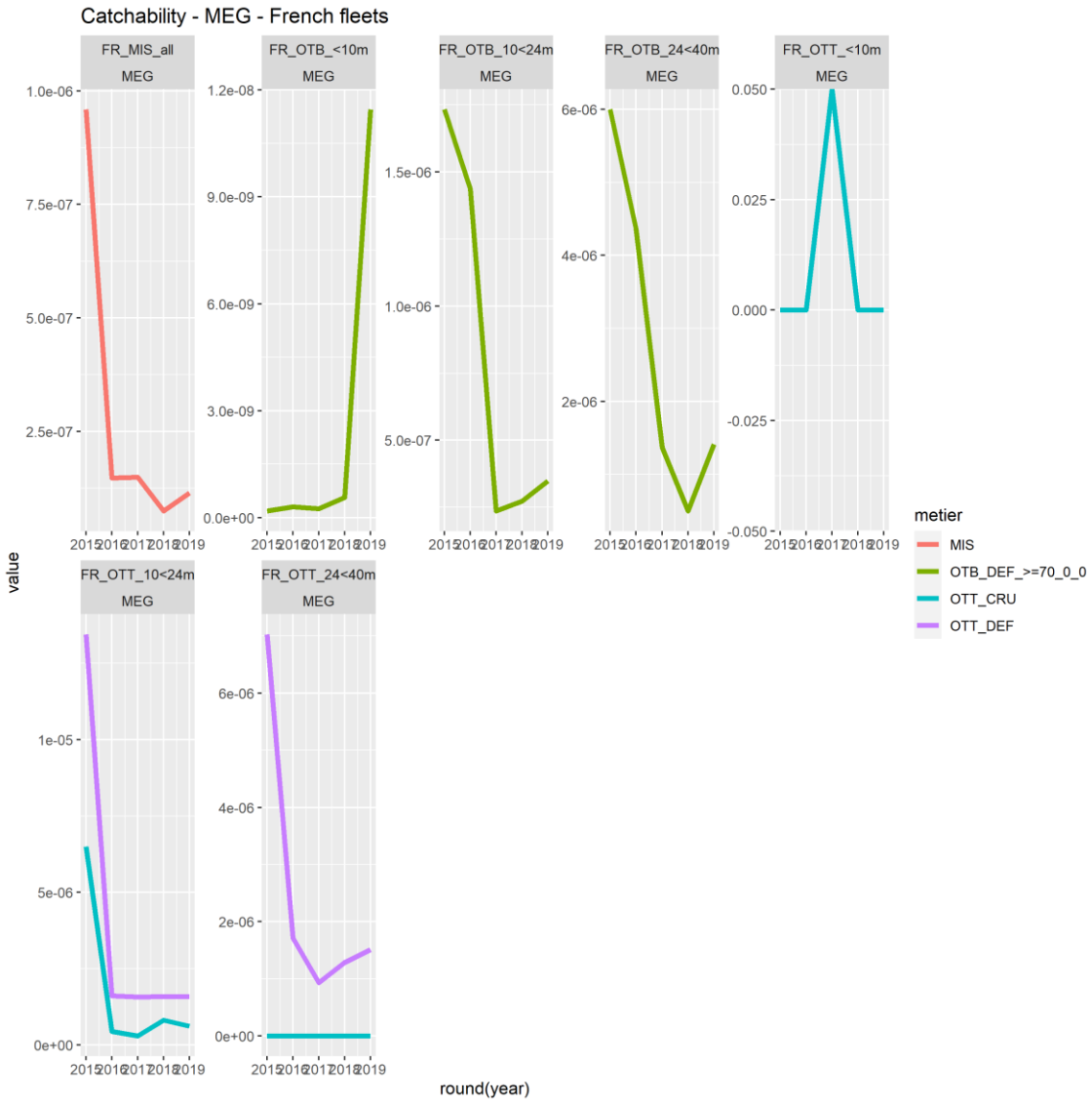


Figure 2.8. Bay of Biscay: trends of French catchability for megrim (meg) by fleet and métier.

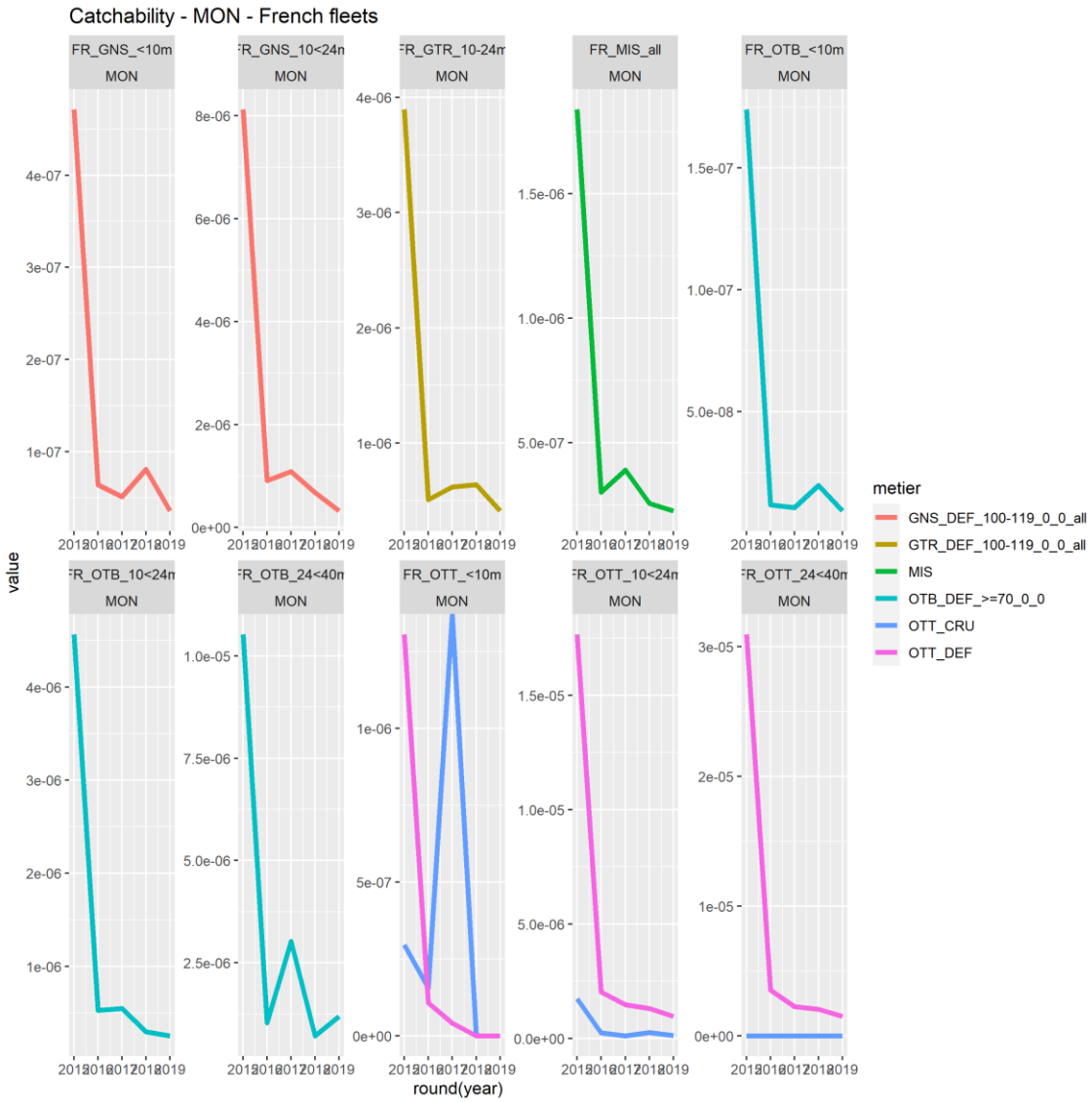


Figure 2.9. Bay of Biscay: trends of French catchability for monkfish (mon) by fleet and métier.

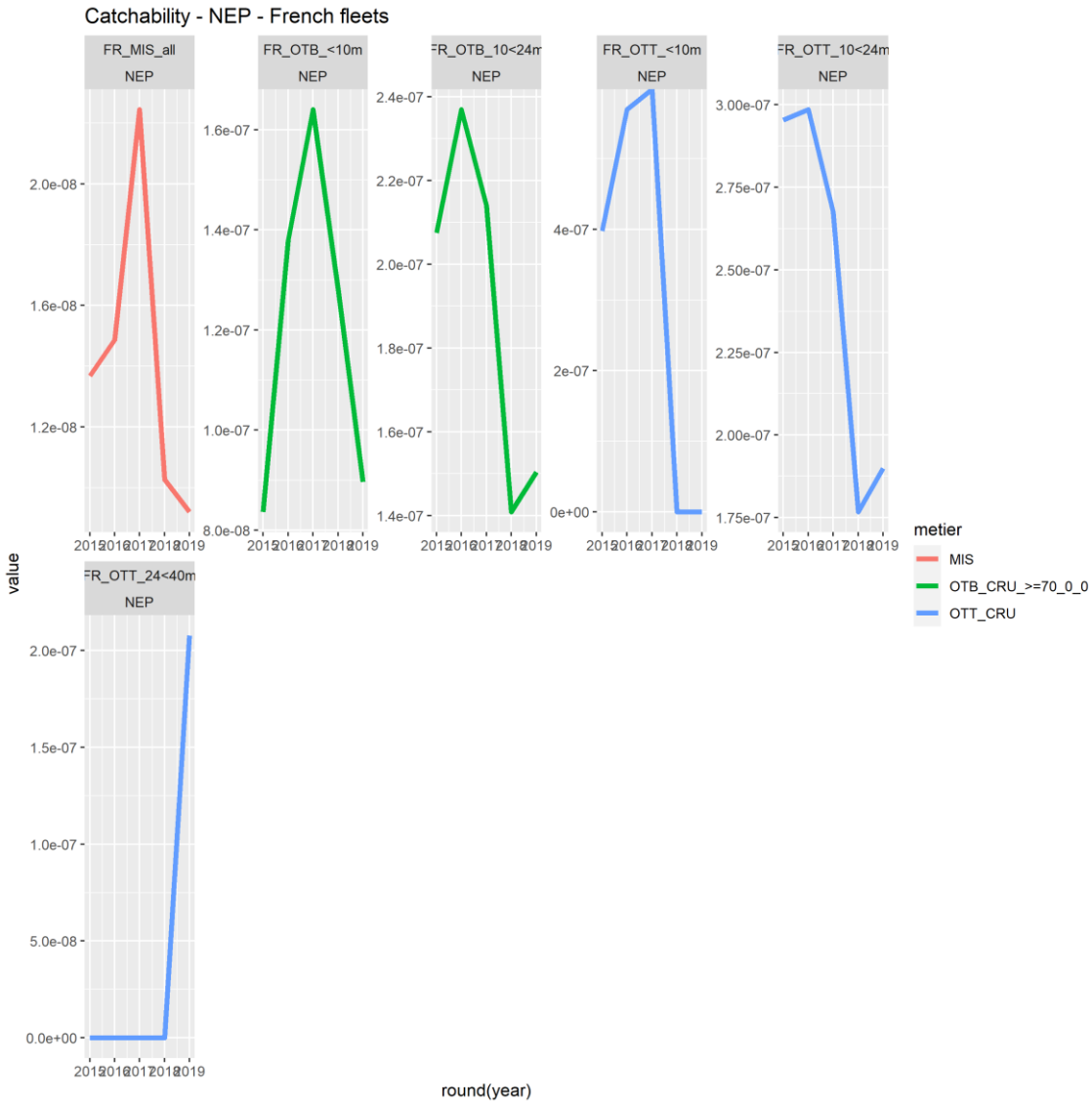


Figure 2.10. Bay of Biscay: trends of French catchability for *Nephrops* (nep) by fleet and métier.

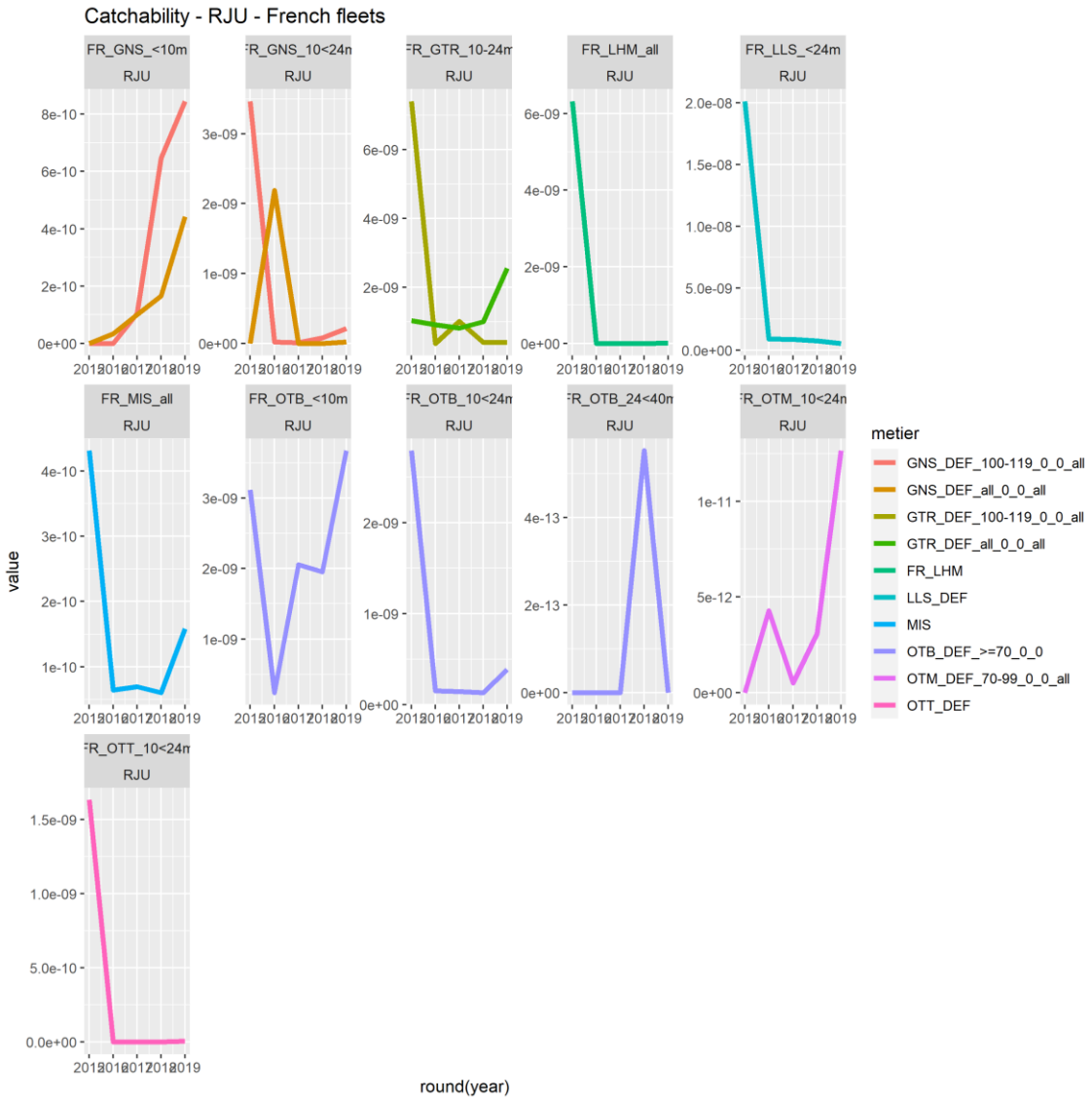


Figure 2.11. Bay of Biscay: trends of French catchability for undulate ray (rju) by fleet and métier.

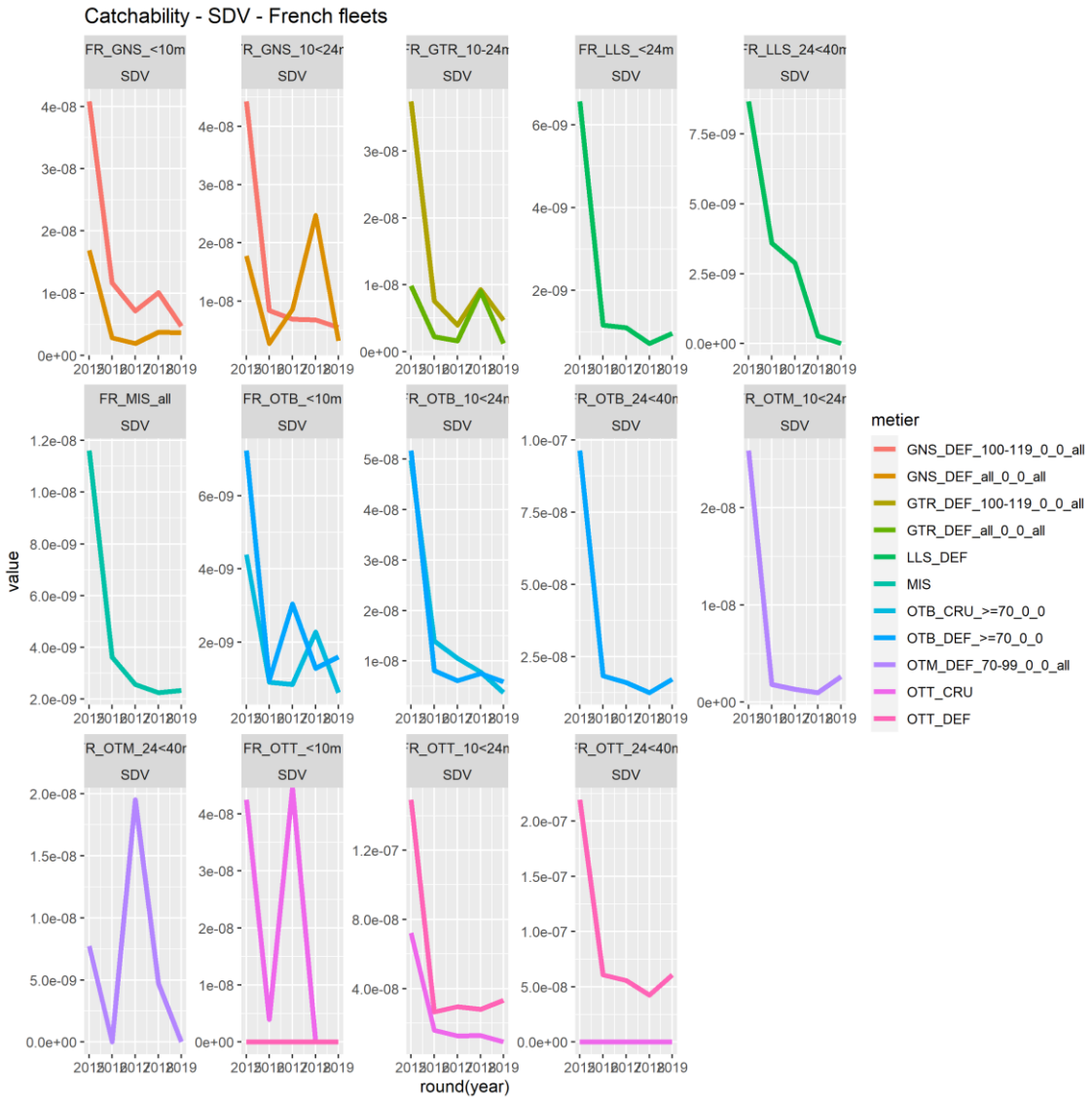


Figure 2.12. Bay of Biscay: trends of French catchability for smooth-hound (sdv) by fleet and métier.

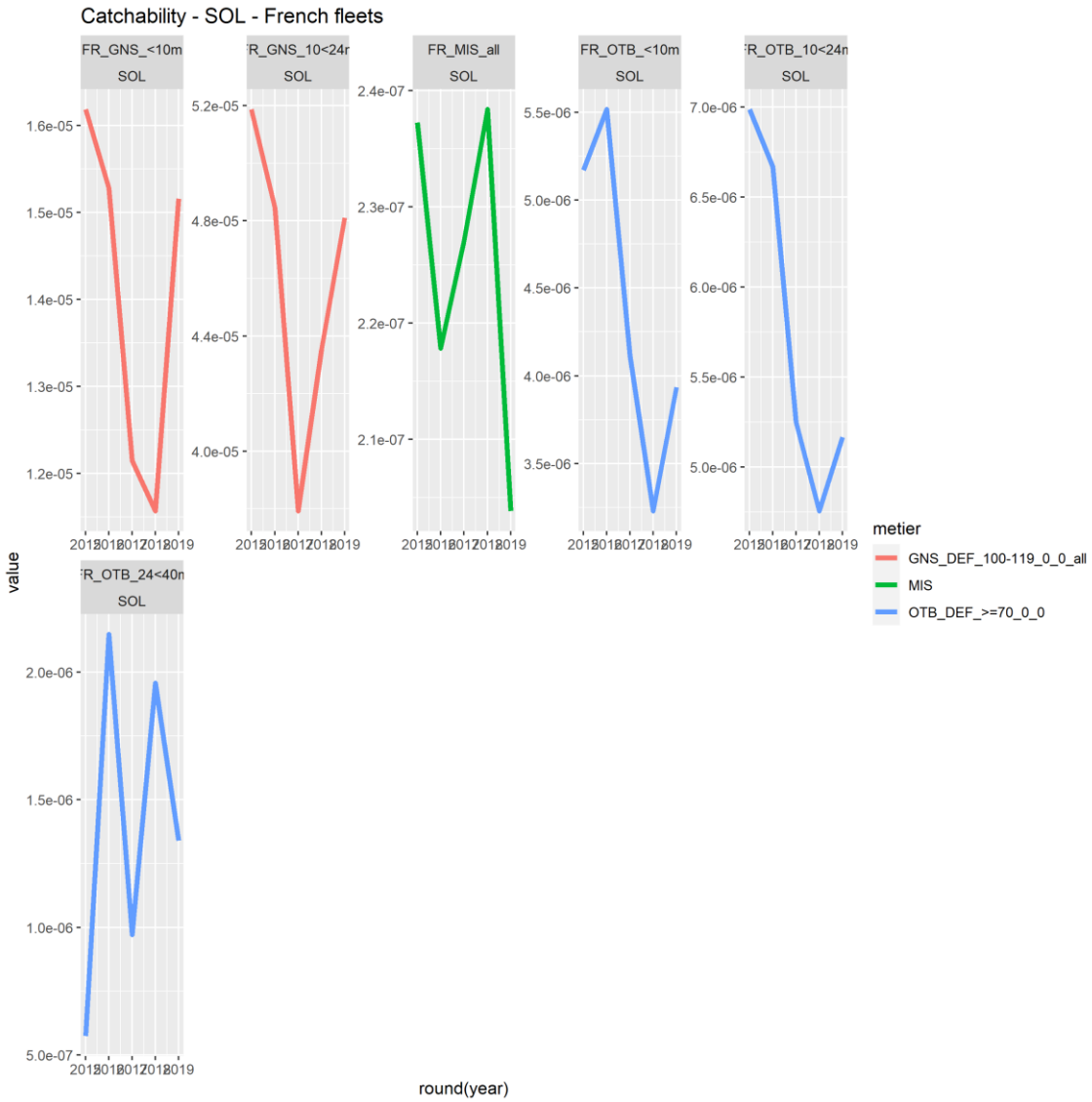


Figure 2.13. Bay of Biscay: trends of French catchability for sole (sol) by fleet and métier.

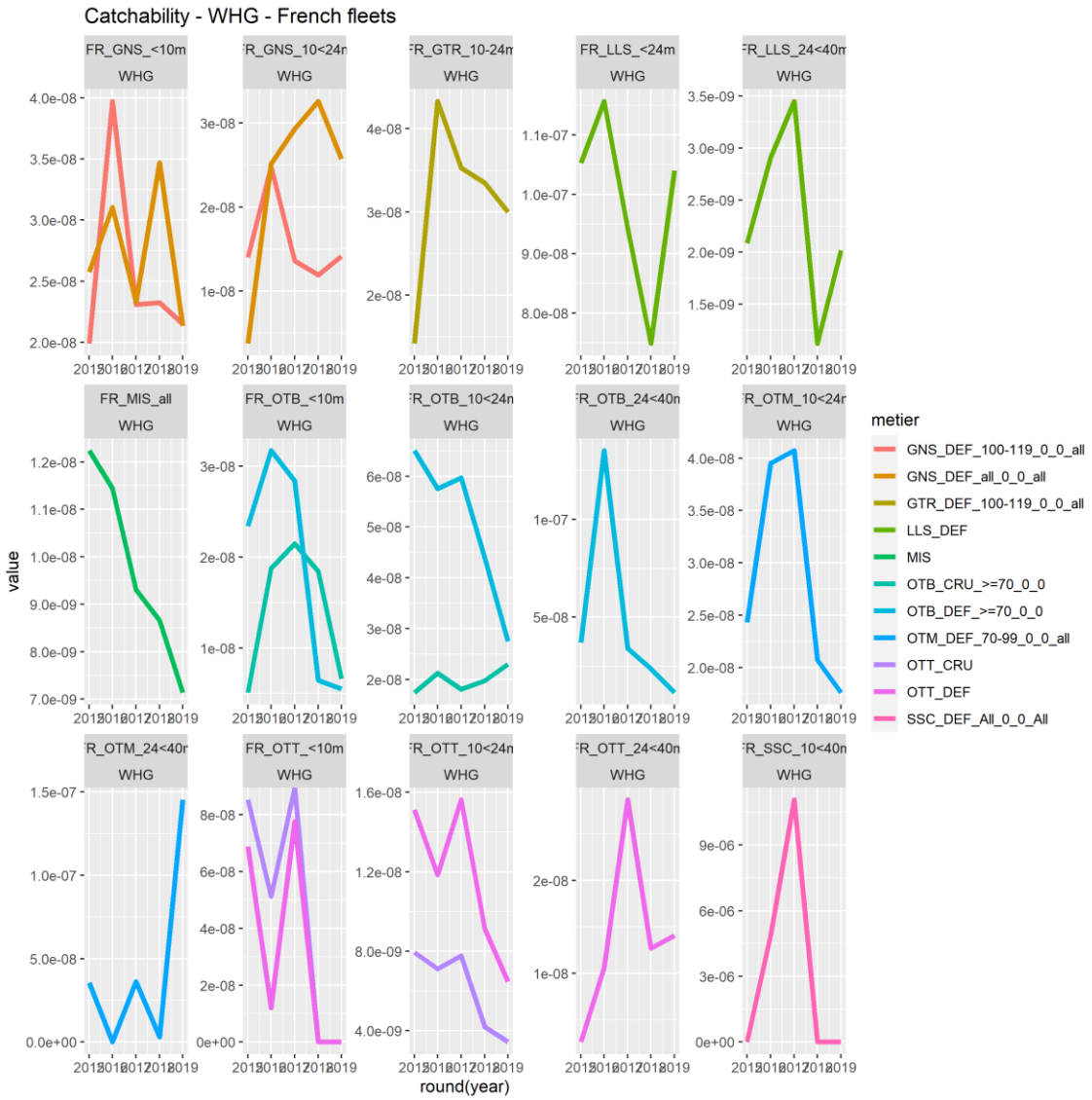


Figure 2.14. Bay of Biscay: trends of French catchability for whiting (wgh) by fleet and métier.

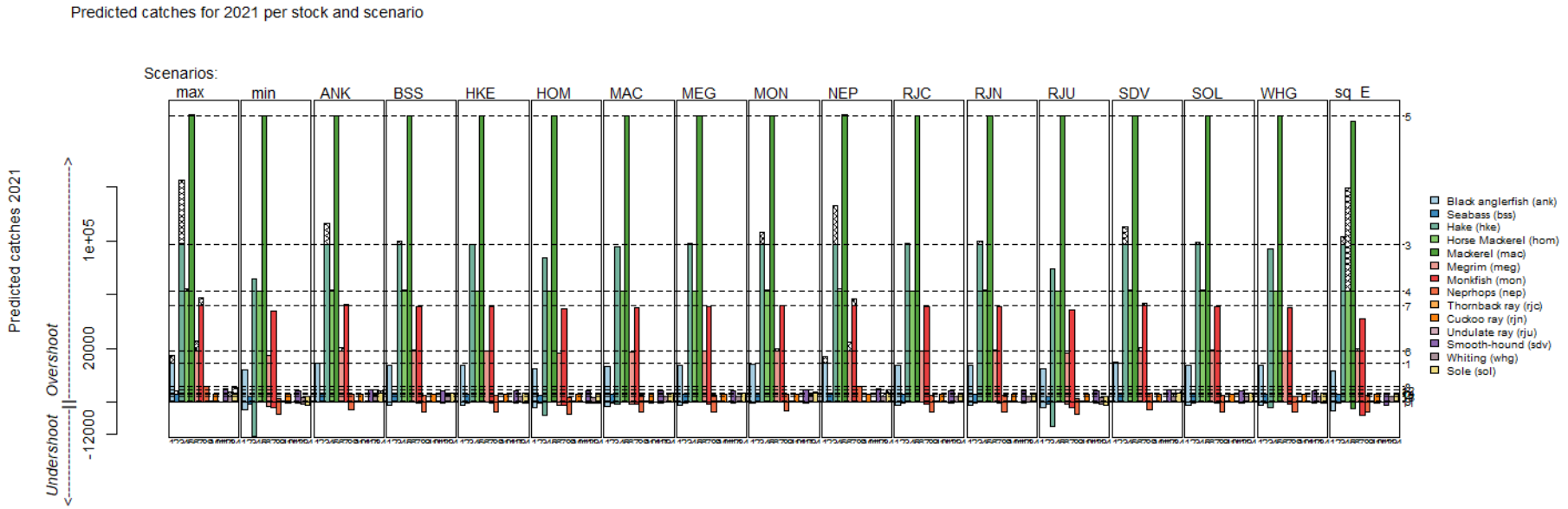


Figure 2.15. Bay of Biscay mixed fisheries forecasts: TAC year results (2021). FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year followed by the FLBEIA scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species catch advice) in cases where catches are predicted to be lower when applying the scenario.

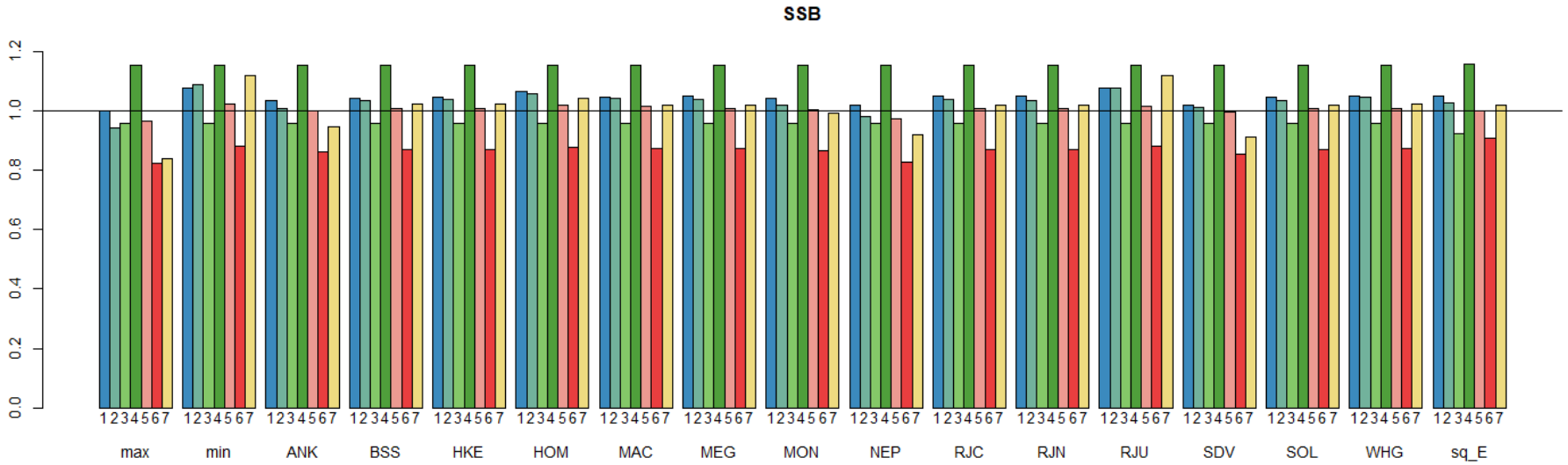


Figure 2.16. Bay of Biscay mixed fisheries forecasts: Estimates of potential SSB at the start of 2022 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2022).

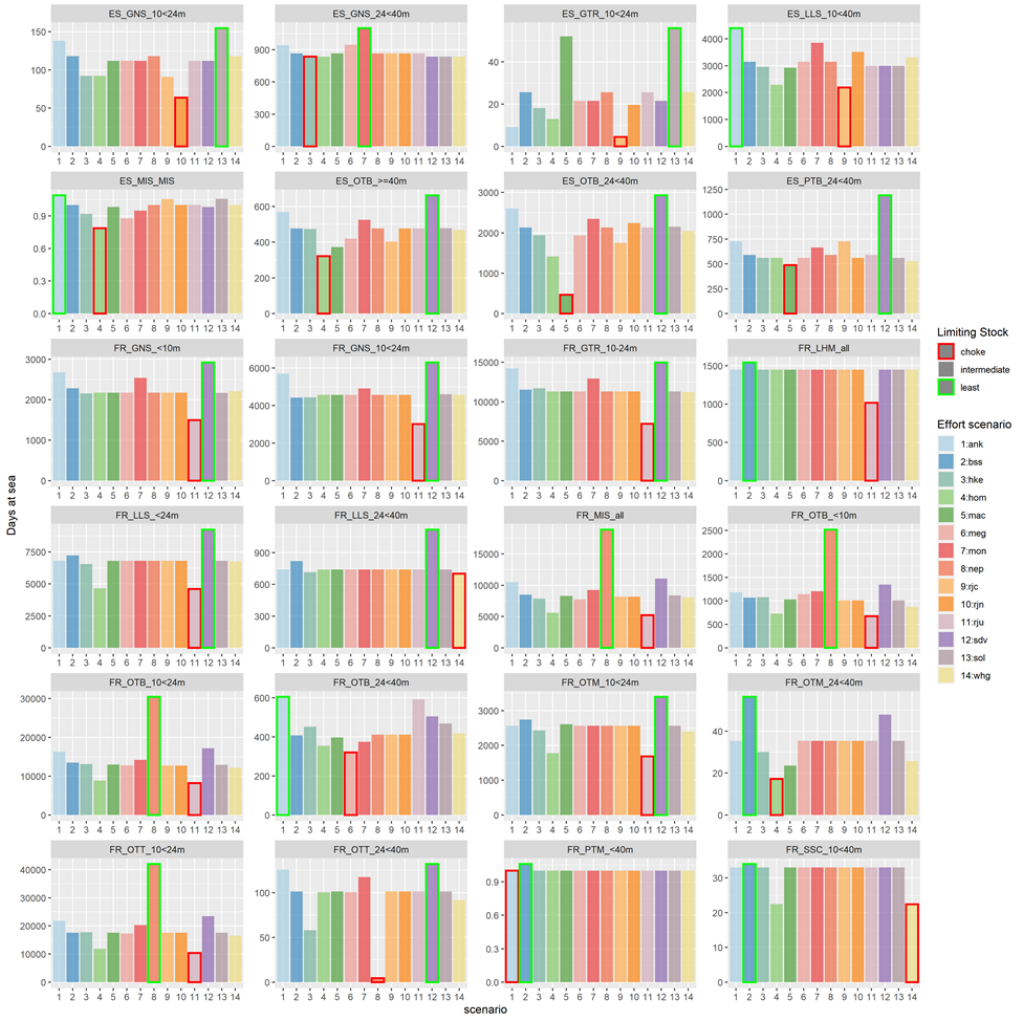


Figure 2.17. Estimates of effort by fleet needed to reach the single-stock advices. Bars highlighted in red correspond to the most limiting species for that fleet in 2021 ("choke species"), whereas the green highlight correspond to the least limiting species. Fleet names are given by country (FR = France, SP = Spain) and by meaningful combinations of main gear and vessel size differing across countries and based on homogeneous average fishing patterns. Vessels in the various fleet segments can engage in several fisheries (métiers) over the year.

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Garcia, D., Sanchez, S., Prellezo, R., Urtizberea, A., and Andreas, M. 2017. FLBEIA: a simulation model to conduct bio-economic evaluation of fisheries management strategies. SoftwareX, 6: 141–147. https://doi:10.1016/j.softx.2017.06.001

ICES. 2018. Working Group on Mixed Fisheries Advice Methodology (WGMIXFISH-METHODS). ICES Scientific Reports, 1:58. 56 pp. http://doi.org/10.17895/ices.pub.5576.

ICES. 2020a. Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). ICES Scientific Reports. 2:49. 845 pp. http://doi.org/10.17895/ices.pub.6033

ICES. 2020b. Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports. 2:77. 789 pp. http://doi.org/10.17895/ices.pub.7470

ICES. 2020c. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 2:82. 1019 pp. http://doi.org/10.17895/ices.pub.7475

3 Celtic Sea

3.1 Background

Fisheries in the Celtic Sea are highly mixed, targeting a range of species with different gears. Otter trawl fisheries target mixed gadoids (cod, haddock, and whiting), *Nephrops*, hake, anglerfishes, megrims, rays as well as cephalopods (cuttlefish and squid). Beam trawl fisheries target flatfish (plaice, sole, turbot), anglerfishes, megrim and cephalopods (cuttlefish and squid), while set-net fisheries target flatfish, hake, pollack, cod, anglerfishes as well as some crustacean species. Beam trawling occurs for flatfish (in 7.e and 7.fg) and rays (7.f). The fisheries are mainly prosecuted by French, Irish, and English vessels with additional Belgian beam trawl fisheries and Spanish trawl and net fisheries along the shelf edge (7.hjk).

The mixed gadoid fishery predominately takes place in ICES areas 7.f and 7.g with these areas responsible for >75% of the landings of each cod, haddock and whiting. Landings are predominately by French and Irish vessels, though UK vessels also take significant landings of these species.

3.1.1 Management measures

In 2020 the ICES advice for all stocks considered in this model in terms of terms of the EU multiannual plan for Western waters and adjacent waters. There are two species specific management plans in this region; a recovery plan for hake (Council Regulation (EC) No 811/2004) which implements a Total Allowable Catch (TAC) annually based on a defined Harvest Control Rule (HCR) and a management plan with both a HCR and effort management element for sole in the Western channel (7.e; Council Regulation (EC) No 509/2007). There are also a number of effort, technical and area closure measures in place, which are summarised below.

The western waters regulation (Council Regulation (EC) No 1954/2003) implements an effort ceiling for ≥15 m vessels fishing for demersal species in Subarea 7 with additional effort ceiling specifications for an area to the South and West of Ireland known as the 'Biologically Sensitive Area' for vessels ≥10 m.

A series of technical measures are in place for demersal trawl gears operating in various parts of the Celtic Sea. This includes maximum number of meshes in circumference, incorporation of a square mesh panel (SMP), and minimum mesh size in the cod end dependent on the target composition and/or area. Technical measures for the recovery of the stock of hake which includes Subarea 7. Commission regulation (EC) No 1162/2001, commission regulation (EC) No 2062/2001, and commission regulation (EC) No 494/2002.The most recent of which relates to incorporation of the SMP detailed in commission implementing regulation (EU) No 737/2012 of 14 August 2012. A summary of current measures is published by BIM of Ireland (http://www.bim.ie/media/bim/content/downloads/BIM-fisheries-management-chart-2020.pdf)

Since 2005, three ICES rectangles (30E4, 31E4, and 32E3) have been closed during the first quarter (Council Regulations 27/2005, 51/2006, and 41/2007, 40/2008 and 43/2009) known as the Trevose closure, with the objective of reducing fishing mortality on cod. A second area closure is in place to reduce fishing mortality on *Nephrops* within FU16, the Porcupine bank fishery. This spatio-temporal closure was in place between 1 May and 31 July 2010-2012, but since 2013 the period of the closure was reduced to May (Council Regulation (EU) 2019/124).

As of the 1 January 2016 a European demersal species landings obligation was introduced (Commission Delegated Regulation (EU) 2015/2438). This regulation prevents the discarding of certain species on a fishery by fishery approach. From 1 January 2020, catches of all quota species in the Celtic Seas are subject to the EU landings obligation rule, except an exemption is in place. An overview of the exemptions of the landings obligation can be found below:

Exemptions to the landing obligation in 2020

Species	Exemption type	ICES Sub-area/division	Gear	Maximum de minimis Exemption
Albacore tuna	De minimis	7	Midwater pair trawls	5
Whiting	De minimis	7b-7-k	Bottom trawls and seines ≥ 80 mm, Pelagic and beam trawls 80 -119 mm	5
Sole	De minimis	7a & 7d-7k	Beam trawls 80 -119 mm equipped with Flemish panel	3
Sole	De minimis	7d - 7g	Trammel nets and gillnets	3
Haddock<30cm	De minimis	6a	Nephrops trawls ≤119mm	3
Haddock	De minimis	7b-c & 7e-7k	Bottom trawls, seines & beam trawls ≥ 80 mm	5
Megrim <20cm	De minimis	7	Bottom trawls 70-99mm & beam trawls 80-199mm	5
Horse mackerel	De minimis	6 & 7b-7k	Bottom trawls, seines & beam trawls	7
Mackerel	De minimis	6 & 7b-7k	Bottom trawls, seines & beam trawls	7
Boarfish	De minimis	7b,7c & 7f-7k	Bottom Trawls	0.5
Argentine	De minimis	EU5b & 6	Bottom Trawls ≥ 100mm	0.6
Species	**Exemption type**	**ICES Sub-area/division**	**Gear**	**Discard Release Notes**
Nephrops	Survivability	6 & 7	Pots, creels or traps	Released whole, immediately & where caught
Nephrops	Survivability	6a <12nm	Bottom trawls 80-110 mm	Released whole, immediately & where caught
Nephrops	Survivability	7	Bottom trawls 70-99 mm with HSG* or ≥ 100 mm	Released whole, immediately & where caught
Skates & rays	Survivability	6 & 7	All gears	Released immediately
Plaice	Survivability	7d- 7g	Trammel nets and otter trawls	Released immediately
Plaice	Survivability	7a-7k	Beam Trawls (vessels ≤221 kW or ≤24 m) inside 12 nm, tows ≤ 1:30 hour	Released immediately
Pot Caught Sp.	Survivability	EU 5b; 6 & 7	Pots, creels and traps	Released immediately

** See list of area-specific Nephrops technical conservation measures below*

Commission Delegated Regulation (EU)1393/2014 as amended by (EU) 2018/190 (pelagic) and Commission Delegated Regulation (EU)2019/2239 (demersal)

3.2 Model

3.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.*, 2007; FLCore 2.6.15.9007, FLFleet 2.6.1, FLAssess 2.6.3, Flash 2.5.11) running with R4.0.3 (R Development Core Team, 2020), and can be full reproduced from ICES TAF repository (https://github.com/ices-taf/2020_CS_MixedFisheriesAdvice). All forecasts were projected using the same fwd() function in the Flash Package. The FCube method is developed as a stand-alone script using FLR objects as inputs and outputs.

Software used in the single-species assessments and forecasts was as outlined in the table below:

Stock	Assessment	Forecast
cod.27.7.e–k	Age-based stochastic analytical assessment (SAM)	SAM
had.27.7.bc,e–k	Age-based stochastic analytical assessment (SAM)	SAM
whg.27.7.bc,e–k	Age-based stochastic analytical assessment (SAM)	SAM
meg.27.7b-k8abd	Bayesian statistical catch at age using catches in the model and forecast	Stochastic
mon.27.78abd	a4a	FLR STF
sol.27.7fg	Age-based stochastic analytical assessment (SAM)	SAM

Stock	Assessment	Forecast
nep.fu.16	Underwater TV survey	NA
nep.fu.17	Underwater TV survey	NA
nep.fu.19	Underwater TV survey	NA
nep.fu.2021	Underwater TV survey	NA
nep.fu.22	Underwater TV survey	NA
nep.out.7	Precautionary approach	NA

3.2.2 Scenarios

FCube (Ulrich *et al.,* 2008; 2011) was used to forecast a number of mixed fisheries forecasts. The basis of the model is to estimate the potential future levels of effort by a fleet corresponding to the fishing opportunities (TACs by stock and/or effort allocations by fleet) available to that fleet, based on fleet effort distribution and catchability by métier. This level of effort was used to estimate landings and catches by fleet and stock, using standard forecasting procedures. The basis for each single-stock advice was retained in the current mixed fisheries framework.

The following eight options (or scenarios) were included in the advice:

Scenario codes	Scenarios
max	**"Maximum":** For each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares*. This option causes overfishing of the single-stock advice possibilities of all stocks.
min	**"Minimum":** For each fleet, fishing stops when the catch for any one of the stocks meets the fleet's stock share. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks.
had.27.7b–k	**"Haddock MSY approach":** All fleets set their effort corresponding to that required to catch their haddock stock share, regardless of other catches.
whg.27.7b–ce–k	**"Whiting MSY approach":** All fleets set their effort corresponding to that required to catch their whiting stock share, regardless of other catches.
sq_E	**"*Status quo* effort":** The effort of each fleet in the TAC year (2021) is set equal to the average effort in the most recent 3 years (2017–2019) for which catch and effort data are available.
val	**"Value":** A simple scenario accounting for the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the fleet's stock shares of each of the stocks, weighted by the historical catch value of that stock (see example below). This option causes overfishing of some stocks and underutilization of others.
cod_F_{AR}MSY	**"Reduced Cod F_{MSY}":** All fleets set their effort corresponding to that required to catch their cod stock share, where the cod TAC is set according to reduced F_{MSY} ($F = 0.147 = F_{MSY} \times SSB_{2021}/MSY\ B_{trigger}$), regardless of other catches.

Scenario codes	Scenarios
range	**"Range":** estimates a fishing mortality by stock (using the F_{MSY} ranges) which, if used for setting single-stock fishing opportunities, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. F_{MSY} ranges are bound by the ranges in the single species advice sheet where the F_{MSY} ranges is adjusted using the ICES advice rule when the stock is below MSY $B_{trigger}$.

*** Throughout this document, the term "fleet's stock share" or "stock share" is used to describe the share of the fishing opportunities for each particular fleet, calculated based on the single-stock advice for 2021 and the historical proportion of the stock landings taken by the fleet (2017–2019).**

3.3 Data compilation

Data used to produce the mixed fisheries forecasts comes from three sources:

1. Stock data: Stock abundance, structure, reference points, advice and trends. This data is supplied by the single species assessment working groups.
2. Fisher behaviour: fleet and métier trends in landings and effort. This data is sourced from the WGMIXFISH data call.
3. Discard rates: InterCatch.

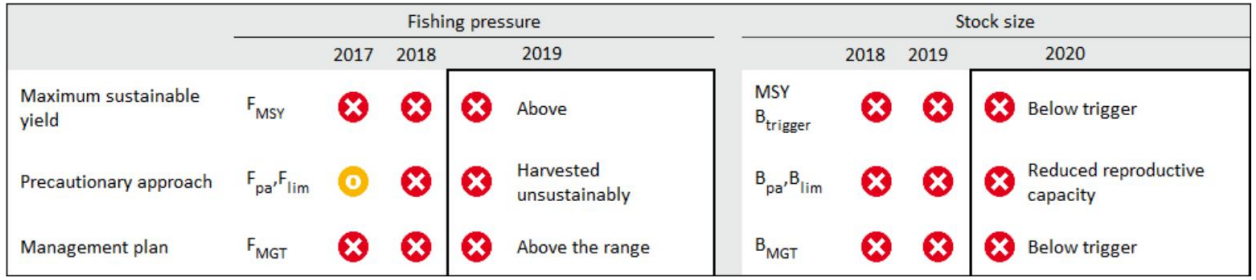
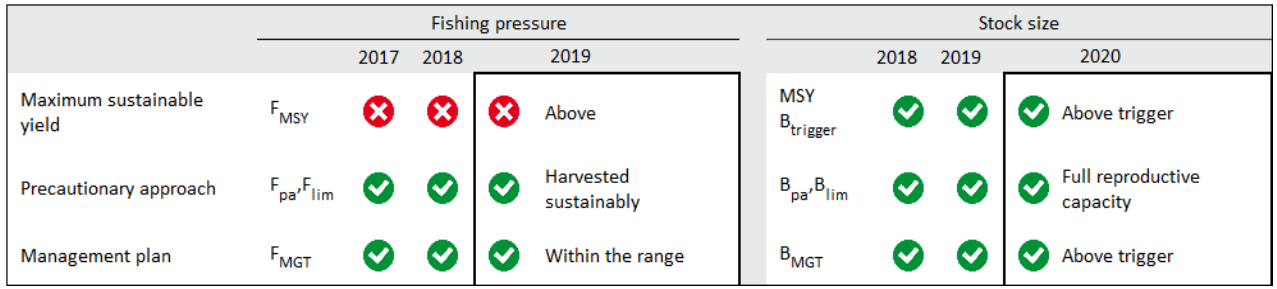
Details on the collection, structure and implementation of these data sources can be found in the stock annex (ICES 2020d). Below specific details of the data sources in 2020 has been described.

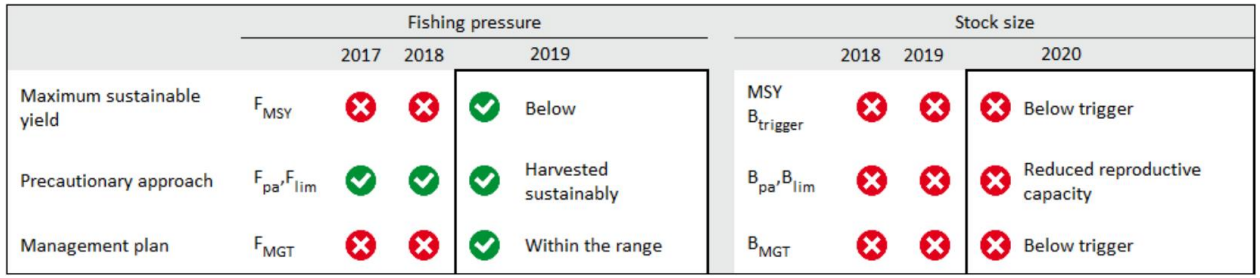
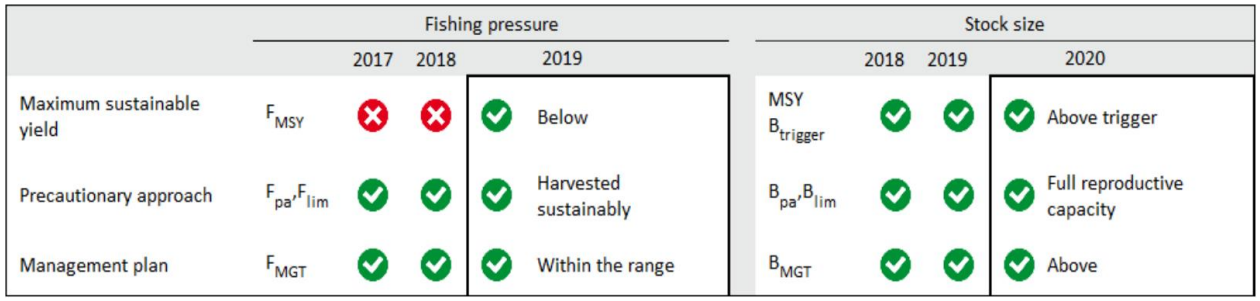
3.3.1 Stock data

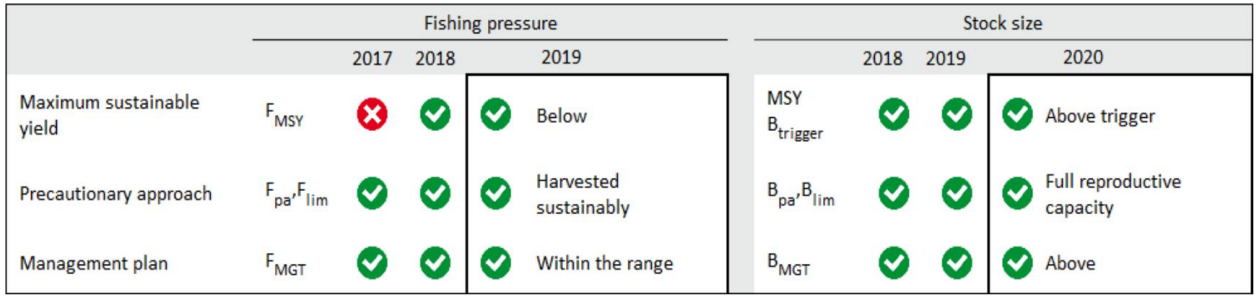
Single species stock abundance and structure was supplied by WGCSE (ICES 2020d) and WGBIE (ICES 2020a) in the form of FLR stock objects. Details of reference points, advice for 2021, TAC and trends in stock status were taken from the advice sheet. The consistent support and cooperation from the chairs and single species stock assessors has greatly eased the workload of WGMIXFISH in 2020. An overview of the trends and advice for demersal stocks included in Celtic Sea mixed fisheries analysis the single species advice for these stocks is drafted by the WGCSE-2019 under considerations by ACOM. A summary of recent trends in described below (Table 3.)

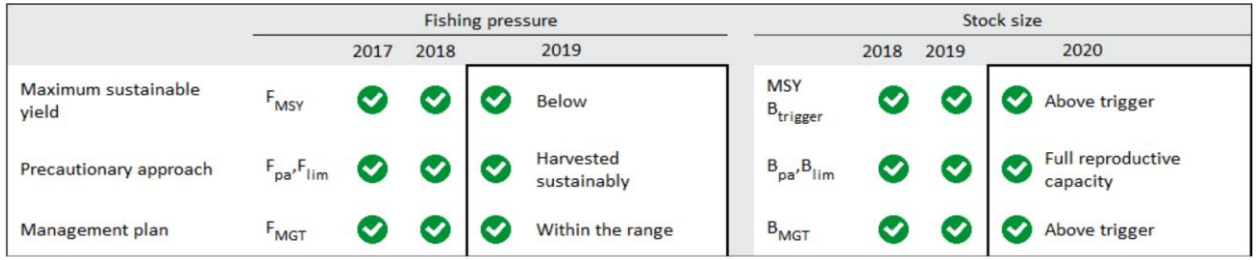
Table 3.1 Summary of advice and stock trends for the stocks included in the Celtic Sea mixed fisheries model (ICES 2020a, 2020d)

Analytical stocks

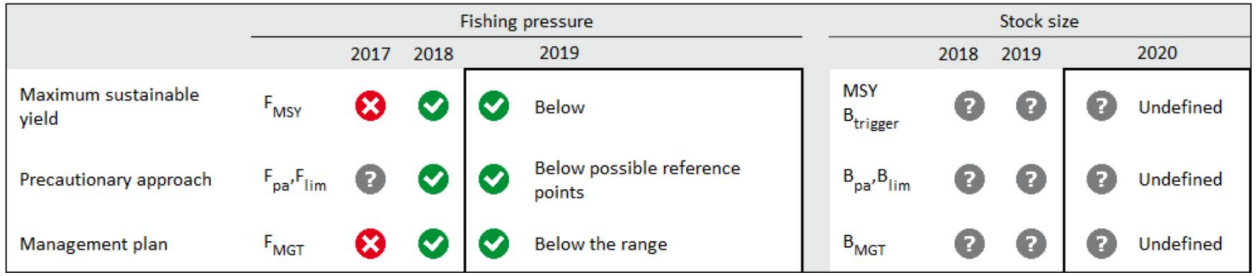
Species	Area	Stock status	Advice 2021
cod.27.7e–k (Cod)	Divisions 7. e–k (western English Channel and southern Celtic Seas)	 Summary: Spawning-stock biomass (SSB) has been fluctuating around MSY $B_{trigger}$ since 2004, except from 2011 to 2013, and has been below B_{lim} since 2017. Fishing mortality (F) has been above F_{MSY} for the entire time-series, and above F_{lim} in recent years. Recruitment has been highly variable over time. Recent recruitment has been low with the exception of the 2013 year class, which was above average.	ICES advises that when the MSY approach and precautionary considerations are applied, there should be zero catch in 2021.
had.27b–k (Haddock)	Divisions 7.b–k (southern Celtic Seas and English Channel)	 Summary: Following a decline from its peak in 2011, the spawning-stock biomass (SSB) has increased since 2014 and is above MSY $B_{trigger}$. Fishing mortality (F) has been above F_{MSY} for the entire time-series but has been gradually declining. Recruitment in 2018 and 2019 was above average.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 12 128 tonnes and 25 454 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (18 382 tonnes) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule.

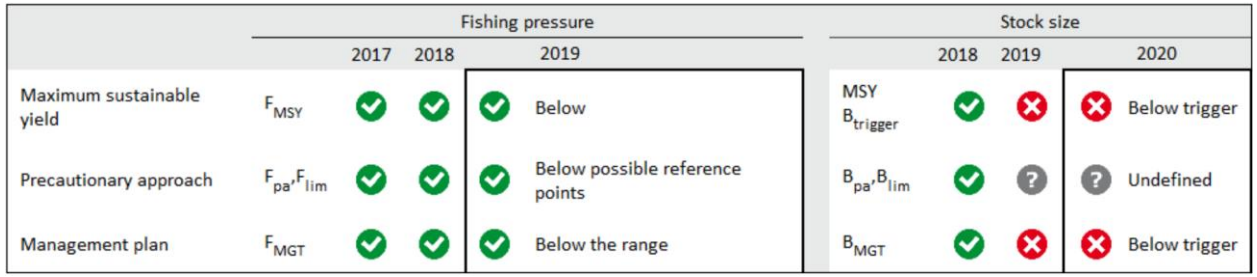
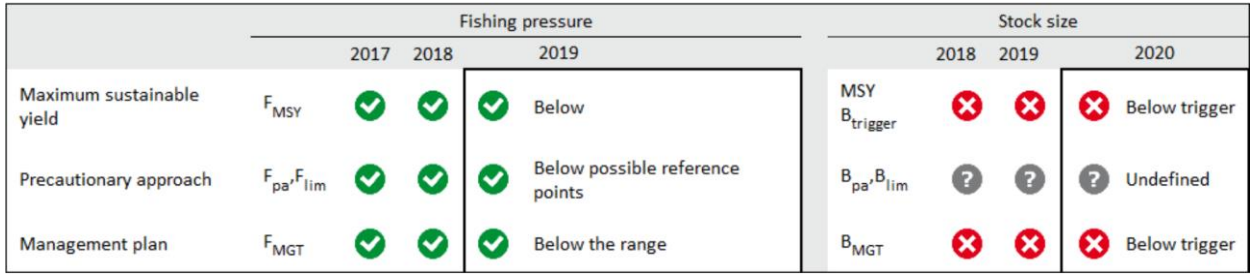
Species	Area	Stock status	Advice 2021
whg.27.b–c, e–k (Whiting)	Divisions 7.b–c and 7.e–k (southern Celtic Seas and western English Chan-	 Summary: The spawning-stock biomass (SSB) has decreased since 2010 and is estimated to have been below MSY $B_{trigger}$ since 2017 and below B_{lim} since 2018. Fishing mortality (F) has generally fluctuated above F_{MSY} throughout the time-series and was below F_{MSY} in 2019. Recruitment has been relatively low since 2010, with the exception of 2013.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 4458 tonnes and 5261 tonnes.
meg.27.7b-k8abd (Megrim)	Divisions 7.b–k, 8.a–b, and 8.d (west and southwest of Ireland, Bay of Biscay)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 12 706 tonnes and 27 748 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (19 184 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two megrim species, *L. whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation

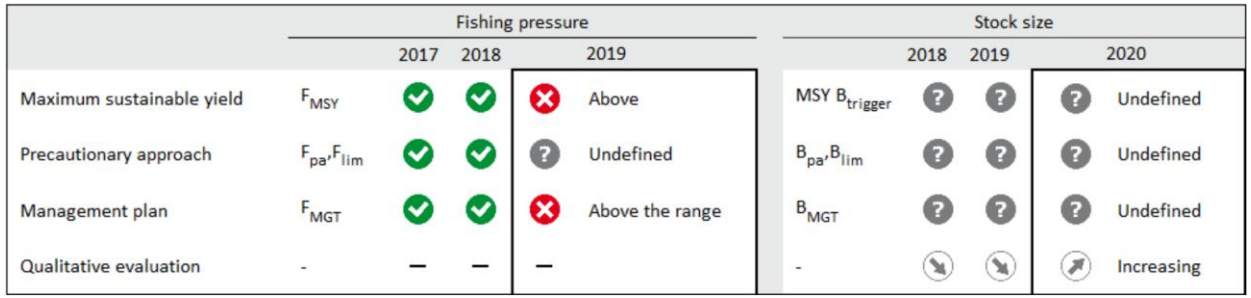
Species	Area	Stock status	Advice 2021
			rates, and could lead to overexploitation of either species.
mon.27.78abd (White anglerfish)	Subarea 7 and in divisions 8.a–b and 8.d (southern Celtic Seas, Bay of Biscay)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 23 320 tonnes and 45 996 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (34 579 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two anglerfish species, *Lophius budegassa* and *L. piscatorius*, under a combined species total allowable catch (TAC) prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

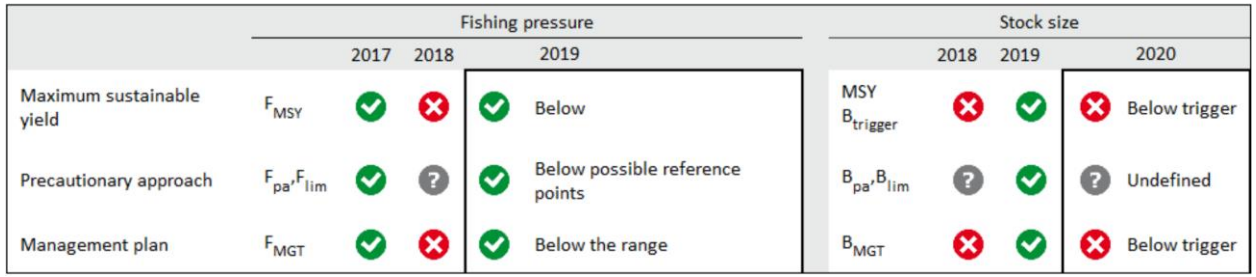
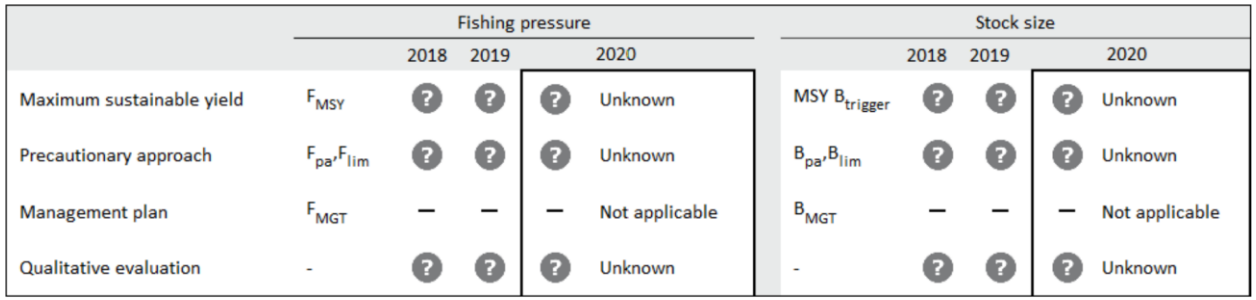
Species	Area	Stock status	Advice 2021
sol.27.7.f–g (Sole)	Divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	 Summary: Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ since 2009; it shows an increasing trend over the last few years and is now close to the highest estimated SSB in the time-series. Fishing mortality (F) has decreased in recent years and has been below F_{MSY} since 2017. Recruitment (R) has been variable; the 2017 and 2019 estimates are among the highest in the time-series.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the plan are between 811 tonnes and 2364 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1413 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

***Nephrops* stocks**

Species	Area	Stock status	Advice 2020
nep.fu.16 (*Nephrops*)	Divisions 7.b–c and 7.j–k, Functional Unit 16 (west and southwest of Ireland,		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, and assuming zero discards, catches in 2021 that correspond to the F ranges in the MAP are between 2653 tonnes and 3290 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

Species	Area	Stock status	Advice 2020
			To ensure that the stock in Functional Unit (FU) 16 is exploited sustainably, management should be implemented at the functional unit level.
nep.fu.17 (*Nephrops*)	Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 443 tonnes and 508 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 17 is exploited sustainably, management should be implemented at the functional unit level.
nep.fu.19 (*Nephrops*)	Divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 531 tonnes and 595 tonnes, assuming recent discard rates. The entire range is considered precautionary when

Species	Area	Stock status	Advice 2020
			applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 19 is exploited sustainably, management should be implemented at the functional unit level.
nep.fu.2021 (*Nephrops*)	Divisions 7.g and 7.h, functional units 20 and 21 (Celtic Sea)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1682 tonnes and 1710 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in functional units 20 and 21 is exploited sustainably, management should be implemented at the level of the combined functional units 20 and 21.

Species	Area	Stock status	Advice 2020
nep.fu.22 (*Nephrops*)	Divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1238 tonnes and 1560 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 22 is exploited sustainably, management should be implemented at the functional unit level.
nep.27.7outFU (*Nephrops*)	Subarea 7, outside the functional units (southern Celtic		ICES advises that when the precautionary approach is applied, landings should be no more than 150 tonnes in each of the years 2021, 2022, and 2023. ICES cannot quantify the corresponding total catches.

3.3.2 Fisher behaviour

Information on fisher behaviour is supplied by the WGMXIFSH data call, which provides disaggregated fleet behaviour at the level of métier which are consistent with the definitions outlined in the DCF. This year there was a new data call for WGMIXFISH, which changed the format in which the data was requested. Although the new structure of the data call greatly increased the quality and consistency of data provided, there were still a number of member state specific issues which were not fixed in time for the advice meeting. These issues were resolved with "quick fixes" but will require a full resubmission during the 2021 data call.

3.3.3 Discard data

Discard ratios were calculated from InterCatch discard estimates (either raw country submission or raised) and applied to the landings data supplied by member states in the WGMIXFISH data call. All discard estimates were retrieved from InterCatch and assigned to the same métiers within the WGMIXFISH csv files. However, this method relies on being able to match métier definitions between the two datasets. The conformity of métiers in MIXFISH and InterCatch was generally high and improving year after year, but it was still not possible to match a few métiers. It would be desirable for countries to keep improving the consistency between data uploaded to InterCatch and data submitted to WGMIXFISH.

3.3.4 Building the fleet

The above data sources are then combined to produce the "fleet object" which is used as an input into FCube. Within this object the fleets were defined by aggregating catch and effort across country, gear group, and vessel length (where applicable). Any fleet catching <1% of any of the stocks included the analysis was binned into an "others" ("OTH") fleet to reduce the dimensions of the model. Effort and catch files were matched to ensure consistency, métiers with effort and no catch were aggregated to the OTH fleet. Within a fleet, a métier was defined as a combination of gear, target species (e.g. demersal fish, DEF, or crustaceans, CRU) and ICES subarea (e.g. 7.b). The final data used contained 24 fleets (country * gear grouping * vessel length category), and an "other" fleet (OTH), from three years (2017 to 2019). Each fleet engages in up to 31 different métiers each (métier * area) catching the stocks incorporated into this model (Table 3., 3.3). The quality and combination of stocks landed by each metier varies greatly (Figure 3.2). Similar aggregating procedure as for the fleets was performed, where any métier catching <1% of a métiers catch of each stock was aggregated into an "OTH" métier.

3.3.5 Quality control

As a quality control procedure the total landings and discards across all fleets were compared to the values estimated from the single-species stock assessments (Table 3.1. Proportion of the stocks total landings and discards (from WGCSE) covered by the MIXFISH fleets. A ratio >1 means that the catch information collated by MIXFISH is higher than the information used by WGCSE.

year	stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discrads
2017	cod.27.7e-k	2462.498	133.7157	1	1.05	2456.977	140.7772
2018	cod.27.7e-k	1483.585	315.1796	0.99	0.82	1475.479	259.091
2019	cod.27.7e-k	1068.683	299.26	0.99	1.12	1059.349	334.7643
2017	had.27.7b-k	8101.405	6674.203	0.98	0.95	7919.8	6335.413
2018	had.27.7b-k	7047.443	5765.312	0.97	1.01	6869.828	5835.205
2019	had.27.7b-k	7657.441	3583.857	1	1.05	7645.89	3748.897
2017	meg.27.7b-k8abd	13506.49	1745.938	0.86	1.41	11621.32	2460.737
2018	meg.27.7b-k8abd	14065.58	2375.937	0.73	0.79	10270.41	1866.239
2019	meg.27.7b-k8abd	12894.45	1916.393	0.8	0.62	10315.29	1188.351
2017	mon.27.78abd	28449	1850.088	0.84	1.11	23949.79	2057.324
2018	mon.27.78abd	22740.15	1290.432	0.9	0.99	20540.95	1280.084
2019	mon.27.78abd	20670.83	1393.703	1	0.93	20692.93	1291.285
2017	nep.fu.16	2632.262	0	0.97	NA	2556.307	0
2018	nep.fu.16	2750.688	0	1	NA	2739.624	0
2019	nep.fu.16	2251.145	0	0.83	NA	1868.44	0
2017	nep.fu.17	294.9642	37.7022	1	1	295.007	37.70767
2018	nep.fu.17	536.4751	106.0466	0.92	0.92	492.91	97.43495
2019	nep.fu.17	166.5352	20.85645	0.95	0.95	157.855	19.76937
2017	nep.fu.19	419.9617	139.23	0.86	0.86	360.3614	119.4707
2018	nep.fu.19	238.2509	70.60755	0.76	0.76	180.8818	53.60577
2019	nep.fu.19	249.4317	112.4597	0.75	0.75	186.5519	84.10942
2017	nep.fu.2021	1849.278	306.3452	0.98	0.98	1811.685	300.1176
2018	nep.fu.2021	1802.603	381.0814	1	1	1800.623	380.6627
2019	nep.fu.2021	2998.976	636.5153	0.87	0.87	2607.354	553.3959
2017	nep.fu.22	3560.159	424.3654	0.99	0.99	3521.265	419.7293
2018	nep.fu.22	1974.487	335.6799	0.97	0.97	1921.253	326.6297

year	stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discrads
2019	nep.fu.22	2083.079	262.2173	0.93	0.93	1938.965	244.0762
2017	nep.out.7	137	0	2.59	NA	354.8023	0
2018	nep.out.7	200	0	1.13	NA	225.3977	0
2019	nep.out.7	242	0	0.71	NA	172.2036	0
2017	sol.27.7fg	779.4103	65.377	1	1	777.6362	65.19055
2018	sol.27.7fg	851.9613	141.18	1	1.1	848.9584	155.9934
2019	sol.27.7fg	1067.313	145.333	1	1.05	1068.594	152.233
2017	whg.27.7b-ce-k	12286.05	2590.652	1.01	1.03	12377.62	2662.36
2018	whg.27.7b-ce-k	8951.826	1763.687	1	1.16	8961.287	2052.569
2019	whg.27.7b-ce-k	5543.099	751.6323	1.19	1.22	6586.573	917.4388

). Some landings may not be allocated to fleets, due to issues such as missing countries or areas or national landings with missing logbook information that cannot be allocated to a fleet. The landings coverage for all fish stocks is very high (above 95% of landings of each fish stock for each of the years 2017–2019 could be allocated to one of the fleets). To address the remaining small inconsistencies between fleet data used by WGMIXFISH and stock data, the differences between them were pooled into the "OTH" fleet (both landings and discards). During data processing a difference in UK landings for *Neprhops* was noted for FU 16 and FU 20-21 in 2019 between InterCatch data and WGMIXFISH data call. After cross checking with the UK data provider it was determined that the InterCatch values where in error. As such the value for landings for these FU was taken from the accessions data and the discrepancy is currently being queried.

3.4 Mixed fisheries forecasts

3.4.1 Description of scenarios

3.4.1.1 Baseline runs

The objectives of the single-species stock baseline runs were to:

1. reproduce as closely as possible the single-species advice produced by ACOM,
2. and act as the reference scenario for subsequent mixed fisheries analyses.

The various single-stock forecasts produced by the single species working groups are performed using different software and setups (see Section 3.2.1 above). The Fcube model has been coded as a method in R 64bits (R Development Core Team, 2008), as part of the FLR framework (Kell *et al.*, 2007, www.flr-project.org). Input data are in the form of FLFleets and FLStocks objects from the FLCore 2.6 package, and two forecast methods were used, stf() from the FLAssess (version 2.6) and fwd() from the Flash (version 2.5) packages. Stock objects were processed using Fla4a (version 1.7), FLXSA (version 2.6), stockassessment (version 0.9). As such, the input parameterisation as well as the stock projections are made externally using existing methods and packages,

while only steps 4 to 6 are internalised in the method, thus keeping full transparency and flexibility in the use of the model. In the mixed-fisheries runs, all forecasts were done with the same FLR forecasts method.

The same forecast settings as the single species assessment are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY approach and Management plan). Some differences can occur in the forecast calculations, (because of the diversity of single-stock assessment methods used) and the WG always investigates in depth the reasons for potential discrepancies. Adjustments to the FCube forecasts are made if necessary to minimise discrepancies to the largest extent possible.

The baseline runs therefore acted as a quality control procedure to ensure that the projections were set up correctly within the FCube script. The baseline run has the additional benefit of acting as a quality control check on the projections produced by the single species stock assessors.

3.4.1.2 Mixed fisheries runs

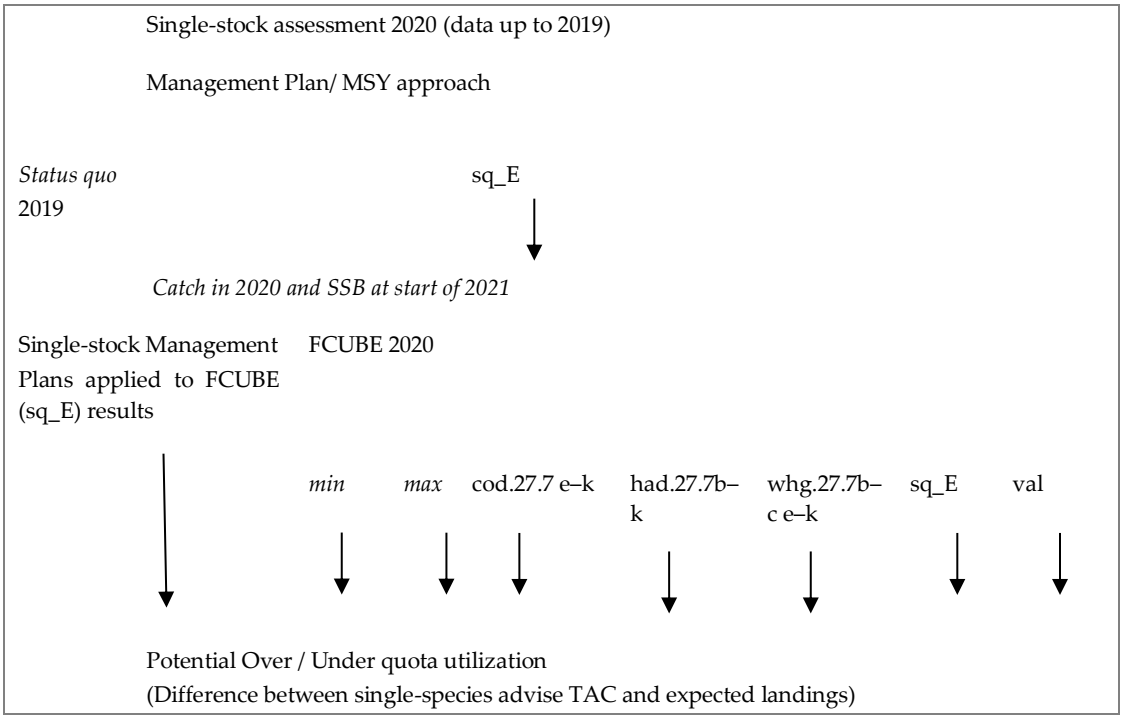
FCube analyses of the intermediate year (2020)

For the mixed fisheries advice, the intermediate year assumption used was the same as that used for the single-stock forecasts, with Fcube only applied in the TAC year.

FCube analyses for the TAC year (2021)

Seven scenarios were run, as outlined in Section 3.2.2 above, in addition to the 'range' scenario.

In summary, the FCube runs followed the scheme below:



3.4.2 Results of FCube runs

3.4.2.1 Baseline run

Table 3.2 summaries the results of the baseline runs for each cod, haddock and whiting in Fcube. Figure 3. shows the required change in fishing mortality for each stock. This trend shows that cod requires the biggest reduction in F, indicating the potential for it to be the 'choke' species for the fisheries that catch cod. No issues were encountered in replicating the single-species advice. The results from these baseline runs are compared with the results from the corresponding ICES runs in Table 3.3 and summarised in Figure 3.. The replicated forecast for all stocks were almost identical to the single-stock advice.

3.4.2.2 Mixed fisheries analyses

Intermediate year

The full overview of the FCube projections to 2021 is presented in

Table 3.4, Figure 3., and Figure 3.. The results for 2020 can be compared to each other as in a single-species option table. For ease of comparison, a table with the landings relative to the single-stock advice is also presented on

value	year	sc	cod.27.7e.k	had.27.7b.k	meg.27.7b.k8abd
catches	2020	sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
Fbar	2020	baseline	0.4770000	0.4060000	0.2100000
		sq_E	0.4770000	0.4060000	0.2127418
	2021	baseline	0.0000000	0.3530000	0.1900000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.1620000	0.3530000	0.1682417
		max	2.0000000	0.6640000	0.5109725
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.3370000	0.4230000	0.2144743
		val	1.2160000	0.3840000	0.2008717
		whg.27.7b-ce-k	0.6180000	0.1910000	0.0988390
FmultVsF19	2020	baseline	0.4200000	1.0000000	1.2000000
		sq_E	0.5409612	0.1647657	1.2000000
	2021	baseline	0.0000000	0.8700000	1.0800000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.3178132	0.1432568	0.9500000
		max	2.2681810	0.2694690	2.8900000
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.5162790	0.1716647	1.2100000
		val	1.3790541	0.1558375	1.1400000
		whg.27.7b-ce-k	0.7008679	0.0775129	0.5600000
landings	2020	baseline	1056.0000000	20172.0000000	20124.0000000
		sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
ssb	2020	baseline	1587.0000000	66388.0000000	106654.0000000
	2021		2942.0000000	71273.0000000	110436.0000000
		sq_E	2942.0000000	71456.0000000	110436.0000000
	2022	cod_fmsy	6075.0000000	91996.0000000	134821.0000000
		had.27.7b-k	2045.0000000	70166.0000000	116711.0000000
		max	977.0000000	55911.0000000	88311.0000000
		min	6075.0000000	91697.0000000	134821.0000000
		sq_E	1746.0000000	66379.0000000	112267.0000000
		val	1948.0000000	68961.0000000	113553.0000000
		whg.27.7b-ce-k	3378.0000000	78993.0000000	123797.0000000

value	year	sc	mon.27.78abd	sol.27.7fg	whg.27.7b.ce.k
catches	2020	sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
Fbar	2020	baseline	0.2200000	0.2960000	0.4950000
		sq_E	0.2193830	0.2960000	0.4950000
	2021	baseline	0.2800000	0.2510000	0.2680000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	0.2272185	0.1140000	0.4900000
		max	0.5683904	0.5270000	0.8890000
		min	0.0000000	0.0000000	0.0000000
		sq_E	0.2789975	0.2460000	0.5650000
		val	0.2635394	0.2400000	0.5080000
		whg.27.7b-ce-k	0.1343606	0.0750000	0.2680000
FmultVsF19	2020	baseline	1.0000000	1.2500000	1.4000000
		sq_E	1.0000000	0.0715683	0.1760882
	2021	baseline	1.2800000	1.0400000	0.7500000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.0400000	0.0275634	0.1743096
		max	2.5900000	0.1274205	0.3162474
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.2700000	0.0594790	0.2009896
		val	1.2000000	0.0580283	0.1807128
		whg.27.7b-ce-k	0.6100000	0.0181338	0.0953367
landings	2020	baseline	24349.0000000	1652.0000000	8743.0000000
		sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
ssb	2020	baseline	68952.0000000	6286.0000000	30970.0000000
	2021		72213.0000000	6194.0000000	32055.0000000
		sq_E	72213.0000000	6194.0000000	32113.0000000
	2022	cod_fmsy	102907.0000000	7462.0000000	42119.0000000
		had.27.7b-k	84206.0000000	6750.0000000	34631.0000000
		max	62737.0000000	4769.0000000	30653.0000000
		min	102907.0000000	7462.0000000	42162.0000000
		sq_E	80486.0000000	6024.0000000	33778.0000000
		val	81577.0000000	6051.0000000	34431.0000000
		whg.27.7b-ce-k	91358.0000000	6988.0000000	37480.0000000

value	year	sc	nep.fu.16	nep.fu.17	nep.fu.19	nep.fu.2021	nep.fu.22	nep.out.7
catches	2020	sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	509.0000000	595.0000000	1711.0000000	1559.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
Fbar	2020	baseline	0.0010000	0.0020000	0.0030000	0.0010000	0.0010000	NA
		sq_E	0.0417372	0.0185618	0.0326273	0.2121641	0.0849483	NA
	2021	baseline	0.0620000	0.0620000	0.0690000	0.0600000	0.0970000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	0.0742993	0.0257433	0.0245911	0.0485506	0.0949084	NA
		max	0.2874574	0.0523919	0.0456170	0.1133129	0.3047684	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	0.0601830	0.0286532	0.0276187	0.0592097	0.0881339	NA
		val	0.0667722	0.0247017	0.0234114	0.0520210	0.0872141	NA
		whg.27.7b-ce-k	0.0410794	0.0151896	0.0141967	0.0298658	0.0541514	NA
FmultVsF19	2020	baseline	0.0190000	0.1260000	0.0820000	0.0040000	0.0150000	NA
		sq_E	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	NA
	2021	baseline	1.4850000	3.3410000	2.1180000	0.2830000	1.1420000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	1.7800000	1.3900000	0.7500000	0.2300000	1.1200000	NA
		max	6.8900000	2.8200000	1.4000000	0.5300000	3.5900000	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	1.4400000	1.5400000	0.8500000	0.2800000	1.0400000	NA
		val	1.6000000	1.3300000	0.7200000	0.2500000	1.0300000	NA
		whg.27.7b-ce-k	0.9800000	0.8200000	0.4400000	0.1400000	0.6400000	NA
landings	2020	baseline	2274.0000000	168.0000000	252.0000000	3029.0000000	2104.0000000	244.0000
		sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	437.0000000	439.0000000	1430.0000000	1371.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
ssb	2020	baseline	NA	NA	NA	NA	NA	NA
	2021		NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
	2022	cod_fmsy	NA	NA	NA	NA	NA	NA
		had.27.7b-k	NA	NA	NA	NA	NA	NA
		max	NA	NA	NA	NA	NA	NA
		min	NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
		val	NA	NA	NA	NA	NA	NA
		whg.27.7b-ce-k	NA	NA	NA	NA	NA	NA

Table 3.5. For all baseline scenarios, WGMIXFISH assumed *status quo F* in 2020.

TAC year FCube runs

The outcomes of the "minimum" and "maximum" scenarios are driven by which of the stocks will be most and least limiting for each individual fleet (Figure 3.). The 2021 forecast with the cod catch advice at zero, implies that catches of all other stocks would also be zero ('min' scenario). Because the zero catch for cod results in the same outcome as the 'min' scenario, the cod scenario is not presented here. The 'max' scenario, leads to an overshoot for all stocks.

In order to provide a scenario with non-zero catch, a reduced cod F_{MSY} scenario is presented ('cod_F_{ARMSY}'). Applying the ICES Advice Rule (AR) gives an F (0.147) for cod and results in undershoots of both haddock and whiting, as fishing is stopped when the cod quota is reached.

The 'max' scenario demonstrates the upper bound of potential fleet effort and stock catches, in that it assumes all fleets continue fishing until all their stock shares for haddock and whiting are exhausted, irrespective of the economic viability of such actions. The 'max' scenario demonstrates the upper bound of potential fleet effort and stock catches (Table 3.2, Figure 3.2), in that it assumes all fleets continue fishing until all their stock shares for all other stocks are exhausted, irrespective of the economic viability of such actions. In 2021, the 'max' scenario indicated that fleets have a number of least limiting stocks which results in over-quota catches of all other stocks

(Figure 3.5). Sole is the least limiting stock for the highest number of fleets (6 of the 24 fleets, representing 43% of the effort in 2019), while the different Norway lobster Functional Units are collectively the least limiting quota for 14 of the 24 fleets (representing 42% of the effort in 2019). It is important to note that the 'Sq_E' scenario shows catches higher than the 'max' scenario. This indicates that the current fishing effort is higher than available fishing opportunities for all three gadoid stocks, indicating other stocks may also play a role in driving effort dynamics in the fisheries.

Mixed fisheries catch scenarios can take specific management priorities into account, and these results indicate that it is not possible to achieve all single-species management objectives simultaneously. ICES single-stock advice for demersal stocks is based on ICES maximum sustainable

yield (MSY) approach. Any catch of cod in 2021 is not considered (

value	year	sc	cod.27.7e.k	had.27.7b.k	meg.27.7b.k8abd
catches	2020	sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
Fbar	2020	baseline	0.4770000	0.4060000	0.2100000
		sq_E	0.4770000	0.4060000	0.2127418
	2021	baseline	0.0000000	0.3530000	0.1900000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.1620000	0.3530000	0.1682417
		max	2.0000000	0.6640000	0.5109725
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.3370000	0.4230000	0.2144743
		val	1.2160000	0.3840000	0.2008717
		whg.27.7b-ce-k	0.6180000	0.1910000	0.0988390
FmultVsF19	2020	baseline	0.4200000	1.0000000	1.2000000
		sq_E	0.5409612	0.1647657	1.2000000
	2021	baseline	0.0000000	0.8700000	1.0800000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.3178132	0.1432568	0.9500000
		max	2.2681810	0.2694690	2.8900000
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.5162790	0.1716647	1.2100000
		val	1.3790541	0.1558375	1.1400000
		whg.27.7b-ce-k	0.7008679	0.0775129	0.5600000
landings	2020	baseline	1056.0000000	20172.0000000	20124.0000000
		sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
ssb	2020	baseline	1587.0000000	66388.0000000	106654.0000000
	2021		2942.0000000	71273.0000000	110436.0000000
		sq_E	2942.0000000	71456.0000000	110436.0000000
	2022	cod_fmsy	6075.0000000	91996.0000000	134821.0000000
		had.27.7b-k	2045.0000000	70166.0000000	116711.0000000
		max	977.0000000	55911.0000000	88311.0000000
		min	6075.0000000	91697.0000000	134821.0000000
		sq_E	1746.0000000	66379.0000000	112267.0000000
		val	1948.0000000	68961.0000000	113553.0000000
		whg.27.7b-ce-k	3378.0000000	78993.0000000	123797.0000000

value	year	sc	mon.27.78abd	sol.27.7fg	whg.27.7b.ce.k
catches	2020	sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
Fbar	2020	baseline	0.2200000	0.2960000	0.4950000
		sq_E	0.2193830	0.2960000	0.4950000
	2021	baseline	0.2800000	0.2510000	0.2680000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	0.2272185	0.1140000	0.4900000
		max	0.5683904	0.5270000	0.8890000
		min	0.0000000	0.0000000	0.0000000
		sq_E	0.2789975	0.2460000	0.5650000
		val	0.2635394	0.2400000	0.5080000
		whg.27.7b-ce-k	0.1343606	0.0750000	0.2680000
FmultVsF19	2020	baseline	1.0000000	1.2500000	1.4000000
		sq_E	1.0000000	0.0715683	0.1760882
	2021	baseline	1.2800000	1.0400000	0.7500000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.0400000	0.0275634	0.1743096
		max	2.5900000	0.1274205	0.3162474
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.2700000	0.0594790	0.2009896
		val	1.2000000	0.0580283	0.1807128
		whg.27.7b-ce-k	0.6100000	0.0181338	0.0953367
landings	2020	baseline	24349.0000000	1652.0000000	8743.0000000
		sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
ssb	2020	baseline	68952.0000000	6286.0000000	30970.0000000
	2021		72213.0000000	6194.0000000	32055.0000000
		sq_E	72213.0000000	6194.0000000	32113.0000000
	2022	cod_fmsy	102907.0000000	7462.0000000	42119.0000000
		had.27.7b-k	84206.0000000	6750.0000000	34631.0000000
		max	62737.0000000	4769.0000000	30653.0000000
		min	102907.0000000	7462.0000000	42162.0000000
		sq_E	80486.0000000	6024.0000000	33778.0000000
		val	81577.0000000	6051.0000000	34431.0000000
		whg.27.7b-ce-k	91358.0000000	6988.0000000	37480.0000000

value	year	sc	nep.fu.16	nep.fu.17	nep.fu.19	nep.fu.2021	nep.fu.22	nep.out.7
catches	2020	sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	509.0000000	595.0000000	1711.0000000	1559.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
Fbar	2020	baseline	0.0010000	0.0020000	0.0030000	0.0010000	0.0010000	NA
		sq_E	0.0417372	0.0185618	0.0326273	0.2121641	0.0849483	NA
	2021	baseline	0.0620000	0.0620000	0.0690000	0.0600000	0.0970000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	0.0742993	0.0257433	0.0245911	0.0485506	0.0949084	NA
		max	0.2874574	0.0523919	0.0456170	0.1133129	0.3047684	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	0.0601830	0.0286532	0.0276187	0.0592097	0.0881339	NA
		val	0.0667722	0.0247017	0.0234114	0.0520210	0.0872141	NA
		whg.27.7b-ce-k	0.0410794	0.0151896	0.0141967	0.0298658	0.0541514	NA
FmultVsF19	2020	baseline	0.0190000	0.1260000	0.0820000	0.0040000	0.0150000	NA
		sq_E	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	NA
	2021	baseline	1.4850000	3.3410000	2.1180000	0.2830000	1.1420000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	1.7800000	1.3900000	0.7500000	0.2300000	1.1200000	NA
		max	6.8900000	2.8200000	1.4000000	0.5300000	3.5900000	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	1.4400000	1.5400000	0.8500000	0.2800000	1.0400000	NA
		val	1.6000000	1.3300000	0.7200000	0.2500000	1.0300000	NA
		whg.27.7b-ce-k	0.9800000	0.8200000	0.4400000	0.1400000	0.6400000	NA
landings	2020	baseline	2274.0000000	168.0000000	252.0000000	3029.0000000	2104.0000000	244.0000
		sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	437.0000000	439.0000000	1430.0000000	1371.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
ssb	2020	baseline	NA	NA	NA	NA	NA	NA
	2021		NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
	2022	cod_fmsy	NA	NA	NA	NA	NA	NA
		had.27.7b-k	NA	NA	NA	NA	NA	NA
		max	NA	NA	NA	NA	NA	NA
		min	NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
		val	NA	NA	NA	NA	NA	NA
		whg.27.7b-ce-k	NA	NA	NA	NA	NA	NA

Table 3.5), precautionary as the stock is estimated to be and remain below B_{lim}. The 'max' and 'Sq_E' scenarios result in whiting and haddock being fished above F_{MSY} in 2021. Whiting is also overfished in the 'haddock MSY approach'.

Scenarios that result in under- or overutilization are useful in identifying imbalance between the fishing opportunities of the various stocks. They indicate the direction in which fleets may have to adapt to fully utilise their catch opportunities without collectively exceeding single-stock fishing opportunities. Under the scenarios presented here, the 'max' scenario suggests that if all fleets' stock shares are to be fully utilised, catches of all other stocks would be considerably would be considerably higher than advised in the single-stock advice. As all fleets catch cod to a greater or lesser extent, any fishing effort directed at catching haddock or whiting is likely to result in catches of cod above the single-stock advice (zero catch), with any catch of cod above the single-stock advice considered not precautionary. The 'cod_F_{ARMSY}' scenario, where the cod TAC is set at reduced F_{MSY}, results in catches of cod, and in underutilizations of both the haddock and whiting single-stock TACs.

Of the presented scenarios, the 'min' and 'range' scenarios meet the objective of all stocks being fished at or below F_{MSY}. In contrast to single-stock advice there is no single recommendation from this advice, instead a range of scenarios are presented. The ICES single-stock advice provides

catch opportunities consistent with the ICES MSY approach. To be consistent with these objectives a scenario is necessary that delivers the SSB and/or F objectives of the single-stock advice for all stocks considered simultaneously. This is not possible in 2021 due to the cod stock being $<B_{lim}$ in 2022, even with a zero cod catch in 2020 and any fisheries for haddock and whiting likely to result in some catches of cod.

The 'min' scenario assumes that fishing stops when the catch for any one of the stocks meets the fleet's stock share. This is similar to the full implementation of the Landing Obligation. Supporting measures aimed at minimizing the misalignment between activity and stock shares for the fleets, such as changes in gear selectivity, spatiotemporal management measures, or reallocation of stock shares, may be required if fishing opportunities are to be fully taken under a fully implemented landing obligation.

In the absence of a full economic behaviour model, a "Value" scenario was run that balances fishing opportunities by stock with their potential market value.

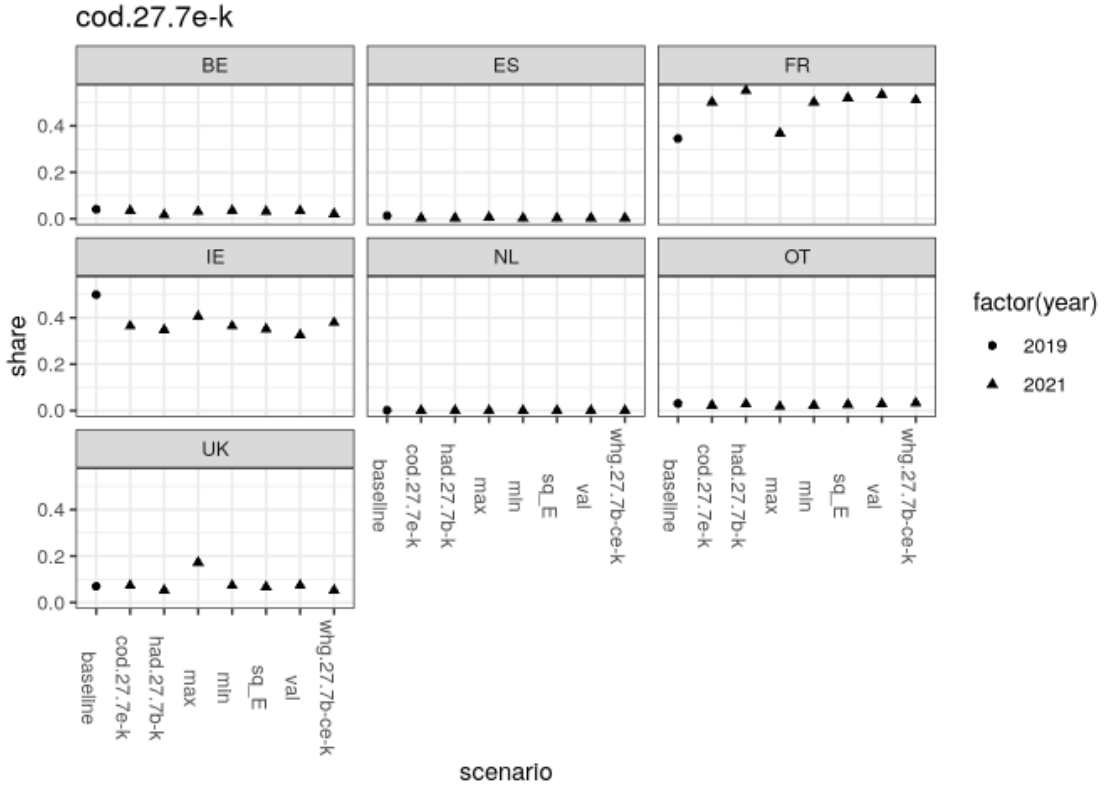
Optimised range option

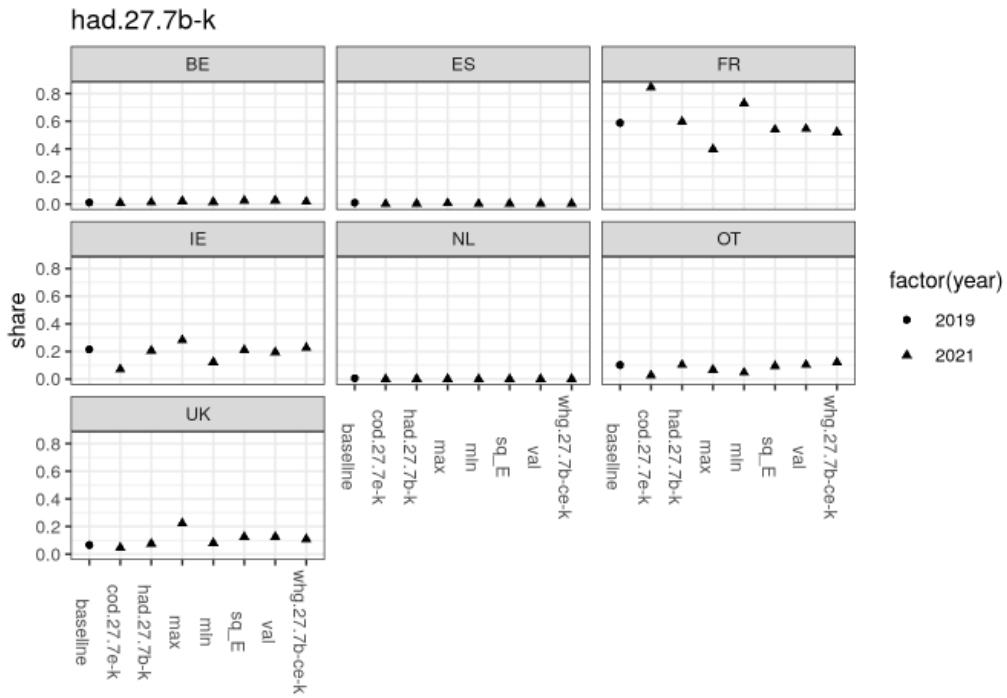
A "range" scenario is presented (Figure 3.), this scenario as described in Ulrich *et al*. (2017) searches for the minimum sum of differences between potential catches by stock under the 'min' and the 'max' scenarios within the F_{MSY} ranges. The outcomes of this scenario are driven by the restrictive nature of the cod advice this year, with the minimum of the F_{MSY} range advice for haddock and whiting resulting from the need to reduce cod catches to a minimum. Other 'range' scenarios could be computed in the future, for example scenarios minimizing the potential for discarding (e.g. catching unwanted catch) or maximizing fleets' revenue or profit.

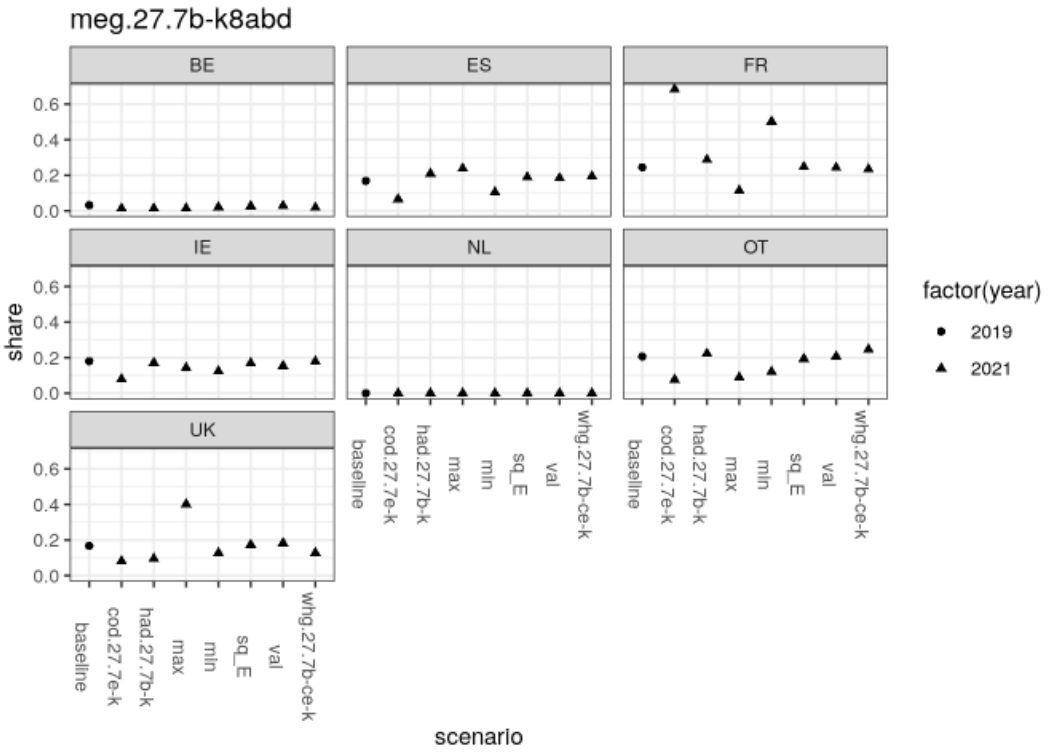
Relative stability

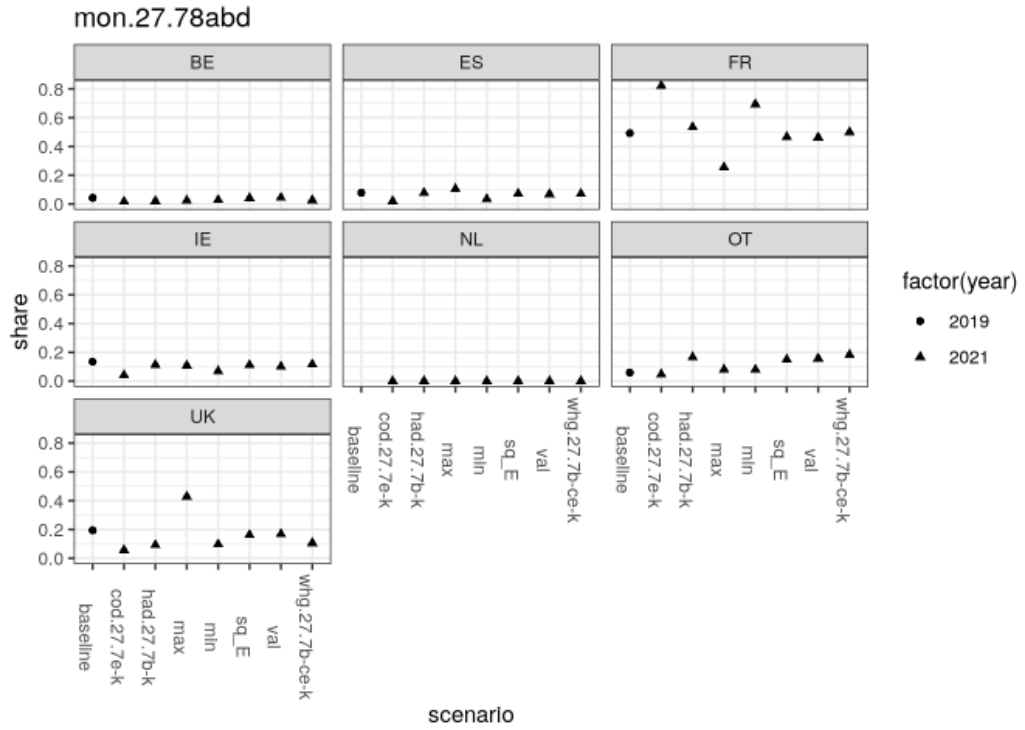
Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input is calculated as the average landing share by fleet and stock in 2020. As a cross-check, the landings by national fleets were summed over nation for each scenario, and the share

by country was compared with this initial input (






meg.27.7b-k8abd
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
0.6
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
scenario
factor(year)
2019
2021


mon.27.78abd
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
0.6
0.8
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
scenario
factor(year)
2019
2021

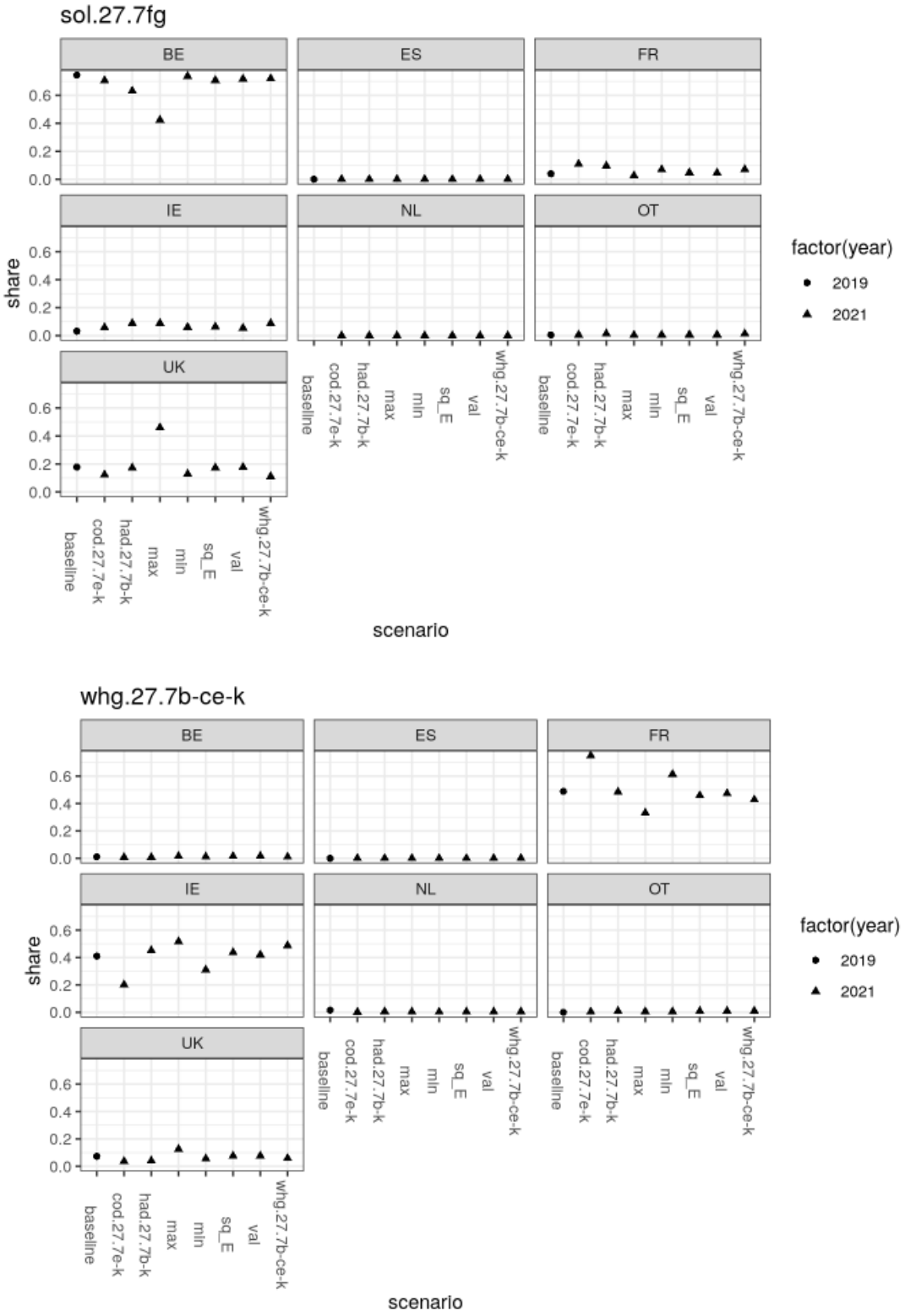


Figure 3.). The results show some deviations across all scenarios which arise because (under the assumption of a full discard ban), fleets with a small share of a stock but high discard rate have their fishing activity limited by that stock, resulting in underutilization of their target stock(s) This can translate to underutilization at the national level, as seen by the change in landings share of the stocks by EU Member States in the mixed fisheries forecasts.

Table 3.2. Celtic Sea. Summary of the 2021 ICES single-species advice. Target Fs are left justified; harvest ratios are right justified. Where a stock/Functional Unit does not have a management plan the landings follow ICES advice.

Species	Agreed TAC (summed TACs) 2020	Total Catch-advice for 2021	Projected landings-advice for 2021	F_{total}/Harvest ratio for 2021	F_{wanted}/ Harvest ratio for 2021	SSB 2021	SSB 2022	Rational
Cod 7. e–k	805*	0	0	0	0	2943	6078	MSY
Haddock 7.bc, 7. e–k	10 859**	18 382	9770	0.353	0.25	71 323	70 434	MAP
Whiting 7.bc, 7. e–k	10 863***	5261	4215	0.368	0.224	32 108	37 494	MAP
Megrim 7.b–k, 8.a–b, 8.d	20 526****	19 184	16 454	0.191	n/a	111 674	115 734	MAP
White anglerfish 7, 8.a-b, 8.d	44 307	34 579	33 100	0.28	0.28	72 213	80 416	MAP
Sole 7.fg	1652	1413	1308	0.251	0.239	6197	6009	MAP
Nephrops FU16	2637*****	3290	3290	0.062^	n/a	n/a	n/a	MAP
Nephrops FU17	16 815******	508	436	0.062^	n/a	n/a	n/a	MAP
Nephrops FU19	16 815******	595	439	0.069^	n/a	n/a	n/a	MAP
Nephrops FU20-21	16 815******	1710	1430	0.060^	n/a	n/a	n/a	MAP
Nephrops FU22	16 815******	1560	1371	0.097^	n/a	n/a	n/a	MAP
Nephrops 7 outside FU	16 815******	150	150	n/a	n/a	n/a	n/a	n/a

*** TAC applies to divisions 7.b–c and 7.e–k, subareas 8–10, and EU waters of CECAF 34.1.1.**

**** TAC applies to divisions 7.b–k and subareas 8–10.**

***** TAC applies to Subarea 7 (except Division 7.a)**

****** TAC Includes *L. boscii* and divisions 7.a and 8.e**

******* '*of which limit*' from the total Subarea 7 TAC**

******** TAC applies to whole of Subarea 7**

^ Harvest ratio for Projected landings + Projected dead discards

Table 3.3. Celtic Sea. Métiers consistent with DCF métier level 5.

Mixed-fisheries métiers	Gear	Target species
Mixed-fisheries métiers	Gear	Target species
OTB_DEF	Otter trawls	Demersal fish
OTT_DEF	Twin otter trawls	Demersal fish
OTB_CRU	Otter trawls	Crustaceans
OTT_CRU	Twin otter trawls	Crustaceans
OTM_DEF	Midwater trawls	Demersal fish
OTM_SPF	Midwater trawls	Small pelagic fish
GNS_DEF	Gillnets	Demersal fish
GTR_DEF	Trammel nets	Demersal fish
SSC_DEF	Scottish seines	Demersal fish
TBB_DEF	Beam trawls	Demersal fish
OTH	Other gears	Any
MIS_MIS	Miscellaneous	Any

Table 3.1. Proportion of the stocks total landings and discards (from WGCSE) covered by the MIXFISH fleets. A ratio >1 means that the catch information collated by MIXFISH is higher than the information used by WGCSE.

year	stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discrads
2017	cod.27.7e-k	2462.498	133.7157	1	1.05	2456.977	140.7772
2018	cod.27.7e-k	1483.585	315.1796	0.99	0.82	1475.479	259.091
2019	cod.27.7e-k	1068.683	299.26	0.99	1.12	1059.349	334.7643
2017	had.27.7b-k	8101.405	6674.203	0.98	0.95	7919.8	6335.413
2018	had.27.7b-k	7047.443	5765.312	0.97	1.01	6869.828	5835.205
2019	had.27.7b-k	7657.441	3583.857	1	1.05	7645.89	3748.897
2017	meg.27.7b-k8abd	13506.49	1745.938	0.86	1.41	11621.32	2460.737
2018	meg.27.7b-k8abd	14065.58	2375.937	0.73	0.79	10270.41	1866.239
2019	meg.27.7b-k8abd	12894.45	1916.393	0.8	0.62	10315.29	1188.351

year	stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discrads
2017	mon.27.78abd	28449	1850.088	0.84	1.11	23949.79	2057.324
2018	mon.27.78abd	22740.15	1290.432	0.9	0.99	20540.95	1280.084
2019	mon.27.78abd	20670.83	1393.703	1	0.93	20692.93	1291.285
2017	nep.fu.16	2632.262	0	0.97	NA	2556.307	0
2018	nep.fu.16	2750.688	0	1	NA	2739.624	0
2019	nep.fu.16	2251.145	0	0.83	NA	1868.44	0
2017	nep.fu.17	294.9642	37.7022	1	1	295.007	37.70767
2018	nep.fu.17	536.4751	106.0466	0.92	0.92	492.91	97.43495
2019	nep.fu.17	166.5352	20.85645	0.95	0.95	157.855	19.76937
2017	nep.fu.19	419.9617	139.23	0.86	0.86	360.3614	119.4707
2018	nep.fu.19	238.2509	70.60755	0.76	0.76	180.8818	53.60577
2019	nep.fu.19	249.4317	112.4597	0.75	0.75	186.5519	84.10942
2017	nep.fu.2021	1849.278	306.3452	0.98	0.98	1811.685	300.1176
2018	nep.fu.2021	1802.603	381.0814	1	1	1800.623	380.6627
2019	nep.fu.2021	2998.976	636.5153	0.87	0.87	2607.354	553.3959
2017	nep.fu.22	3560.159	424.3654	0.99	0.99	3521.265	419.7293
2018	nep.fu.22	1974.487	335.6799	0.97	0.97	1921.253	326.6297
2019	nep.fu.22	2083.079	262.2173	0.93	0.93	1938.965	244.0762
2017	nep.out.7	137	0	2.59	NA	354.8023	0
2018	nep.out.7	200	0	1.13	NA	225.3977	0
2019	nep.out.7	242	0	0.71	NA	172.2036	0
2017	sol.27.7fg	779.4103	65.377	1	1	777.6362	65.19055
2018	sol.27.7fg	851.9613	141.18	1	1.1	848.9584	155.9934
2019	sol.27.7fg	1067.313	145.333	1	1.05	1068.594	152.233
2017	whg.27.7b-ce-k	12286.05	2590.652	1.01	1.03	12377.62	2662.36
2018	whg.27.7b-ce-k	8951.826	1763.687	1	1.16	8961.287	2052.569
2019	whg.27.7b-ce-k	5543.099	751.6323	1.19	1.22	6586.573	917.4388

Table 3.2. Celtic Sea. Baseline run outputs from the FCube FLR package.

year	value	cod.27.7e-k	had.27.7b-k	meg.27.7b-k8abd	mon.27.78abd	sol.27.7fg	whg.27.7b-ce-k
2020	catch	1056	20172	20124	24349	1652	8743
2020	discards	0	0	0	0	0	0
2020	Fbar	0.477	0.406	0.21	0.22	0.296	0.495
2020	FmultVsF19	0.42	1	1.2	1	1.25	1.4
2020	landings	1056	20172	20124	24349	1652	8743
2020	ssb	1587	66388	106654	68952	6286	30970
2021	catch	0	18374	19030	34577	1417	5267
2021	discards	0	0	0	0	0	0
2021	Fbar	0	0.353	0.19	0.28	0.251	0.268
2021	FmultVsF19	0	0.87	1.08	1.28	1.04	0.75
2021	landings	0	18374	19030	34577	1417	5267
2021	ssb	2942	71273	110436	72213	6194	32055
2022	ssb	6075	70024	114497	80416	5997	37456

year	value	nep.fu.16	nep.fu.17	nep.fu.19	nep.fu.2021	nep.fu.22	nep.out.7
2020	catch	2274	168	252	3029	2104	244
2020	discards	0	0	0	0	0	0
2020	discards.dead	0	0	0	0	0	NA
2020	discards.surviving	0	0	0	0	0	NA
2020	Fbar	0.001	0.002	0.003	0.001	0.001	NaN
2020	FmultVsF19	0.019	0.126	0.082	0.004	0.015	NaN
2020	landings	2274	168	252	3029	2104	244
2021	catch	3290	508	595	1710	1560	150
2021	discards	0	72	156	281	188	0
2021	discards.dead	0	54	117	211	141	NA
2021	discards.surviving	0	18	39	70	47	NA
2021	Fbar	0.062	0.062	0.069	0.06	0.097	NaN
2021	FmultVsF19	1.485	3.341	2.118	0.283	1.142	NaN
2021	landings	3290	437	439	1430	1371	150

Table 3.3. Comparison between baseline run and ICES advice. Figures for 2020 compare results from the baseline run to the ICES intermediate year results. The baseline run uses the same assumptions for F in the intermediate year as the forecasts leading to ICES advice.

year	stock	value	FCube.baseline	Single.Spp.Advice	diff
2020	cod.27.7e-k	catch	1056.00	1055.00	0.1
2020	cod.27.7e-k	discards	0.00	250.00	-100.0
2020	cod.27.7e-k	Fbar	0.48	0.48	0.0
2020	cod.27.7e-k	landings	1056.00	805.00	31.2
2020	cod.27.7e-k	ssb	1587.00	1587.00	0.0
2020	had.27.7b-k	catch	20172.00	20274.00	-0.5
2020	had.27.7b-k	discards	0.00	11084.00	-100.0
2020	had.27.7b-k	Fbar	0.41	0.41	-1.0
2020	had.27.7b-k	landings	20172.00	9190.00	119.5
2020	had.27.7b-k	ssb	66388.00	66169.00	0.3
2020	meg.27.7b-k8abd	catch	20124.00	20350.00	-1.1
2020	meg.27.7b-k8abd	discards	0.00	3149.00	-100.0
2020	meg.27.7b-k8abd	Fbar	0.21	0.21	0.0
2020	meg.27.7b-k8abd	landings	20124.00	17201.00	17.0
2020	meg.27.7b-k8abd	ssb	106654.00	123589.00	-13.7
2020	mon.27.78abd	catch	24349.00	24343.00	0.0
2020	mon.27.78abd	discards	0.00	1480.00	-100.0
2020	mon.27.78abd	Fbar	0.22	0.22	0.0
2020	mon.27.78abd	landings	24349.00	22863.00	6.5
2020	mon.27.78abd	ssb	68952.00	68952.00	0.0
2020	nep.fu.16	catch	2274.00	2637.00	-13.8
2020	nep.fu.16	discards	0.00	0.00	NaN
2020	nep.fu.16	discards.dead	0.00	0.00	NaN
2020	nep.fu.16	discards.surviving	0.00	0.00	NaN
2020	nep.fu.16	Fbar	0.00	0.06	-98.4
2020	nep.fu.16	landings	2274.00	2637.00	-13.8
2020	nep.fu.16	ssb	NA	1010.00	NA

2020	nep.fu.17	catch	168.00	800.00	-79.0
2020	nep.fu.17	discards	0.00	107.00	-100.0
2020	nep.fu.17	discards.dead	0.00	80.00	-100.0
2020	nep.fu.17	discards.surviving	0.00	27.00	-100.0
2020	nep.fu.17	Fbar	0.00	0.08	-97.4
2020	nep.fu.17	landings	168.00	694.00	-75.8
2020	nep.fu.17	ssb	NA	493.00	NA
2020	nep.fu.19	catch	252.00	839.00	-70.0
2020	nep.fu.19	discards	0.00	203.00	-100.0
2020	nep.fu.19	discards.dead	0.00	152.00	-100.0
2020	nep.fu.19	discards.surviving	0.00	51.00	-100.0
2020	nep.fu.19	Fbar	0.00	0.08	-96.4
2020	nep.fu.19	landings	252.00	636.00	-60.4
2020	nep.fu.19	ssb	NA	386.00	NA
2020	nep.fu.2021	catch	3029.00	1150.00	163.4
2020	nep.fu.2021	discards	0.00	215.00	-100.0
2020	nep.fu.2021	discards.dead	0.00	161.00	-100.0
2020	nep.fu.2021	discards.surviving	0.00	54.00	-100.0
2020	nep.fu.2021	Fbar	0.00	0.06	-98.3
2020	nep.fu.2021	landings	3029.00	935.00	224.0
2020	nep.fu.2021	ssb	NA	617.00	NA
2020	nep.fu.22	catch	2104.00	2820.00	-25.4
2020	nep.fu.22	discards	0.00	368.00	-100.0
2020	nep.fu.22	discards.dead	0.00	276.00	-100.0
2020	nep.fu.22	discards.surviving	0.00	92.00	-100.0
2020	nep.fu.22	Fbar	0.00	0.13	-99.2
2020	nep.fu.22	landings	2104.00	2452.00	-14.2
2020	nep.fu.22	ssb	NA	1121.00	NA
2020	nep.out.7	catch	244.00	188.00	29.8
2020	nep.out.7	discards	0.00	NA	NA
2020	nep.out.7	discards.dead	NA	NA	NA
2020	nep.out.7	discards.surviving	NA	NA	NA
2020	nep.out.7	Fbar	NaN	NA	NaN
2020	nep.out.7	landings	244.00	188.00	29.8
2020	nep.out.7	ssb	NA	NA	NA

2020	sol.27.7fg	catch	1652.00	1652.00	0.0
2020	sol.27.7fg	discards	0.00	123.00	-100.0
2020	sol.27.7fg	Fbar	0.30	0.30	0.0
2020	sol.27.7fg	landings	1652.00	1529.00	8.0
2020	sol.27.7fg	ssb	6286.00	6293.00	-0.1
2020	whg.27.7b-ce-k	catch	8743.00	8774.00	-0.4
2020	whg.27.7b-ce-k	discards	0.00	1836.00	-100.0
2020	whg.27.7b-ce-k	Fbar	0.50	0.50	0.0
2020	whg.27.7b-ce-k	landings	8743.00	6938.00	26.0
2020	whg.27.7b-ce-k	ssb	30970.00	31034.00	-0.2
2021	cod.27.7e-k	catch	0.00	0.00	NaN
2021	cod.27.7e-k	discards	0.00	0.00	NaN
2021	cod.27.7e-k	Fbar	0.00	0.00	NaN
2021	cod.27.7e-k	landings	0.00	0.00	NaN
2021	cod.27.7e-k	ssb	2942.00	2943.00	0.0
2021	had.27.7b-k	catch	18374.00	18382.00	0.0
2021	had.27.7b-k	discards	0.00	8612.00	-100.0
2021	had.27.7b-k	Fbar	0.35	0.35	0.0
2021	had.27.7b-k	landings	18374.00	9770.00	88.1
2021	had.27.7b-k	ssb	71273.00	71323.00	-0.1
2021	meg.27.7b-k8abd	catch	19030.00	19184.00	-0.8
2021	meg.27.7b-k8abd	discards	0.00	2730.00	-100.0
2021	meg.27.7b-k8abd	Fbar	0.19	0.19	-0.5
2021	meg.27.7b-k8abd	landings	19030.00	16454.00	15.7
2021	meg.27.7b-k8abd	ssb	110436.00	111674.00	-1.1
2021	mon.27.78abd	catch	34577.00	34579.00	0.0
2021	mon.27.78abd	discards	0.00	1479.00	-100.0
2021	mon.27.78abd	Fbar	0.28	0.28	0.0
2021	mon.27.78abd	landings	34577.00	33100.00	4.5
2021	mon.27.78abd	ssb	72213.00	72213.00	0.0

2021	nep.fu.16	catch	3290.00	3290.00	0.0
2021	nep.fu.16	discards	0.00	0.00	NaN
2021	nep.fu.16	discards.dead	0.00	0.00	NaN
2021	nep.fu.16	discards.surviving	0.00	0.00	NaN
2021	nep.fu.16	Fbar	0.06	0.06	0.0
2021	nep.fu.16	landings	3290.00	3290.00	0.0
2021	nep.fu.16	ssb	NA	1264.00	NA
2021	nep.fu.17	catch	508.00	508.00	0.0
2021	nep.fu.17	discards	72.00	72.00	0.0
2021	nep.fu.17	discards.dead	54.00	54.00	0.0
2021	nep.fu.17	discards.surviving	18.00	18.00	0.0
2021	nep.fu.17	Fbar	0.06	0.06	0.0
2021	nep.fu.17	landings	437.00	436.00	0.2
2021	nep.fu.17	ssb	NA	394.00	NA
2021	nep.fu.19	catch	595.00	595.00	0.0
2021	nep.fu.19	discards	156.00	156.00	0.0
2021	nep.fu.19	discards.dead	117.00	117.00	0.0
2021	nep.fu.19	discards.surviving	39.00	39.00	0.0
2021	nep.fu.19	Fbar	0.07	0.07	0.0
2021	nep.fu.19	landings	439.00	439.00	0.0
2021	nep.fu.19	ssb	NA	320.00	NA
2021	nep.fu.2021	catch	1710.00	1710.00	0.0
2021	nep.fu.2021	discards	281.00	281.00	0.0
2021	nep.fu.2021	discards.dead	211.00	211.00	0.0
2021	nep.fu.2021	discards.surviving	70.00	70.00	0.0
2021	nep.fu.2021	Fbar	0.06	0.06	0.0
2021	nep.fu.2021	landings	1430.00	1430.00	0.0
2021	nep.fu.2021	ssb	NA	1020.00	NA
2021	nep.fu.22	catch	1560.00	1560.00	0.0
2021	nep.fu.22	discards	188.00	188.00	0.0
2021	nep.fu.22	discards.dead	141.00	141.00	0.0
2021	nep.fu.22	discards.surviving	47.00	47.00	0.0
2021	nep.fu.22	Fbar	0.10	0.10	0.0
2021	nep.fu.22	landings	1371.00	1371.00	0.0
2021	nep.fu.22	ssb	NA	750.00	NA

2021	nep.out.7	catch	150.00	150.00	0.0
2021	nep.out.7	discards	0.00	NA	NA
2021	nep.out.7	discards.dead	NA	NA	NA
2021	nep.out.7	discards.surviving	NA	NA	NA
2021	nep.out.7	Fbar	NaN	NA	NaN
2021	nep.out.7	landings	150.00	150.00	0.0
2021	nep.out.7	ssb	NA	NA	NA
2021	sol.27.7fg	catch	1417.00	1413.00	0.3
2021	sol.27.7fg	discards	0.00	105.00	-100.0
2021	sol.27.7fg	Fbar	0.25	0.25	0.0
2021	sol.27.7fg	landings	1417.00	1308.00	8.3
2021	sol.27.7fg	ssb	6194.00	6197.00	0.0
2021	whg.27.7b-ce-k	catch	5267.00	5261.00	0.1
2021	whg.27.7b-ce-k	discards	0.00	1046.00	-100.0
2021	whg.27.7b-ce-k	Fbar	0.27	0.27	0.0
2021	whg.27.7b-ce-k	landings	5267.00	4215.00	25.0
2021	whg.27.7b-ce-k	ssb	32055.00	32108.00	-0.2
2022	cod.27.7e-k	ssb	6075.00	6078.00	0.0
2022	had.27.7b-k	ssb	70024.00	70434.00	-0.6
2022	meg.27.7b-k8abd	ssb	114497.00	115734.00	-1.1
2022	mon.27.78abd	ssb	80416.00	80416.00	0.0
2022	sol.27.7fg	ssb	5997.00	6009.00	-0.2
2022	whg.27.7b-ce-k	ssb	37456.00	37494.00	-0.1

Table 3.4. Celtic Sea. Results of Final FCube runs.

value	year	sc	cod.27.7e.k	had.27.7b.k	meg.27.7b.k8abd
catches	2020	sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
Fbar	2020	baseline	0.4770000	0.4060000	0.2100000
		sq_E	0.4770000	0.4060000	0.2127418
	2021	baseline	0.0000000	0.3530000	0.1900000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.1620000	0.3530000	0.1682417
		max	2.0000000	0.6640000	0.5109725
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.3370000	0.4230000	0.2144743
		val	1.2160000	0.3840000	0.2008717
		whg.27.7b-ce-k	0.6180000	0.1910000	0.0988390
FmultVsF19	2020	baseline	0.4200000	1.0000000	1.2000000
		sq_E	0.5409612	0.1647657	1.2000000
	2021	baseline	0.0000000	0.8700000	1.0800000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.3178132	0.1432568	0.9500000
		max	2.2681810	0.2694690	2.8900000
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.5162790	0.1716647	1.2100000
		val	1.3790541	0.1558375	1.1400000
		whg.27.7b-ce-k	0.7008679	0.0775129	0.5600000
landings	2020	baseline	1056.0000000	20172.0000000	20124.0000000
		sq_E	1056.0000000	20109.0000000	20124.0000000
	2021	baseline	0.0000000	18374.0000000	19030.0000000
		cod_fmsy	0.0000000	6.0000000	0.0000000
		had.27.7b-k	2813.0000000	18407.0000000	16948.0000000
		max	3628.0000000	30918.0000000	43865.0000000
		min	0.0000000	6.0000000	0.0000000
		sq_E	3035.0000000	21518.0000000	21128.0000000
		val	2885.0000000	19924.0000000	19918.0000000
		whg.27.7b-ce-k	1856.0000000	10633.0000000	10300.0000000
ssb	2020	baseline	1587.0000000	66388.0000000	106654.0000000
	2021		2942.0000000	71273.0000000	110436.0000000
		sq_E	2942.0000000	71456.0000000	110436.0000000
	2022	cod_fmsy	6075.0000000	91996.0000000	134821.0000000
		had.27.7b-k	2045.0000000	70166.0000000	116711.0000000
		max	977.0000000	55911.0000000	88311.0000000
		min	6075.0000000	91697.0000000	134821.0000000
		sq_E	1746.0000000	66379.0000000	112267.0000000
		val	1948.0000000	68961.0000000	113553.0000000
		whg.27.7b-ce-k	3378.0000000	78993.0000000	123797.0000000

value	year	sc	mon.27.78abd	sol.27.7fg	whg.27.7b.ce.k
catches	2020	sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
Fbar	2020	baseline	0.2200000	0.2960000	0.4950000
		sq_E	0.2193830	0.2960000	0.4950000
	2021	baseline	0.2800000	0.2510000	0.2680000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	0.2272185	0.1140000	0.4900000
		max	0.5683904	0.5270000	0.8890000
		min	0.0000000	0.0000000	0.0000000
		sq_E	0.2789975	0.2460000	0.5650000
		val	0.2635394	0.2400000	0.5080000
		whg.27.7b-ce-k	0.1343606	0.0750000	0.2680000
FmultVsF19	2020	baseline	1.0000000	1.2500000	1.4000000
		sq_E	1.0000000	0.0715683	0.1760882
	2021	baseline	1.2800000	1.0400000	0.7500000
		cod_fmsy	0.0000000	0.0000000	0.0000000
		had.27.7b-k	1.0400000	0.0275634	0.1743096
		max	2.5900000	0.1274205	0.3162474
		min	0.0000000	0.0000000	0.0000000
		sq_E	1.2700000	0.0594790	0.2009896
		val	1.2000000	0.0580283	0.1807128
		whg.27.7b-ce-k	0.6100000	0.0181338	0.0953367
landings	2020	baseline	24349.0000000	1652.0000000	8743.0000000
		sq_E	24349.0000000	1652.0000000	8752.0000000
	2021	baseline	34577.0000000	1417.0000000	5267.0000000
		cod_fmsy	0.0000000	1.0000000	2.0000000
		had.27.7b-k	28697.0000000	688.0000000	8772.0000000
		max	62333.0000000	2619.0000000	13692.0000000
		min	0.0000000	1.0000000	2.0000000
		sq_E	34467.0000000	1391.0000000	9781.0000000
		val	32772.0000000	1364.0000000	8995.0000000
		whg.27.7b-ce-k	17664.0000000	459.0000000	5260.0000000
ssb	2020	baseline	68952.0000000	6286.0000000	30970.0000000
	2021		72213.0000000	6194.0000000	32055.0000000
		sq_E	72213.0000000	6194.0000000	32113.0000000
	2022	cod_fmsy	102907.0000000	7462.0000000	42119.0000000
		had.27.7b-k	84206.0000000	6750.0000000	34631.0000000
		max	62737.0000000	4769.0000000	30653.0000000
		min	102907.0000000	7462.0000000	42162.0000000
		sq_E	80486.0000000	6024.0000000	33778.0000000
		val	81577.0000000	6051.0000000	34431.0000000
		whg.27.7b-ce-k	91358.0000000	6988.0000000	37480.0000000

value	year	sc	nep.fu.16	nep.fu.17	nep.fu.19	nep.fu.2021	nep.fu.22	nep.out.7
catches	2020	sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	509.0000000	595.0000000	1711.0000000	1559.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
Fbar	2020	baseline	0.0010000	0.0020000	0.0030000	0.0010000	0.0010000	NA
		sq_E	0.0417372	0.0185618	0.0326273	0.2121641	0.0849483	NA
	2021	baseline	0.0620000	0.0620000	0.0690000	0.0600000	0.0970000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	0.0742993	0.0257433	0.0245911	0.0485506	0.0949084	NA
		max	0.2874574	0.0523919	0.0456170	0.1133129	0.3047684	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	0.0601830	0.0286532	0.0276187	0.0592097	0.0881339	NA
		val	0.0667722	0.0247017	0.0234114	0.0520210	0.0872141	NA
		whg.27.7b-ce-k	0.0410794	0.0151896	0.0141967	0.0298658	0.0541514	NA
FmultVsF19	2020	baseline	0.0190000	0.1260000	0.0820000	0.0040000	0.0150000	NA
		sq_E	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	NA
	2021	baseline	1.4850000	3.3410000	2.1180000	0.2830000	1.1420000	NA
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		had.27.7b-k	1.7800000	1.3900000	0.7500000	0.2300000	1.1200000	NA
		max	6.8900000	2.8200000	1.4000000	0.5300000	3.5900000	NA
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	NA
		sq_E	1.4400000	1.5400000	0.8500000	0.2800000	1.0400000	NA
		val	1.6000000	1.3300000	0.7200000	0.2500000	1.0300000	NA
		whg.27.7b-ce-k	0.9800000	0.8200000	0.4400000	0.1400000	0.6400000	NA
landings	2020	baseline	2274.0000000	168.0000000	252.0000000	3029.0000000	2104.0000000	244.0000
		sq_E	NA	NA	NA	NA	NA	NA
	2021	baseline	3290.0000000	437.0000000	439.0000000	1430.0000000	1371.0000000	150.0000
		cod_fmsy	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		had.27.7b-k	5012.5901668	196.6153638	198.5203810	1272.9584650	1669.2524230	179.8099
		max	19393.2554166	400.1440447	368.2602331	2970.9740548	5360.2791223	613.5746
		min	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000
		sq_E	4060.2330300	218.8396632	222.9621328	1552.4313071	1550.1033245	163.7590
		val	4504.7710992	188.6596233	188.9969943	1363.9502207	1533.9249089	167.5433
		whg.27.7b-ce-k	2771.4153199	116.0108179	114.6078043	783.0561888	952.4162242	102.0188
ssb	2020	baseline	NA	NA	NA	NA	NA	NA
	2021		NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
	2022	cod_fmsy	NA	NA	NA	NA	NA	NA
		had.27.7b-k	NA	NA	NA	NA	NA	NA
		max	NA	NA	NA	NA	NA	NA
		min	NA	NA	NA	NA	NA	NA
		sq_E	NA	NA	NA	NA	NA	NA
		val	NA	NA	NA	NA	NA	NA
		whg.27.7b-ce-k	NA	NA	NA	NA	NA	NA

Table 3.5. Mixed-fisheries advice in the Celtic Seas ecoregion. Catch per mixed-fisheries scenario 2021, in absolute values.

Stock	Single-stock catch advice (2021)**	Catch per mixed-fisheries scenario (2021)						range*	
		max	min	sq_E	cod_F_{AR}MSY	val	had.27.7b–k	whg.27.7b–ce–k	
cod.27.7e–k	0	3614	0	2787	544	2631	2548	1669	743
had.27.7b–k	18382^	30722	0	21448	3295	19781	18471	10766	12540
meg.27.7b–k8abd	19184^	43915	0	21130	2562	19925	16952	10355	13093
mon.27.78abd	34579^	62462	0	34467	4641	32785	28702	17808	23556
sol.27.7fg	1413^	2620	0	1391	183	1364	688	459	823
whg.27.7b–ce–k	5261^	13657	0	9751	1573	8939	8678	5273	4473

Stock	Single-stock catch advice (2021)**	Catch per mixed-fisheries scenario (2021)						range*	
		max	min	sq_E	cod_F_{AR}MSY	val	had.27.7b–k	whg.27.7b–ce–k	
nep.fu.16	3290^	15254	0	3193	485	3543	3942	2181	-
nep.fu.17	508^	412	0	225	26	194	202	119	-
nep.fu.19	595^	351	0	212	25	180	189	109	-
nep.fu.2021	1710^	3015	0	1574	193	1383	1290	795	-
nep.fu.22	1560^	4652	0	1345	183	1331	1449	827	-
nep.out.7	150	510	0	141	20	143	152	87	-

*** The results of the "range" scenario are bounded by the single-stock MSY ranges (or reduced ranges) and does not directly account for any technical interactions. These catches could only be achieved with substantial changes in fishing patterns.**

**** Advised catches of no more than the indicated value.**

^ Single-stock advice based on F ranges (or reduced ranges) in accordance with the MAP for demersal stocks in the western waters (EU, 2019). The value presented here is for catches corresponding to F_{MSY} (or F_{MSY} × SSB_{2021}/MSY $B_{trigger}$).

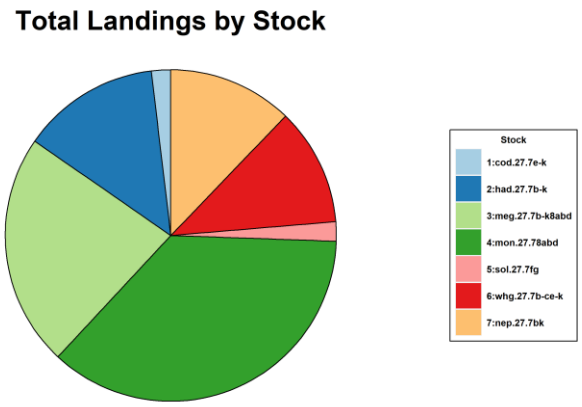


Figure 3.1. Celtic Sea. Distribution of landings of those stocks included in the mixed fisheries projections.

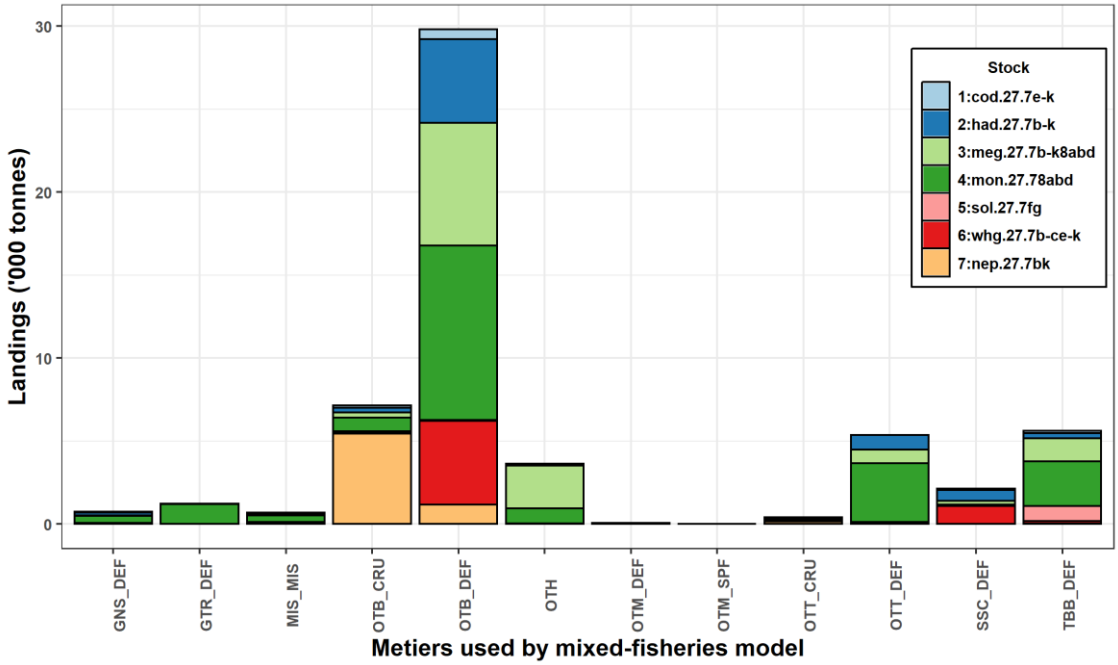


Figure 3.2. Celtic Sea. Landings distribution of species by métier with landings consisting of ≥1% of any of the stocks (1-7)(average from 2017-2019) Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks 1–7)(average from 2017-2019).

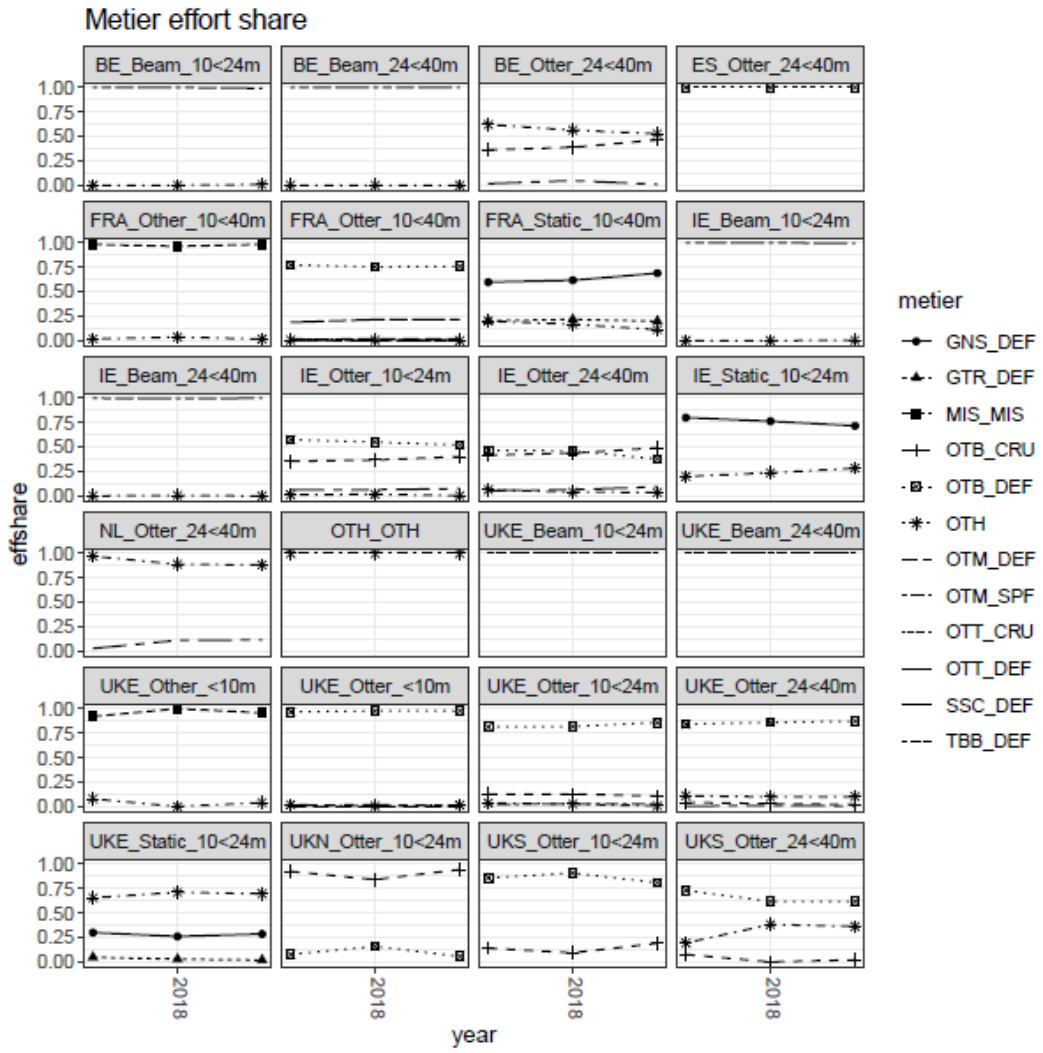


Figure 3.3. Effort share (in proportion) by métier for each fleet.

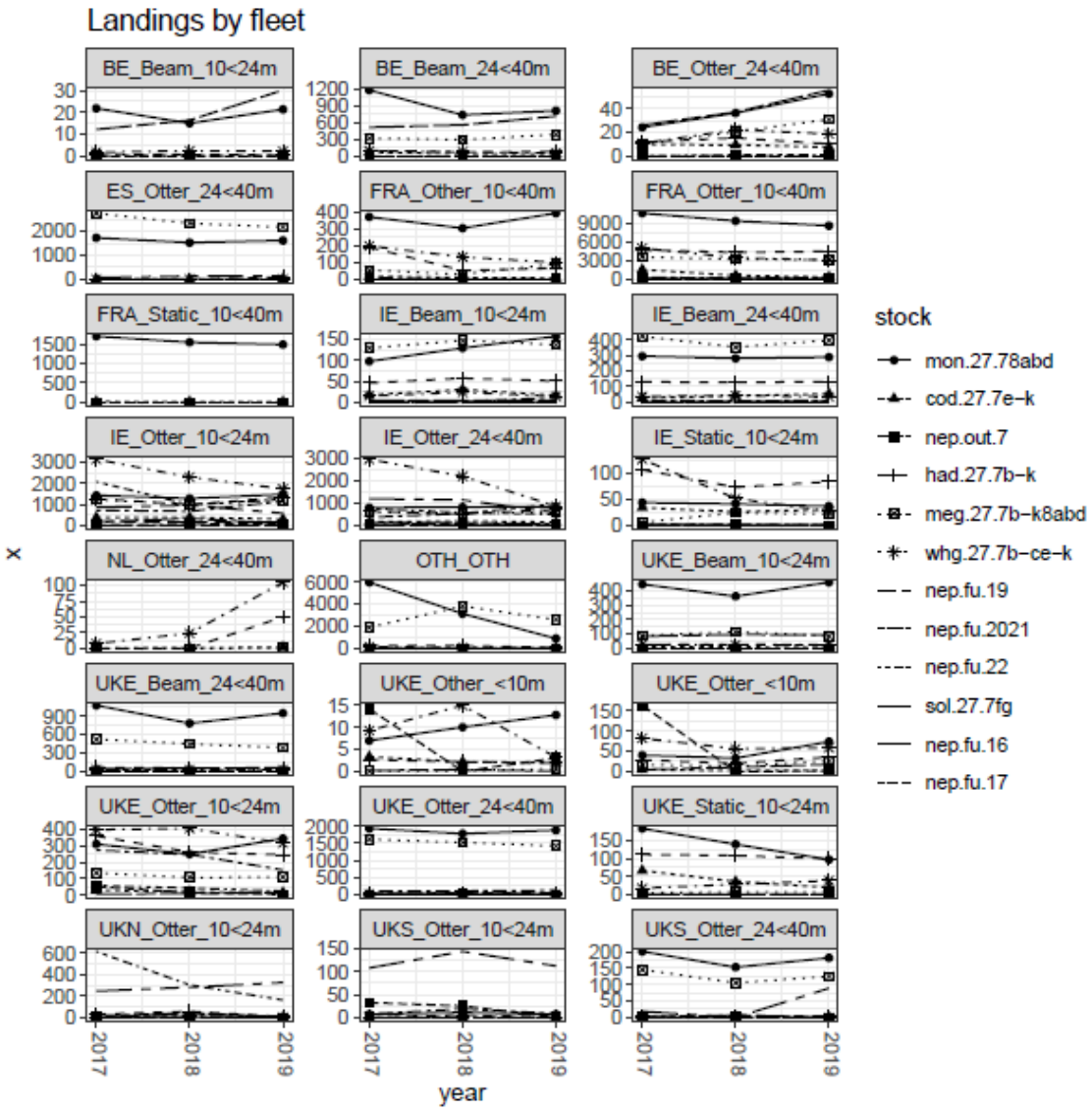


Figure 3.4. Landings by fleet, stock and year. Note: different scales on the y-axis.

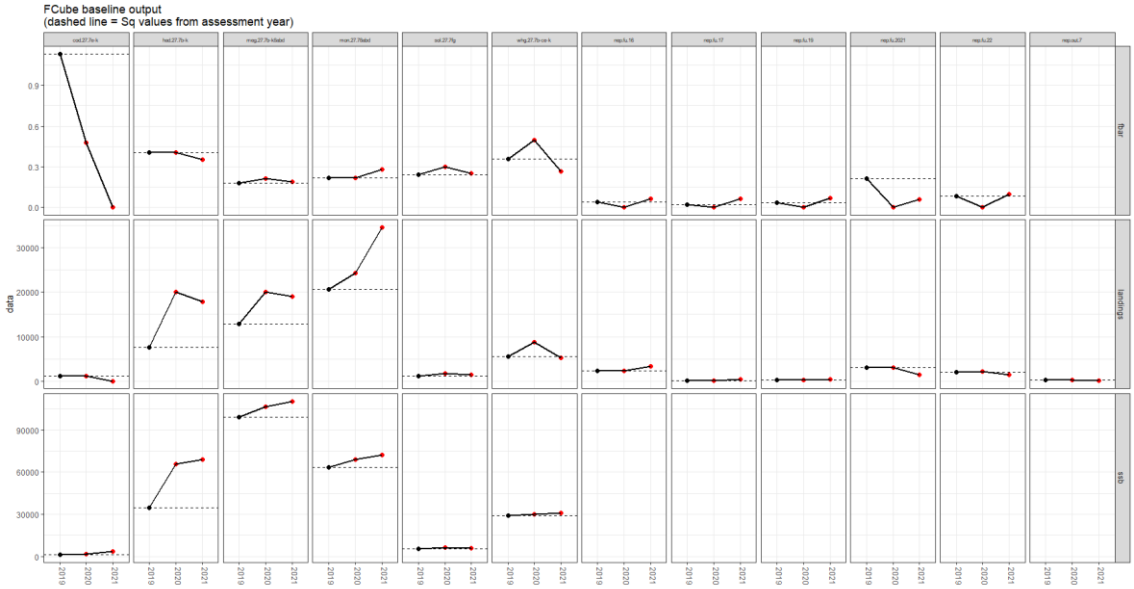


Figure 3.5. Change in fishing mortality (Fbar), landings (tonnes) and SSB (tonnes) assumed in the intermediate year (2020) and required for the TAC year (2021) under the single-stock forecast assumptions consistent with the MSY approach.

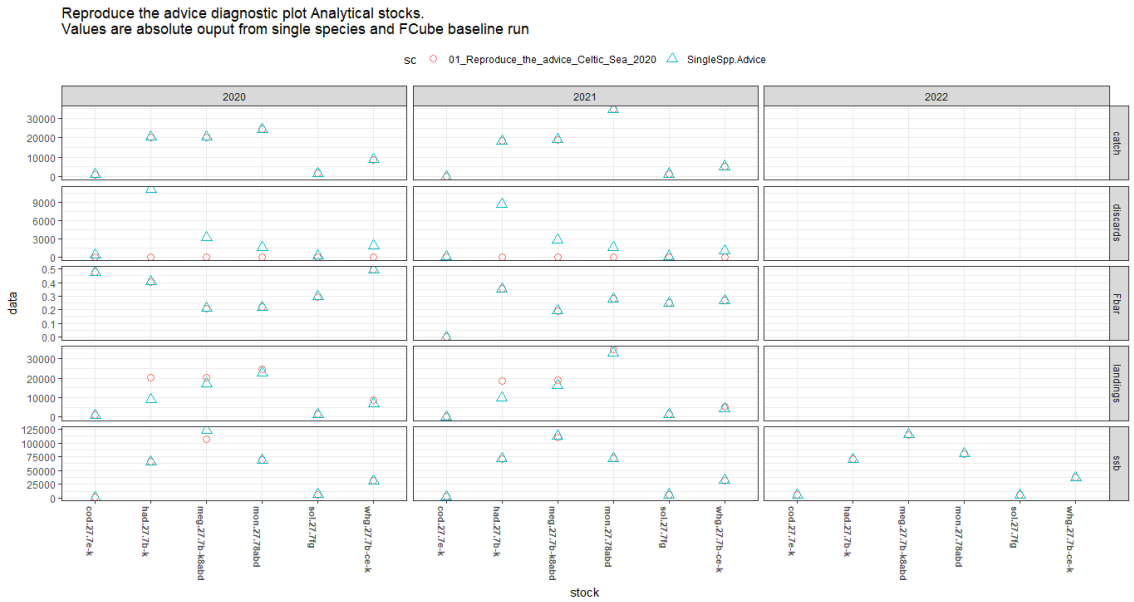


Figure 3.6. Celtic Sea. Difference between FCube baseline run and single-species advice for finfish stocks, showing Fbar (2020–2021), catch, discards and landings (2020–2021) and SSB (2019–2022).

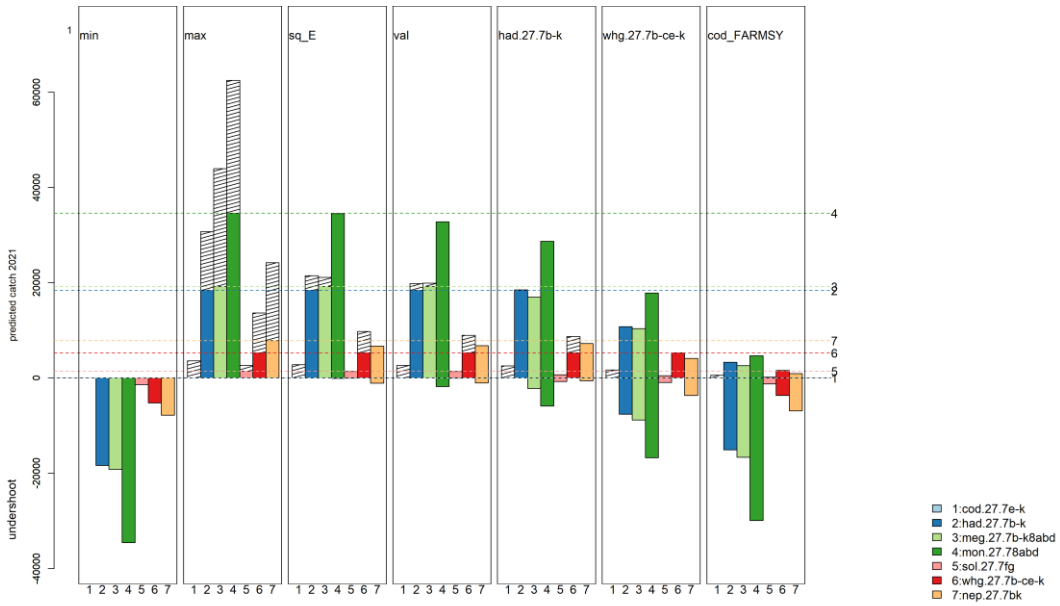


Figure 3.7. Celtic Sea. TAC year results (2021). FCube estimates of potential landings by stock after applying the status quo effort scenario to all stocks in the intermediate year followed by the FCube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species TAC) in cases where landings are predicted to be lower when applying the scenario.

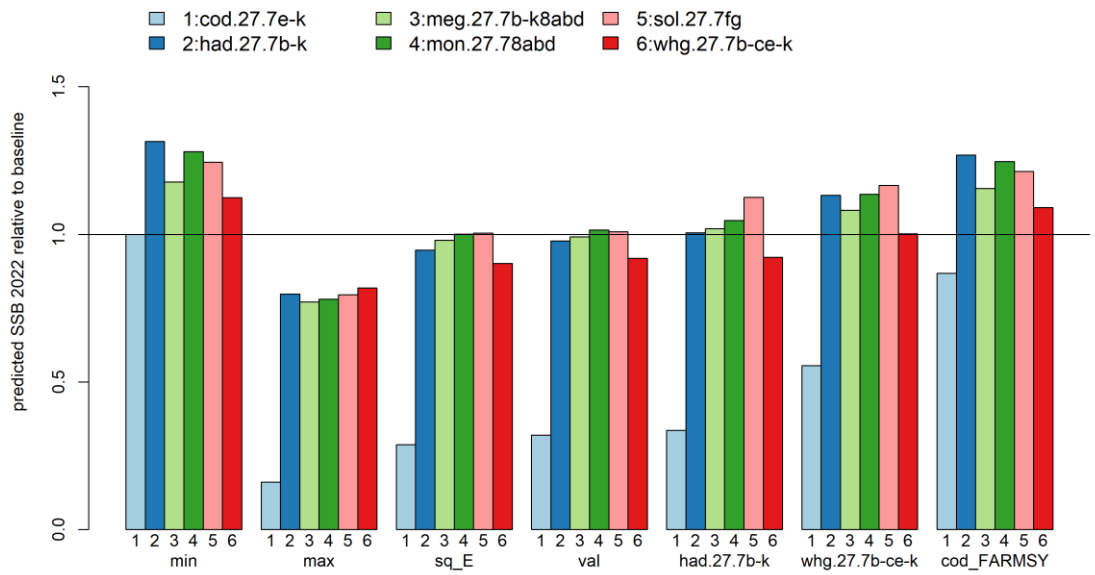


Figure 3.8. Mixed fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential SSB at the start of 2022 by stock after applying the mixed fisheries scenarios, relative to SSB resulting from the single-stock advice forecast (the horizontal line).

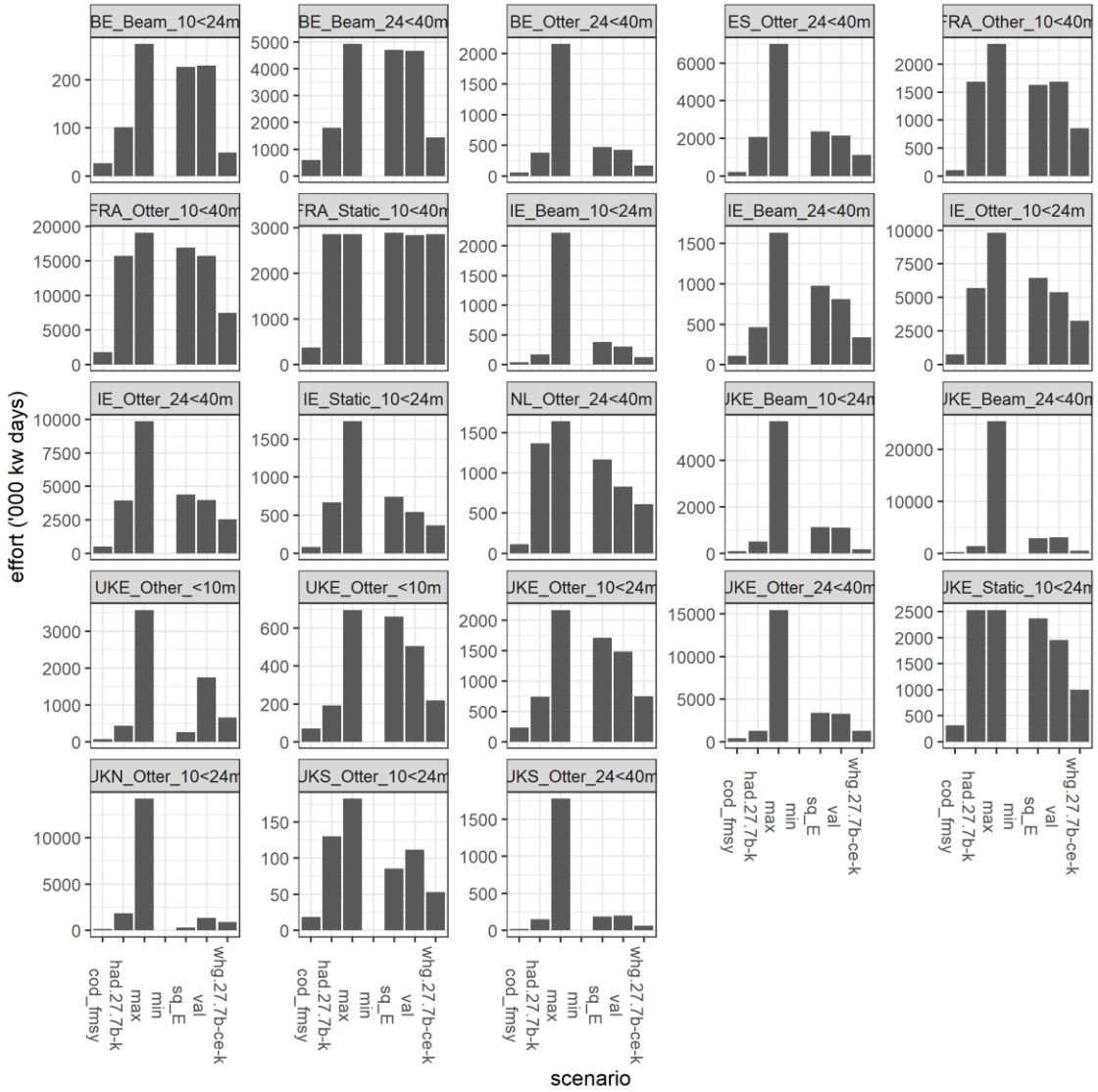


Figure 3.93. Celtic Sea. FCube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2021 (baseline run).

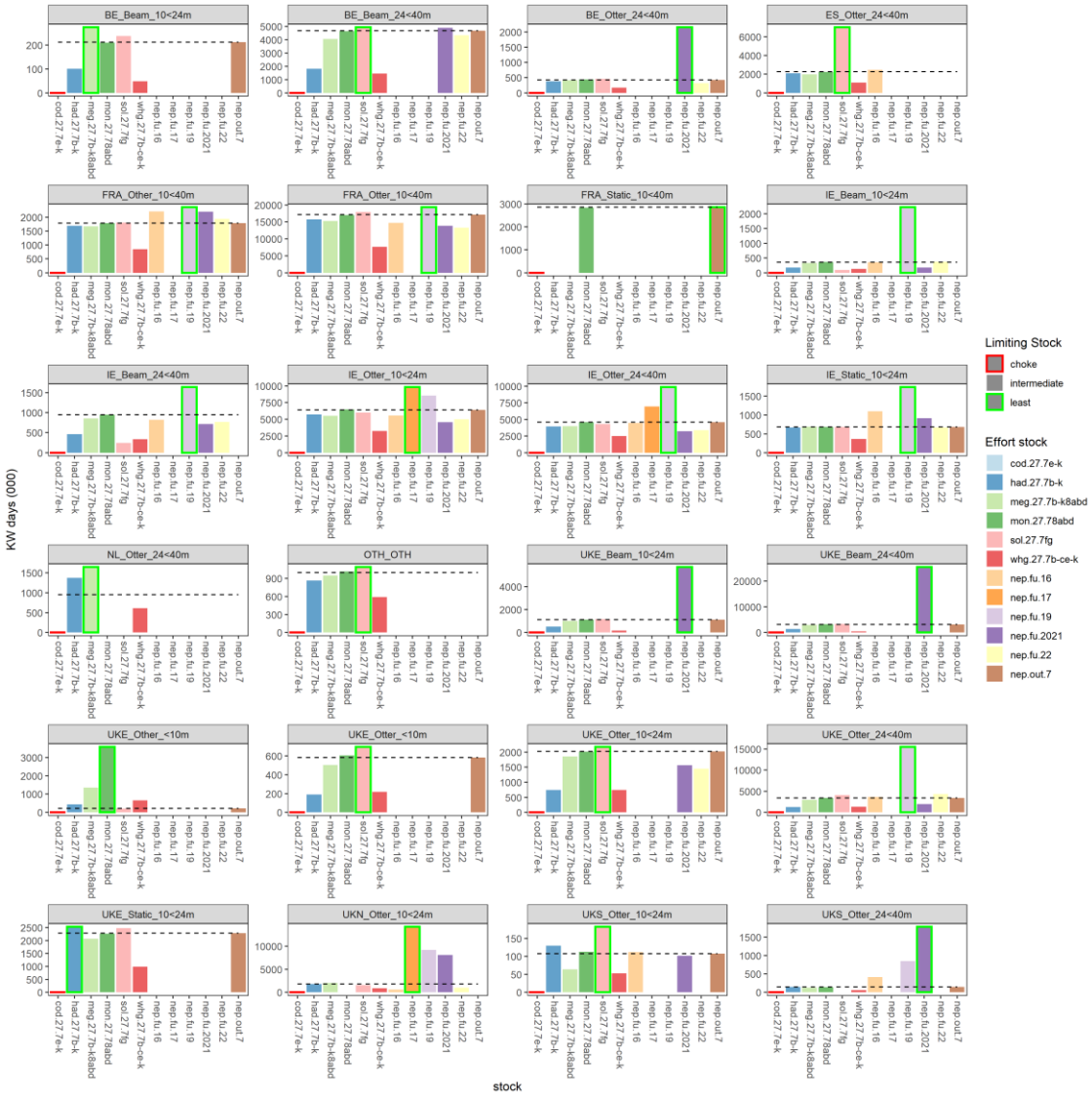


Figure 3.4. Estimates of effort by fleet needed to reach the single-stock advices. Bars highlighted in red correspond to the most limiting species for that fleet in 2021 ("choke species"), whereas the green highlight correspond to the least limiting species.

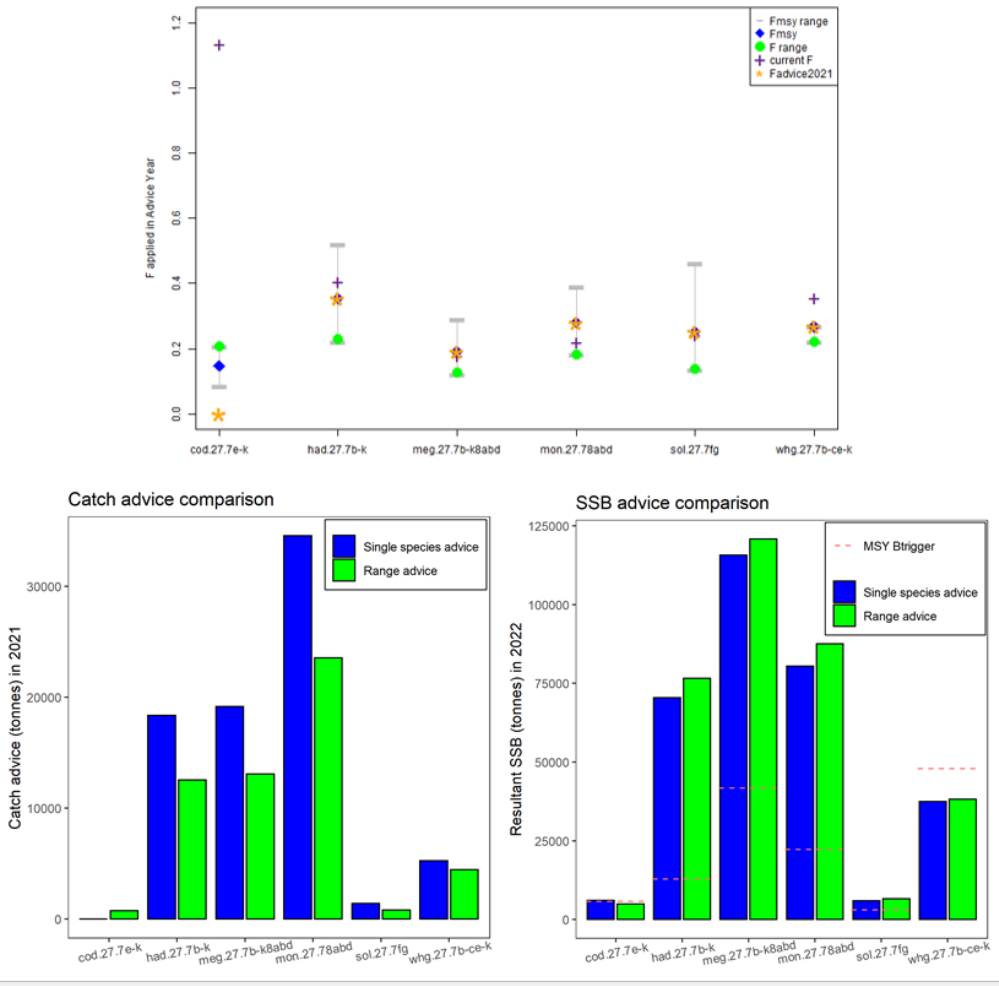
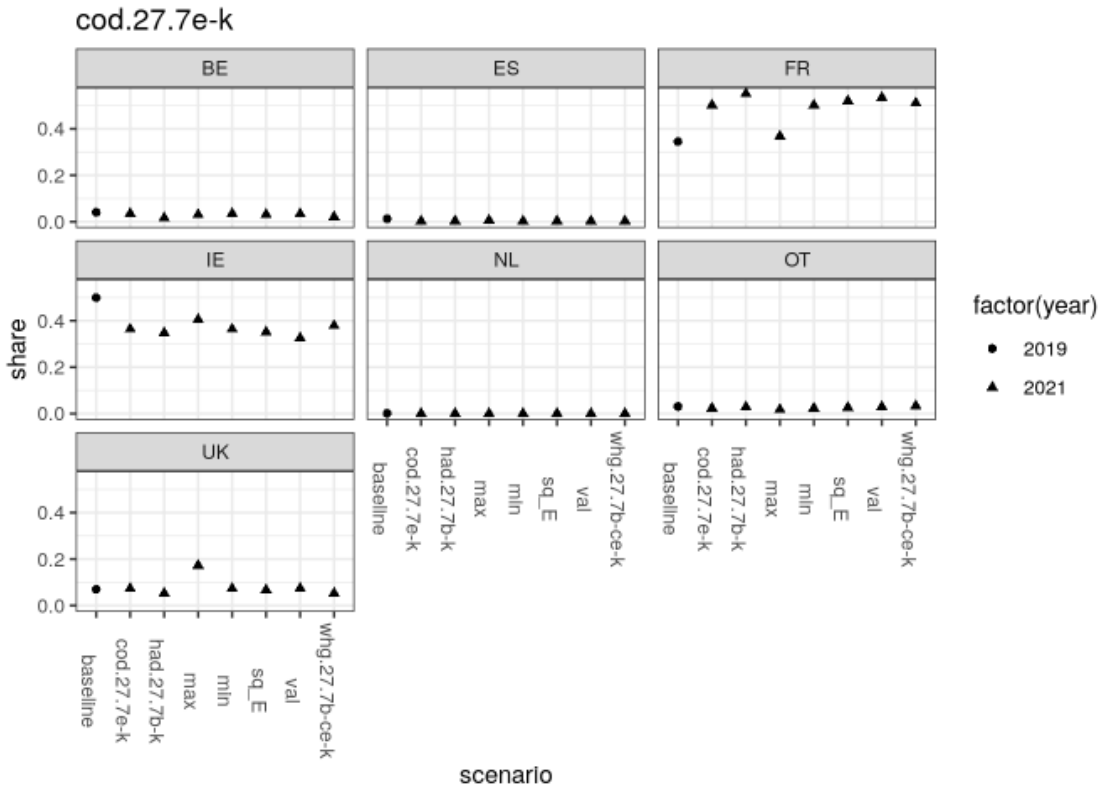
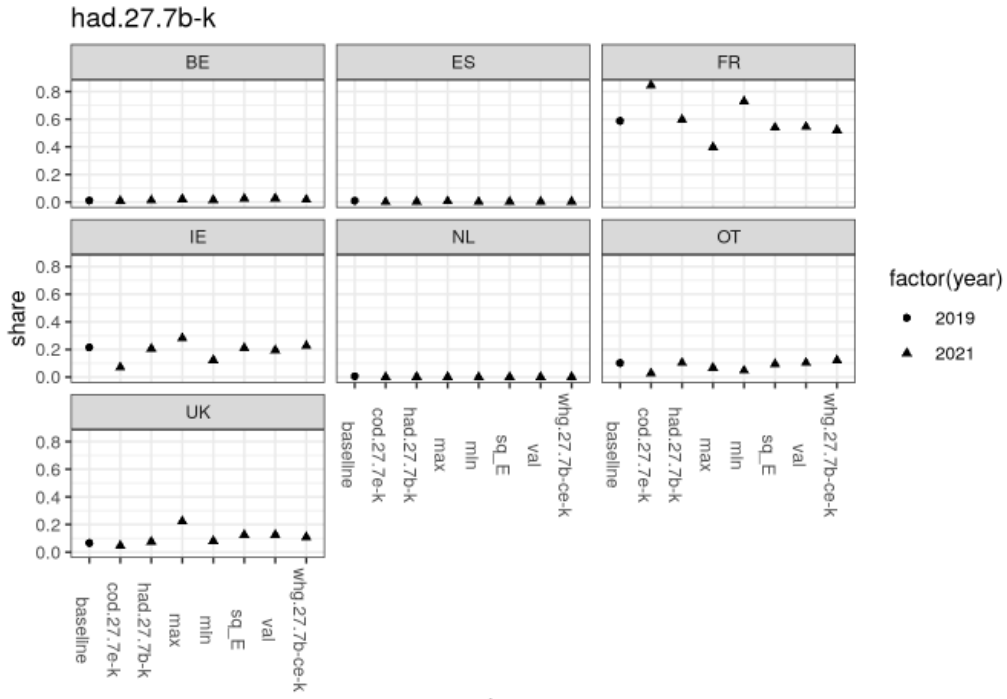
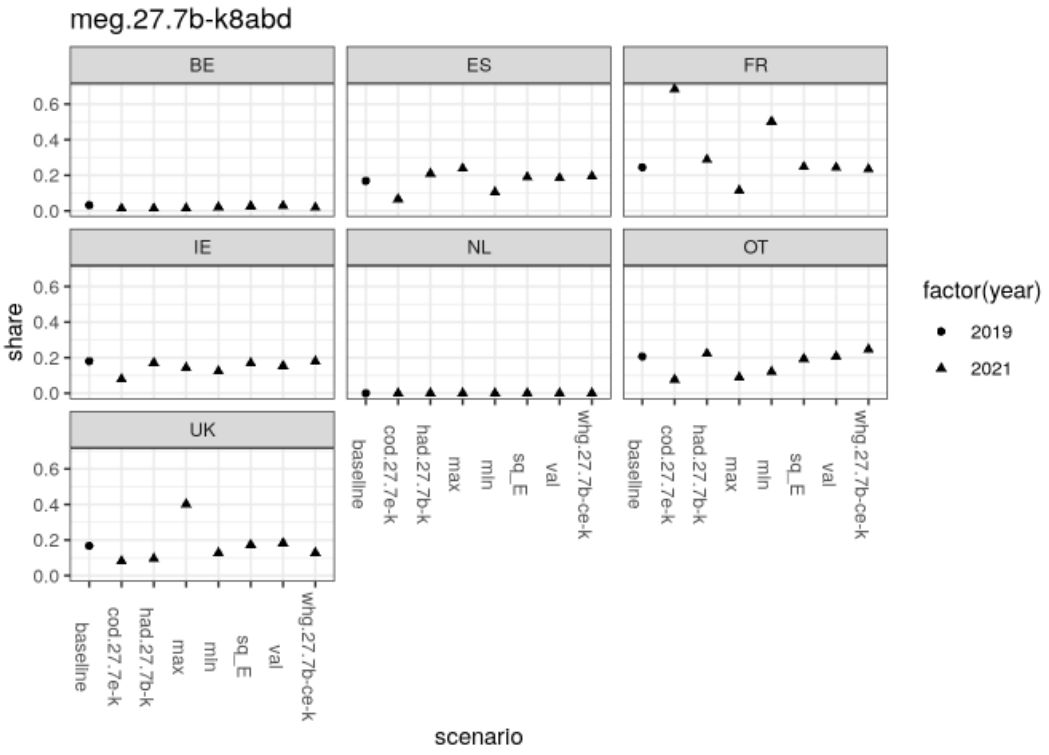
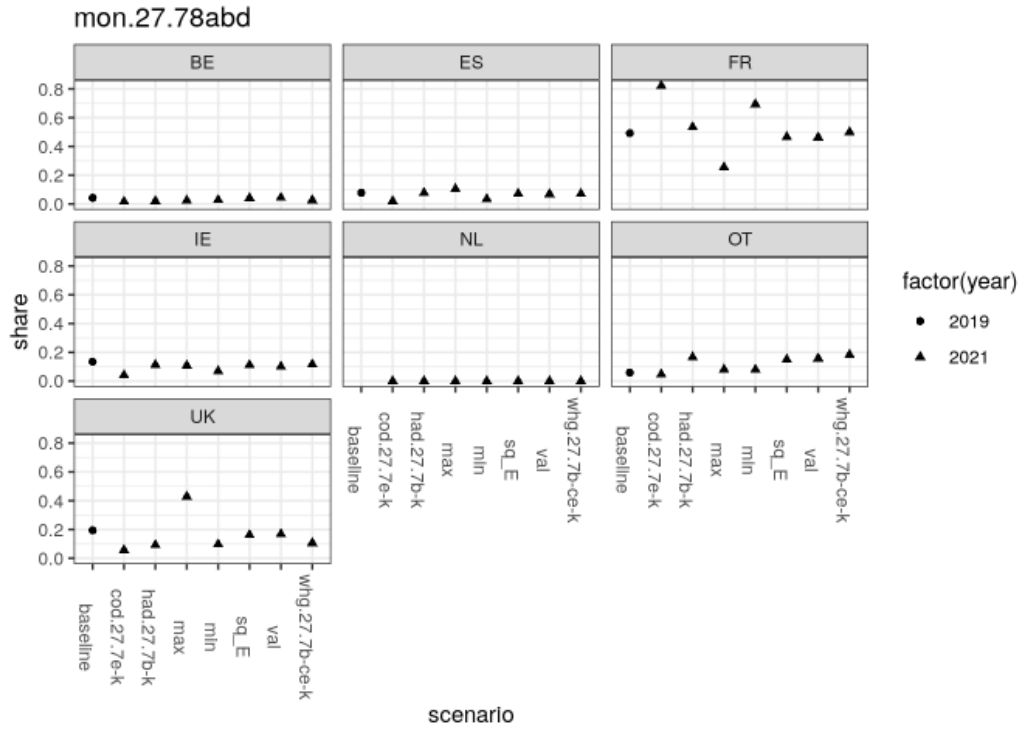


Figure 3.5. Range scenario advice for divisions 7.b–c and 7.e–k. Left: the fishing mortality rates for each stock which reduce the mismatch between opportunities for the three stocks (green point), along with the current fishing mortality (purple cross), the fishing mortality corresponding to the single-stock advice (yellow star) and the F_{MSY} (blue rotated square) and the F_{MSY} ranges (grey lines). Right: Comparison of the outcomes in terms of total catches in 2021 (top) and SSB in 2022 (Bottom) between the F_{MSY}-based single-stock advice and the F-range based forecast.


cod.27.7e-k
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
scenario
factor(year)
2019
2021


had.27.7b-k
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
0.6
0.8
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
factor(year)
2019
2021


meg.27.7b-k8abd
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
0.6
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
scenario
factor(year)
2019
2021


mon.27.78abd
BE
ES
FR
IE
NL
OT
UK
share
0.0
0.2
0.4
0.6
0.8
baseline
cod.27.7e-k
had.27.7b-k
max
min
sq_E
val
whg.27.7b-ce-k
scenario
factor(year)
2019
2021

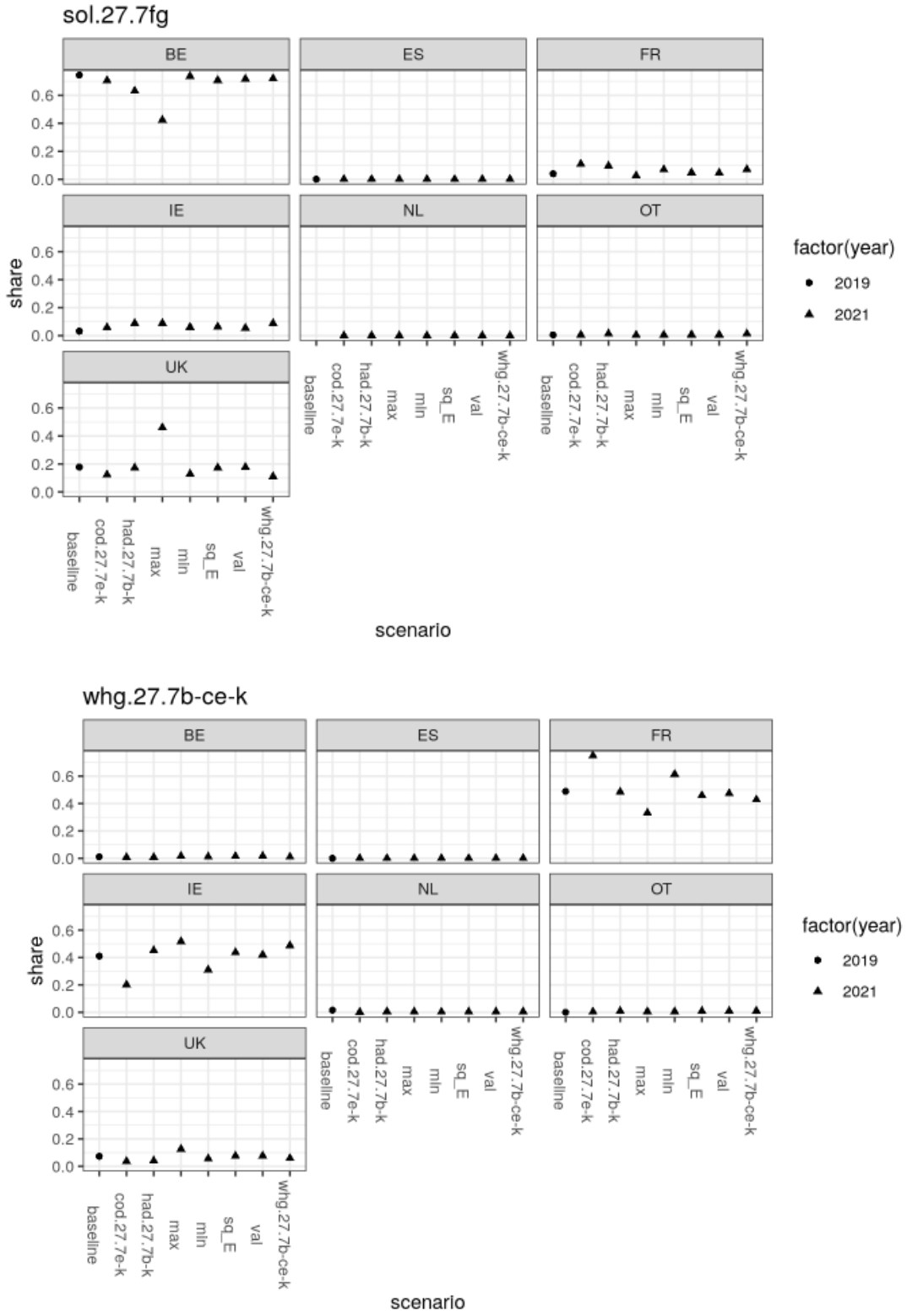


Figure 3.6. Test for relative stability. Changes of relative share of species' landings by country in 2019 and 2021 compared to the 2020 share, for the 'baseline' and 6 FCube scenarios.

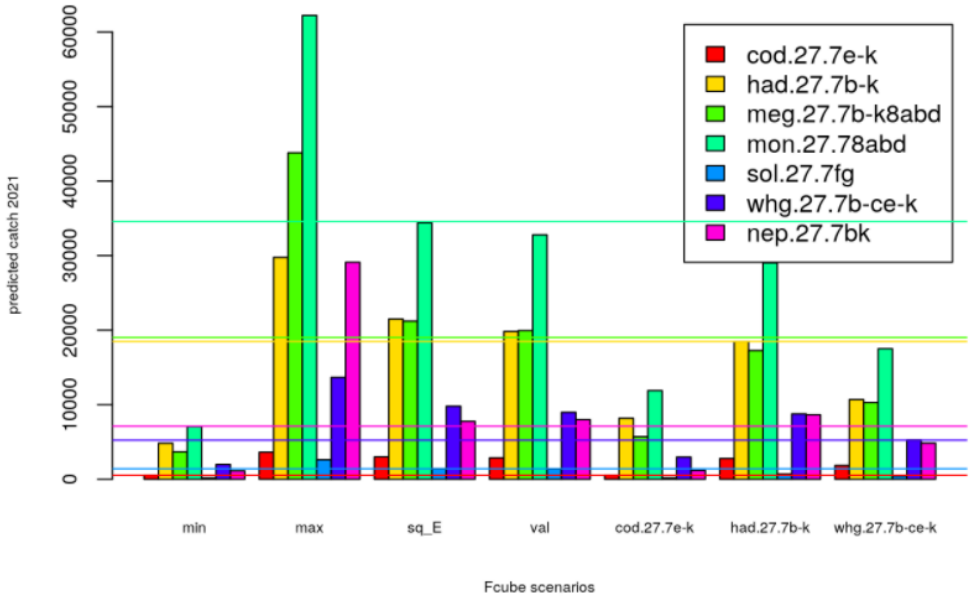


Figure 3.7. Celtic Sea predicted catch per mixed fisheries scenarios (2021).

4 Iberian waters

4.1 Background

4.1.1 Management measures

The Regulation (EU) 2019/472 of the European Parliament and of the Council, published in 19 March 2019, has established a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, repealing the Southern hake and Norway lobster recovery (EC Nº 2166/2005) which set effort reduction measures Catch option for 2020 were presented in EU Reg 2020/123.The new multiannual management plan (EU Regulation 2019/472) includes 36 demersal and deep-sea stocks including 15 Norway lobster FUs in Western Waters 10 of those stocks (and FUs) are caught in ICES Division 8.c and/or 9.a. The five stocks considered in the mixed fisheries analysis of Iberian Waters: hake, megrims and black and white anglerfishes

4.2 FLBEIA

4.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.,* 2007); www.flr-pro-ject.org; FLCore 2.6.15; FLAssess 2.6.3;) running with R 3.6.3 (R Development Core Team, 2020). All forecasts were projected using the FLBEIA Package (v1.15.5) (García *et al.,* 2017). FLBEIA is an FLR package that facilitates the bioeconomic evaluation of management strategies in a multi-stock and multi-fleet framework. It can be used to produce both short and long-term simulations.

Software used in the single-species assessments and forecasts was as outlined in the table below:

Stocks	Assessment	Forecast
BLACK ANGLERFISH 8c9	SPiCT	NA
HAKE 8c9ac	Cat 3 (index based)	NA
FOUR-SPOT MEGRIM 8c9a	XSA	MFDP
MEGRIM 8c9a9a	XSA	MFDP
WHITE ANGLERFISH 8c9a	SS3	SS3 (ad hoc R code)

4.2.2 Scenarios

The basis of the model is to estimate the potential future levels of effort by a fleet corresponding to the fishing opportunities (TACs by stock and/or effort allocations by fleet) available to that fleet, based on fleet effort distribution and catchability by métier. This level of effort was used to estimate landings and catches by fleet and stock, using standard forecasting procedures.

In 2020, single-stock ICES advice was given according to MSY approach for all stocks, except hake and black anglerfish for which the precautionary approach was applied (Table 2.1). Therefore, the same basis was retained in the current mixed fisheries framework, in which the following eight scenarios are considered in the advice:

1. **"max"**: The underlying assumption was that fishing stops when all quota species are fully utilised with respect to the upper limit corresponding to single-stock exploitation boundary. Each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares. This option causes overfishing of the single-stock advice possibilities for most stocks.
2. **"min"**: The underlying assumption was that fishing stops when the catch for the first quota species meets the upper limit corresponding to single-stock exploitation boundary. Each fleet, fishing stops when the catch for any one of the stocks meets the fleet's stock share *. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks.
3. **"ank" / "Black anglerfish PA approach"**: The underlying assumption was that all fleets set their effort in 2021 at the level corresponding to their black anglerfish quota share, regardless of other catches.
4. **"hke" / "Hake PA approach"**: The underlying assumption was that all fleets set their effort in 2021 at the level corresponding to their hake quota share, regardless of other catches.
5. **"ldb" / "Four-spotted megrim MSY approach"**: The underlying assumption was that all fleets set their effort in 2021 at the level corresponding to their four-spot megrim quota share, regardless of other catches.
6. **"meg" / "Megrim MSY approach"**: The underlying assumption was that all fleets set their effort in 2021 at the level corresponding to their megrim quota share, regardless of other catches.
7. **"mon" / "White anglerfish MSY approach"**: The underlying assumption was that all fleets set their effort in 2021 at the level corresponding to their white anglerfish quota share, regardless of other stocks.
8. **"sq_E"/ "*Status quo* effort"**: The effort of each fleet in 2021 is set equal to the average effort in the last three years (2017-2019) for which landings and discard data are available.

4.3 Stock input data and recent trends

4.3.1 Stocks

4.3.1.1 Data

The final dataset extracted from InterCatch for use by WGBIE includes discards estimates for all stocks and some métiers, which are included in the assessment of hake and both megrims. InterCatch files also provided non-reported landings besides the official landings. The fleet information specifically required by the WGMIXFISH, needed to split landings by fleet segment and métier, were provided by Spain and Portugal with official landings and economic value. France only provided landings. Discards and non-reported landings were added during the meeting from the respective InterCatch files.

This year, Portugal provided new series of effort and landings for the period 2009-2019. Landings for anglerfishes and megrims were not at the level of species. The landings ratio by species calculated by year, quarter, and gear from InterCatch information, was applied to split the Portugal landings at the species level. For the period 2009-2016, Spain sent effort and official landings as a unique series. Data for the period 2017-2019 were sent by two laboratories, IEO and AZTI, independently. Landings for anglerfishes and megrims were not at the species level for the period 2009-2016. As the IEO effort data for year 2018 was in fishing days instead of in days-at-sea, this year effort was extracted from previous year DataCall. Time-series of landings and discards

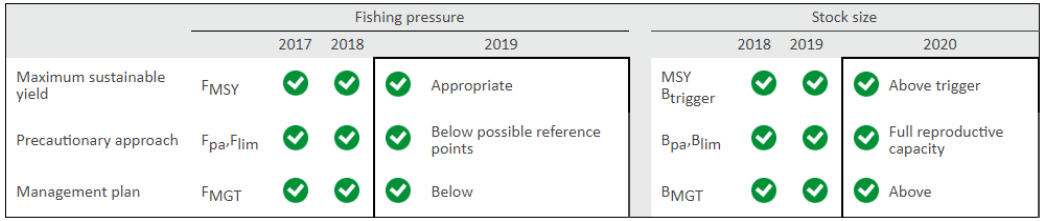
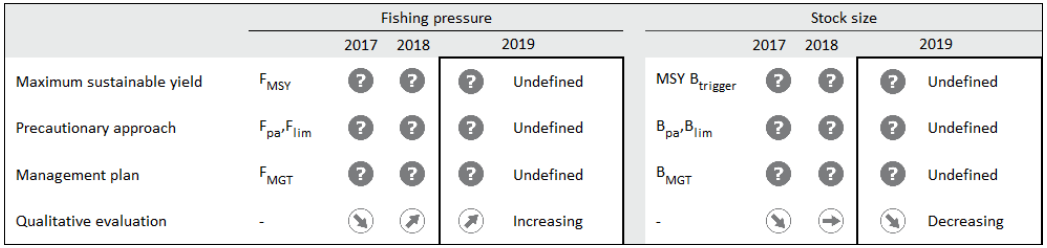
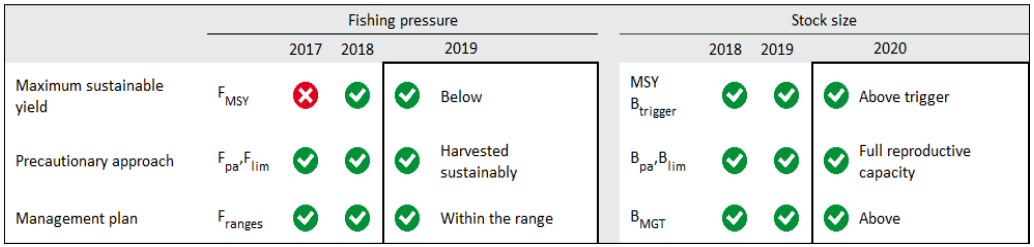
were checked between single stock assessment and the data compiled by the WGMIXFISH from data call and InterCacth.

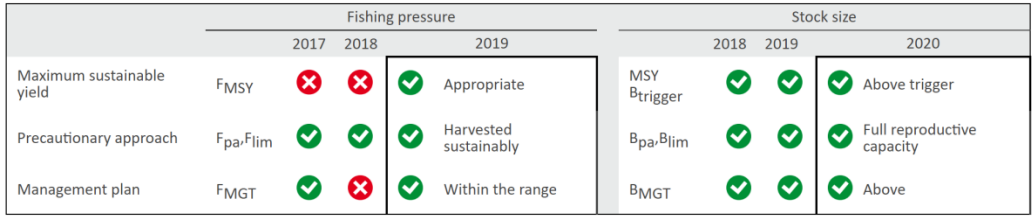
The assessment data for the stocks with analytical assessment were directly provided by the respective stock coordinators., as an FLStock object for white anglerfish and in excel files for both megrims. White anglerfish are being assessed using a Stock Synthesis length based statistical assessment. However, the implementation of FLBEIA requires an annual and age based dynamics. This can lead to differences in the projections carried out with both approaches. The projections carried out with FLBEIA are routinely compared to those carried out in the single-species assessment working group to assess the potential impact of using different approaches. The black anglerfish stock is assessed with a stock production model (SPiCT) and hake with a biomass index and both results are only indicative of trends. The single-stock advice for hake and black anglerfish are provided following ICES guidelines for category 3 stocks (ICES, 2016).

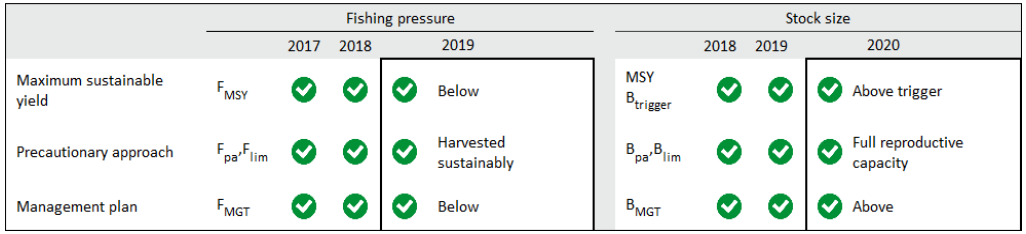
4.3.1.2 Trends and advice

Recent trends in SSB, F and recruitment are described on a stock-by-stock basis in ICES (2020a), and latest advice by stock is available on the ICES website. In order to give a global overview of the Iberian demersal stocks included in this analysis, this information is summarised below. It should be noted that although there is only one advice, additional management considerations are also listed in the single-species advice. Table 4.1 lists the final advised TACs for 2021.

Table 4.1. Summary of stocks included in the advice

Species	Area	Stock status	Advice 2021
ank.27.8c-9a (black anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 **Summary:** The assessment is indicative of trends only. The stock biomass (B) increased from 2005 to 2016 and has since decreased. Fishing mortality (F) has decreased since 1994.	ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 1800 tonnes.
hke.27.8c-9a (Hake)	Divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)	 **Summary:** The stock-size indicator is variable, although it shows a historical upward trend. It has decreased slightly in recent years.	ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 7825 tonnes
ldb.27.8c-9a. (Four-spot Megrim)	Divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1148 tonnes and 2375 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1690 tonnes) can only be taken under conditions specified in the

Species	Area	Stock status	Advice 2021
		Summary: The spawning-stock biomass (SSB) has been increasing since 2002 and has been above MSY $B_{trigger}$ since 2008. Fishing mortality (F) has decreased in the last three years and is now below F_{MSY}. Recruitment has been variable without trend over the time-series, and 2017 is the lowest estimated value.	MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two megrim species, *Lepidorhombus whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation rates, and could lead to overexploitation of either species.
meg.27.8c-9a (Megrim)	Divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)	 **Summary**: The spawning-stock biomass (SSB) has generally increased from a minimum in 2008 and is well above MSY $B_{trigger}$ in 2019. Large variation is evident in fishing mortality (F) for much of the time-series. F has declined from F_{lim} in 2014 to below F_{MSY} in the last two years. Estimated recruitment (R) from 2015 to 2017 is the highest since the mid-1990s.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 312 tonnes and 571 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (468 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two megrim species, *Lepidorhombus whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation rates, and could lead to overexploitation of either species.

Species	Area	Stock status	Advice 2021
mon.27.8c-9a (white anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	 **Summary**: The spawning-stock biomass (SSB) has been increasing since 1994 and has been above MSY $B_{trigger}$ since 2005. Fishing mortality (F) has been decreasing and below F_{MSY} since 2010. Recruitment (R) has been low in recent years, with no evidence of strong year classes since 2001.	ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the plan are between 1295 tonnes and 2472 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1872 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two anglerfish species, *Lophius budegassa* and *L. piscatorius,* under a combined species total allowable catch (TAC), prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

4.4 Fleets and métiers

4.4.1 Catch and effort data

Métier-based landings and effort files requested by the WGMIXFISH data call were provided by the three countries with fleets operating in Atlantic Iberian waters, i.e. Spain, Portugal, and France. InterCatch data files are used to compile discards and non-reported landings which are not provided in the MIXFISH data call. Due to missing megrims landings in 2014, only the last 5 years (2015–2019) were used to carry out a comparison of effort and catches by country, fleet and métier. Proportion of landings by stock considered in the mixed fisheries projections is presented in Figure 2.1. Hake was the dominant species, comprising of 82% of total landings, followed by white anglerfish (6%), four spot megrim (5%), black anglerfish (5%) and megrim (2%).

4.4.2 Definitions of fleets and métiers

The WGMIXFISH data call provided landings and effort which was combined to provided fleet and métier information for Spain, Portugal and France. The final data provided to the WG contained 14 métiers (Table 2.2).Regarding fleet segments, vessel size categories were not included because in the case of Spanish trawlers the disaggregation by length match the disaggregation by métier. In the case of Portugal, the contribution of the smallest categories was small, and their catch profile was similar to the biggest category, hence a single fleet was used for the three categories.

Total catches (in weight) were obtained by multiplying the catch-at-age in numbers by the average weight at age used as input in the WGMIXFISH analysis are compared with the total catches (in weight) used by WGBIE in the single-species assessments (Table 4.8). All discrepancies are lower than 1%.

More than 40 métiers are reported, from these, 14 métiers (Table 4.2) were chosen based on their relevance for the Portuguese and Spanish fisheries and on the species catchability considered for advice. This métier list is then regrouped for the mixed fisheries analysis according to their target assemblage of species and the technical characteristics of the fishing gear, resulting in 10 métiers (Figure 2.2). Hake provides the highest catches of all métiers except for DEF_>=100_0_0, which corresponds with the Spanish gillnet targeting white anglerfish ("*rasco*"). Megrims are mainly caught by the bottom otter trawl métiers, identified here as DEF_>=55_0_0 and DEF_>65_0_0.

With respect to the fleet segments used in the mixed fisheries analysis, these were defined combining the country and the fishing gear group (first three letters of the métier acronym, e.g. ESP_DEF_>=55_0_0).

4.4.3 Trends

Analyses of trends by fleet were carried out for 2015–2019 data. A number of exploratory graphs were produced to aid quality checking of the data once compiled into the final fleets object for

catches, effort and catchability. The catchability plots by stock, fleet and métier for Spain (

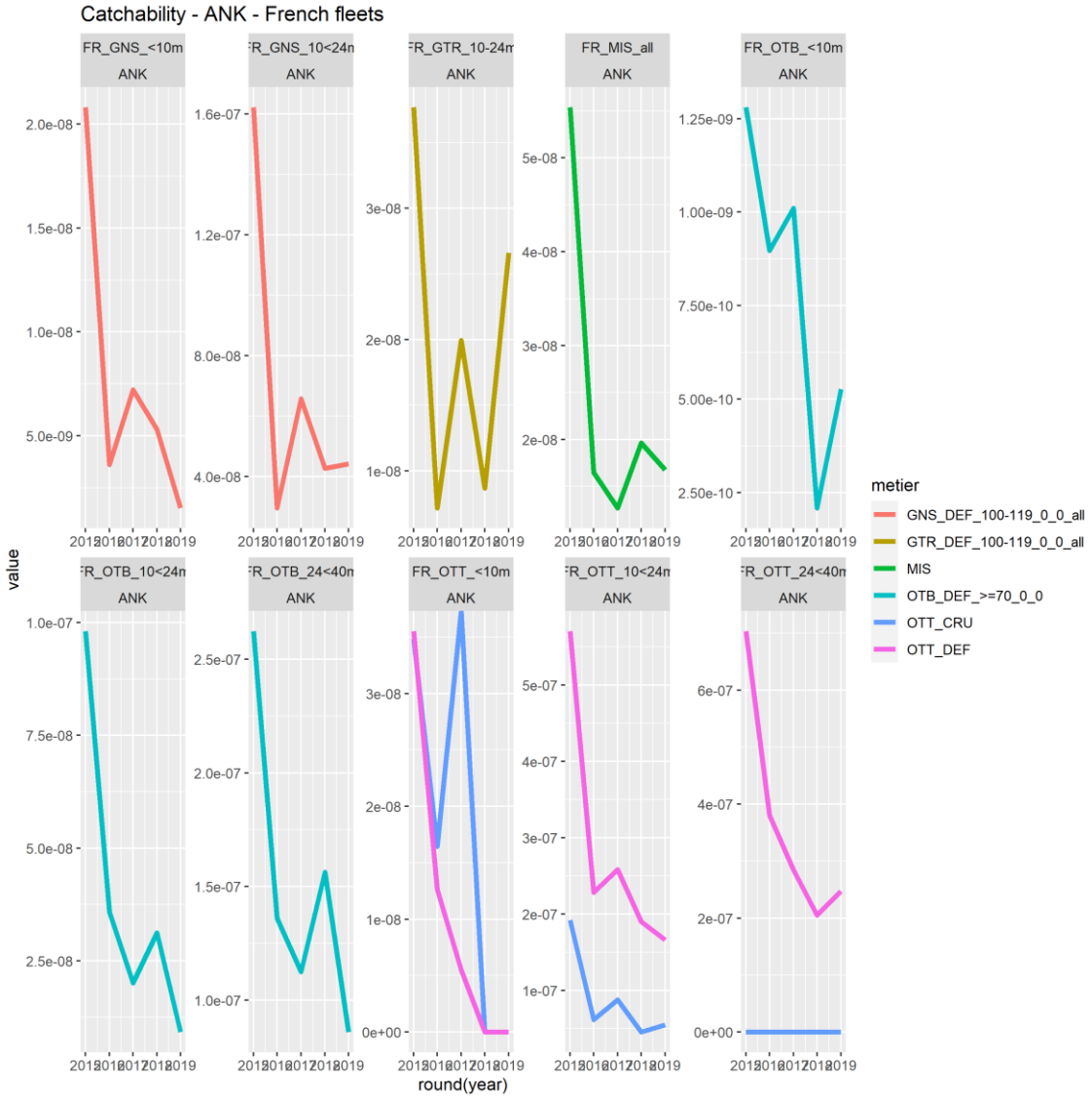


Figure 2.3. Bay of Biscay: trends of French catchability for black anglerfish (ank) by fleet and métier.

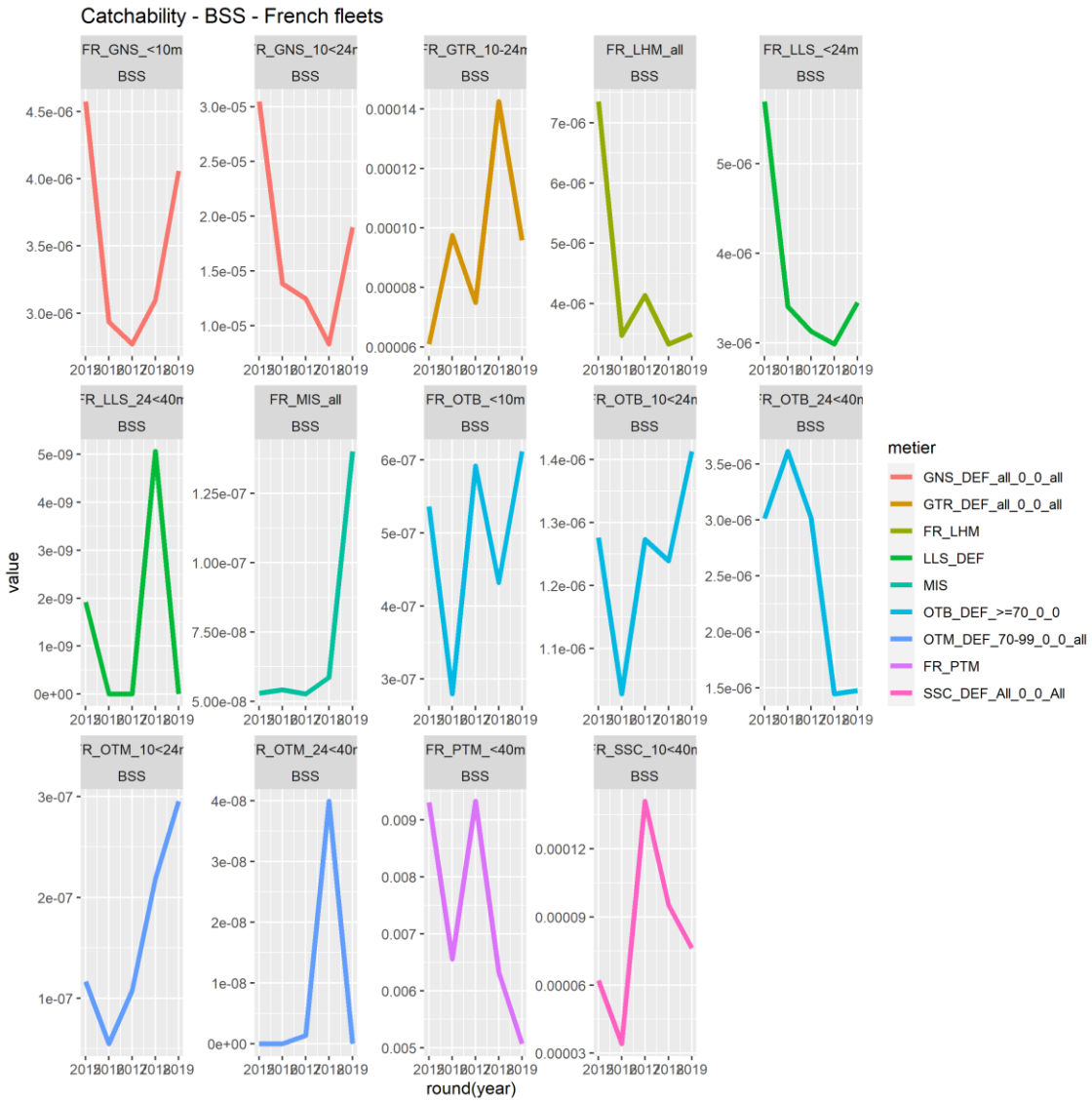


Figure 2.4. Bay of Biscay: trends of French catchability for seabass (bss) by fleet and métier.

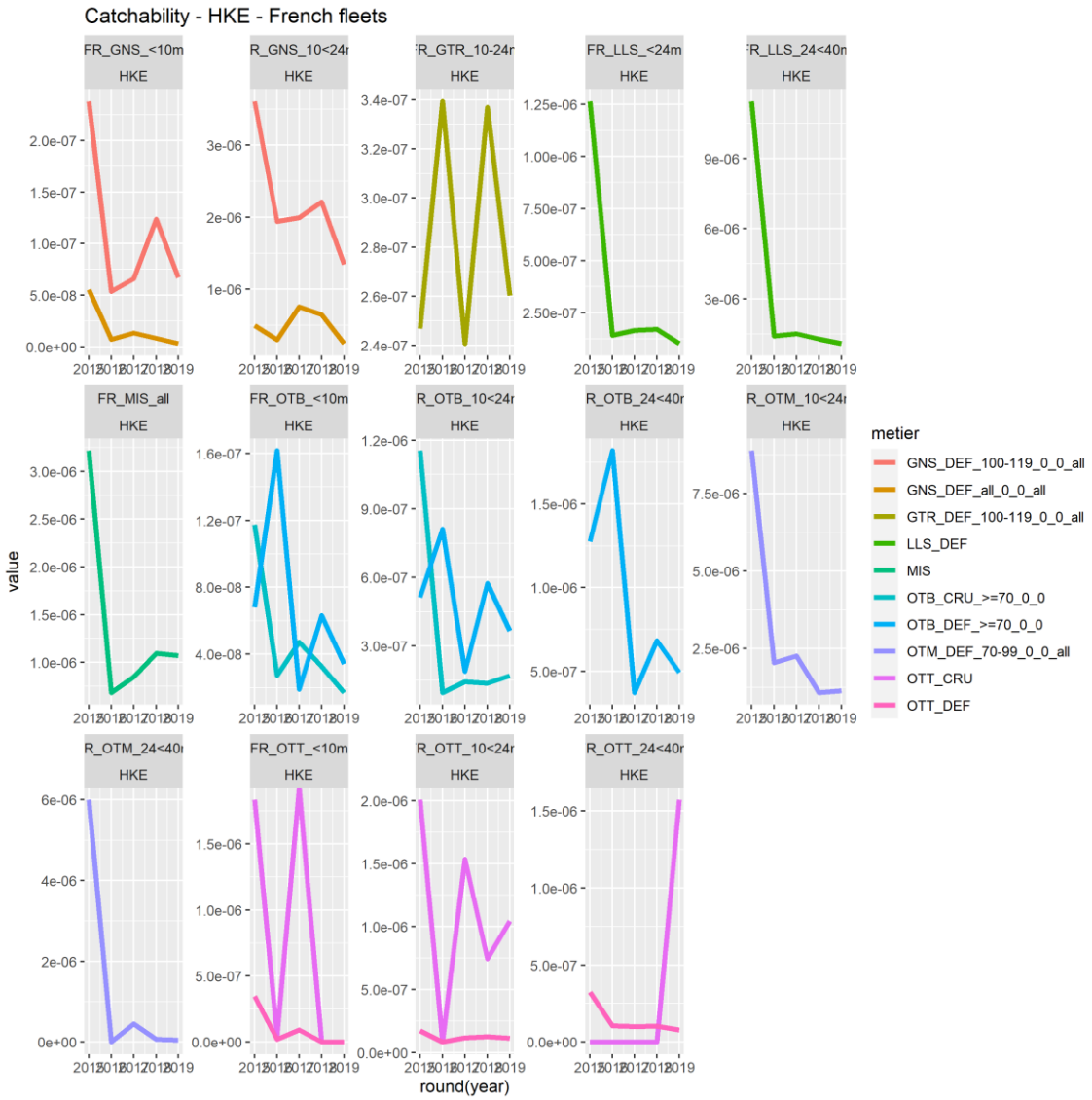


Figure 2.5. Bay of Biscay: trends of French catchability for hake (hke) by fleet and métier.

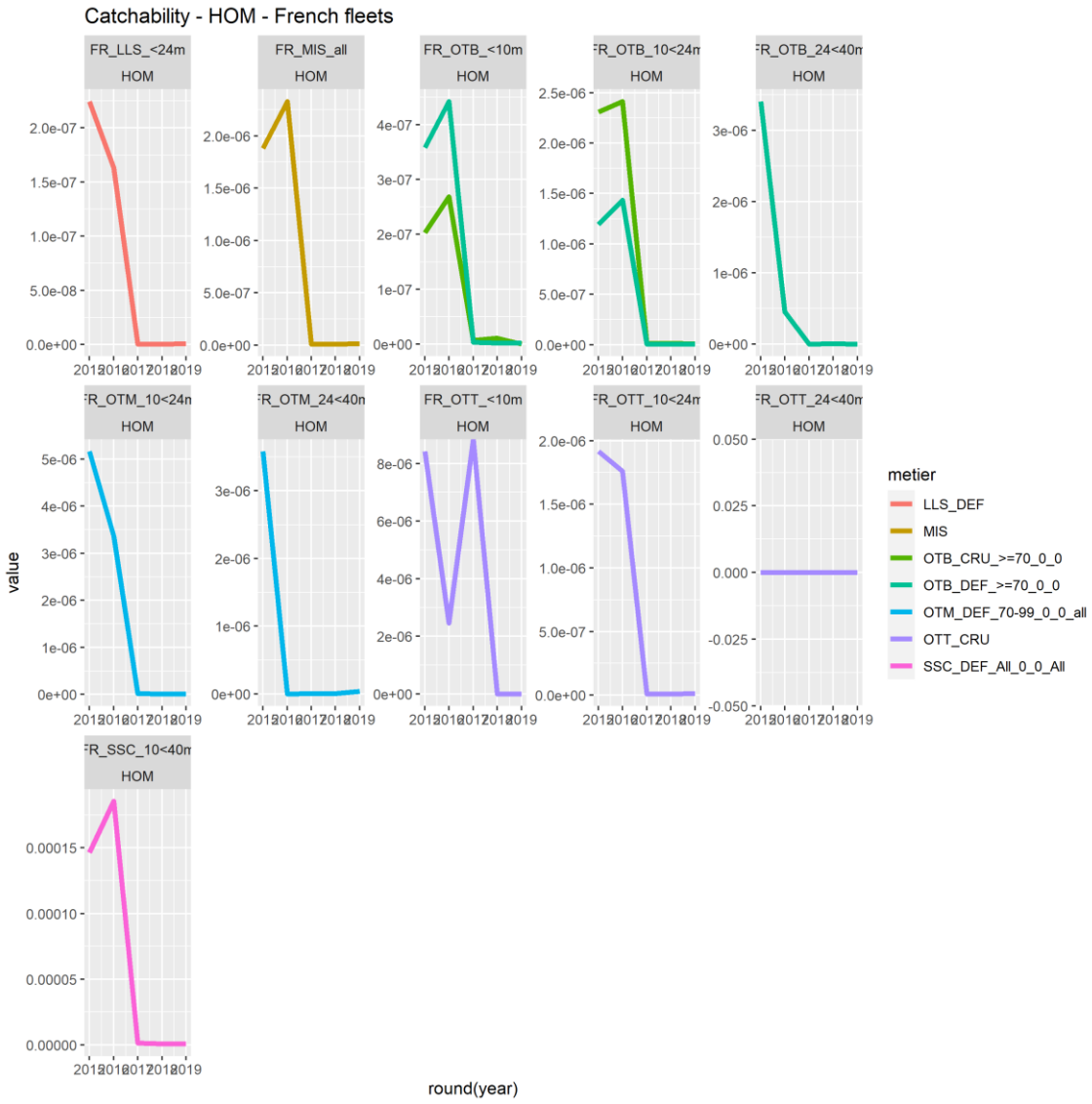


Figure 2.6. Bay of Biscay: trends of French catchability for horse mackerel (hom) by fleet and métier.

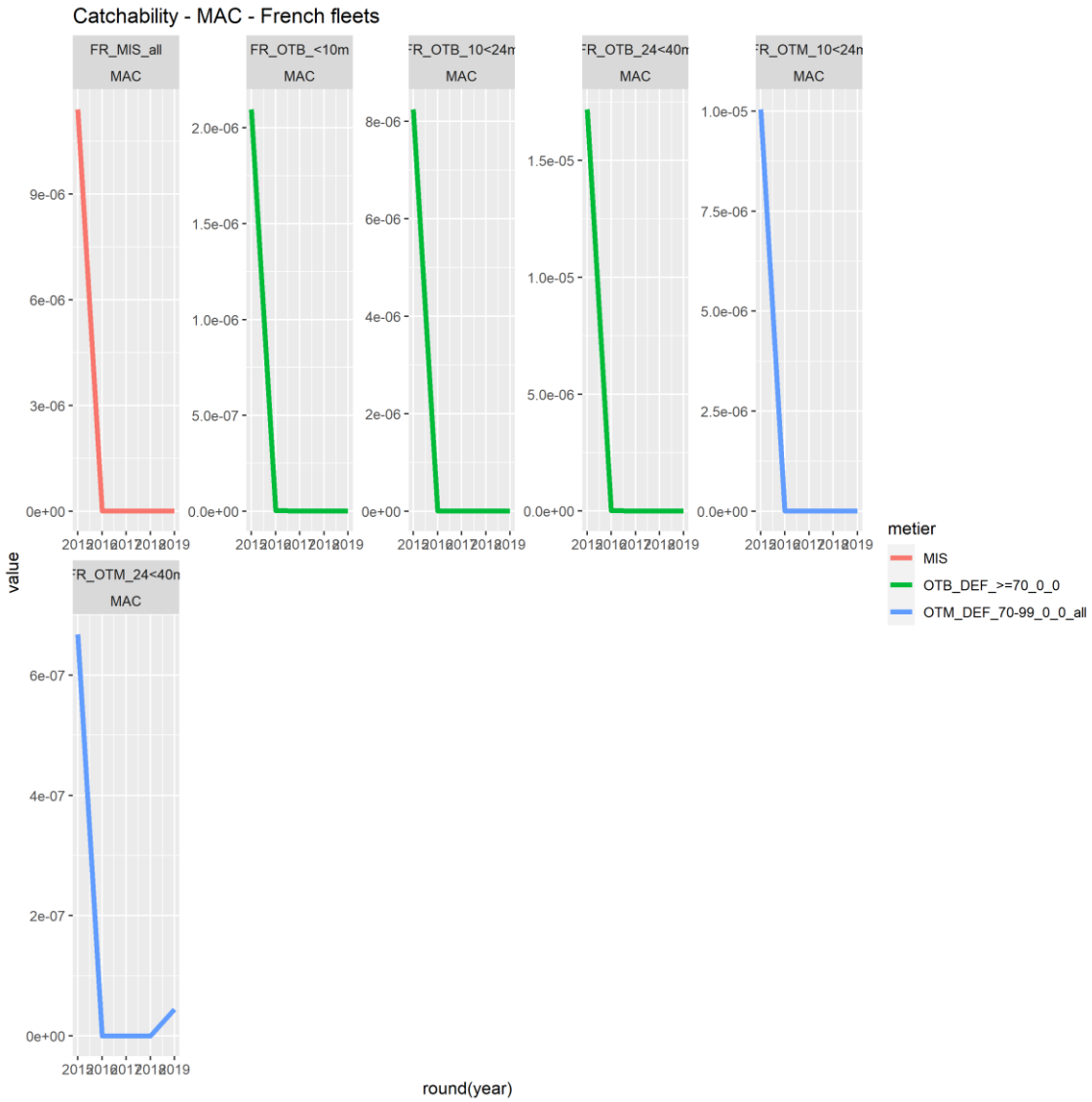


Figure 2.7. Bay of Biscay: trends of French catchability for mackerel (mac) by fleet and métier.

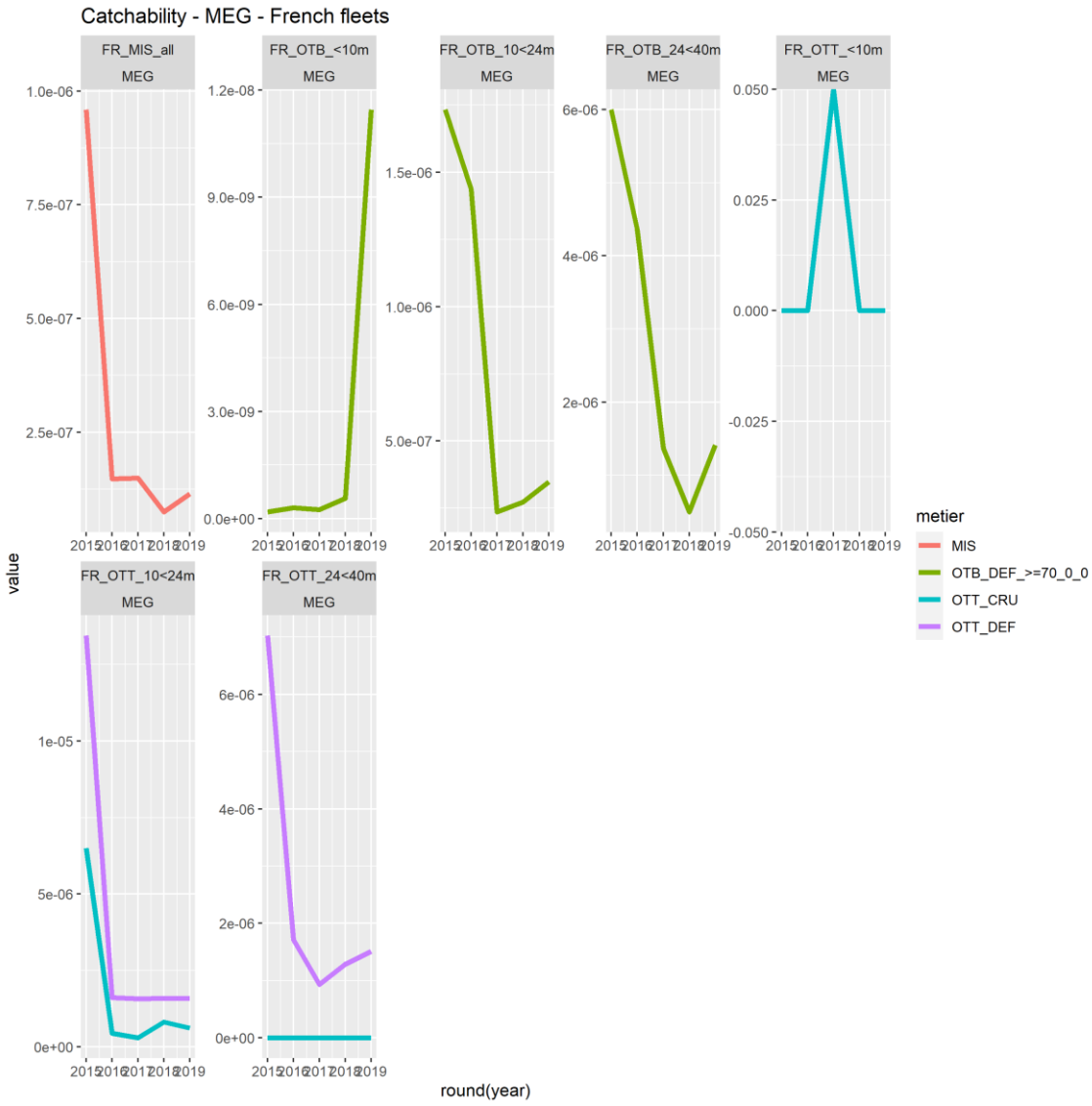


Figure 2.8. Bay of Biscay: trends of French catchability for megrim (meg) by fleet and métier.

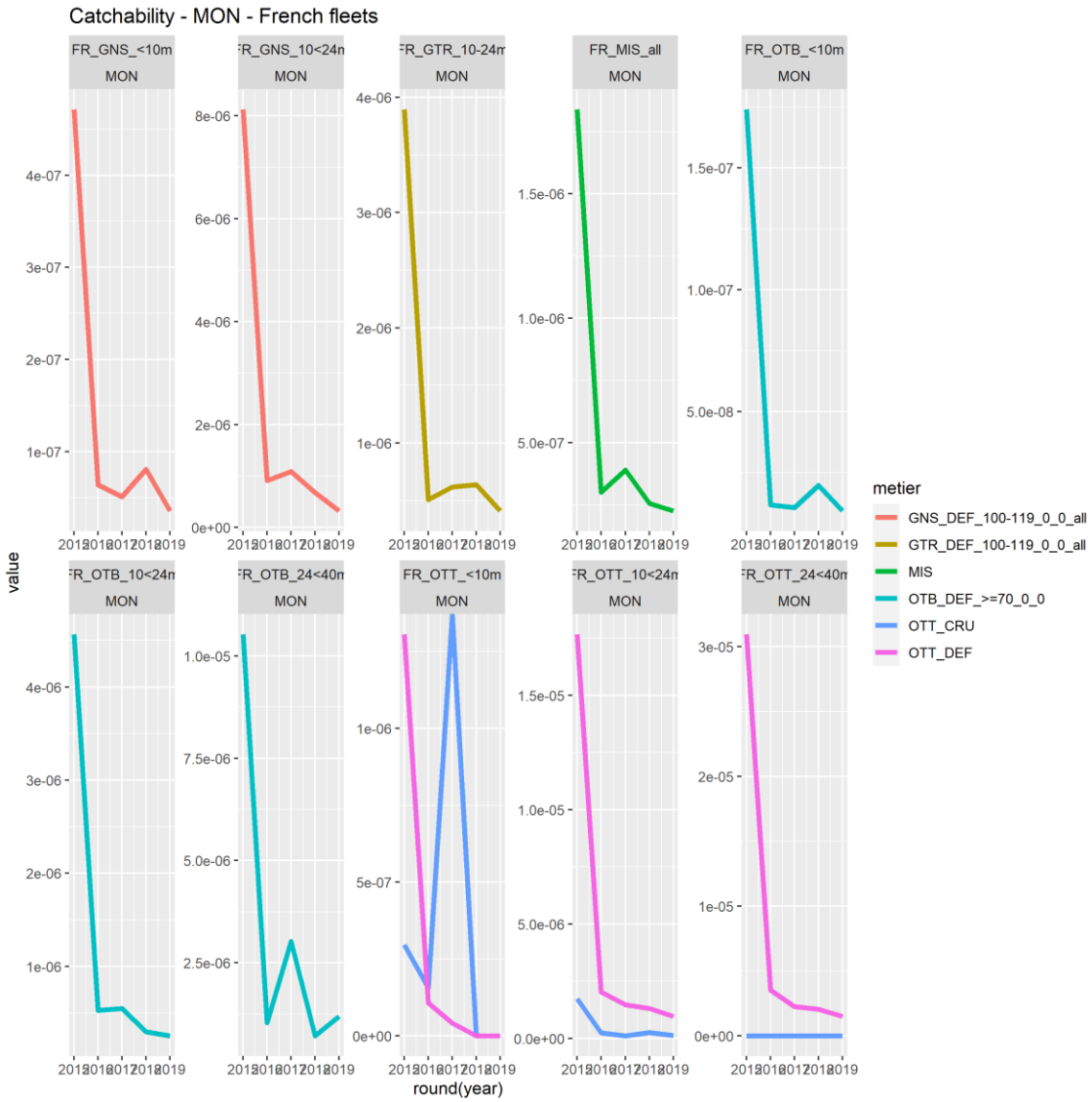


Figure 2.9. Bay of Biscay: trends of French catchability for monkfish (mon) by fleet and métier.

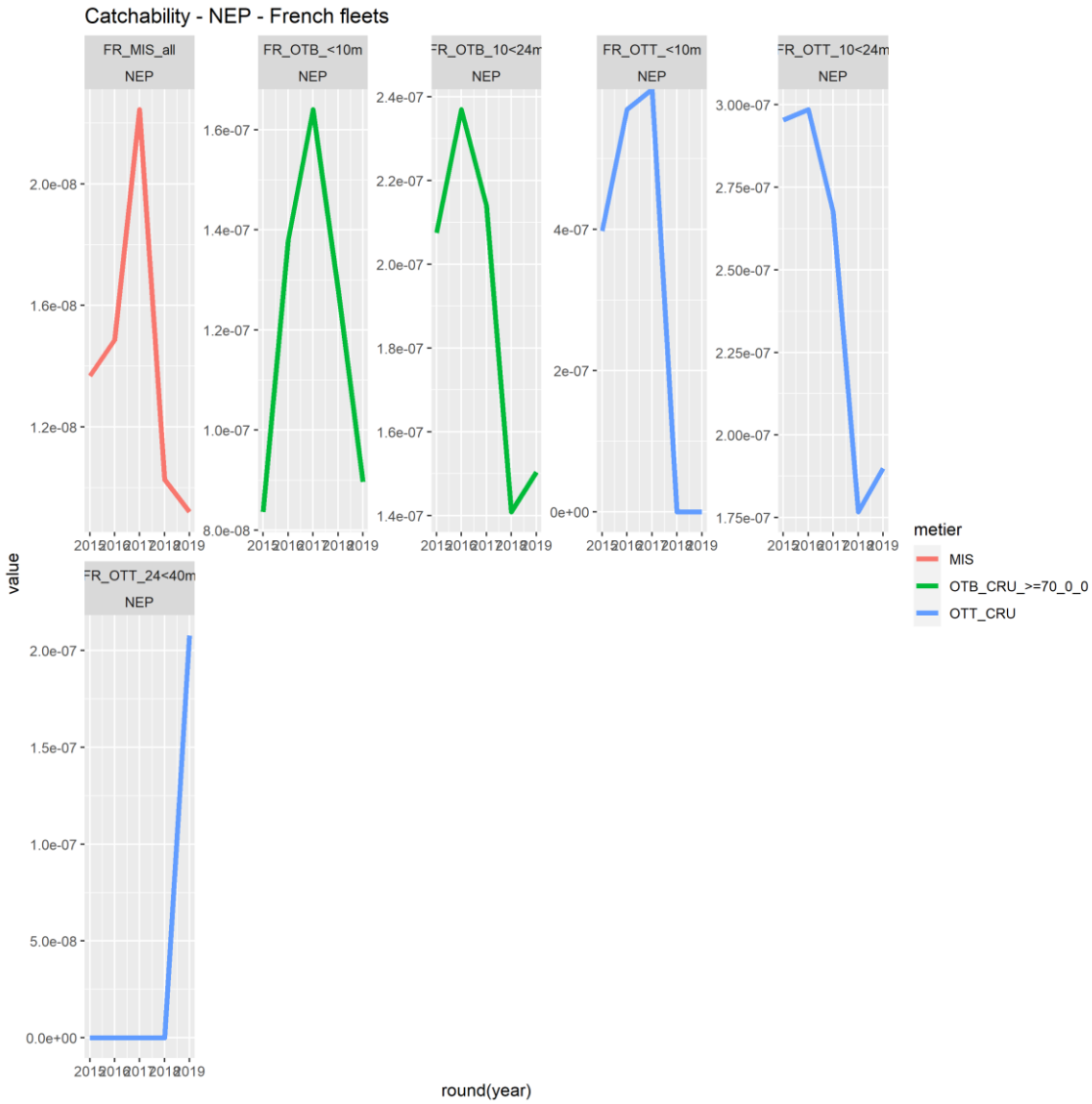


Figure 2.10. Bay of Biscay: trends of French catchability for *Nephrops* (nep) by fleet and métier.

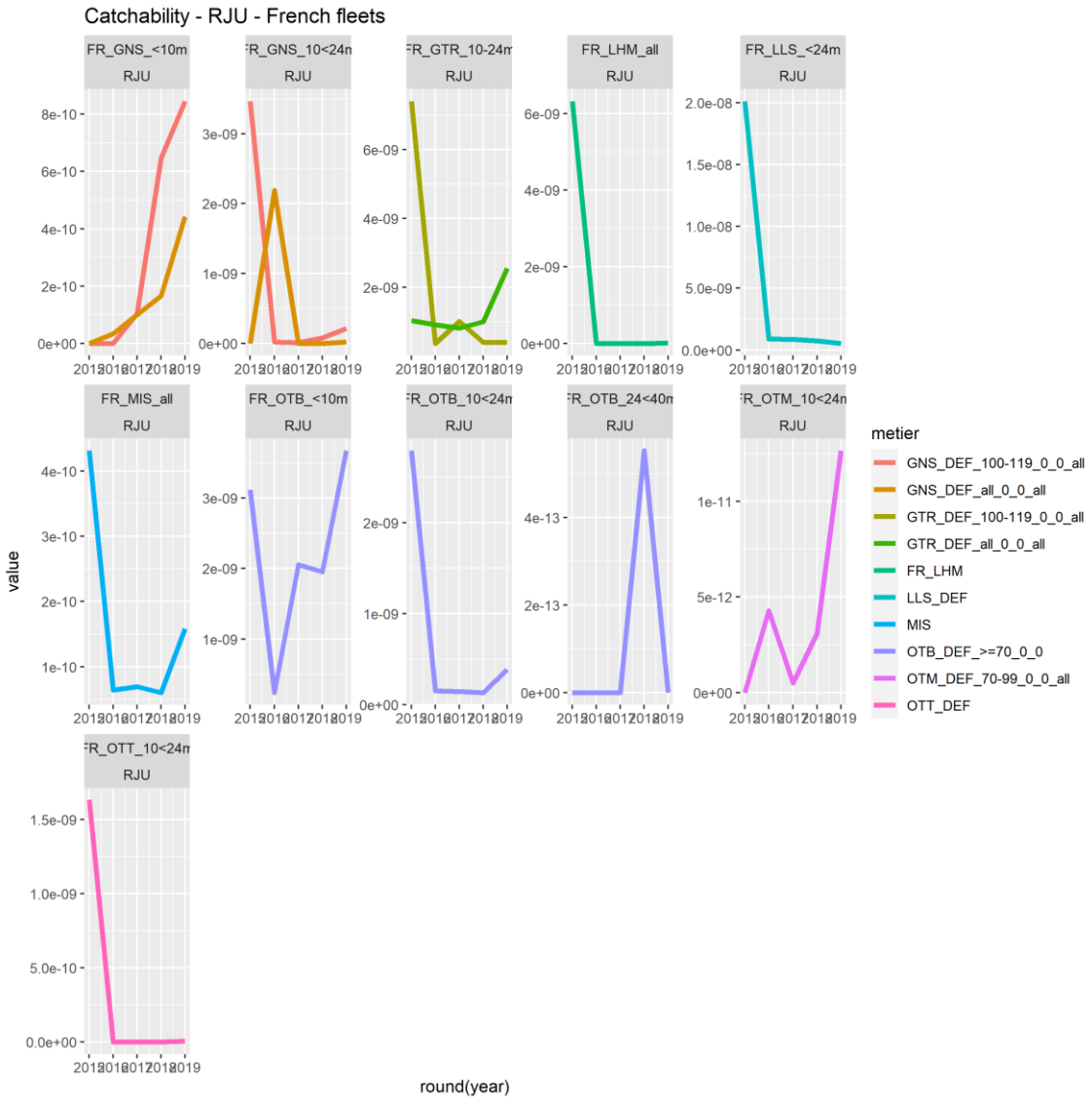


Figure 2.11. Bay of Biscay: trends of French catchability for undulate ray (rju) by fleet and métier.

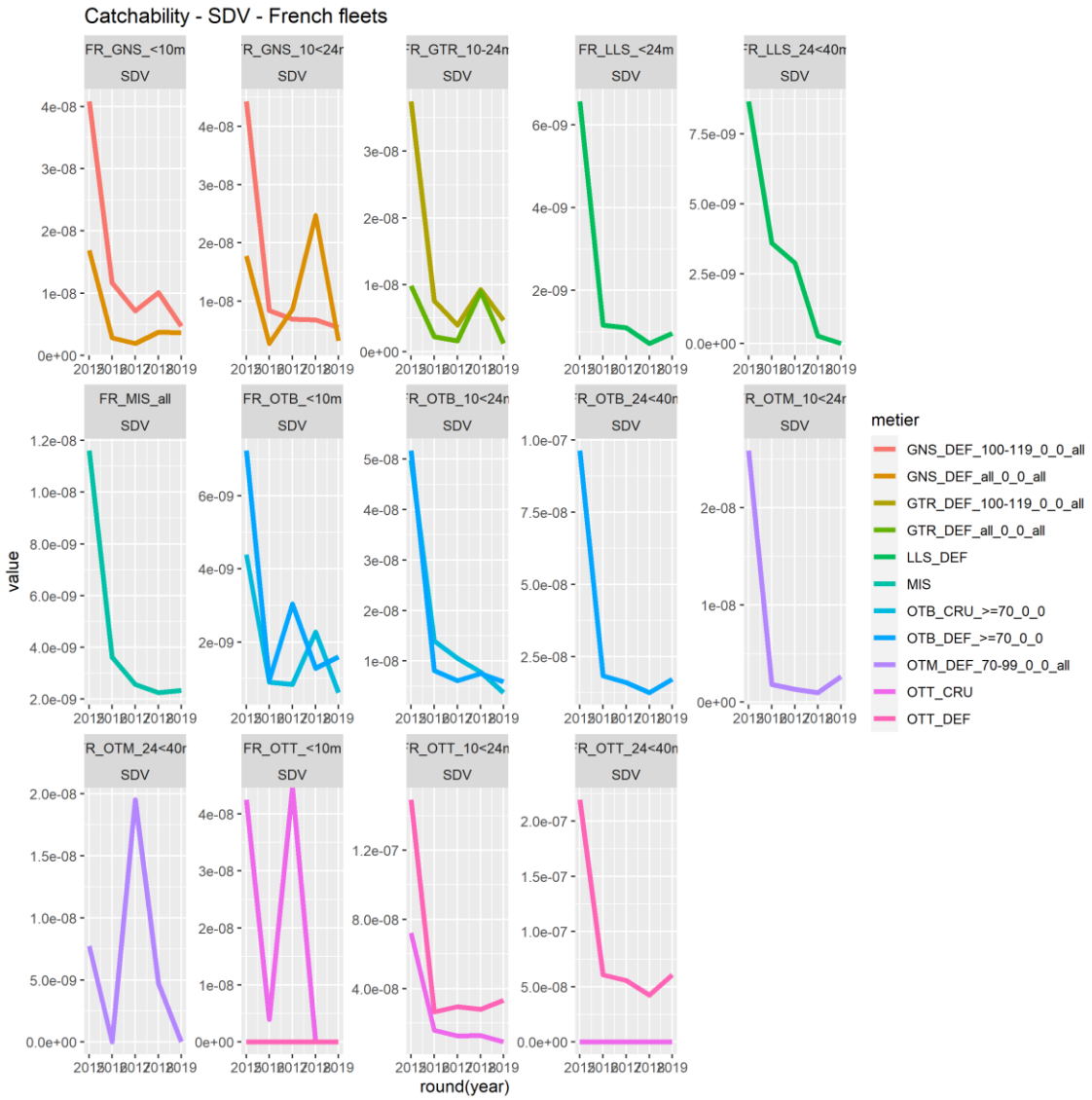


Figure 2.12. Bay of Biscay: trends of French catchability for smooth-hound (sdv) by fleet and métier.

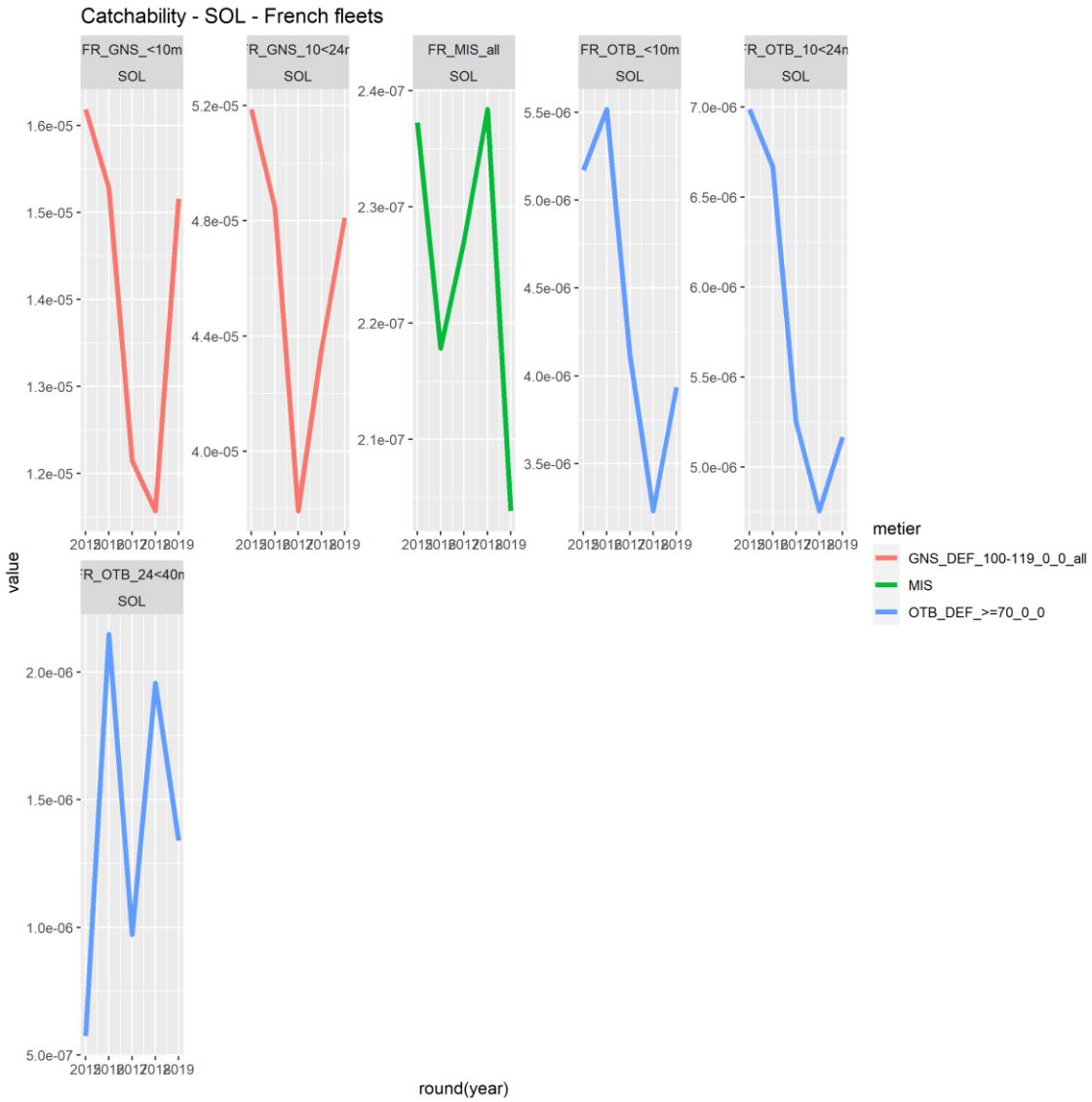


Figure 2.13. Bay of Biscay: trends of French catchability for sole (sol) by fleet and métier.

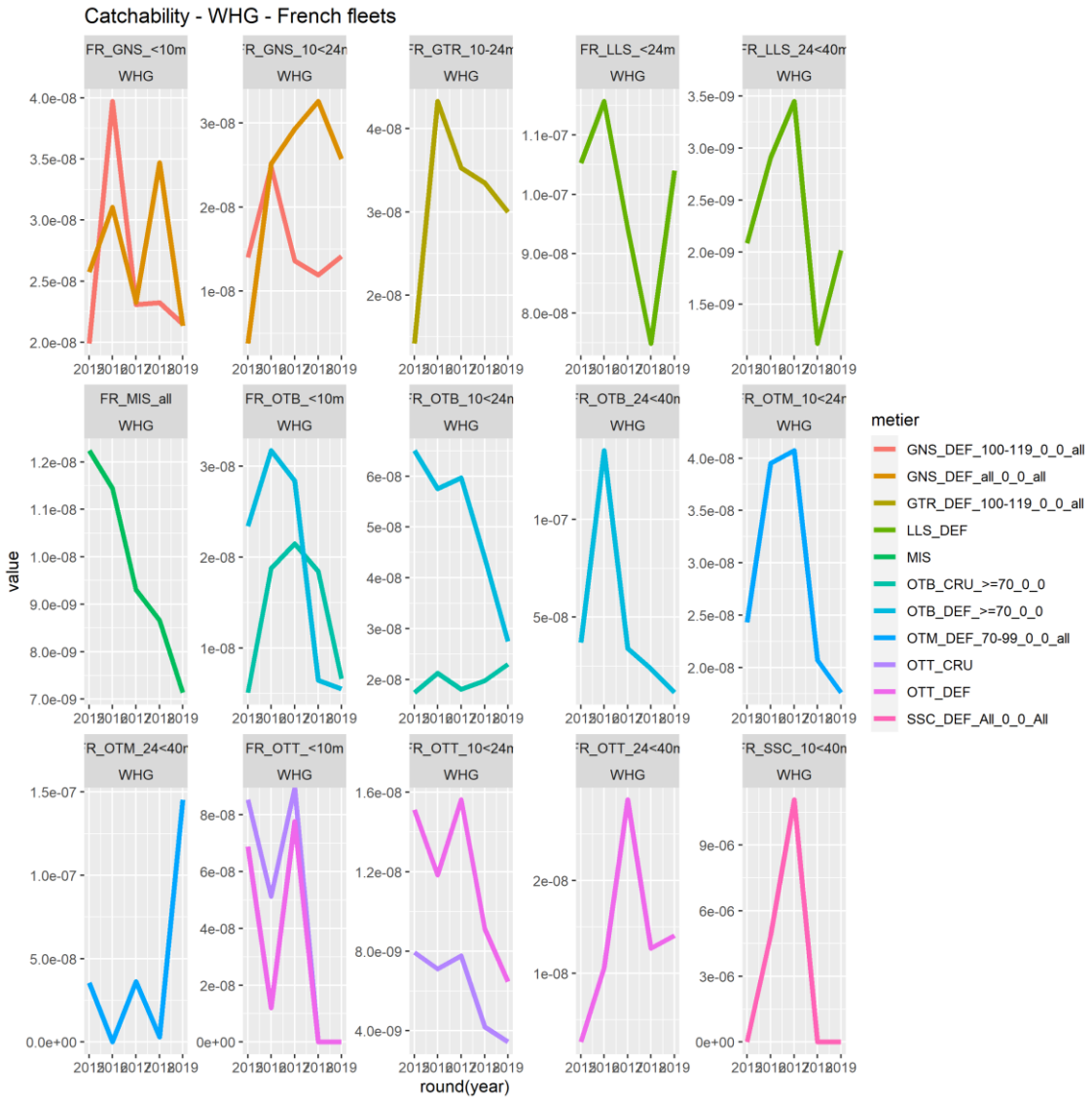


Figure 2.14. Bay of Biscay: trends of French catchability for whiting (wgh) by fleet and métier.

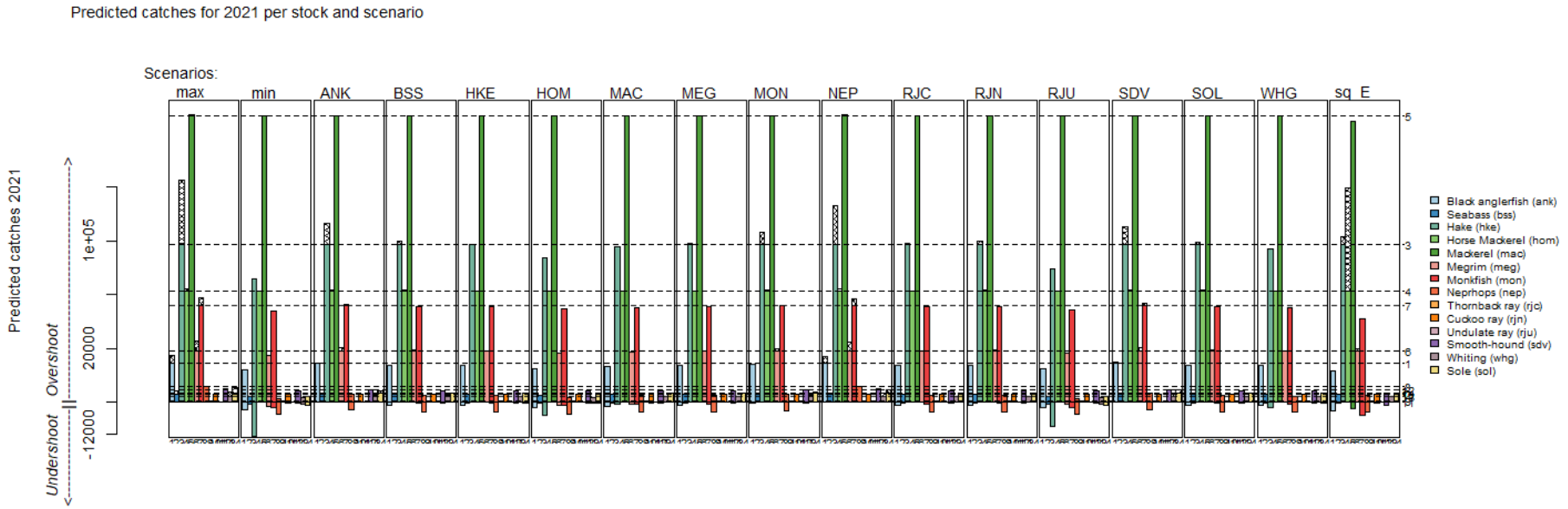


Figure 2.15. Bay of Biscay mixed fisheries forecasts: TAC year results (2021). FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year followed by the FLBEIA scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species catch advice) in cases where catches are predicted to be lower when applying the scenario.

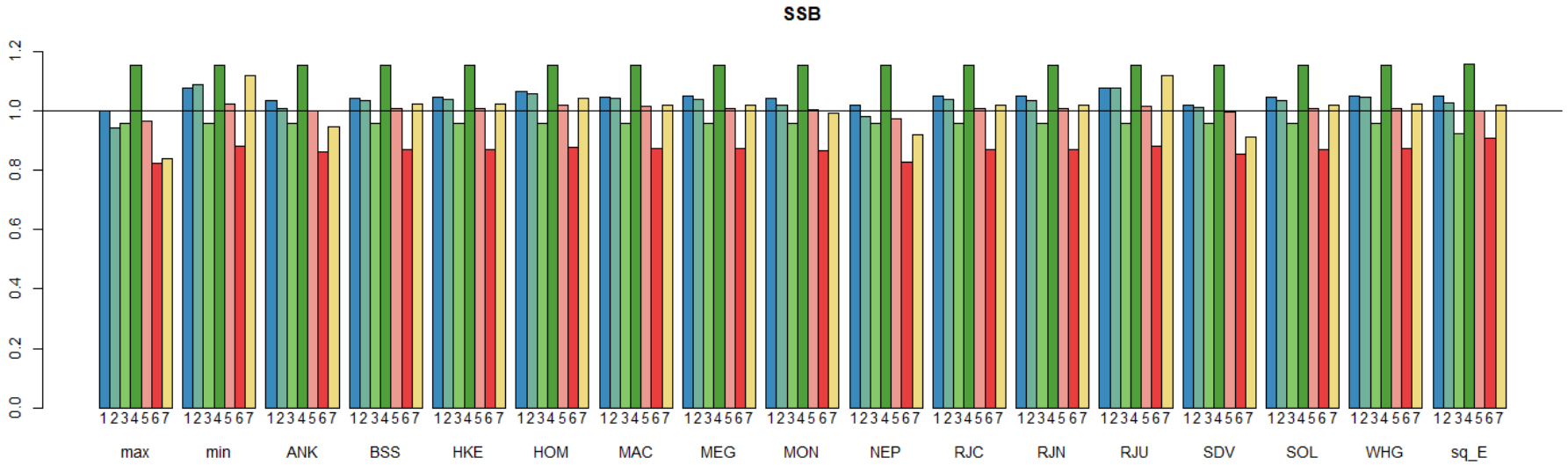


Figure 2.16. Bay of Biscay mixed fisheries forecasts: Estimates of potential SSB at the start of 2022 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2022).

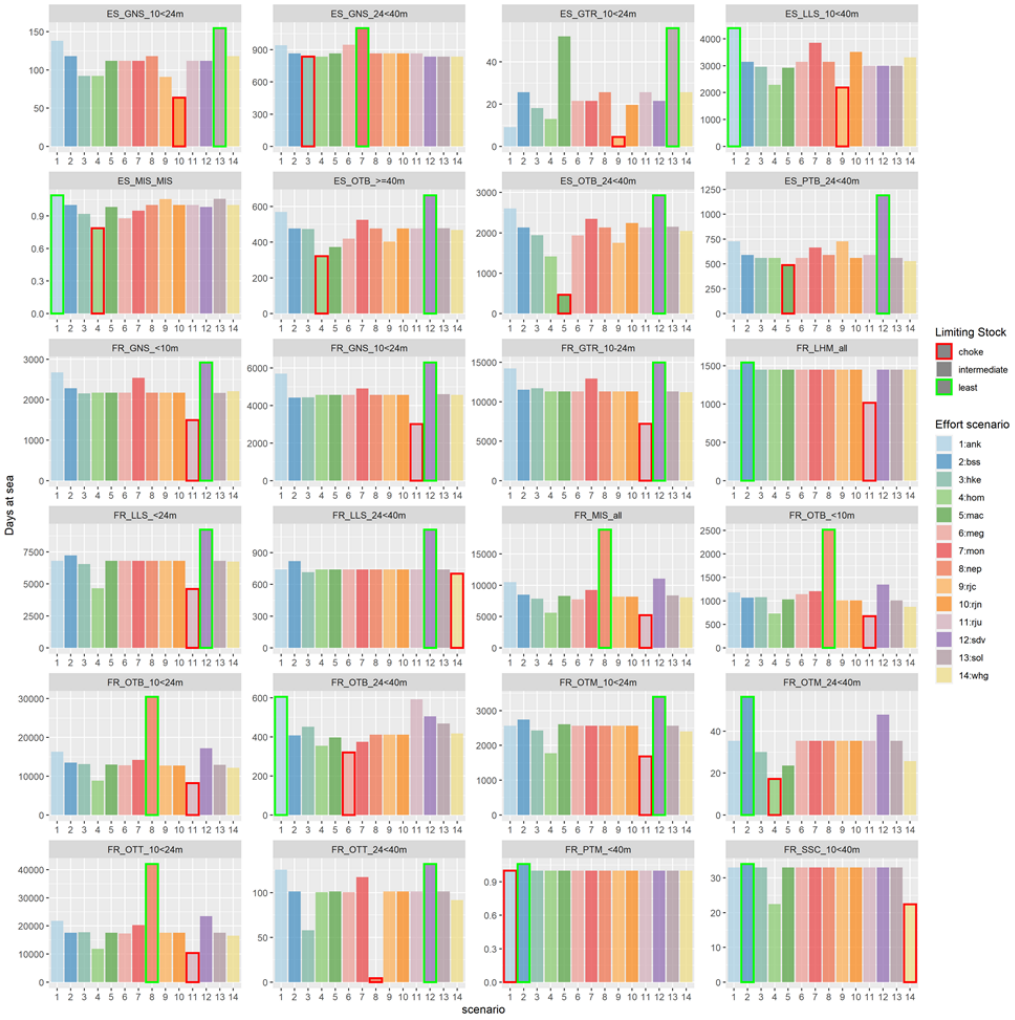


Figure 2.17. Estimates of effort by fleet needed to reach the single-stock advices. Bars highlighted in red correspond to the most limiting species for that fleet in 2021 ("choke species"), whereas the green highlight correspond to the least limiting species. Fleet names are given by country (FR = France, SP = Spain) and by meaningful combinations of main gear and vessel size differing across countries and based on homogeneous average fishing patterns. Vessels in the various fleet segments can engage in several fisheries (métiers) over the year.

) and Portugal (Figure 4.4) for 2015-2019 are included in this report as a key assumption in the projections is that catchability by stock and métier and effort distribution in 2020 and 2021 remain constant in the last three years. In reality, fishing patterns may change over time but no assessment has been made on the impact of this variability on the simulations. In some specific cases, like hake and black anglerfish in Spanish otter trawlers or megrim in Portuguese otter trawlers, the catchability has decreased since 2017 which points out a possible decreasing trend that should be confirmed when more data is available.

4.5 Mixed fisheries forecasts

Discrepancies were found between the FLBEIA baseline runs and the single-stock forecasts. These were quite minor for estimated catches in 2020 and 2021 (

Table 2.). The differences in the SSB and F are also low, slightly higher in the advice year (SSB at the beginning of 2022 and estimated F in 2021), but always below 4% (Table 4.6)

4.5.1 Description of scenarios

4.5.1.1 Baseline runs

The objectives of the single-species stock baseline runs were to:

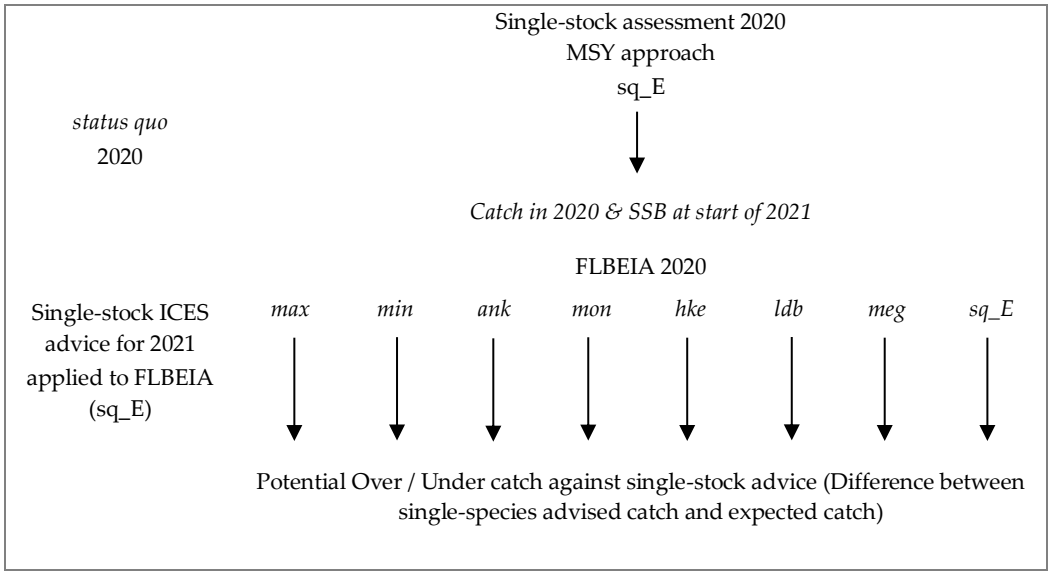
- reproduce as closely as possible the single-species advice produced by ACOM, and
- act as the reference scenario for subsequent mixed fisheries analyses.

The various single-stock forecasts presented by WGBIE are performed using different software and setups (see Section 4.2.1 above). However, for the purposes of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the "FLBEIA" library (García *et al*., 2017). The same forecast settings as in the stock annex for each Category 1 stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY approach). For Category 3 stocks, intermediate year catch for hake was assumed equal to latest catch. In the case of black anglerfish, catch was estimated by applying the ratio among catch, assuming Fsq in the intermediate year, and the corresponding TAC for white anglerfish. The estimates provided in the ICES advice sheets were used for the stocks with analytical assessment.

4.5.1.2 Mixed fisheries runs

The mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2020), with the FLBEIA scenarios used for the TAC year (2021). The *status quo* effort assumption for the intermediate year is considered a plausible assumption because is in line with the standard single-stock short-term forecasting approach. As last year, the projections were run assuming a full and perfect implementation of a discard ban (i.e. all quota species caught must be landed, with no exemptions, *de minimis* or inter-species flexibilities).

In summary, the FLBEIA runs followed the scheme below:



4.5.2 Results of FLBEIA runs

4.5.2.1 Baseline runs

The rationale behind the single-species baseline runs is given in Section 2.3.1.2. The ICES single-stock advice for three stocks in 2020 (ICES, 2020) is based on the maximum sustainable yield (MSY) approach and on precautionary approach for hake and black anglerfish. The issues and problems encountered in replicating the single-species advice for each species are identified below. The results from these baseline runs are compared with the results from the corresponding ICES runs in Table 4.4 (baseline outputs), Table 4.5. (Catch differences) and Table 2.. (SSB and F differences)

There are some minor differences between the single-stock catch and SSB values, and the values obtained from the baseline run scenario although lower than 3%.

Black anglerfish: Discrepancies around 4% for catches in 2020 and near 0 in 2021 are inside acceptable limits. No F and SSB projections for Category 3 stocks.

Hake: Discrepancies below 1% for catches in 2020 and 2021 are inside acceptable limits. No F and SSB projections for Category 3 stocks.

Four-spot megrim: Discrepancies in catch, biomass and F are lower than 3%.

Megrim: Discrepancies in catch, biomass and F are lower than 3%.

White anglerfish: Minor discrepancies in 1% in SSB were obtained for white anglerfish. The assessment of this stock is performed by applying the SS3 model (Methot, 2000) disaggregated by length.

The ouputs of the scenarios at the start of the advice year were all consistent with the single-stock forecasts with negligible differences. The minor differences were considered acceptable regarding the modelling of the technical interactions between stocks and fleets.

4.5.2.2 Mixed fisheries analyses

The full overview of the FLBEIA projections to 2021 is presented in Table 2., Figure 4.16, and Figure 4.13. The results for 2021 can be compared to each other as in a single-species option table. For ease of comparison, the landings relative to the single-stock advice are presented in Figure 4.16.

The "max" scenario shows the upper bound of potential fleet effort and stock catches and the stock which, to reach its F_{MSY} target, needs the maximum increase in effort is, according to the current analysis, black and white anglerfish. However, through assuming that all fleets continue fishing until all their stock shares are exhausted irrespective of the economic viability of such actions, this scenario is generally considered with low plausibility.

ICES single-stock advice (Cat. 1) provides TACs expected to meet single-stock F_{MSY}, and expected to meet precautionary approach for Cat. 3 stocks. To be consistent with these objectives a scenario is necessary that delivers the SSB and/or F objectives of the single-stock advice for all stocks considered simultaneously. The "min" scenario meets this outcome. Additionally, this scenario assumes that fleets would stop fishing when their first stock share is exhausted, regardless of the actual importance of this stock share for the fleet. This scenario reflects the constraints that result from a strictly implemented discard ban. Fishing effort should be reduced more than 34% of its 2019 observed level to comply with this scenario, consistent with the reductions in fishing mortality advised for hake, and causing reductions of catches in the remaining species higher than those determined by their respective single-stock advice.

The results of **"ank"** and **"mon"** scenario are pretty much the same of those of the "**max**" scenario indicating that both anglerfish would be the least limiting stock. Within the scenarios based on each of the stocks. The "**hke**" scenario gives the same result as the "min" scenario, showing hake as the choke species in this group. This scenario shows potential loss of fishing opportunities for black and white anglerfish and, in a lesser extent, for megrims.

The "**ldb**" and "**meg**" scenarios provide a similar perspective, increasing the fishing opportunities of the stocks in comparison with the "hke" scenario. Megrims and anglerfishes are mainly caught by bottom otter trawl gears, while hake occurs in the catches of almost all the Iberian métiers.

The "**mon**" scenario estimates effort levels close to those in "ank" and "max" scenarios. This scenario maintains the single-stock advice for white anglerfish, but multiplies by 3 the single-stock advice for hake and almost doubles the advice for both megrims.

The "**sq_E**" scenario is similar than the "ldb" scenario. Under this scenario the quota of megrim for 2021 would be caught and almost the entire quota of four-spot megrim. However, with this level of effort, the hake catches approach double the hake quota and anglerfishes catches would be around half of their quotas.

Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input was derived from the landing share by fleet and stock in 2019 The landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results did not show big deviations across all scenarios (Figure 4.8).

Table 4.8. Iberian waters: Summary of the 2021 catch and target Fs, resulting from the advice approaches considered by ICES (2020). TACs refer to total catches, as they are used in the assessment model, except for black and white anglerfish, which represent only landings.

Stock	TAC 2021	F 2021	SSB 2022	Rational
Black anglerfish 8c9a	1800 t	n/a	n/a	Precautionary approach
Hake 8c9a	7825 t	n/a	n/a	Precautionary approach
Four-spot megrim 8c9a	1690 t	0.19	7955 t	MSY approach

Stock	TAC 2021	F 2021	SSB 2022	Rational
Megrim 8c9a	468 t	0.19	2231 t	MSY approach
White anglerfish 8c9a	21 461 872 t	0.24	10 647 t	MSY approach

Table 4.9. Métier categories used in the Iberian waters mixed fisheries analysis.

Acronym	DCF definition	Description
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Spanish set gillnet ("*rasco*") targeting white anglerfish in ICES Division 8.c with mesh size of 280 mm
GNS_DEF_0_0_0	Set gillnet targeting demersal fish	Artisanal Portuguese fleet using set gillnets
GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60–79 mm	Spanish small set gillnet ("*beta*") targeting a variety of demersal fish in north-western Spanish waters
GNS_DEF_80-99_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 80–99 mm	Spanish set gillnet ("*volanta*") targeting hake with nets of 90 mm mesh size in north-western Spanish waters
GTR_DEF_0_0_0	Trammel net targeting demersal fish	Artisanal Portuguese fleet using trammel nets
GTR_DEF_60-79_0_0	Trammel net targeting demersal fish with mesh sizes within the range 60–79 mm	Spanish trammel net targeting a variety of demersal species in north-western Spanish waters
LLS_DEF_0_0_0	Set longline targeting demersal fish	Spanish set longline targeting a variety of demersal fish in Spanish Iberian waters
MIS_MIS_0_0_0_HC	Miscellaneous	Portuguese and Spanish artisanal fleet not covered by other métiers
OTB_CRU_>=55_0_0	Bottom otter trawl targeting crustaceans using mesh sizes larger than 55 mm	Portuguese bottom otter trawl targeting *Nephrops* and rose shrimp
OTB_DEF_>=55_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting hake, anglerfish, and megrim using "*baca*" nets of 70 mm mesh size in divisions 8.c and 9.a
OTB_DEF_>=65_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 65 mm	Portuguese bottom otter trawl targeting demersal fish in Division 9.a
OTB_ MCD_>=55_0_0	Bottom otter trawl targeting mixed crustaceans and demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting a variety of fish and crustaceans using nets of 55 mm mesh size in south-western Iberian waters (Gulf of Cadiz and Southern Portuguese waters)
OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting pelagic (horse mackerel, mackerel…) and demersal fish (hake) by using "*jurelera*" nets of 55 mm mesh size in north-western Spanish waters
PTB_ MPD _>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Bottom pair trawl targeting pelagic (blue whiting, mackerel…) and demersal fish (hake) by using nets of 55 and 70 mm mesh size in north-western Spanish waters

Table 4.8. Iberian waters: Proportion of the stocks total catches (from WGBIE) covered by the WGMIXFISH fleets. A ratio >1 means that the catch information in WGMIXFISH is larger than the information used by WGBIE.

YEAR	STOCK	WGBIE	WGMIXFISH	DIFFERENCE	RATIO
2019	ANK	1800	1800	0	1
2019	HKE	7825	7825	0	1
2019	LDB	1690	1690	0	1
2019	MEG	468	468	0	1
2019	MON	1872	1872	0	1

Table 4.11. Iberian waters: Baseline run outputs from the FLBEIA package.

	ANK	HKE	LDB	MEG	MON
2020_Fbar	NA	NA	0.167	0.23	0.087
2020_Fmult	NA	NA	1.14	1.35	1
2020_Landings	763	10 531	1210	479	799
2020_SSB	NA	NA	7636	2425	12 420
2021_Fbar	NA	NA	0.193	0.191	0.24
2021_Fmult	NA	NA	1.16	0.85	2.8
2021_Landings	1800	6834	1468	436	1872
2021_SSB	NA	NA	8010	2297	12 072
SSB_2022	NA	NA	7913	2165	10 482

Table 4.12. Iberian waters: Comparison between baseline run and ICES advice. Figures for 2019 compare results from the baseline run - that use the same assumptions for F in the intermediate year as the forecasts leading to ICES advice–to the ICES intermediate year results.

	ANK	HKE	LDB	MEG	MON
2020_Catches Baseline	794	13 040	1399	531	799
2020_Catches ICES	763	12 861	1399	531	799
2020_% diff	1.04	1.01	1	1	1
2021_Catches Baseline	1800	7825	1690	468	1872
2021_Catches ICES	1800	7825	1690	468	1872
2021_% diff	1	1	1	1	1

Table 4.13. Iberian waters: FLBEIA baseline run outputs for SSB and F relative to ICES advice.

	SSB_2019	SSB_2020	SSB_2021	SSB_2022	F_2019	F_2020	F_2021
LDB	1	1	1	0.99	1	1	1.03
MEG	1	1	0.98	0.97	1	1	1.02
MON	1	1	0.99	0.98	0.96	0.97	0.98

Table 4.14. Results of running FLBEIA scenarios on the TAC year (2021). Comparison of the single-stock ICES advice and potential landings in the various FLBEIA scenarios.

4	WGBIE	WGMIX FISH	max	min	ank	hke	ldb	meg	mon	E_sq
ank.27.8c9a	1800	1800	1.01	0.28	1	0.28	0.49	0.35	1.01	0.44
hke.27.8c9a	7825	7825	3.8	0.99	3.7	1	1.78	1.2	3.7	1.67
ldb.27.8c9a	1690	1690	1.74	0.57	1.74	0.57	1	0.76	1.74	0.87
meg.27.8c9a	468	468	1.61	0.75	1.61	0.75	1.19	1	1.6	1.14
mon.27.8c9a	1872	1872	1.07	0.29	1	0.29	0.58	0.35	1	0.55

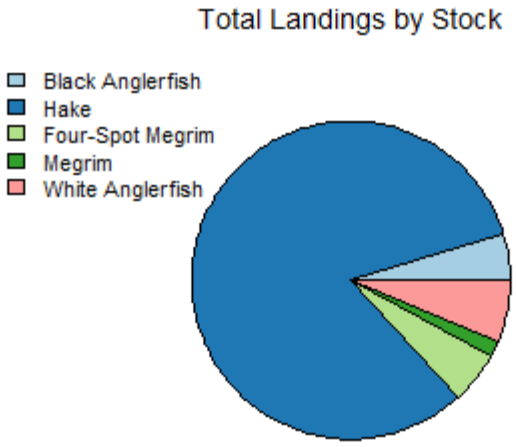


Figure 4.12. Mixed fisheries for the Atlantic Iberian Waters. Catch distribution by the stocks included in the mixed fisheries projections: 5% for black anglerfish, 82% hake, 5% megrim, 2% four-spot megrim and 6% for white anglerfish.

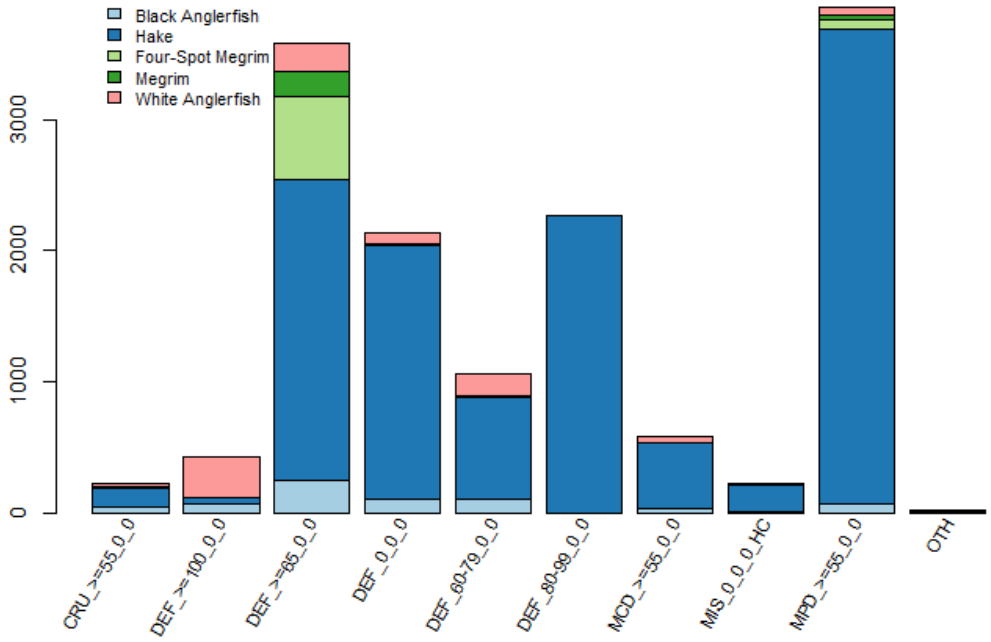


Figure 4.13. Iberian waters: Catch distribution of species by the métiers included in the mixed fisheries projections.

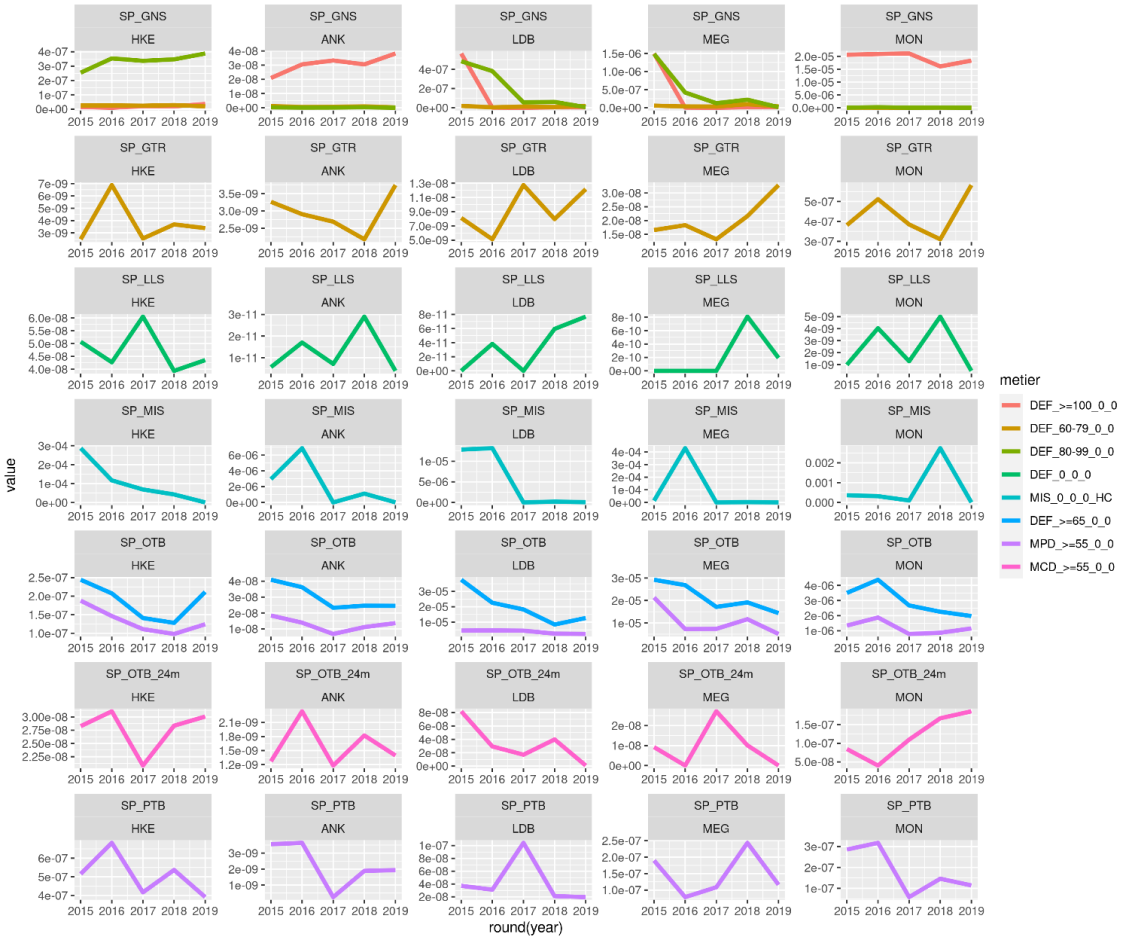


Figure 4.14. Iberian waters: trends of Spnish catchability by stock, fleet and métier from 2015-2019.

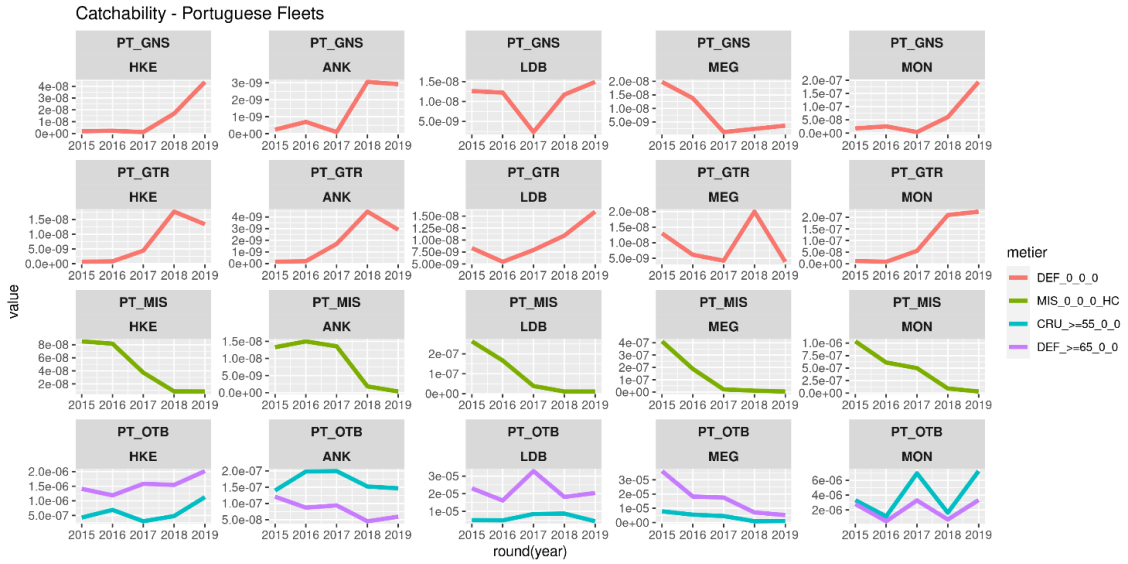


Figure 4.15. Iberian waters: trends of Portuguese catchability by stock, fleet and metier from 2015-2019.

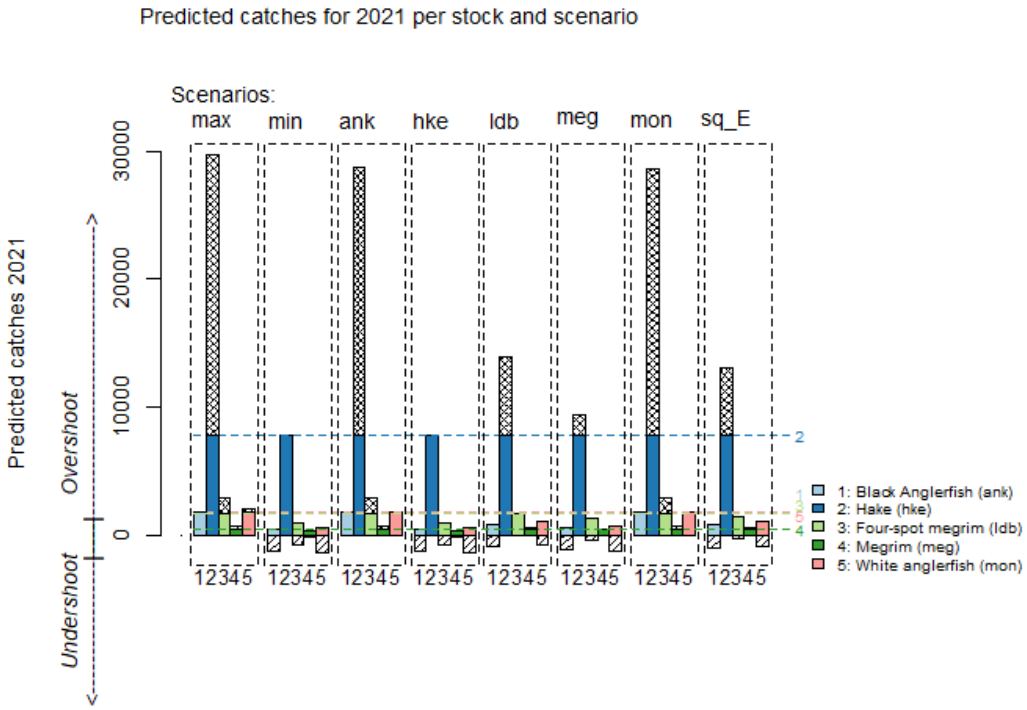


Figure 4.16. Iberian waters mixed fisheries forecasts: TAC year results (2021). FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year followed by the FLBEIA scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species catch advice) in cases where catches are predicted to be lower when applying the scenario.

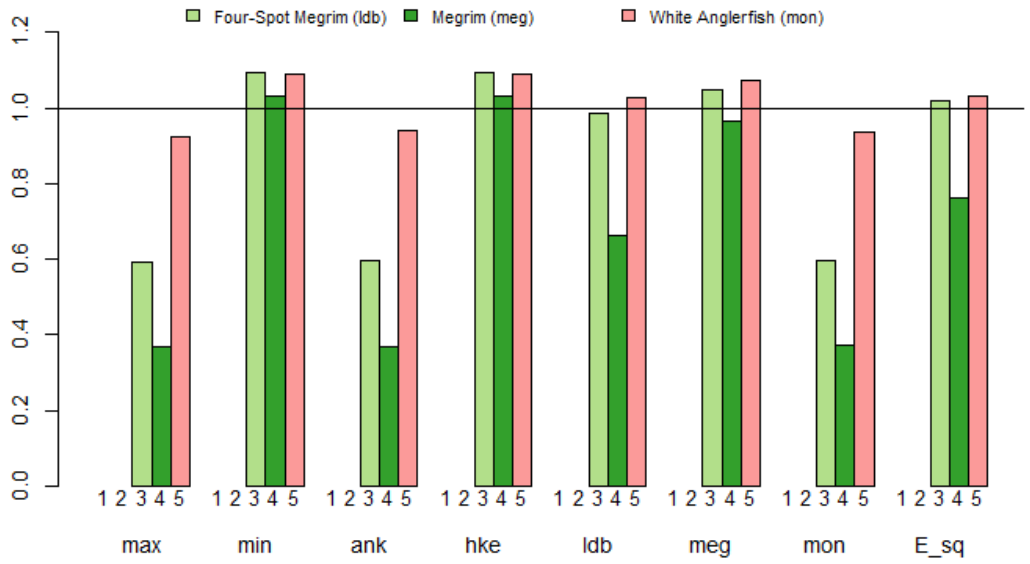


Figure 4.13. Iberian waters mixed fisheries forecasts: Estimates of potential SSB at the start of 2022 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2022).

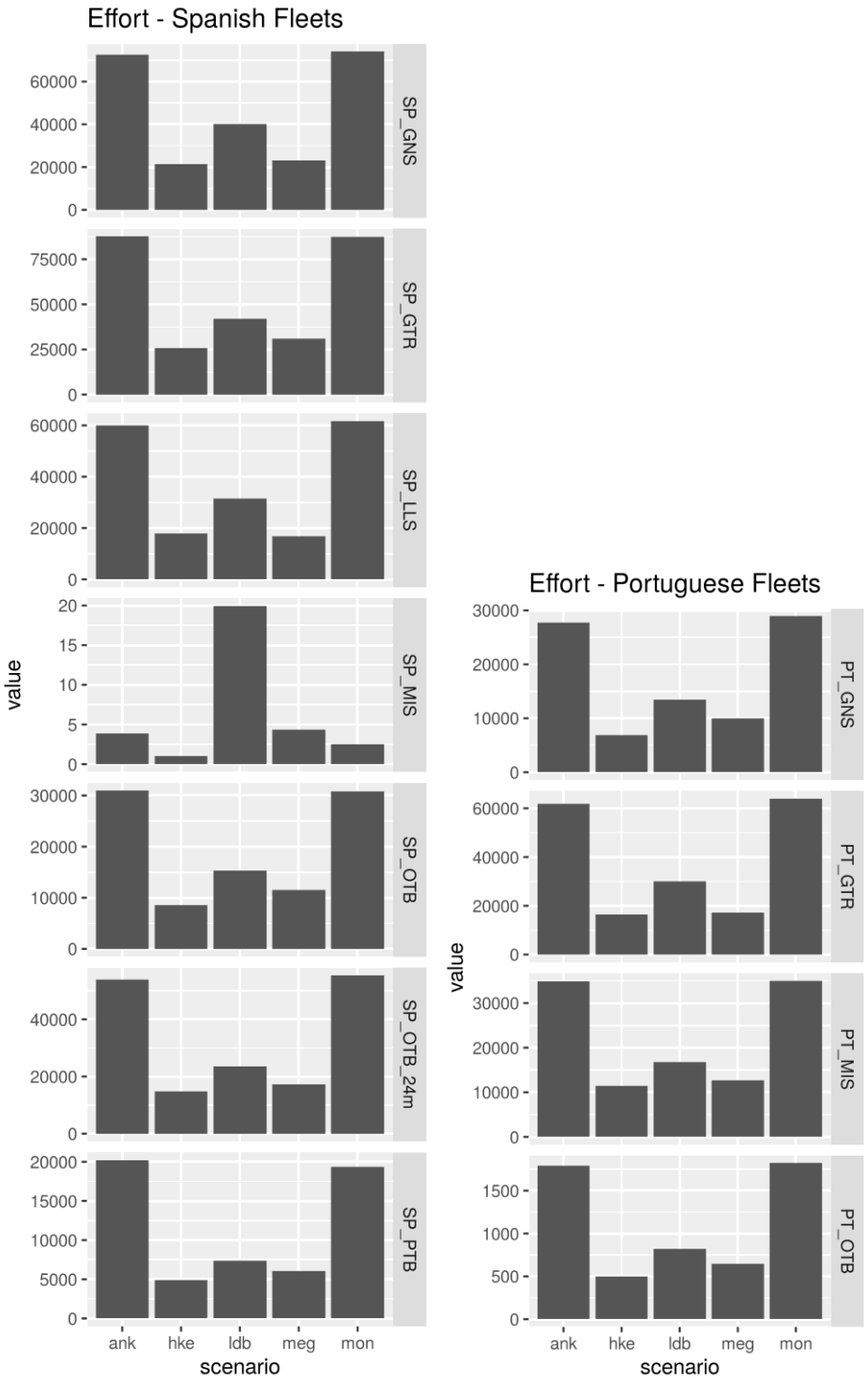


Figure 4.18. Iberian waters mixed-fisheries forecasts: TAC year results (2021). FLBEIA estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2021 (baseline run).

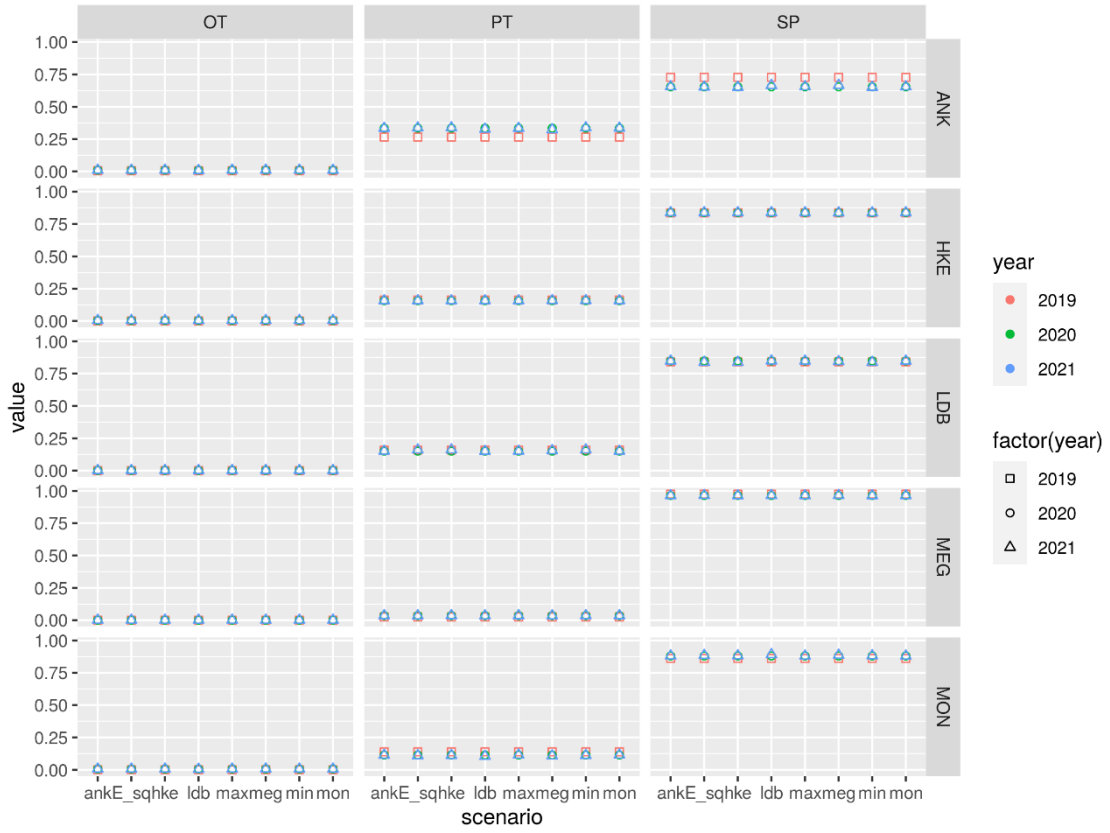


Figure 4.8. Iberian waters mixed fisheries forecasts: Test for relative stability. Changes of relative share of landings by country in 2020 and 2021 compared to the 2019 share for the eight FLBEIA scenario

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5 Irish Sea

5.1 Background

The focus of the Irish Sea subgroup in 2020 is on the development and validation of a comprehensive FCube model for the region. WGMIXFISH aims to produce mixed fisheries advice for the Irish Sea for the year 2022, in 2021.

The Irish Sea, ICES Division 7.a, is a relativity enclosed sea basin situated between Ireland and Great Britain. It is connected to the Celtic Sea (7.g) in the south by St George's Channel, and in the north it is linked to the West of Scotland (6.a) by the Northern Channel. Within the Irish Sea there are distinct habitat patches formed from a combination of bathymetry, topographical features and hydrography. The area is contrasted between a deeper channel, in the west, and shallower bays in the east. The channel has a maximum depth exceeding 275 m while the eastern bays have depths less than 50 m. A large well-defined deep-water mud basin is located in the north-western region close to the Northern Irish and Irish coastline. There is another distinct mud habitat in the east of the division. These two mud habitats are identified as two separate *Nephrops* functional units (FU14 and FU15).

5.2 Management considerations

Seven species are managed by TACs in Division 7.a namely cod, haddock, herring, plaice, sole, whiting, and *Nephrops* (FU14 and FU15). Single species advice for these stocks is issued annually by the ICES Working Group for the Celtic Seas Ecoregion (WGCSE). Category 1 analytical assessments are conducted for all fish stocks except cod, which was changed to a category 3 assessment in 2019. Cod is currently assessed using a trends based assessment based on the NIGFS scientific survey. *Nephrops* stocks are assessed using UWTV based stock assessment models.

Nephrops is the main demersal species landed by Irish Sea fisheries. The species is mainly targeted using otter trawls (OTB) with mesh size in the range 70–99 mm. Although landings of other species in the *Nephrops* fishery constitute a small proportion of the overall landings there is evidence of significant discarding in these fisheries, including whiting (ICES, 2019a). At present ICES advice is zero catch for whiting 2020 and 2021, and as such it is expected to be a key 'choke' species from a mixed fisheries perspective. The TAC for this species is 721 tonnes in 2020, following a ICES technical service that examined the likely catches in 2020 for bycatch stocks for which zero catch advice had been issued (ICES, 2019b).

Haddock account for the second highest landings and are mainly caught in otter trawls (OTB) and mid-water otter trawls (OTM). Plaice accounts for the third highest landings in the Irish Sea, and is mainly targeted by beam trawls (TBB) which are also the primary gear landing of sole. At present no directed commercial fishery of cod is permitted. However, landings of cod are primarily observed in otter trawls (OTB), with a small proportion in mid-water trawls. The majority of landings and discards of whiting also arise from otter trawls (ICES, 2019a).

In addition to demersal fisheries, a seasonal pelagic herring fishery operates in late summer to early autumn in the pre and post spawning period. Dredge fisheries target king and queen scallops, with king scallops in coastal areas and the queen scallop fishery operating in the central area south of the Isle of Man. To a lesser extent queen scallops are also targeted using trawl nets during the late summer when swimming activity is most pronounced.

Four nations dominate the fishing effort namely Northern Ireland, Republic of Ireland, England and Belgium. There is variation in the landings profiles of each métier at the country level, reflecting different fishing patterns, practice, and quota shares.

5.3 FCube

5.3.1 Model development

The mixed fisheries model being developed for the Irish Sea includes all TAC stocks in Division 7.a except herring. Namely, it includes cod, haddock, plaice, sole, whiting, and *Nephrops* FU14 and FU15. Herring is not included, as it is not generally considered to be an important component of mixed fisheries interactions, due to differences in both its ecology and in fishing approaches. However, there is evidence of some bycatch of whiting in this fishery, and it may be considered for inclusion in future years (ICES 2019a).

The FCube model for these species was developed using the FLR framework (Kell *et al.*, 2007; FLCore 2.6.13.9901, FLFleet 2.6.1, FLAssess 2.5.3, Flash 2.5.11) running in R 4.0.0 (R Development Core Team, 2020). Forecasts for fish stocks with analytical assessments (haddock, plaice, sole and whiting) were projected using the fwd() function in the Flash Package.

5.3.2 Data

For model development data relating to the 2018 assessment year were used. Data on landings and discards for the period 2015-2017 for all species were collated from the Intercatch database and the WGMIXFISH accessions data (WGMIXFISH 2020 data-call). Stock objects were updated where necessary based on WGCSE single-species stock assessments, and a new stock object was created for *Nephrops* FU14 from the single-species stock assessment data. Information on TAC's, fishing pressure, harvest rates, and stock assessment methods were also taken from the WGCSE advice documents and reports for the period.

5.3.3 Key model developments

The Irish Sea subgroup successfully implemented an FCube model for the Division 7.a, which includes all demersal fish species with TACs and both *Nephrops* FU's (14 and 15). This model incorporates Category 1 analytical assessments for all fish stocks except cod. Cod was changed to a category 3 stock in 2019, and is now assessed using a trends based assessment based on the NIGFS scientific survey. In the FCube model cod is projected based on the application of the ratio of the SSB in the past 2 data years to the SSB in the past 3 data years to the advised catch and F in the intermediate year. Further, model development will incorporate the independent index based on the NIGFS data, as per the current single-species assessments for this stock. *Nephrops* stocks are projected using UWTV based SSB estimates, harvest rates and discard estimates following procedures outlined in the single-species stock assessments. TAC for *Nephrops* is set for the whole of area 7, which includes *Nephrops* FU's in the broader Celtic Seas region. It is therefore necessary from a mixed fisheries modelling perspecitve to divide this TAC between FU's within the Celtic Seas region. In conjunction with the WGMIXFISH Celtic Seas subgroup, it was decided that the TAC for area 7 should be divided between the Irish Sea (FU14 – FU15) and rest of the Celtic Sea region, proportional to the long-term division of *Nephrops* landings between the Irish Sea and the rest of area 7 (2000-2018). This results in 52% of the TAC being allocated the Irish Sea. Division of TACs between FU's within the Irish Sea is then based on the proportion of landings the division in the most recent data year (2017), resulting in a split of the Irish Sea portion

of the TAC with 95% allocated to FU15 and 4% to FU14 (ca. 1% of the landings of *Nephrops* in Division 7.a came from outside of the FU's).

The model scripts were validated against the single-species assessments for all stocks, and sucessfully reproduced the advice numbers within a margin of error for all stocks except cod. In the case of cod this mismatch is to be expected, as the current stock assessment used in the mixed fisheries model reflects current single-species assessment methods for cod which were updated in 2019, whilst the test data being used is from 2018. It is therefore expected that when the landings, discards and stock data are updated to the current year in 2021, the mixed fisheries estimates for this species will better match the single-species advice.

Fleet objects were updated based on the new accessions data from the 2020 WGMIXFISH datacall, and conditioned according the methods used by the North Sea subgroup. The results of the fleet conditioning process were assessed based on data visualisations, and agree with the expected patterns of fishing effort between stocks, nations and fleets.

The FCube assessment was developed as a stand-alone script using FLR objects as inputs and outputs. The resulting FCube model was run across the following scenarios, 'min – each fleet stops fishing when single stock's TAC limit is reached', 'max – each fleet stops fishing when TAC limit is reached for all stocks', 'species-specific models' – in which fleets stop fishing when the TAC limit is reached for the species of interest (run for all species) and 'Status quo effort – each fleet fishes with effort equal to that observed in the most recent data year'. The results of these scenarios showed strong similarities between the 'min' and the 'whiting' scenario, suggesting that whiting is a limiting species for mixed fisheries in the Irish Sea. Specifically, whiting was the most limiting species for nine of the 14 fleets, with cod and haddock limiting for two fleets each and plaice for one fleet.

5.3.4 Next steps

The next steps in model development will be: a) to refine the structure of the fleet objects to better reflect the fishing practices and technical interactions observed in Irish Sea fisheries, b) to add SAM based assessments for plaice and sole to the mixed fisheries code, c) to implement index based projections for cod based on the NIGFS survey data, and d) to add a 'range' scenario which estimates the fishing mortality by stock (within the F_{MSY} ranges) which, if used for setting single-stock fishing opportunities, would reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot.

5.4 Conclusion

The core output of the Irish subgroup has been the implementation of a mixed fisheries model for the Irish Sea which includes all demersal fish stocks which are managed by TACs in Division 7.a and both *Nephrops* functional units. This is a key development given the importance of *Nephrops* fisheries for the Irish Sea region, and the fisheries overlap between *Nephrops* and fish species previously included in the Irish Sea FCube model. The model remains in the testing phase, and further development will be required before it can be used as the basis for advice. This development is will take place in 2020/2021, and mixed fisheries advice for the Irish Sea will be issued by WGMIXFISH in 2021.

6 Kattegat

This section describes the initial mixed fisheries analysis of the Kattegat.

Following the zero catch advice of cod in Kattegat (subdivision 21) ICES was requested to investigate the mixed fishery situation in Kattegat with a focus on the impact of mixed fisheries on the management of Kattegat cod.

Data used:

This analysis was conducted on catch data which were submitted to WGMIXFISH in 2020. This dataset consists of data from two countries (Sweden and Denmark) from 2009 to 2019. It contains effort and catch information on vessels operating in the Kattegat.

Total catches (tonnes) for each species were plotted, the species that accounted for the largest catches were herring, sprat and Norway lobster (Figure 6.1). Herring and sprat are dominating the Danish catches, followed by "Other" (all species not included in the 2020 Data Call) and Norway lobster, the same four species are dominating the Swedish catches although in a slightly different order (Figure 6.2). The dominating species in terms of value is the Norway lobster, by far the most valuable fishery in Kattegat (Figure 6.3).

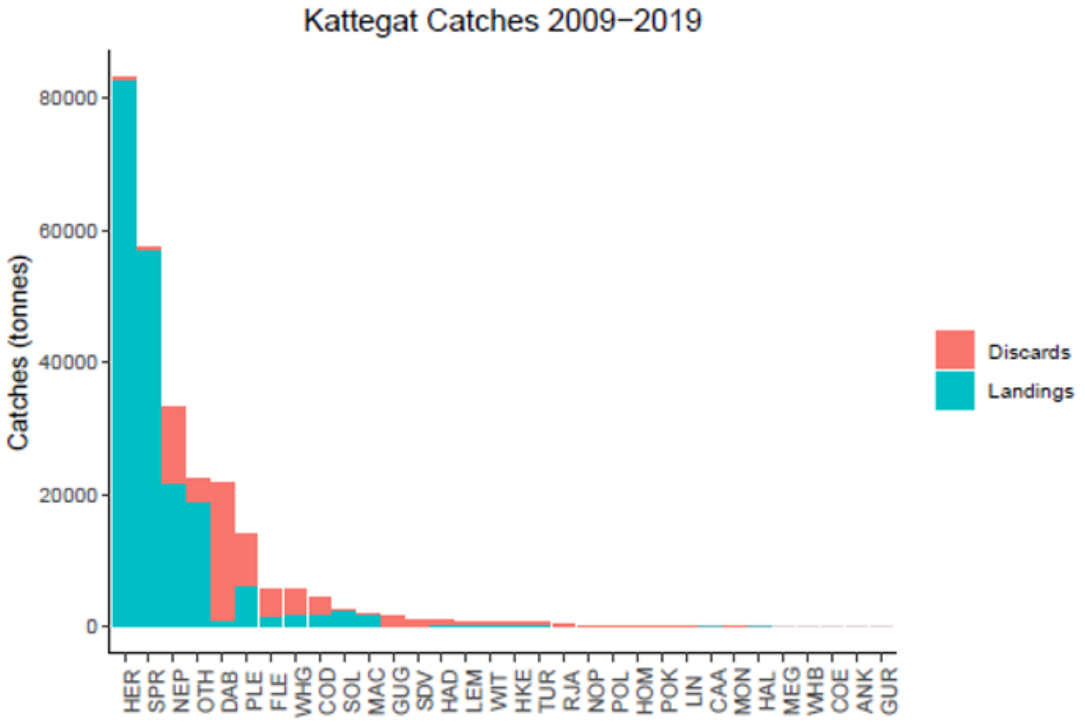


Figure 6.1. Distribution of catch weight per species 2009-2019.

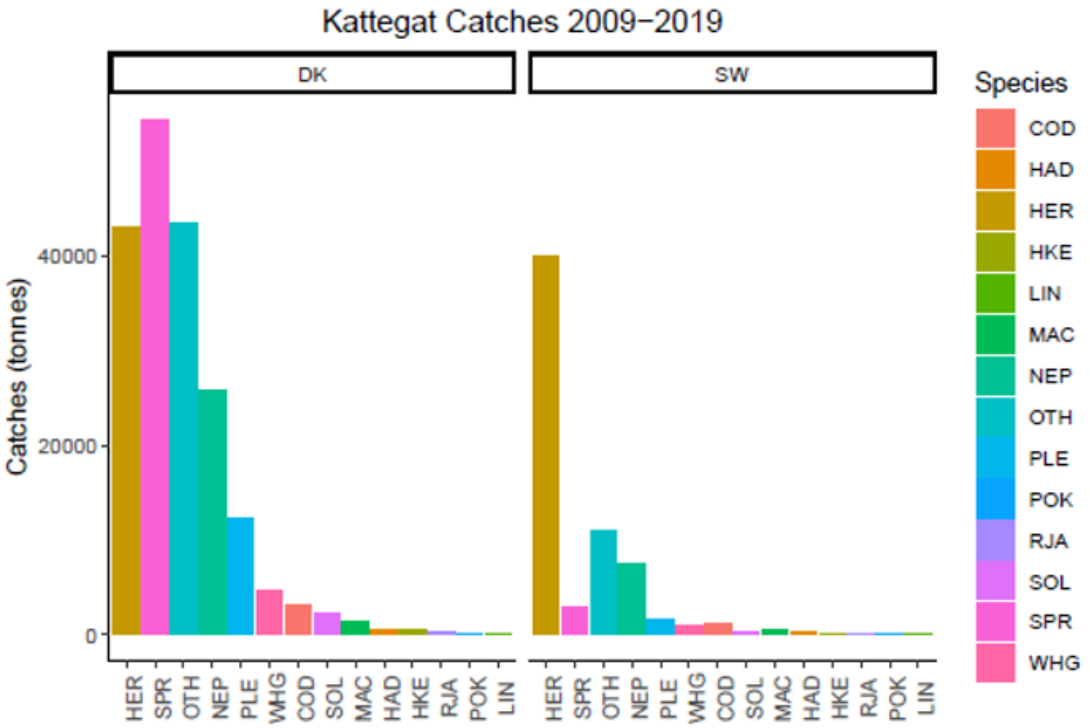


Figure 6.2. Distribution of catches by country in Kattegat 2009-2019.

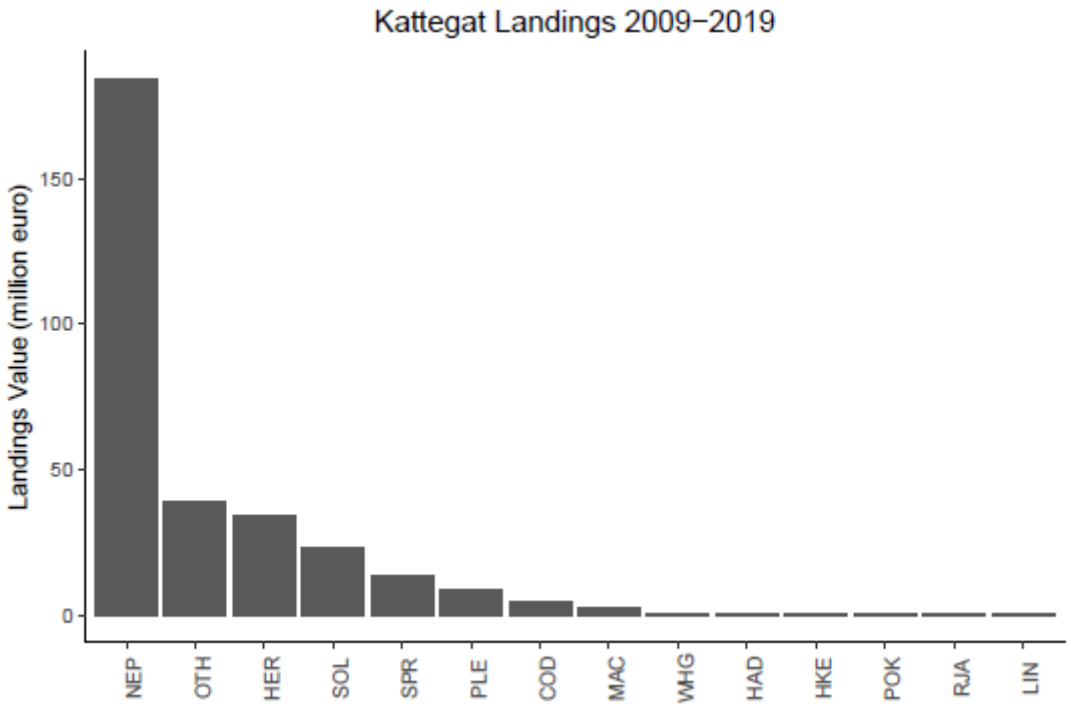


Figure 6.3. Landings value by species 2009-2019.

Cod is caught mainly in three métiers (DCF level 5) operating in the Kattegat. Over the 11-year period (2009-2019), catches of cod were predominately (91%) by bottom trawls targeting crustaceans (OTB_CRU) (Table 6.1). There were some catches of cod (5%) in gillnets targeting demersal

Fish (GNS_DEF). There were some minor catches of cod (1%) also in the trawlers targeting demersal fish (OTB_DEF). There is no targeted cod fishery in the Kattegat at present, cod is mainly taken as bycatch in the Norway lobster fishery (Table 6.1, Figures 6.4-6.6). The other species caught in the OTB_CRU fishery, except Norway lobster and cod, are "Others" (mostly dab), plaice, hake, sole and haddock (figures 6.4-6.6).

The main difference between the Danish and Swedish fishery is that, with the exception of Norway lobster, the Danish fishers have larger quotas, hence the proportion of fish species are larger in the Danish fishery compared to the Swedish.

Table 6.1. Cod mixing by métier (level 5).

Metier (lvl 5)	COD catches (tonnes)	COD catches %	Total catches (tonnes)	COD per Metier %
OTB_DEF	45.29	1.08	597.80	8
GTR_DEF	29.76	0.71	628.92	5
GNS_DEF	207.62	4.96	4830.67	4
OTB_CRU	3832.07	91.45	98164.77	4
SDN_DEF	22.64	0.54	602.32	4
LLS_FIF	11.61	0.28	355.40	3
FPO_CRU	0.11	0.00	330.02	0
MIS_MIS	40.85	0.97	131628.51	0
OTB_SPF	0.20	0.00	21132.85	0

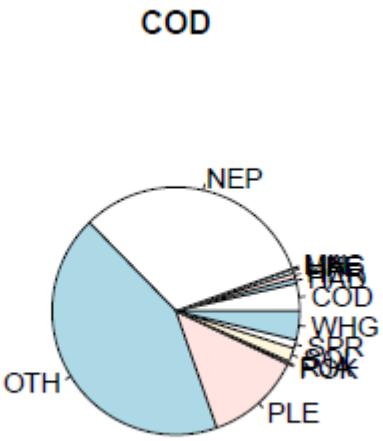


Figure 6.4. Species composition of métiers which typically catch cod, from 2009-2019, covering ICES area 27.3.21.

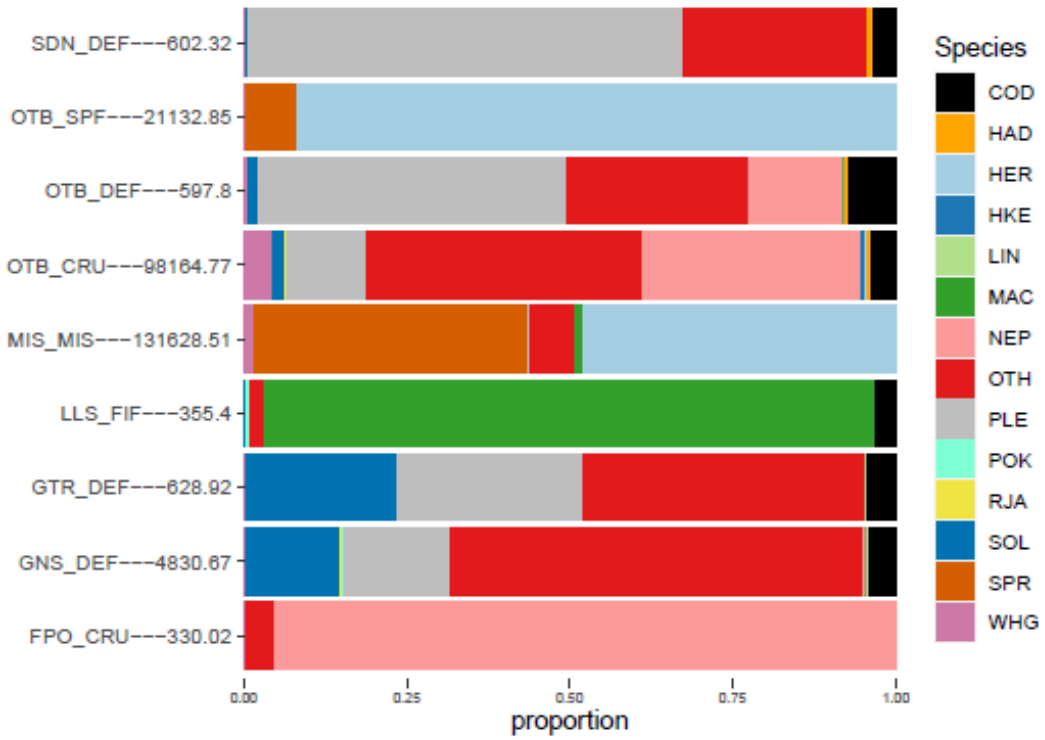


Figure 6.5. The catches profile by métier (level 5) describing the proportion of species by métier.

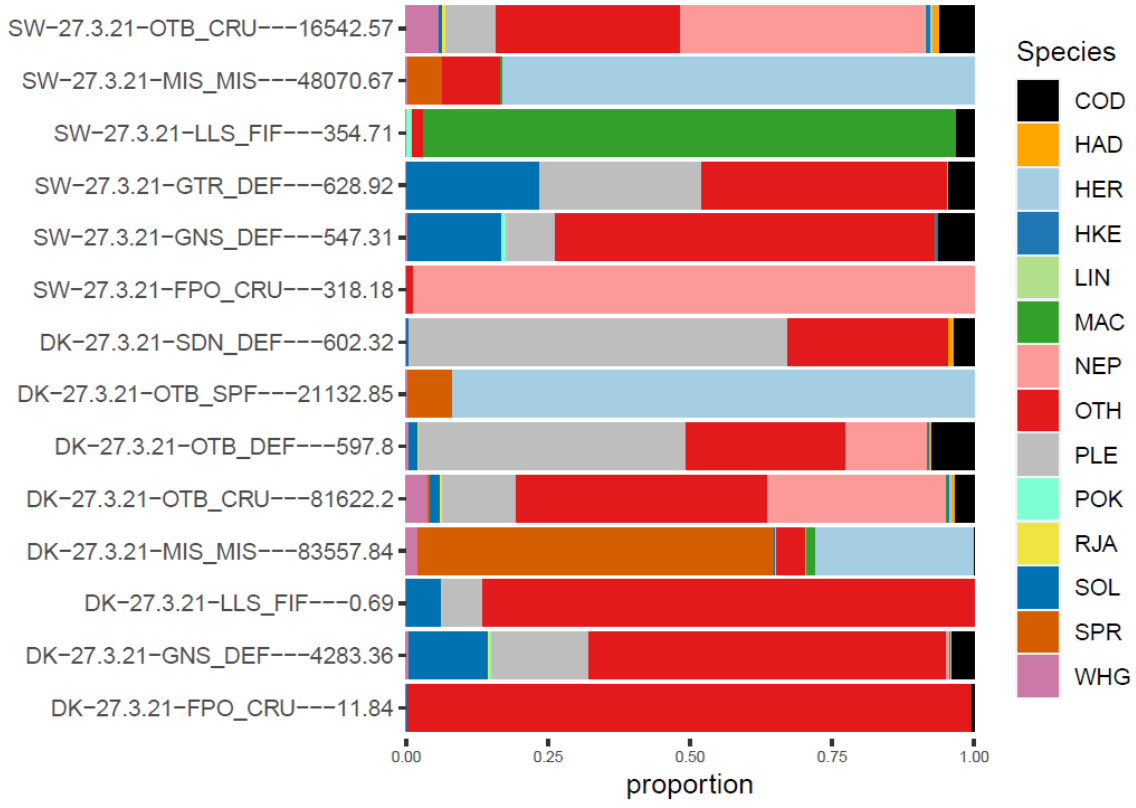


Figure 6.6. The catch profile of the main métiers catching cod (level 5) by country in Kattegat 2009-2019.

Since the major mortality of cod is associated to the OTB_CRU fishery targeting Norway lobster it implies that the fishing mortality of the cod stock is closely linked to effort of the same fishery. The highest effort in terms of KW-days is found in the OTB_CRU (figures 6.7 and 6.8); Denmark deploys double the effort compare to Sweden over the period analysed (Figure 6.9). The removal of the effort system in 2016, together with the loss of fishing opportunities for cod in the Baltic Sea, has most likely resulted in the steep increase in the effort in the Norway lobster fishery from 2017.

The uptake of the TAC for Norwegian lobster in the Division 3.a was 71% in 2018, bi-annual advice next due in 2020, allowing for a further increase in the effort of the trawl fishery targeting it. In order for the 0 advice on cod to be an effective measure for the rebuilding of the cod stock in Kattegat, the effort of the OTB_CRU needs to be limited or there is an urgent need for the OTB_CRU fishery to be more selective. There are selective gears in place for targeting Norway lobster, for example the Swedish sorting grid that has a bycatch of less than 1.5% cod (Figure 6.10). The sorting grid was extensively used in previous years by Swedish fishers but the uptake of the gear has decreased substantially since 2016 when the effort limitation was removed.

In order for a rebuilding of the cod stock in Kattegat there should either be a substantial decrease in the overall effort or incentives to increase the use of selective gears to decouple the exploitation of cod from other species targeted.

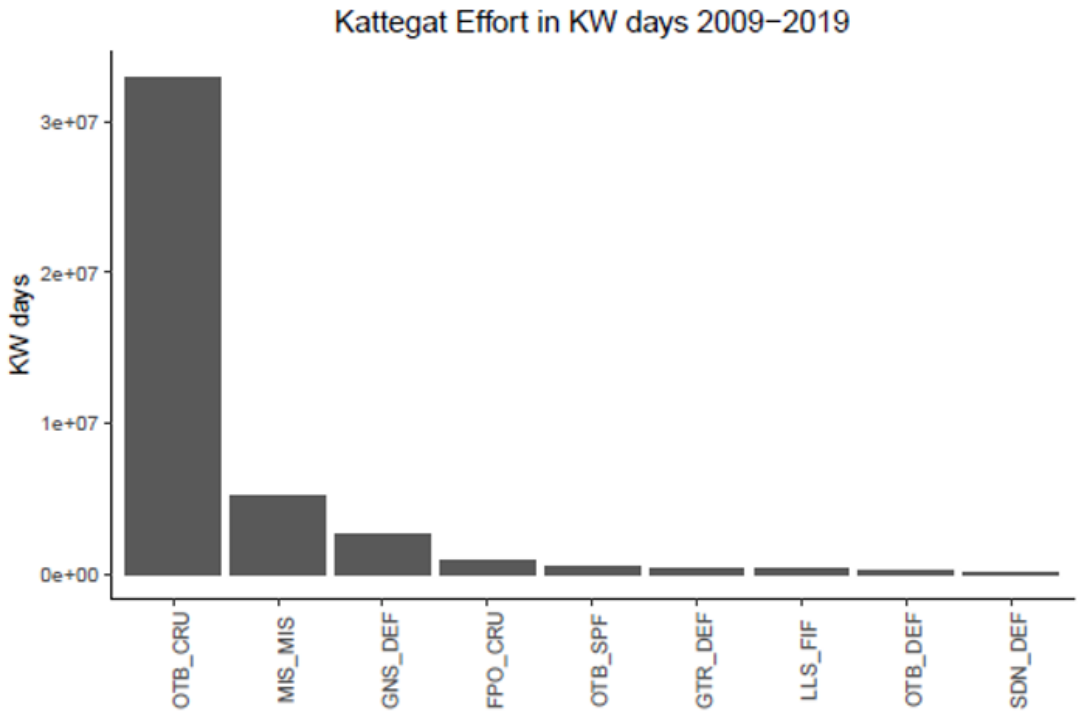


Figure 6.7. Total effort (KW days) over the complete time-series (2009-2019) for level 5 métiers operating in Kattegat.

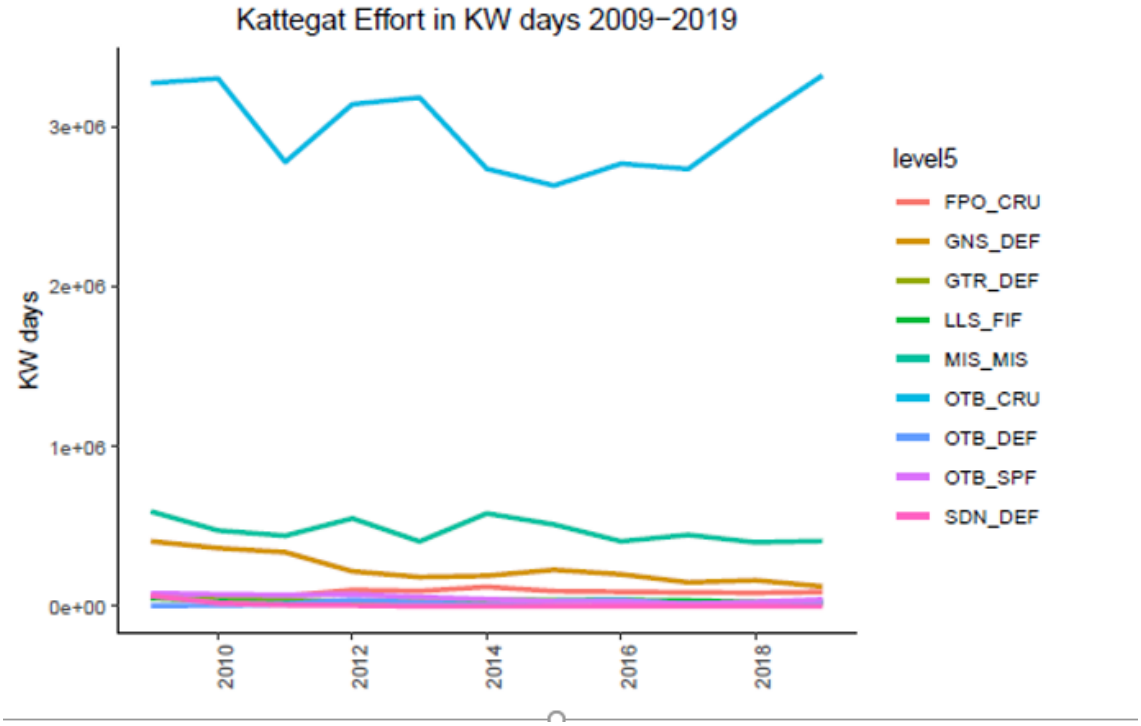


Figure 6.8. Effort (KW days) by year for level 5 métiers operating in Kattegat.

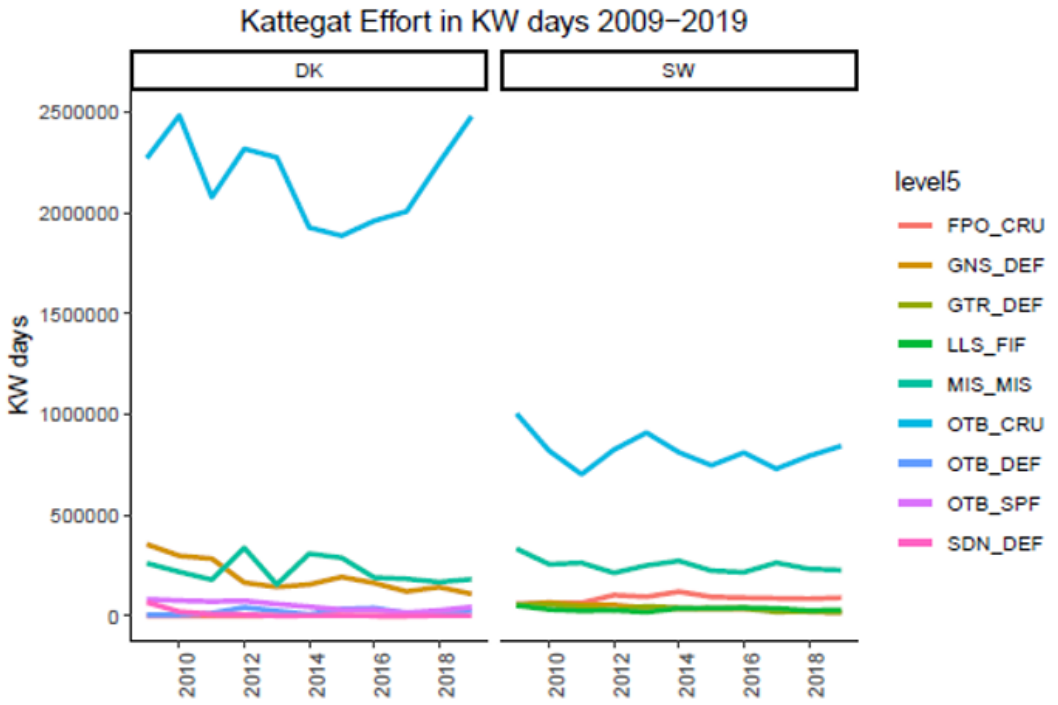


Figure 6.9. Total effort (KW days) by country over complete time-series (2009-2019) for level 5 métiers operating in Kattegat.

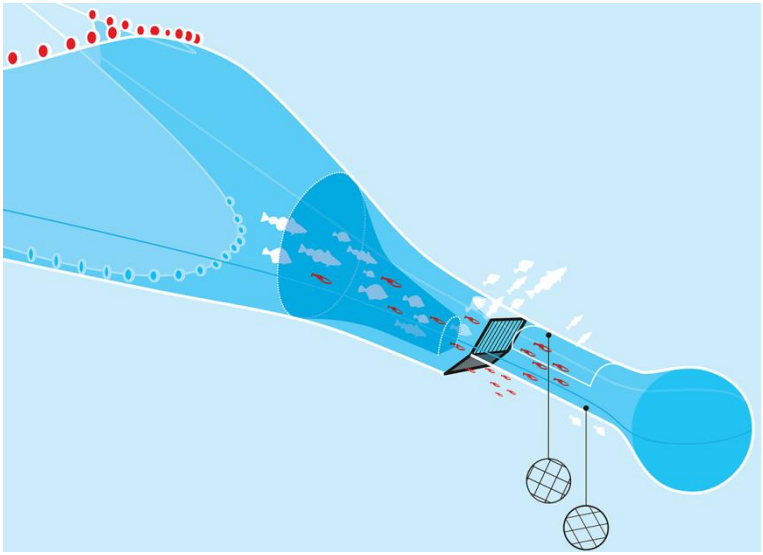


Figure 6.10. The Swedish sorting grid catching less than 1.5% of cod.

Table 6.2. Percentage change in fishing mortality, harvest rate or advised catch between 2020 and 2021; as implied by ICES advice for the main demersal stocks being caught in mixed fishing operations with cod.

Species	Corresponding EC TAC AREA	ICES stock code	F_{2020}	Advised F_{2021}	Change in Ices advice 2021-2020
Cod *(Gadus morhua)*	21	cod.27.21	NA	0	0
Norway lobster (*Nephrops noreegi-cus*)	3a	nep.fu.3-4	NA	NA	+6%
Sole *(Solea solea)*	20-24	sol.27.20-24	0.197	0.23	+11%
Whiting *(Merlangius merlan-gius)*	3a	whg.27.3a	NA	NA	+132%
Plaice *(Pleuronectes platessa)*	21-23	ple.27.21-23	0.38	0.31	-52%
Haddock *(Melanogrammus ae-glefinus)*	Subarea 4, division 6a, subdivision 20	Had.27.46a20	0.197	0.194	+65%

Plans for WGMIXFISH 2021.

In 2021 analyses will be continued together with an exploration of the possibilities of giving mixed fisheries advice for Kattegat in the future.

7 North Sea

7.1 Background

Please refer to the North Sea Mixed Fisheries stock annex for a full description of the geographical area and the fishery.

7.2 Effort limitations

In previous years, WGMIXFISH advice has considered restrictions to effort in line with legislation related to the cod recovery plan (Council Regulation (EC) 1342/2008). Since 2018, in preparation with the full implementation of the landing obligation for all stocks in 2019, new legislation was issued that removed these restrictions (Council Regulation (EU 2019 amending EU 2018/973). Some limitations now exist in terms of fleet capacity rather than effort, but these are not considered in the current WGMIXFISH scenarios.

7.2.1 Stock-based management plans

In the context of the new CFP, the EU has developed a Multiannual management plan (MAP) for the management of the North Sea demersal mixed fisheries, which has been in force since 2018[2], and replacing the former single-stock long term management plans with a unique framework defining objectives and constraints for both target and bycatch demersal species. The majority of the stocks included in the North Sea demersal mixed fisheries analysis are shared between the EU and Norway. As Norway is not involved in the EU MAP, ICES gives advice based on the ICES MSY approach. Only for stocks that are not shared (North Sea sole, eastern English Channel plaice), the ICES advice is based on the MAP. Some of the stocks included in the mixed fisheries analysis are considered as bycatch under the MAP (North Sea turbot and witch). However, these stocks have now Category 1 assessment, and since they are stock shared with Norway, ICES also gives advice for the stocks on the basis of the ICES MSY framework (while according to the MAP, they should be management according to the precautionary approach).

In the mixed fisheries simulations, it is assumed that TACs for 2021 will be based on the ICES advice and may therefore not correspond for all stocks to the application of the EU MAP. In practice, the TACs for shared stocks are agreed during EU/Norway negotiations, and may deviate from the ICES advice.

7.3 FCube

7.3.1 Software

All analyses were conducted using the FLR framework[3] (Kell *et al.*, 2007; FLCore 2.6.13, FLAssess 2.6.3, FLash 2.5.11) running with at least R 3.5.1 (R Development Core Team, 2020). The code, software and versions are part of the ICES Transparent Assessment Framework[4] (TAF) and can

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018R0973&from=EN

[3] https://flr-project.org

[4] https://github.com/ices-taf/2020_NrS_MixedFisheriesAdvice

be fully reproduced from this repository. All forecasts were projected using a modified version of the fwd() function in the FLash Package. Some stock assessments (e.g. cod 4,7d and 20; haddock 4, 6a and 20; whiting 4 and 7d) use data from the current year (intermediate year) and therefore produce stock abundance estimates for this year, which are used as the starting numbers for the short term forecasts. The FLash fwd() function is not designed to use stock abundances provided in the first year of the projections and overwrites any existing values with the outcome of the survival equation, using numbers and mortality rates from the previous year. Therefore the FLash fwd() function was modified so that, if stock abundances-at-age are provided for the first year in the short term foreacast, they are effectively used as starting values and not replaced.

The FCube method was developed as a stand-alone script using FLR objects as inputs and outputs. Software and models used in the single-species assessments and forecasts are outlined in the table below. For the *Nephrops* stocks, the assessment methods are more simple and conducted on excel spreadsheets.

Species	Assessment	Forecast
COD 4, 7.d and 20	SAM	SAM
HADDOCK 4, 6.a and 20	TSA	MFDP
PLAICE 4 and 20	AAP	FLR 2.3, FLash
PLAICE 7.d	AAP	FLR 2.x, FLash
SAITHE 3.a, 4 and 6	SAM	SAM
SOLE 4	AAP	FLR, FLash
TURBOT 4	SAM	FLR, FLash
WHITING 4 and 7.d	SAM	MFDP
WITCH 3.a, 4 and 7.d	SAM	SAM

7.3.2 Scenarios

The FCube model was proposed by Ulrich *et al.* in 2008, and has developed over time to reflect the challenges that have arisen in demersal mixed fisheries management (Ulrich *et al.*, 2011, 2017). The basis of the FCube model is to estimate the potential future levels of effort by a fleet corresponding to the fishing opportunities (TACs by stock and/or effort allocations by fleet) available to that fleet, based on fleet effort distribution, and catchability by métier. This level of effort was used to estimate the catches by fleet and stock, using standard forecasting procedures.

Single-species ICES advice for North Sea stocks of interest is given according to specific single-species options, existing management plan, ICES maximum sustainable yield (MSY) approach, or precautionary approach (PA). The basis for each single-stock advice is retained in the current mixed fisheries framework.

Incorporating *Nephrops* into the mixed fisheries advice produces a number complicating factors: For example, *Nephrops* are fished in distinct geographic areas or functional units (FU), only some of which receive an abundance estimate (necessary to calculate a catchability). This WG followed the approach adopted by ICES (2009) which is to perform the normal FCube prediction for those FUs with absolute abundance estimates, then to calculate a ratio of change from the current

yields to the ICES advice for the same FUs. For those FUs without absolute abundance estimates, landings resulting from the FCube run were simply taken to be the most recently recorded landings multiplied by the same ratio R. To do this, landings for each métier had to be apportioned across the FUs. This was facilitated by the supply of effort and catch data by FU.

As in previous years, the following seven options (or scenarios) were included in the advice:

1. "**max**": For each fleet, fishing effort in 2021 stops when all stock shares* of that fleet have been caught up. This option causes overfishing of the single-stock advice possibilities of most stocks. The underlying assumption is that fishing stops for a fleet when all quota species are fully utilised for that fleet with quotas set corresponding to single-stock exploitation boundary for each species.
2. "**min**": The underlying assumption is that fishing stops for a fleet when the catch for the first quota species for that fleet meets the corresponding single-stock exploitation boundary. This option causes underutilization of the single-stock advice possibilities of other stocks. This scenario can highlight some potential "choke species" issues.
3. "**sq_E**" (*status quo* effort): The effort of each fleet in 2020 and 2021 is set equal to the effort in the most recently recorded year for which landings and discard data are available (2019).
4. "**val**" (value): A simple scenario accounting for the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the quota of each of the stocks, weighted by the historical catch value of that stock. This option causes overfishing of some stocks and underutilisation of others. The "val" scenario is a simple proxy balancing fishing opportunities by stock with their potential market value, in the absence of a formal economic behaviour model. For example, if a fleet would need 100 days fishing for catching its share of stock A, and 200 days fishing for catching its share of stock B, and if the value (tonnage × mean price) of that fleet's stock shares is 75% from stock A and 25% from stock B, then the resulting effort would be (100 × 0.75) + (200 × 0.25) = 125 days.
5. "**cod-ns**" (Cod MSY approach): All fleets set their effort in 2020 and 2021 corresponding to their cod stock share, regardless of other catches. (There are small differences in the cod catches between this scenario and the single-stock advice because of the slightly different forecast methods used.) This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks. This scenario can highlight some potential "choke species" issues.
6. "**range**": as described in Ulrich *et al.* (2017), this scenario searches for the minimum sum of differences between potential catches by stock under the "min" and the "max" scenarios within the F_{MSY} range for each stock.

FIDES data option

In the 2019 MIXFISH advice, the assumptions for the "min" scenario and consequently for the "range" scenario were modified to more realistically reflect choke situations at the fleet level by using the most recent year of FIDES data as follows:

Choke species are assessed at the country-level comparing the sum of fleet catches and catches at status quo effort for each fleet, assuming that quota reallocation between fleets can occur at country level. For each fleet, fishing effort after the intermediate year stops when the most limiting of the predefined choke stock shares of that fleet is attained. If a fleet has no identified choke stock then the status quo effort for that fleet is used. This corresponds to the assumption that where one or more national quotas are fully utilised, all fishing will cease for that Member State (MS). If a MS had unused quota for a given stock, it is not considered as a choke species for the fleets of that MS, making the hypothesis that national quotas are easier to reallocate between

fleets than countries. To forecast catches, recent catchability and fishing mortality are calculated by national fleet.

This year, the FIDES resulted in results for the "range" scenario with F_{range} larger than F_{MSY}. The section 7.7 explains the modelling processes that produced these unexpected results (**Figure 7.15**).

7.4 Stock input data and recent trends

7.4.1 Stock input data

The assessment data for the different stocks were taken from ICES WGNSSK (ICES, 2020e). Similar to last year, all stock inputs formatted as FLStock objects were directly provided to WGMIXFISH by the respective stock coordinators, and this eased greatly the quality of the process of collecting stock data.

An increasing number of WGNSSK stocks are being assessed using stochastic assessments (SAM model for North Sea cod, saithe, turbot whiting and witch flounder, TSA for Northern shelf haddock). Therefore, for some of these stocks the advice is based on stochastic forecasts, which cannot easily be fully replicated in the deterministic FCube software. However, FCube projections are routinely compared to the median projections of the single-species stochastic forecasts on which single-stock advice is based and results are very similar (see Section 7.6.2.1 below); as such, WGMIXFISH does not consider the difference impacts significantly on the mixed fisheries advice.

In 2019, the Eastern Channel sole was classified as category 3 species and therefore is not included since 2019 in the WGMIXFISH considerations.

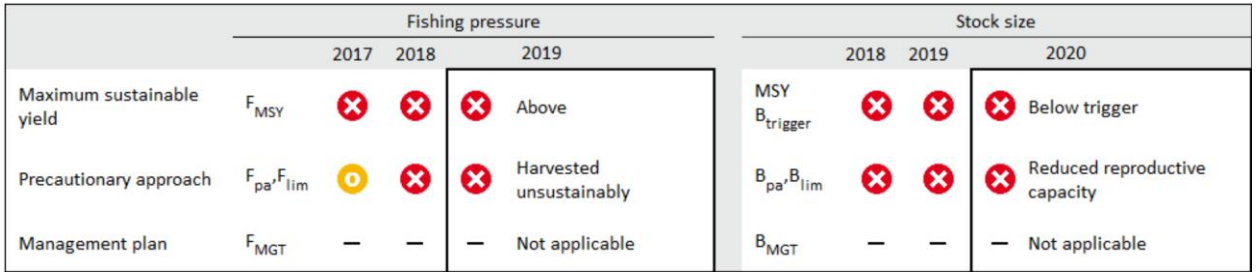
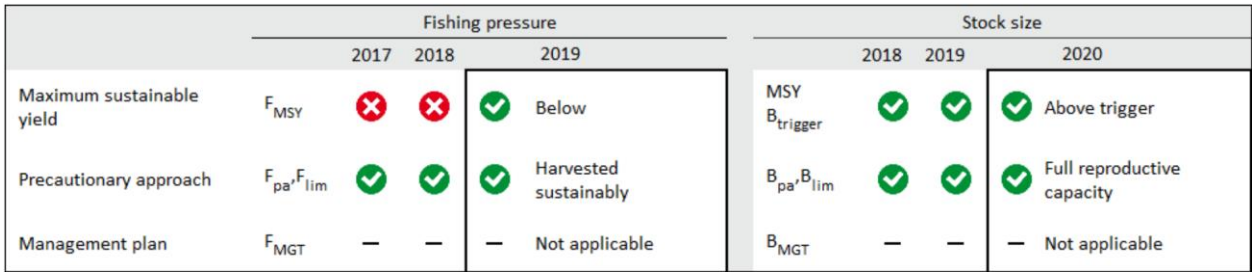
Nephrops stocks were incorporated in the evaluation by functional unit. For the *Nephrops* stocks in FU5, FU6, FU7, FU8, FU9, FU10, FU32, FU33, FU34 and *Nephrops* from areas outside the functional units, the ICES advices were taken for the F_{MSY} approach.

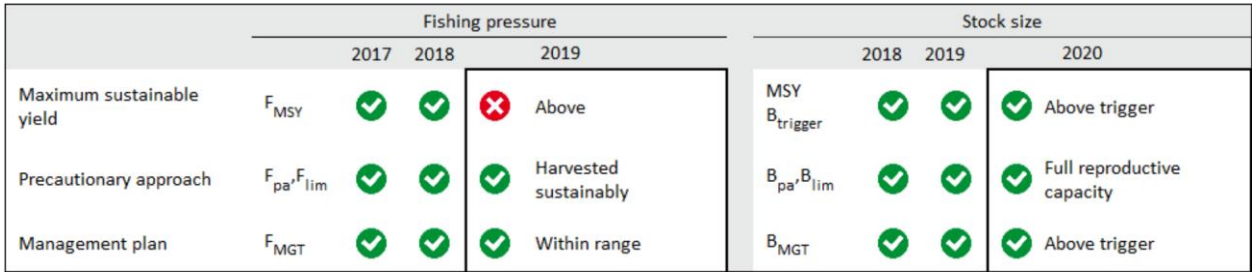
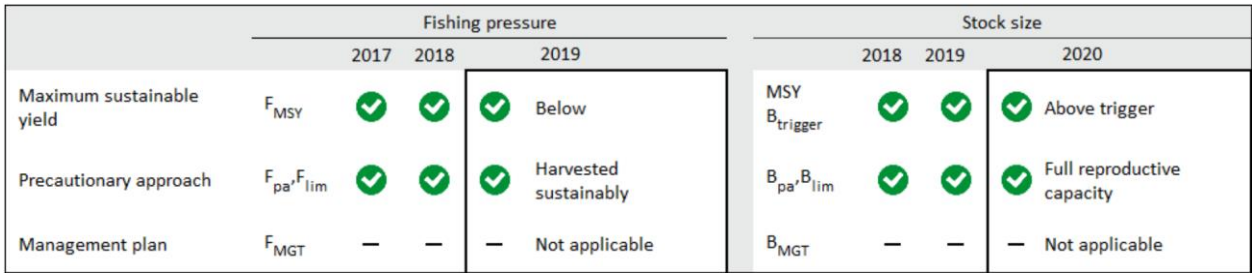
The functional units with separate stock indices and harvest rates from underwater surveys (FU6, FU7, FU8 and FU9) were treated as separate *Nephrops* identities in the projections whereas the five other functional units (FUs 5, 10, 32, 33 and 34) and catches outside the functional units in the North Sea were omitted in the projections.

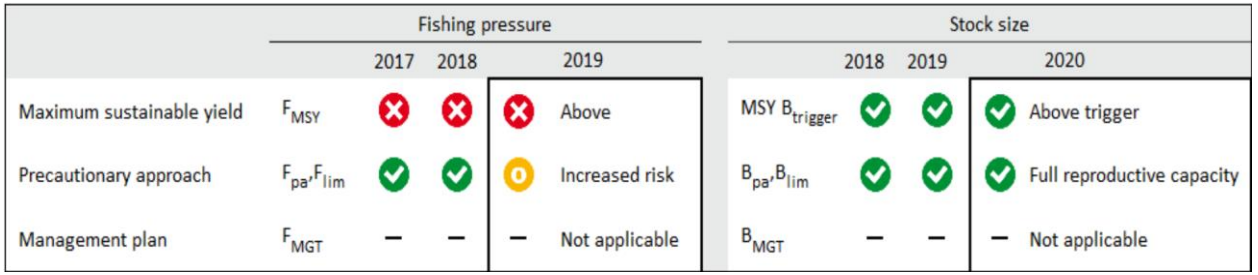
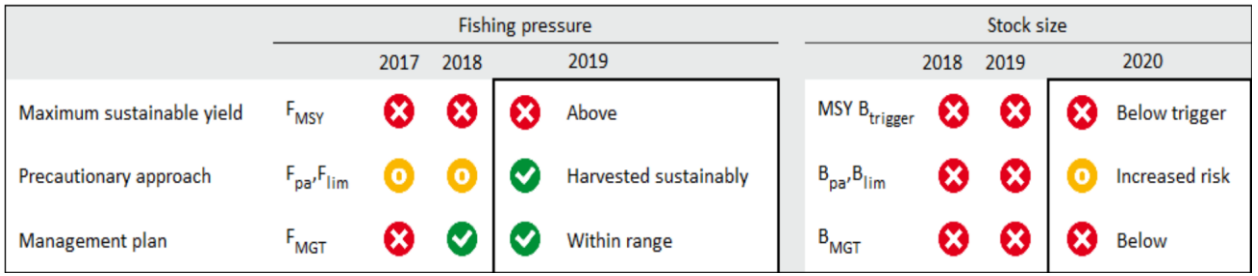
7.4.2 Recent trends and advice

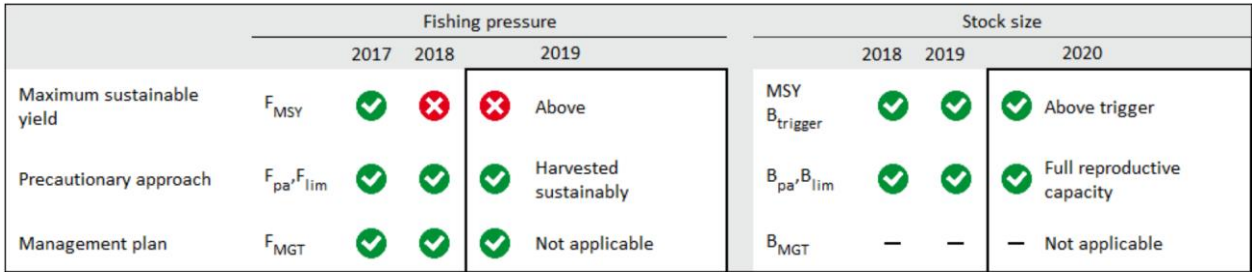
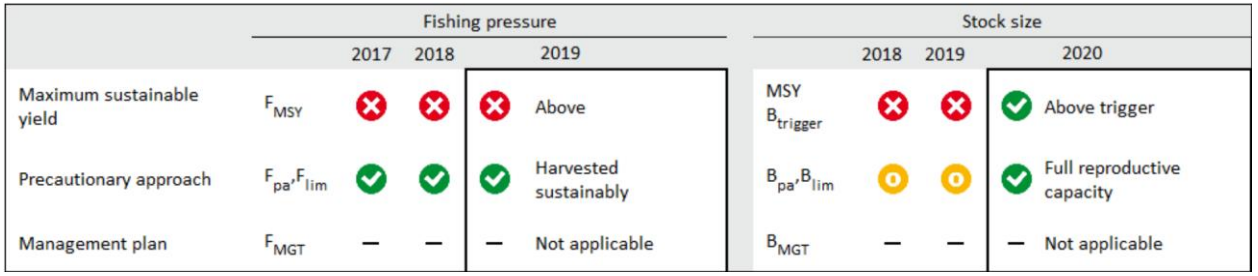
The advice for these stocks is drafted by the WGNSSK-2020 (ICES 2020e) under considerations by ACOM. Recent trends are described on a stock-by-stock basis in ICES (2020e), and latest advice by stock is available on the ICES website. In order to give a global overview of all North Sea demersal stocks at one time, this information is summarised below. It should be noted that although there is only one advice, additional management considerations are also listed each single-species advice document.

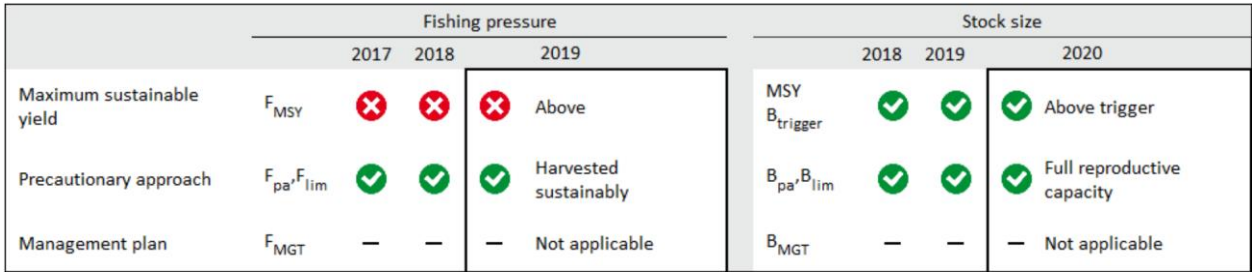
Analytical stocks

Species	Area	Stock status	Advice 2021
cod.27.47d20 (Cod)	Subarea 4, Division 7.d, and Subdivision 20 (North Sea, eastern English Channel, Skagerrak)	 **Summary**: Fishing mortality (F) has increased since 2016 and is above F_{lim} since 2018. Spawning-stock biomass (SSB) has decreased since 2015 and is below B_{lim}. Recruitment since 1998 remains poor.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 14 755 tonnes.
had.27.46a20 (Haddock)	Subarea 4, Division 6.a, and Subdivision 20 (North Sea, West of Scotland, Skagerrak)	 **Summary**: Fishing mortality (F) has declined since the beginning of the 2000s and is below F_{MSY} now. Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 69 280 tonnes.

Species	Area	Stock status	Advice 2021
ple.27.420 (Plaice)	Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	 **Summary**: The spawning-stock biomass (SSB) is well above MSY $B_{trigger}$ and has markedly increased since 2008, following a substantial reduction in fishing mortality (F) since 1999. Recruitment has been fluctuating around the long-term average since the mid-1990s. Since 2009, fishing mortality (F) has been estimated below F_{MSY}.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 162 607 tonnes.
ple.27.7d (Plaice)	Division 7.d (Eastern Channel)	 **Summary**: The spawning-stock biomass (SSB) has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing mortality (F) has declined since the early 2000s, with an increase in the recent years to slightly above F_{MSY}. Recruitment(R) is currently around the average of the last 10 years of the time-series.	ICES advises that when the EU multiannual plan (MAP) for the Western Waters is applied, catches from the Division 7.d plaice stock in 2021 that correspond to the F ranges are between 6066 tonnes and 11 130 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (8402 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

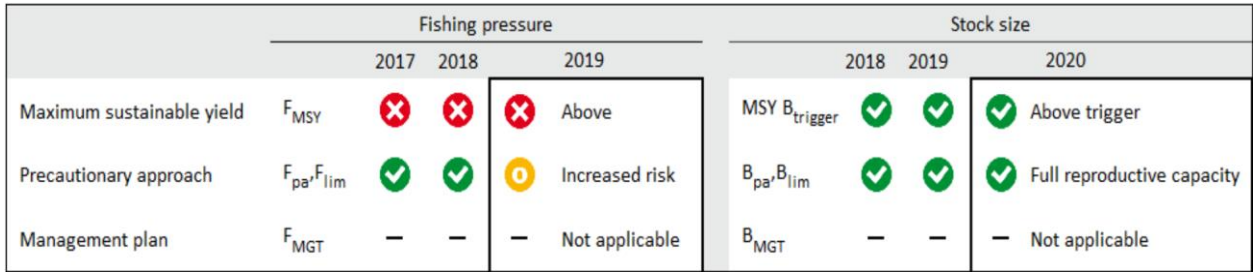
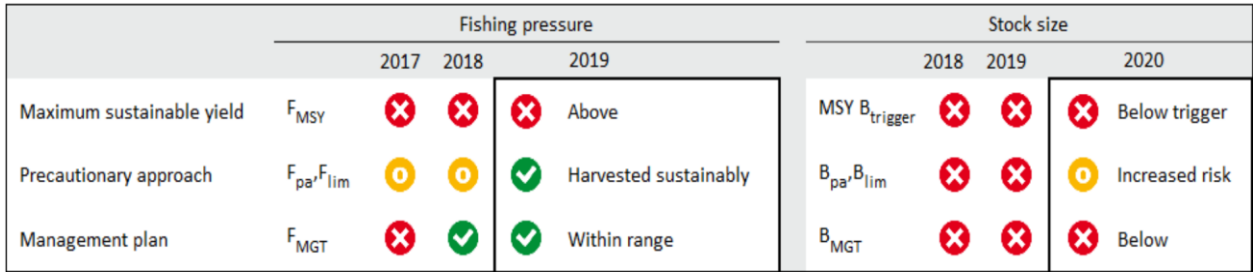
Species	Area	Stock status	Advice 2021
pok.27.3a46 (Saithe)	Subareas 4 and 6, and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	 **Summary**: Spawning-stock biomass (SSB) has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality (F) is increasing since 2016 and is above F_{MSY}. Recruitment(R) has shown an overall decreasing trend over time with lowest levels in the past 10 years.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 65 687 tonnes.
Sol.27.4 (Sole)	Subarea 4 (North Sea)	 **Summary**: The spawning-stock biomass (SSB) has fluctuated around B_{lim} since 2003 and has been estimated below MSY $B_{trigger}$ since 1999. Fishing mortality (F) has declined since 1999 and is close to F_{MSY} in 2019. Recruitment(R) has fluctuated in 2019 is estimated to be the highest since 1957.	ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the MAP are between 13 237 tonnes and 32 920 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (21 361 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

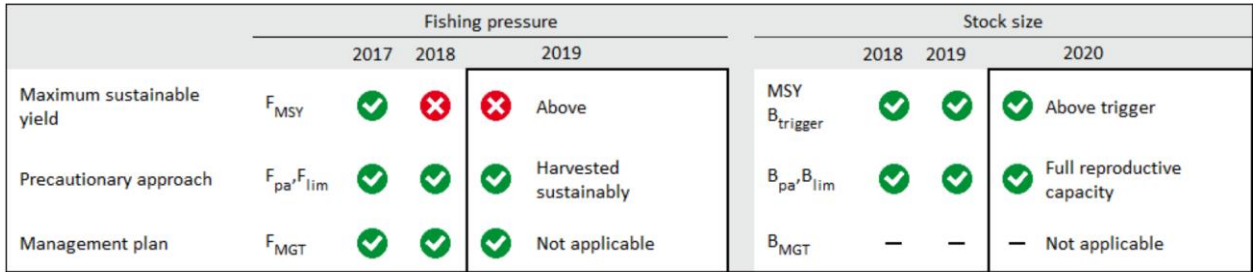
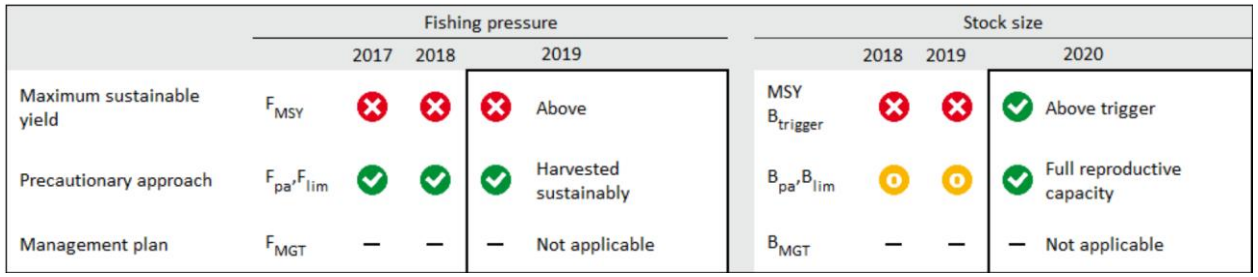
Species	Area	Stock status	Advice 2021
tur.27.4 (Turbot)	Subarea 4 (North Sea)	 Summary: Recruitment(R) is variable without a trend. Fishing mortality (F) has decreased since the mid-1990s, and is slightly below F_{MSY} since 2018. The spawning-stock biomass (SSB) has increased since 2005 and has been above MSY $B_{trigger}$ since 2013.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 3948 tonnes.
whg.27.47d (Whiting)	Subarea 4 (North Sea) and Division 7.d (Eastern Channel)	 **Summary:** Spawning-stock biomass (SSB) has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just below it in 2019. Fishing mortality (F) has been above F_{MSY} throughout the time-series, apart from 2005. Recruitment(R) has been fluctuating without trend..	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 26 304 tonnes. Management should be implemented at the stock level

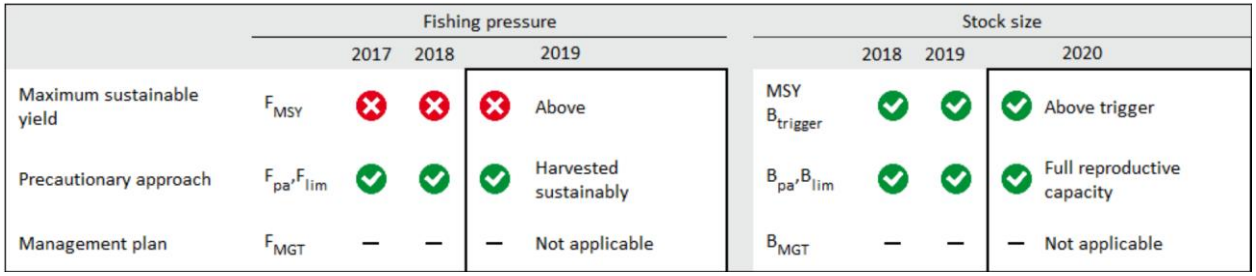
Species	Area	Stock status	Advice 2021
wit.27.3a47d (Witch)	(North Sea, Skagerrak and Kattegat, eastern English Channel	 **Summary:** Fishing mortality (F) has been above F_{MSY} since the beginning of the time-series. Spawning-stock biomass (SSB) that was below B_{lim} around 2010, has increased since then and is now above MSY $B_{trigger}$. Recruitment (R) has declined since 2010 and is currently at a low level.	ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 1 733 tonnes.

Nephrops stocks

Species	Area	Stock status	Advice 2020
Nephrops	Botney Gut-Silver Pit (FU 5)	The state of this stock is unknown. Preliminary stock surveys (2010 and 2012) indicate relatively high density compared to neighbouring FUs.	ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should be no more than 1570 tonnes.

Species	Area	Stock status	Advice 2020
Nephrops	Farn Deeps (FU 6)	 **Summary**: The stock abundance index has increased since 2015, and currently it is above MSY $B_{trigger}$. Harvest rates have been above the MSY level since 2001, except for 2008 and 2017.	ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1 991 tonnes and 2310 tonnes. The entire range is considered precautionary when applying the ICES advice rule. In order to ensure the stock in Functional Unit (FU) 6 is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to FU 6 could rapidly lead to overexploitation.
Nephrops	Fladen Ground (FU 7)	 **Summary**: The stock size declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015. From 2016 the stock size increased and is currently above MSY $B_{trigger}$. The harvest rate has declined since 2010 and remains well below F_{MSY}.	ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the plan are between 8 430 tonnes and 9 579 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 7 is exploited sustainably, management should be implemented at the functional unit level. In recent years, the catch in FU 7 has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs.

Species	Area	Stock status	Advice 2020
Nephrops	Firth of Forth (FU 8)	 **Summary:** The stock size has been above MSY $B_{trigger}$ for most of the time-series. The harvest rate is varying and is now above F_{MSY}.	ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the plan are between 2556 tonnes and 3931 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit 8 is exploited sustainably, management should be implemented at the functional unit level.
Nephrops	Moray Firth (FU 9)	 **Summary**: The stock has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate has fluctuated around F_{MSY} and is now above.	ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2021 that correspond to the F ranges in the plan are between 911 tonnes and 1180 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit 9 is exploited sustainably, management should be implemented at the functional unit level.

Species	Area	Stock status	Advice 2020
Nephrops	Noup (FU 10)	Underwater TV (UWTV) surveys in Functional Unit (FU) 10 have been conducted sporadically and indicated that the density is relatively low (0.13 *Nephrops* m−2). Landings are at a historical minimum.	ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should not exceed 46 tonnes. In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level.
Nephrops	Norwegian Deep (FU 32)	The state of this stock is unknown. Harvest rates are thought to be low for this stock even if a low density is assumed (e.g. the lowest observed density in the North Sea is in Functional Unit (FU) 7, Fladen Ground). Catches have been decreasing since 2006. Discarding has been low in the last 4 years.	ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should be no more than 381 tonnes. If this stock is not under the Norwegian discard ban in 2021 and 2022 and discard rates do not change from the average, this implies landings of no more than 379 tonnes.
Nephrops	Horns Reef (FU 33)	 **Summary:** The state of this stock is unknown. Landings have been relatively stable since 2004, fluctuating without trend at around 1000 tonnes. The mean density of Norway lobster decreased by 43% from 2017 to 2018.	ICES advises that when the precautionary approach (PA) is applied, wanted landings in each of the years 2021 and 2022 should not exceed 956 tonnes. ICES cannot quantify the corresponding total catches. To ensure that the stock in Functional Unit (FU) 33 is exploited sustainably, management should be implemented at the functional unit level.

Species	Area	Stock status	Advice 2020
Nephrops	Devils Hole (FU 34)	The state of the stock is unknown. The mean survey density indicates the stock has declined from 2009 to 2017.	ICES advises that when the precautionary approach is applied, catches in each of the years 2021 and 2022 should not exceed 566 tonnes. In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level.

7.5 Fleets and métiers

7.5.1 Catch and effort data

Prior to 2012, catch (landings and discards) and effort data were submitted to WGMIXFISH as comma separated files structured around the distinction of gear, mesh size and vessel length categories (based to a large extent on the format used by the STECF for the evaluation of effort management). From 2012 to 2014 a joint WGNSSK/WGMIXFISH data call has been issued, with age and discards data by métier (consistent with the DCF definition of métiers) to be submitted to InterCatch, and landings and effort data by métier and vessel length class to be submitted as .csv files. Since 2015, ICES generalised the data call to most stocks and regions. The process and the quality of data have thus continuously improved over time.

In 2019, InterCatch data were extracted for the longest time-series possible , on the basis that most North Sea demersal stocks have been benchmarked in the recent years, and thus have updated catch-at-age information starting in 2004. Nevertheless, it was realised that information prior to 2009 is still incomplete for some stocks; the reasons for these were not investigated. Consequently, the data presented here cover only the period 2009–2019.

Noticeably, although the data collation process is smoother, it remains a very tedious and time-demanding work. The processes developed to automate the various steps of merging different data sets from different countries and different data sources together have increased the amount of checks and graphical visualization of the data. Starting this year, data submissions have been evaluated with the aid of newly developed quality control routines, which summarized in a report. This process has aided both data submitters and participants of WGMIXFISH in terms of identifying problematics entries and has greatly eased the model conditioning process.

The relative size of landings of the stocks incorporated in the mixed fisheries projections is shown in Figure 7.1.

Despite the data now being available according to DCF categorization, WGMIXFISH was of the opinion to continue using the categorization following the EU Cod management plan as used in previous years, both in order to maintain the consistency of the MIXFISH time-series and in order to continue addressing management-oriented scenarios and issues. WGMIXFISH métiers are thus defined as combinations of gear, mesh size and area (North Sea (Area 4), Skagerrak (Area 3.a) or Eastern Channel (Area 7.d), see Table 7.1 and Figure 7.2.

The consistency between DCF and EU Cod plan categories had been investigated by WGMIXFISH 2011 and during the pilot data call performed in autumn 2011. It was determined that most DCF métiers as sampled by individual nations could automatically be allocated to a corresponding EU Cod plan métier, with two exceptions: the TBB_DEF_70-99_0_0 métier in the North Sea (as the corresponding BT2 métier is only defined for the mesh sizes 80–99) and the OTB_DEF (or CRU)_90-119_0_0 métier in the Skagerrak, which straddles over the TR1 (>=100 mm) and TR2 (70–99 mm) categories. As in previous years, the TBB_DEF_70-99_0_0 métier was assumed equivalent to BT2, and the Skagerrak 90-119_0_0 was assumed as TR2, to maintain consistency with previous data. Since 2012 the Swedish *Nephrops* fishery with an escapement grid, OTB_CRU_70-89_2_35 has been kept distinct from the other DCF métiers.

The final dataset extracted from InterCatch for use by WGNSSK includes discards estimates (either imported or raised) for all stocks and métiers. These InterCatch estimates have been used to estimate a discard ratio for each métier/stock combination, which allows allocating discards for all WGMIXFISH fleets and métiers with matching names, such that:

$$d^* = \left(\frac{D}{L}\right) l$$

Where d* is the discard value for the métier used by FCube, l is the weight of landings for the métier used by FCube and L and D are the weight of landings and discards entered for the (vessel length aggregated by métier in InterCatch).

7.5.2 Definitions of fleets and métiers

The procedure for establishing fleets and métiers was not revised in 2020, and has therefore been the same since 2012. Nevertheless, as the procedure is applied to the last data year, the number of fleets and métiers can vary slightly from one WGMIXFISH report to the next.

In summary, the procedure follows a number of steps:

- Matching DCF métiers with definitions used in the cod long-term management plan
- Establishing fleets by country, gear type and, when deemed necessary, vessel length group
- Matching consistency between effort and catch data files. Métiers without catch of any of the modelled stocks in the last data year (now 2019) are not retained.
- Aggregating "small" métiers to reduce the number of units in the modelling. A métier failing to catch at least 1.0% of at least one of the stocks considered in the most recent data year is classified as small. Within each fleet, all these small métiers are then aggregated by fleet in one "Other" métier (OTH). Further, all small fleets (i.e. containing only the "OTH" métier), are aggregated into one single "OTH" fleet.

In 2019, the final data used contained 40 national fleets (including the OTH fleet). These fleets engage in one to ten different métiers each, resulting in 141 combinations of country*fleet*métier*area catching fish and and *Nephrops* stocks considered this year (Table 7.1). The balance of landings of the stocks across gear categories is shown in Figure 7.2.

As a cross check of the data, the total landings and discards across all fleets was compared to the values estimated from the single-species stock assessments. Some landings may not be allocated to fleets, due to for example missing countries or areas (e.g. Area 6.a for saithe and haddock) or national landings with missing logbook information that cannot be allocated to a fleet. The landings coverage for all fish stocks is very high (between 90% and 100% of landings of each fish stock could be allocated to one of the fleets) but more variable for the *Nephrops* stocks (between 69% and 100%). To address the remaining small inconsistencies between fleet data used by WGMIXFISH and stock data, the differences between them were pooled into the "OTH" fleet (both landings and discards).

7.5.3 Trends

A number of overview graphs (using the Lattice and ggplot package in R) were produced to aid quality checking of the data once compiled into the final fleets object. Some are useful to show the relative importance of the fleets chosen and trends in their effort and catches. Effort by fleet in absolute levels (Figure 7.3) and relative trends (Figure 7.4), and landings by fleet and stock (Figure 7.5**Error! Reference source not found.**) are included in this report.

7.6 Mixed fisheries forecasts

7.6.1 Description of scenarios

7.6.1.1 Baseline runs

The objectives of the single-species stock baseline runs are to reproduce as closely as possible the single-species advice produced by ACOM, and act as the reference scenario for subsequent mixed fisheries analyses.

The various single-stock forecasts presented by WGNSSK are performed using different software and setups (see Section 7.3 above). However, for the purpose of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the 'fwd()' method in FLR (FLash R add-on package). The same forecast settings as in WGNSSK are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (EU Multiannual Plan or MSY approach).

Some differences can occur in the forecast calculations, sometimes because of the diversity of single-stock assessment methods used, and the WG always investigates in depth the reasons for potential discrepancies. Adjustments to the FCube forecasts are made if necessary to minimise discrepancies to the largest extent possible. In 2020, such differences occurred when WGMIXFISH replicated the forecast for the stocks with a state-space assessment model (SAM) (cod, saithe, whiting, and witch), and the stocks that use the Multi Fleet Deterministic Projection (MFDP) forecast software (haddock and whiting).

The single-species advice for the stocks assessed with SAM, as implemented in the *stockassessment* and *FLSAM* R packages rely on a stochastic forecast procedure that uses the estimates of the final assessment year (2020) as the base year for the intermediate year. Depending on the intermediate year assumptions, the 2020 catch is assumed equal to the 2020 TAC (in case of a TAC constraint) and the fishing mortality in 2020 is set accordingly, or the 2020 catch is calculated from the *status quo* effort (in case of a *status quo* F assumption). In either case, the resulting catch numbers at age in 2020 will be stochastic as the predicted selectivity in 2020 is subjected to process error. In addition, the 2020 stock size used in the SAM forecast is based on cohort projection within the assessment that is subjected to process errors related fish survival and recruitment, hence, both SSB and recruitment are simulated from the model. In contrast, the 2020 stock size in FCube is estimated by deterministic forward projection using 2019 as starting year and average fishing selectivity in the past 3 years. This results in different assumptions about the stock status in 2020 for both forecasts with higher SSB estimates in FCube for the intermediate year, 2020.

To minimize this difference, the fwd() function, used in the forecast procedure of FCube, was modified to overwrite stock numbers in the intermediate year in case these are produced by the assessment model (as is the case for e.g. SAM). This significantly reduced the differences between the FCube short-term forecast and the stochastic forecast procedure of SAM.

The MFDP procedure is used for haddock and whiting to conduct the short term projections in order to allow for the incorporation of multiple fleets (human consumption fleet and industrial fleet, as specified in the assessment). The current FLR functions designed for projections do not allow for the inclusion of multiple fleets, and therefore, the forecast in MIXFISH is conducted using only the exploitation pattern of the human consumption fleet. As the partial fishing mortality from the industrial fleet is markedly lower than the human consumption fleet, this methodological difference has only a minor effect on the outcome of the projections.

The intention of the baseline runs was mainly to act as a check to ensure that the projections were set up correctly within the FCube script, but these runs also have the incidental benefit of acting as a quality control check on the WGNSSK projections themselves.

7.6.1.2 Mixed fisheries runs

Prior to 2013, projections were run applying the FCube scenarios two years in a row, i.e. both for the intermediate year and the TAC year. This allowed WGMIXFISH to analyse why management plans often did not deliver their expected results and why some short-term forecasts had been over-optimistic in the past (Kraak *et al*., 2013), by evaluating the impact of the assumptions in the intermediate year.

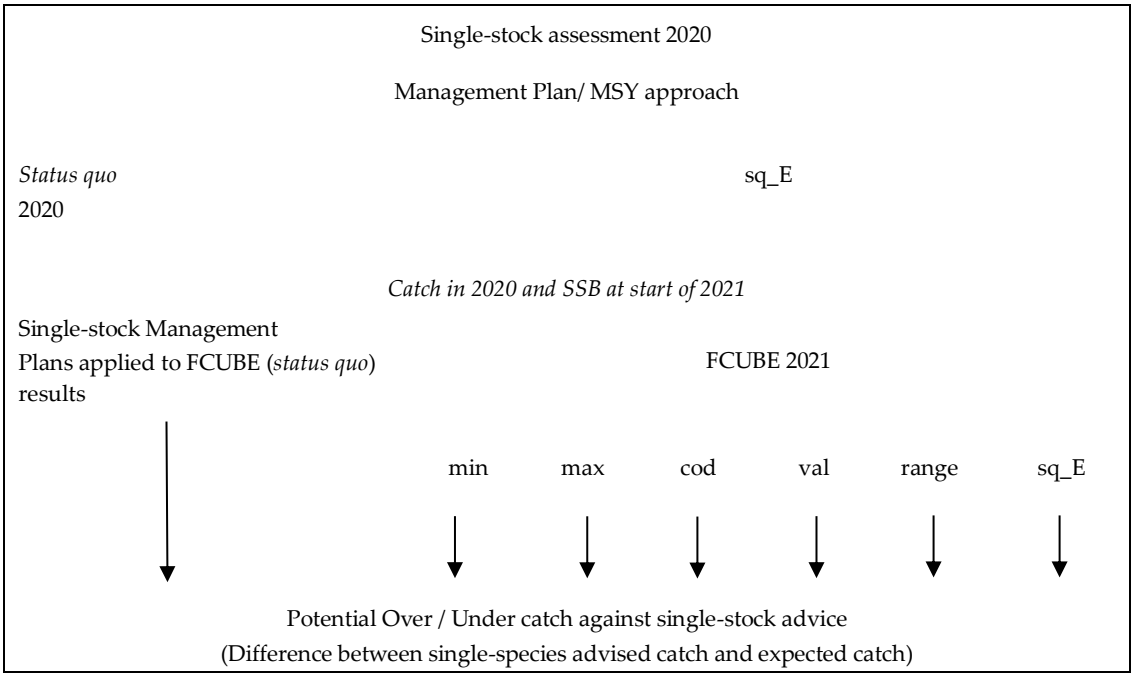
However, since 2013, the working group adopted a forecast approach for the intermediate year on the basis of s*tatus quo* effort. The *status quo* effort assumption is considered a plausible assumption and is more in line with the standard single-stock short-term forecasting approach (which apply a *status quo* F, unless a TAC constraint is used).

An important change to the projections was implemented in 2015, to account for the landings obligation. Historically, the mixed fisheries projections have been presented in terms of landings and overshoots or undershoots of the retained portion of the catch, assuming fishing fleets would discard as observed in past years and that only the landings counted against the fleets' stock shares.

This year, the projections were run assuming a full and perfect implementation of the discard ban (i.e. all quota species caught must be landed since 2019, with no exemptions, *de minimis* or inter-species flexibilities) for species under landing obligation, i.e. all catches are assumed to be landed and to count against the quota.

While WGMIXFISH is aware that the landings obligation may not be enforced for all stocks in 2021, and that discards will not disappear overnight, it was considered that this option would bring new insights to where the choke effects will lie. The main implication of this change in the results would be that stocks for which some fleets had high discards in the past may become more limiting for those fleets, due to the mismatch between their catches (which now all count against the fleets' stock shares) and their stock shares based on historical landings.

In summary, the FCube runs followed the scheme below:



7.6.2 Results of FCube runs

7.6.2.1 Baseline run

The Figure 7.6 summarises the trends in single-stocks advice between the last data year (2019) and the two forecast years (2020 and 2021). For the COD-NS stock, a steep reduction in Fbar is expected in 2020 and this decrease will continue over the advice year 2021. This decrease in Fbar is reflected in the landings with landings corresponding to the 2021 advice being less than half of the landings reported for 2019. Given this strong reduction in Fbar, North Sea cod is likely to be the most limiting stock in the mixed fisheries projections. The fishing mortality for the advice year is also decreasing compared to current level for saithe (POK), corresponding to a decrease in the landings corresponding to the advice in 2021.This decrease is of a smaller magnitude than in cod, and, since saithe has been one of the least limiting stocks in previous mixed fisheries analysis, it is not expected to be a limiting stock this year either.

The comparison between the FCube baseline run and the ICES single-species advice is summarised in Table 7.2 for the *Nephrop* stocks and in Figure 7.7 for the fish stocks. The issues encountered in replicating the single-species advice in FCube are detailed below.

Cod: The North Sea cod forecast is a stochastic projection, and is produced internally in SAM by generating 1000 replications within the confidence interval of the F-at-age, N-at-age and catch multiplier estimates. The short-term forecast conducted at WGMIXFISH does not use SAM, but a simple deterministic forecast.

Some small differences were observed (2.8% for the Fbar value for 2020, -3.1% in the estimated catches in 2021 and -3.3% difference in SSB in 2021). Nevertheless, the FCube forecast was considered sufficiently close that it could be used as a satisfactory basis for the mixed fisheries projection.

Haddock: In 2020, the haddock was assessed using a TSA (time-series analysis, Fryer, 2002) assessment model and MFDP programme as the forecasting software. The method developed in WGNSSK to parameterise future selectivity and weight-at-age for haddock are sometimes quite specific and do not always follow common standards (e.g. weights-at-age in the forecasted period produced by a growth model instead of the commonly used assumption of constant weights equal to the average over the recent years). Those specific values could not be reproduced in the forecasting procedure of FCube and were therefore entered manually.

The forecast results were slightly different with a -0.7% and -0.6% discrepancy between SSB projections in 2021 and 2022 respectively. Forecasted catches in 2021 showed a -1.8% difference. The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

It was not possible to fully understand the reason for these small differences. The MFDP uses two distinct fleets (human consumption and industrial), with distinct selectivity, which is not the case for the FLR forecast which does not include the industrial bycatch. Although this fishery represents only a small percentage (less than 1% in 2020) of the total catch, this difference in method could potentially explain the small discrepancies in the forecast.

Whiting: Although whiting is now assessed using SAM, the WGNSSK forecast is deterministic, conducted using MFDP. The WGNSSK forecast treats the industrial bycatch separately from the landings for human consumption, with specific future weights-at-age and selectivity and assumes a F value independent from the value of target F for the human consumption fishery. The FCube forecast used at WGMIXFISH did not allow for multiple fleets and therefore the industrial bycatch is included in the landings component. The future landings selectivity and weights-at-age were recalculated as the weighted means of the values in the landings for human consumption and industrial bycatch.

This difference in forecast procedure resulted in small discrepancies in the output with differences in catches of -0.3% and 2.4% for 2020 and 2021 respectively, and of -0.3% in 2022 for the SSB.

Saithe: As for cod, the 2020 saithe assessment and forecast were carried out using the SAM assessment model. The difference in forecast procedure compared to WGMIXFISH resulted in differences in the output of -2.1% in the 2020 catches and -4.2% in the 2021 catches and -3.4% and -5.3% in 2021 and 2022 for SSB. The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

North Sea Plaice: Straightforward, no problems encountered. The 1% difference in the 2021 catch is explained by the fact that the expected catch of North Sea plaice taking place in Division 7.d have been removed after calculation from the single-stock advice, while this is taken into account at a later stage in the WKMIXFISH analyses.

English Channel Plaice: Significant migrations of plaice occur between the North Sea, Eastern Channel and Western Channel. As a result, only a proportion of the plaice TAC defined in Subdivision 7.d corresponds to the Eastern Channel plaice. The forecast takes account of the expected quantity of plaice caught in the eastern channel adjusting for these migrations.

The results from the FCube forecast were identical to those of the single-species forecast.

North Sea Sole: The results from the FCube forecast were identical to those of the single-species forecast.

Turbot: The turbot assessment is conducted with SAM, but the WGNSSK forecast procedure is deterministic using the FLR package. These results were reproduced identically at WGMIXFISH.

The turbot assessment does not include discard information (for lack of accurate discard-at-age data), and therefore the landings (in the assessment and in the short term projections) are equal to the catches. WGNSSK applies a correction of the projected landings to take into account the 11% discard rate in weight. This has not been reproduced in the WGMIXFISH baseline run - since mixed fisheries projections are based on landing values - and explains the 11% difference in the 2021 catch between the single-stock advice and the WGMIXFISH baseline run.

Witch: This stock was included for the first time this year. As for other stock where SAM is used for the forecast, small differences with the single species advice were encountered, of -3.1% and -2.8% for the catches in 2020 and 2021, and -3.1% and -6.8% for SSB in 2021 and 2022.

***Nephrops*:** The forecasts applied the recommended harvest rates to the most recent abundance estimates available for the relevant FUs (FU 6, 7 8 and 9). The ICES advice for 2020 is given assuming that the landing obligation is applied in 2019 for all FUs, with an exemption of high survival for catches with pots (FPO), and for catches with bottom trawls (OTB, TBN) with a mesh size of at least 80 mm equipped with a netgrid selectivity device. The WGNSSK procedure was reproduced as closely as possible in FCube and the differences in the forecasted 2020 landings were in all cases under 1%.

7.6.2.2 Mixed fisheries analyses

The full overview of the FCube projections are presented in Table 7.3 and in Figure 7.8 to Figure 7.11. Figure 7.8 displays the catch by scenario for each of the species. Potential overshoot/undershoot on this figure are calculated by comparing the single-species catch advice for 2021 with the mixed fisheries catch estimates. As ple.27d, tur.27.4, and wit.27.3a.47 have low landings compared to other stocks, the results for these stocks are also presented in detail in Figure 7.9. The anticipated SSBs in 2021 of the FCube scenarios are shown in **Figure 7.10**, and **Figure 7.11** shows the effort needed to reach the single-stock advice and highlights the most and least limiting stock

per fleet. A summary of catches by scenario, including the single-stock advice values for reference, is presented in Table 7.4.

The outcomes of the "min" and "max" scenarios are driven by the stocks that will be most and least limiting for each individual fleet. Cod was estimated to be the most limiting stock in the "min" scenario. The "min" scenario assumes that fleets would stop fishing when their first quota share is exhausted, regardless of the actual importance of this quota share, thus leading to a distorted perception of plausible fleet behaviour. While this can be considered an unlikely scenario as long as discarding is allowed, this scenario reflects the constraints that result from a strictly implemented discard ban. For 2020, assuming a strictly implemented landings obligation (i.e. a discard ban where all catches of quota species must be counted against quota, with no flexibilities such as exemptions, *de minimis* allowed discards or inter-species flexibility, as the "min" scenario represents), cod would be the most limiting stock, constraining 39 of the 40 fleet segments (**Figure 7.11**). Plaice in the Eastern Channel constrains one fleet segment. This would result on undershooting the catch quota for all the stocks (Figure 7.9 and **Figure 7.10**).

Conversely, in the "max" scenario, North Sea haddock, North Sea plaice and Eastern Channel plaice would be the least limiting for 3, 27 and 1 fleet segments, respectively. Finally, if Norway lobster were managed by separate TACs, Norway lobster in FU 7 would be the least limiting for 9 fleet segments (**Figure 7.11**). Under the "max" scenario all stocks are overshooted (Figure 7.9).

The "cod_ns" scenario reflects the fishing mortality corresponding to the single-species advice for cod.27.47d20 (based on the ICES MSY approach), and the results present fishing opportunities for other stocks in a mixed fisheries context. According to the single-stock advice, a reduction of about 50% in cod F is required (from 0.3 in 2020 to 0.16 in 2021). It is assumed that effort reductions in fleets (to achieve new partial Fs) apply equally to all fleets with any cod catch, including those where it represents a small bycatch component. Similar scenarios based on the single-stock advice for the other finfish stocks could be provided by ICES, but the "cod_ns" scenario is considered here because cod is assumed to be the most limiting species. For this reason, the "min" and "cod_ns" scenarios produced very similar results in terms of catches and ssb in the short forecast period.

In the "val" scenario fishing opportunities by stock and their potential market value are taking into consideration. For 2021, this scenario estimates effort levels close to the *status quo*. Historically this scenario has been observed to predict effort levels closer to the realised effort than the other scenarios (Ulrich *et al.*, 2011). In this scenario, some overshoot of cod, whiting, and sole, and undershoot of plaice and haddock fishing opportunities are predicted.

Mixed fisheries results for *Nephrops* are displayed after combining functional units 6-9 (FUs 6-9) in one plot, but stock status and fishing opportunities differ widely across FUs. In particular, FU7 (Fladen Ground) is exploited well below the MSY target, and acts as a least limiting stock for 9 fleets. In order to ensure *Nephrops* stocks are exploited sustainably in the different FUs, management should therefore be implemented at the FU level. Potential undershoot of catch opportunities for FU7 should not be transferred to other FUs.

Optimised range option

The results of the "range" scenario are presented (**Figure 7.12** and **Figure 7.13**), where the potential TAC mismatch in 2021 are minimised by setting target fishing levels within the F_{MSY} ranges. This scenario returns a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2021, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. This "range" scenario suggests that the potential for mixed-fisheries mismatch would be lowered with a 2021 TAC resulting in an Fbar in the lower part of the F_{MSY} range for North Sea plaice, saithe and sole, and at the highest possible value for cod. For the rest of the stocks the Fbar should be very close to F_{MSY}.

7.7 FIDES results explained

It should first be noted that, using the quotas uptakes in 2019 from FIDES (**Figure 7.14**), only UK, BE and DK were limited in their initial quotas by cod. Haddock, *Nephrops* and whiting are limiting most countries. Saithe is limiting most countries except France, sole in the North Sea is limiting most countries except The Netherlands that have more than 80% of the TAC. Plaice in the Eastern English Channel is only limiting the Netherlands and plaice in the North Sea only limits France and Sweden. Witch is limiting Denmark, Sweden, and Germany.

The share of each country's TAC from the initial quota from 2019 is used to compute the share of 2021 TAC for the different species.

The range scenario explores the F_{MSY} ranges for all species to find the set of Fs that reduce the differences in catches between the "min" and "max" scenarios. For each set of explored stock fishing mortalities, the "min" and "max" scenarios are the ran and squared difference of catches by stock computed. There is no constraint on the space of F exploration except that the values are to be taken inside the $F_{MSY\text{-}lower}$ and $F_{MSY\text{-}upper}$ range for each stock.

This year, the optimal set of F by stock that minimize the differences of catches between the "min" and "max" scenarios are the following F:

cod 27.47d20	had 27.46a20	ple 27.7d	Ple 27.420	pok 27.3a46	Sol 27.4	whg 27.47d	tur.27.4	wit.27.3a47d
0.1556352	0.1681403	0.3262239	0.1781085	0.4886348	0.2971852	0.1606577	0.3305505	0.1817482

The algorithm then returns optimal solution with F for Eastern English plaice, saithe, and North Sea sole in the upper part of the range and sometimes (Eastern English Channel plaice) close to $F_{MSY\text{-}upper}$.

To understand the results of the range scenario, a focus was made on North Sea sole for which only focusing on Dutch fleet will illustrate the different steps of the algorithm. In fact, sole in the North Sea does not seem to limit the Dutch fleets in term of quotas and most of the TAC is taken by Dutch fleets and looking at their efforts/landings will explain most of the fishing mortalities applied to that stock.

Given the set of fishing mortalities given above, the effort corresponding to each fleet and for each stock is computed using the previous catchabilities to search for the most limiting stock for each fleet. The partial F by countries and stocks are also computed using the country share of the TAC resulting from the selected Fs. These partial Fs are compared to the F by countries corresponding to the status-quo effort for all fleets. If the partial F coming are higher than the F at staus quo effort then the stock is considered to be chocking in the TAC year and if the partial Fs are below F at status-quo effort the stock is not considered as a chocking species and removed from the "min" scenario.

Table 7.5 and Table 7.6 present the chocking species and the corresponding efforts by stock respectively given the set of Fs provided before.

Given the TAC allocation, for these F values, only sole, saithe and plaice in the Eastern English Channel are limiting the Dutch fleets (Table 7.7). Given the past catchabilities and the quota allocation for the Dutch fleets, cod is not supposed to limit Dutch fleets in 2021. The minimum effort for these fleets in the "min" scenario is then 2816 for NL_BEAM<24, 17731 for NL_Beam>=40 and 3734 for NL_Beam24-40. The maximum effort for these fleets in the "max" scenario is then 2903 for NL_BEAM<24, 21350 for NL_Beam>=40 and 3734 for NL_Beam24-40

These efforts have to be compared and very close to the status quo effort for these 3 fleets that are respectively 2656 for NL_BEAM<24, 19529 for NL_Beam>=40 and 3415 for NL_Beam24-40.

The effort used for the "min" scenario are then at the scale or above the status-quo effort for these fleets. Resulting in final F for sole in the "min" scenario at the level or above the F at status-quo effort and far from F that would have resulted of using the effort corresponding to the effort to catch cod in the "classical "min" scenario.

Conclusion

The FIDES scenario might seem more realistic than the "min" scenario in the way that many countries seem not to be limited by North Sea cod as they are not able to catch their national quotas. However, some adjustment in the algorithm are needed in the "range" scenario in order not to explore the upper part of the range when no real mixed fisheries interaction justify it in order not to present mixed fisheries projections that can be inconsistent with ICES advice [above F_{MSY}].

One way of doing it might be to limit the effort in the "min" scenario to the effort corresponding to the single species advice if no other stock is limiting the fleets.

The mixed fisheries results obtained with the FIDES scenario are presented in **Figure 7.15** for information.

Table 7.1. Final fleet and métier categories used in the mixed fishery analysis. 4, 3AN and 7D refer to ICES area. Effort is in kWdays and catch is in tonnes, and both figures are for the year 2019.

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
BE_Beam<24	BT2.4	149.37	238.25	FR_Nets	GT1.7D	324.15	153.19
BE_Beam<24	BT2.7D	208.23	903.12	FR_Nets	OTH	0.94	0.08
BE_Beam<24	OTH	547.17	32.98	FR_OTH	OTH	3481.32	1001.04
BE_Beam>=24	BT1.4	1232.30	2871.93	FR_OTH	pelagic.4	645.24	46.77
BE_Beam>=24	BT2.4	539.65	1864.79	FR_OTH	pelagic.7D	480.96	154.05
BE_Beam>=24	BT2.7D	1482.56	2475.89	FR_OTH	TR2.4	91.04	465.19
BE_Otter	OTH	80.09	38.54	FR_OTH	TR2.7D	377.05	890.9
BE_Otter	TR1.4	479.38	1218.92	FR_Otter>=40	TR1.4	3159.75	11519.65
BE_Otter	TR2.4	661.24	2397.32	FR_Otter>=40	TR1.6A	1361.26	1260.52
DK_<10towed	OTH	18.38	40.31	FR_Otter10-40	OTH	66.14	30.35
DK_<10towed	TR2.3AN	99.62	278.71	FR_Otter10-40	TR1.6A	462.84	27.67
DK_Beam	BT1.4	402.11	651.71	FR_Otter10-40	TR1.7D	46.38	0.11
DK_Beam	OTH	525.25	16.57	FR_Otter10-40	TR2.4	346.03	1137
DK_Otter<24	OTH	181.62	94.2	FR_Otter10-40	TR2.7D	3099.49	7143.99
DK_Otter<24	TR1.3AN	264.54	621.46	GE_Beam<24	beam_oth.4	3778.9	521.69
DK_Otter<24	TR1.4	523.31	1664.57	GE_Beam<24	OTH	309.14	396.81
DK_Otter<24	TR2.3AN	2322.91	3700.12	GE_Beam>=24	BT2.4	2831.19	3621.31
DK_Otter<24	TR2.4	38.57	172.18	GE_Otter<24	OTH	220.82	265.33
DK_Otter>=24	OTB32-69.4	3034.79	139.88	GE_Otter<24	TR1.3AN	28.73	29.71
DK_Otter>=24	OTB32-69.6A	856.76	17.67	GE_Otter<24	TR2.3AN	0.94	0.05
DK_Otter>=24	OTH	941.16	400.38	GE_Otter<24	TR2.4	991.74	1619.91
DK_Otter>=24	TR1.3AN	302.18	654.42	GE_Otter>=40	OTB32-69.4	2543.69	19.77
DK_Otter>=24	TR1.4	3589.84	10642.52	GE_Otter>=40	OTH	39.07	2.77

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
DK_Otter>=24	TR2.3AN	740.83	820.36	GE_Otter>=40	TR1.4	1602.93	1276.34
DK_Otter>=24	TR2.4	208.10	541.7	GE_Otter>=40	TR3.4	241.48	2.77
DK_Seine	TR1.3AN	432.36	4436.8	GE_Otter24-40	OTH	60.12	177.12
DK_Seine	TR1.4	761.92	2085.55	GE_Otter24-40	TR1.4	4051.73	7230.59
DK_Static	GN1.3AN	555.08	1595.44	GE_Otter24-40	TR2.4	666.23	855.5
DK_Static	GN1.4	987.40	3289.97	NL_Beam<24	BT1.3AN	38.34	655.35
DK_Static	OTH	36.34	265.27	NL_Beam<24	BT1.4	44.64	736.88
EN_<10	GN1.4	119.24	56.09	NL_Beam<24	BT2.4	360.01	1824.4
EN_<10	GN1.7D	98.80	262.68	NL_Beam<24	OTH	2212.64	35.32
EN_<10	GT1.4	29.80	8.86	NL_Beam>=40	BT1.3AN	911.35	2925.37
EN_<10	GT1.7D	202.45	100.9	NL_Beam>=40	BT1.4	2777.95	6803.92
EN_<10	OTH	409.94	44.06	NL_Beam>=40	BT2.4	15781.85	32403.5
EN_<10	pots.4	1793.63	153.9	NL_Beam>=40	OTH	58.68	408.83
EN_<10	pots.7D	766.32	0.67	NL_Beam24-40	BT1.3AN	122.11	408.75
EN_<10	TR1.4	56.42	202.39	NL_Beam24-40	BT1.4	328.96	763.55
EN_<10	TR2.4	438.98	1038.05	NL_Beam24-40	BT2.4	2624.76	6476.2
EN_<10	TR2.7D	170.47	715.54	NL_Beam24-40	OTH	339.84	4.17
EN_Beam	BT1.4	774.15	2088.98	NL_Otter	OTH	32.52	78.65
EN_Beam	BT2.4	925.65	2853.75	NL_Otter	otter_oth.4	878.94	1217.93
EN_Beam	BT2.7D	75.62	157.44	NL_Otter	otter_oth.7D	1113.19	690.83
EN_FDF	OTH	71.44	15.36	NL_Otter	TR1.4	865.83	3347.69
EN_FDF	TR1.4	372.24	2278.44	NL_Otter	TR2.4	962.14	5083.53
EN_FDF	TR2.4	108.10	377.05	NL_Pelagic	pelagic.4	2762.31	177.75
EN_Otter<24	OTH	17.22	27.12	NL_Pelagic	pelagic.6A	3525.71	58.34
EN_Otter<24	TR1.4	365.58	1101.44	NL_Pelagic	pelagic.7D	697.48	0.12
EN_Otter<24	TR1.6A	1.34	0.03	OTH_OTH	OTH	23240.39	5317.77
EN_Otter<24	TR2.4	941.28	2639.92	SC_Otter<10	OTH	6.84	13.1
EN_Otter<24	TR2.7D	103.95	150.32	SC_Otter<10	TR2.4	302.15	717.23
EN_Otter>=40	OTH	99.00	31.77	SC_Otter<10	TR2.6A	256.7	4.05
EN_Otter>=40	TR1.4	349.34	713.3	SC_Otter<24	TR1.4	6505.76	24245.51
EN_Otter24-40	OTH	18.50	44.12	SC_Otter<24	TR1.6A	1017.7	620.41
EN_Otter24-40	otter_oth.4	281.15	224.98	SC_Otter<24	TR2.4	1632.64	7394.32
EN_Otter24-40	otter_oth.7D	398.26	245.86	SC_Otter<24	TR2.6A	2620.83	1068.68
EN_Otter24-40	TR1.4	557.97	1375.42	SC_Otter>=24	OTH	54.44	233.21
EN_Otter24-40	TR1.6A	8.37	3.6	SC_Otter>=24	TR1.4	8374.13	55799.9
EN_Pelagic	pelagic.4	691.01	5.37	SC_Otter>=24	TR1.6A	1551.81	5248.13
EN_Pelagic	pelagic.6A	632.76	3.08	SC_Otter>=24	TR2.7D	197.4	181.16
EN_Pelagic	pelagic.7D	247.87	0.04	SC_Static	GN1.4	294.28	15.78
EN_Static	OTH	28.49	5.3	SC_Static	LL1.4	1276.17	209.6

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
EN_Static	pots.4	1958.15	9.94	SC_Static	LL1.6A	560.49	1.72
EN_Static	pots.7D	435.08	0.67	SC_Static	pots.4	3917.72	68.6
FR_<10	GN1.7D	14.14	0.55	SW_Otter	OTH	1643.71	386.12
FR_<10	GT1.7D	75.24	54.68	SW_Otter	TR1.4	292.89	1271.13
FR_<10	OTH	240.57	106.17	SW_Otter	TR2.3AN	838.13	769.29
FR_<10	TR2.7D	56.95	493.77	SW_Otter	TR2_grid.3AN	799	18.52
FR_Beam	BT2.7D	88.11	117.27	SW_Static	OTH	113.87	38.43
FR_Nets	GN1.7D	22.85	0.94	SW_Static	pots.3AN	835.85	5.03
FR_Nets	GT1.4	86.18	147.33				

Table 7.2. Comparison between baseline run and ICES advice for *Nephrops in the TAC year. The values for *Nephrops* FUs that do not receive an absolute ICES abundance estimate are set according to the ICES approach for data-limited *Nephrops* stocks. No 'ICES advice' values are given for *Nephrops* in the intermediate year because the baseline run uses values based on recorded landings in the previous year which can vary significantly from the advice for each FU.**

year	value	scenario	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
2021	landings	ICES_advice	1031	2093	9434	3514.0	1172.0	46	379	956	530	301
2021	landings	FCube_single_spp	1031	2092	9435	3512.0	1171.0	46	379	956	530	301
2021	landings	Difference (%)	0	0	0	-0.1	-0.1	0	0	0	0	0

***These numbers are landings values; ICES advice does not provide total catch.**

Table 7.3. Results of Final FCube runs.

scenario	year	value	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	WHG-NS	TUR	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
baseline	2020	landings	15137	27950	4129	57634	74125	14660	17905	3402	2304	21	188	1590	1170	1156	4301	8911	2648	1376	714
baseline	2021	landings	12264	49037	3424	88209	58589	19302	15225	3514	1643	46	379	956	530	1031	2092	9435	3512	1171	301
baseline	2020	catch	17679	41896	9843	111959	78710	17545	30976	3402	2396										
baseline	2021	catch	14302	70534	8409	164164	62948	21395	26923	3514	1685	46	381	956	566	1570	2309	9579	3930	1180	301
baseline	2020	FmultVsF19	0.467	1.077	1	1	1	0.942	1	0.991	0.99						1.02	1.278	0.716	0.94	
baseline	2021	FmultVsF19	0.254	1.098	0.841	1.266	0.788	0.762	0.826	0.98	0.76						0.489	1.339	0.891	0.797	
baseline	2019	Fbar	0.638	0.177	0.297	0.166	0.461	0.272	0.208	0.367	0.2						0.166	0.056	0.183	0.148	
baseline	2020	Fbar	0.298	0.19	0.297	0.166	0.461	0.256	0.208	0.364	0.2						0.169	0.072	0.131	0.139	
baseline	2021	Fbar	0.162	0.194	0.25	0.21	0.363	0.207	0.172	0.36	0.15						0.081	0.075	0.163	0.118	
baseline	2020	ssb	55511	210875	38830	1253492	163414	34569	169979	8393	5503										
baseline	2021	ssb	75721	207563	38191	1302883	146224	88036	180169	9161	5319										
baseline	2022	ssb	107326	474002	39205	1374316	155944	86158	184549	9449	5106										
max	2020	landings	28777	25820	4511	57634	74118	15451	17903	3695	2365	20.32	184.78	1559.53	1147.4	1133.85	4188.63	7138.79	4094.49	1479.46	700.241
max	2021	landings	38819	57485	5182	89070	87043	29657	22877	4537	2684	62.69	516.5	1302.82	722.276	1405.03	5452.66	9359.85	5352.33	1926.02	410.198
max	2020	discards	6115	11162	6230	54333	4690	3023	12573	0	164										
max	2021	discards	9630	23055	7597	76667	6765	3186	17153	0	217										
max	2021	Ld_MgtPlan	9863	49372	3331	88209	58591	19093	15230	3409	1634	46	379	956	530	1031	2092	9435	3512	1171	301
max	2020	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
max	2021	FmultVsF19	1.3	1.29	1.39	1.28	1.28	1.27	1.3	1.4	1.33						1.29	1.34	1.45	1.32	
max	2020	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	
max	2021	Fbar	0.831	0.229	0.415	0.212	0.589	0.344	0.27	0.514	0.27						0.215	0.075	0.265	0.195	
max	2020	ssb	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
max	2021	ssb	61012	209776	37168	1302883	146230	87094	179206	8857	4968										
max	2022	ssb	55628	464775	33218	1372812	128885	74573	173556	7962	4527										
max	2020	ssb_MgtPlan	56372	210508	38830	1253492	163414	34569	169933	8393	5485										

scenario	year	value	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	WHG-NS	TUR	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
max	2021	ssb_MgtPlan	61012	209776	37168	1302883	146230	87094	179206	8857	5287										
max	2022	ssb_MgtPlan	91065	476347	38370	1374316	155950	85343	183351	9181	5078										
min	2020	landings	28777	25820	4511	57634	74118	15451	17903	3695	2365	20.32	184.78	1559.53	1147.4	1133.85	4188.63	7138.79	4094.49	1479.46	700.241
min	2021	landings	9643	11652	1184	18559	20355	6655	4815	1066	567	11.87	97.771	246.619	136.724	265.967	1036.35	1766.27	1013.05	366.047	77.649
min	2020	discards	6115	11162	6230	54333	4690	3023	12573	0	164										
min	2021	discards	2172	4572	1745	16377	1521	700	3472	0	43										
min	2021	Ld_MgtPlan	9863	49372	3331	88209	58591	19093	15230	3409	1634	46	379	956	530	1031	2092	9435	3512	1171	301
min	2020	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
min	2021	FmultVsF19	0.25	0.24	0.28	0.25	0.25	0.25	0.25	0.27	0.25						0.25	0.25	0.27	0.25	
min	2020	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	
min	2021	Fbar	0.158	0.043	0.083	0.041	0.114	0.067	0.051	0.099	0.05						0.041	0.014	0.05	0.037	
min	2020	ssb	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
min	2021	ssb	61012	209776	37168	1302883	146230	87094	179206	8857	5597										
min	2022	ssb	91343	530327	44543	1498206	193128	98037	196669	11759	5644										
min	2020	ssb_MgtPlan	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
min	2021	ssb_MgtPlan	61012	209776	37168	1302883	146230	87094	179206	8857	5287										
min	2022	ssb_MgtPlan	91065	476347	38370	1374316	155950	85343	183351	9181	5078										
cod-ns	2020	landings	28777	25820	4511	57634	74118	15451	17903	3695	2365	20.32	184.78	1559.53	1147.4	1133.85	4188.63	7138.79	4094.49	1479.46	700.241
cod-ns	2021	landings	9643	11652	1198	18559	20355	6655	4815	1066	567	11.87	97.771	246.619	136.724	265.967	1036.35	1766.27	1013.05	366.047	77.649
cod-ns	2020	discards	6115	11162	6230	54333	4690	3023	12573	0	164										
cod-ns	2021	discards	2172	4572	1767	16377	1521	700	3472	0	43										
cod-ns	2021	Ld_MgtPlan	9863	49372	3331	88209	58591	19093	15230	3409	1634	46	379	956	530	1031	2092	9435	3512	1171	301
cod-ns	2020	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
cod-ns	2021	FmultVsF19	0.25	0.24	0.28	0.25	0.25	0.25	0.25	0.27	0.25						0.25	0.25	0.27	0.25	
cod-ns	2020	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	

scenario	year	value	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	WHG-NS	TUR	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
cod-ns	2021	Fbar	0.158	0.043	0.084	0.041	0.114	0.067	0.051	0.099	0.05						0.041	0.014	0.05	0.037	
cod-ns	2020	ssb	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
cod-ns	2021	ssb	61012	209776	37168	1302883	146230	87094	179206	8857	5597										
cod-ns	2022	ssb	91343	530327	44501	1498206	193128	98037	196669	11759	5644										
cod-ns	2020	ssb_MgtPlan	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
cod-ns	2021	ssb_MgtPlan	61012	209776	37168	1302883	146230	87094	179206	8857	5287										
cod-ns	2022	ssb_MgtPlan	91065	476347	38370	1374316	155950	85343	183351	9181	5078										
sq_E	2020	landings	28777	25820	4511	57634	74118	15451	17903	3695	2365	20.32	184.78	1559.53	1147.4	1133.85	4188.63	7138.79	4094.49	1479.46	700.241
sq_E	2021	landings	32061	44829	4247	71001	71520	24257	18126	3735	2119	47.96	395.16	996.769	552.602	1074.97	4188.63	7138.79	4094.49	1479.46	313.836
sq_E	2020	discards	6115	11162	6230	54333	4690	3023	12573	0	164										
sq_E	2021	discards	7748	17868	6234	61527	5501	2592	13445	0	169										
sq_E	2021	Ld_MgtPlan	9863	49372	3331	88209	58591	19093	15230	3409	1634	46	379	956	530	1031	2092	9435	3512	1171	301
sq_E	2020	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
sq_E	2021	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
sq_E	2020	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	
sq_E	2021	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	
sq_E	2020	ssb	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
sq_E	2021	ssb	61012	209776	37168	1302883	146230	87094	179206	8857	5142										
sq_E	2022	ssb	63683	482834	35800	1404518	143579	80077	179644	8827	4823										
sq_E	2020	ssb_MgtPlan	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
sq_E	2021	ssb_MgtPlan	61012	209776	37168	1302883	146230	87094	179206	8857	5287										
sq_E	2022	ssb_MgtPlan	91065	476347	38370	1374316	155950	85343	183351	9181	5078										
val	2020	landings	28777	25820	4511	57634	74118	15451	17903	3695	2365	20.32	184.78	1559.53	1147.4	1133.85	4188.63	7138.79	4094.49	1479.46	700.241
val	2021	landings	26668	36046	3433	65128	56756	22624	15024	3512	1751	39.53	325.66	821.455	455.409	885.9	2596.14	6363.18	3671.45	1297.95	258.638

scenario	year	value	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	WHG-NS	TUR	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
val	2020	discards	6115	11162	6230	54333	4690	3023	12573	0	164										
val	2021	discards	6324	14307	5045	56559	4326	2413	11069	0	138										
val	2021	Ld_MgtPlan	9863	49372	3331	88209	58591	19093	15230	3409	1634	46	379	956	530	1031	2092	9435	3512	1171	301
val	2020	FmultVsF19	1	0.99	1.11	1	1	1	1	1.09	1.02						0.99	1.02	1.11	1.01	
val	2021	FmultVsF19	0.79	0.79	0.87	0.91	0.76	0.92	0.81	1.02	0.82						0.62	0.91	0.99	0.89	
val	2020	Fbar	0.638	0.175	0.329	0.166	0.46	0.272	0.208	0.402	0.21						0.165	0.057	0.203	0.15	
val	2021	Fbar	0.504	0.139	0.259	0.151	0.35	0.251	0.169	0.373	0.17						0.102	0.051	0.182	0.131	
val	2020	ssb	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
val	2021	ssb	61012	209776	37168	1302883	146230	87094	179206	8857	5253										
val	2022	ssb	70219	495386	38083	1414888	157714	81742	183615	9069	5017										
val	2020	ssb_MgtPlan	56372	210508	38830	1253492	163414	34569	169933	8393	5485										
val	2021	ssb_MgtPlan	61012	209776	37168	1302883	146230	87094	179206	8857	5287										
val	2022	ssb_MgtPlan	91065	476347	38370	1374316	155950	85343	183351	9181	5078										

Table 7.4. Mixed fisheries for the North Sea. Catch per mixed-fisheries scenario 2021, in absolute values.

Stock	Single-stock catch advice (2021) *	Catch per mixed fisheries scenario (2021)					
		max	min	cod-ns	sq_E	val	range
cod.27.47d20	14755	48449	11815	11815	39809	32992	14097
had.27.46a20	69280	80540	16224	16224	62697	50353	62872
ple.27.7d	8402**	12779	2929	2965	10481	8478	8335
ple.27.420	162607	165737	34936	34936	132528	121687	123819
pok.27.3a46	65687	93808	21876	21876	77021	61082	44099
sol.27.4	21361**	32843	7355	7355	26849	25037	14850
tur.27.4	3948	4537	1066	1066	3735	3512	3477
whg.27.47d	26304	40030	8287	8287	31571	26093	25102
wit.27.3a47d	1733	2901	610	610	2288	1889	1680
nep.fu.5	1570	1405	266	266	1075	886	NA
nep.fu.6	2310**	5453	1036	1036	4189	2596	NA
nep.fu.7	9579**	9360	1766	1766	7139	6363	NA
nep.fu.8	3931**	5352	1013	1013	4094	3671	NA
nep.fu.9	1180**	1926	366	366	1479	1298	NA
nep.fu.10	46	63	12	12	48	40	NA
nep.fu.32	381	516	98	98	395	326	NA
nep.fu.33	956	1303	247	247	997	821	NA
nep.fu.34	566	722	137	137	553	455	NA
nep.27.4outFU	301	410	78	78	314	259	NA

NA: stocks for which ranges of F_{MSY} are either not available or not yet included in the scenario.

*** Advised catches no more than the indicated value.**

**** Single-stock advice is based on ranges in accordance with the EU MAP for demersal stocks in the North Sea (EU, 2019). The value presented here is for catches corresponding to F_{MSY}.**

Table 7.5. [FIDES results presented for information]. Choke species for all fleets.

Fleet	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	TUR	WHG-NS	WIT	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
BE_Beam<24	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
BE_Beam>=24	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
BE_Otter	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_<10towed	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_Beam	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_Otter<24	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_Otter>=24	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_Seine	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
DK_Static	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_<10	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Beam	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_FDF	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Otter<24	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Otter>=40	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Otter24-40	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Pelagic	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
EN_Static	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_<10	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_Beam	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_Nets	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_OTH	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_Otter>=40	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FR_Otter10-40	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
GE_Beam<24	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
GE_Beam>=24	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
GE_Otter<24	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
GE_Otter>=40	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
GE_Otter24-40	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NL_Beam<24	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NL_Beam>=40	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NL_Beam24-40	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NL_Otter	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NL_Pelagic	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Fleet	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	TUR	WHG-NS	WIT	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
OTH_OTH	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SC_Otter<10	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SC_Otter<24	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SC_Otter>=24	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SC_Static	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SW_Otter	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SW_Static	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Table 7.6. [FIDES results presented for information]. Effort by stock.

Fleet	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	TUR	WHG-NS	WIT	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
BE_Beam<24	215	865	821	969		989	744	705	815	905							905		
BE_Beam>=24	774	3112	2955	3484	3450	3558	2676	2534	2930	3255							3255		3255
BE_Otter	290	1167	1108	1307	1294	1335	1004	951	1099	1221							1221		1221
DK_<10towed	28	113		126	125	129	97		106										
DK_Beam	220	887		993	983	1014	762	722	835										
DK_Otter<24	792	3185		3566	3532	3641	2739	2594	2999			4367				3331	3331		3331
DK_Otter>=24	2300	9250		10355	10256	10575	7953	7533	8710			12683				9674	9674		9674
DK_Seine	284	1142		1278	1266	1306	982	930	1075										1194
DK_Static	375	1510		1690	1674	1726	1298	1229	1422										
EN_<10	971	3907	3710	4374	4332	4467	3359	3182	3679		1976								4086
EN_Beam	451	1812	1720	2028	2009	2072	1558	1476	1706	1895							1895		1895
EN_FDF	131	528		591	585	603	454	430	497	552	267							552	552
EN_Otter<24	340	1367	1298	1530	1515	1563	1175	1113	1287	1429	691	1874	1162	1126				1429	1429
EN_Otter>=40	107	429	407	480	475	490	369	349	404	448							448		448
EN_Otter24-40	301	1209	1148	1353	1340	1382	1039	985	1138	1264	611	1658						1264	1264
EN_Pelagic	374	1503						1224											
EN_Static	576	2316	2199	2592		2647	1991	1886			1171								
FR_<10	92		351	414		423	318	301											
FR_Beam			80																
FR_Nets	103		394	465		475	357												
FR_OTH	1207	4853	4608	5433	5381	5549	4173	3953											
FR_Otter>=40	1075	4323			4793				4071										
FR_Otter10-40	956	3845	3650	4304	4263		3306	3131	3620										
GE_Beam<24	972	3909		4376		4469	3361	3183	3681										4088
GE_Beam>=24	688			3099		3165	2381	2255	2607	2895							2895		2895

Fleet	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-NS	TUR	WHG-NS	WIT	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
GE_Otter<24	295	1188		1330	1317	1358	1021	967	1118	1242							1242		1242
GE_Otter>=40	1053	4233		4739	4694			3448	3986										
GE_Otter24-40	1136	4569		5115	5066	5223	3928	3721	4302	4778							4778		4778
NL_Beam<24	631	2539		2843	2816	2903	2183	2068	2391	2656							2656		2656
NL_Beam>=40	4643	18675	17731	20905	20706	21350	16057	15208	17584	19530						19530	19530		19530
NL_Beam24-40	812	3266		3656		3734	2808	2660	3075	3416							3416		3416
NL_Otter	916	3684	3498	4124	4085	4212	3167	3000	3469	3853	1863	5051					3853		3853
NL_Pelagic	1661	6680	6342		7406			5440											
OTH_OTH	238	956	908	1070	1060	1093	822	779	900	1000	484	1311	813	788	1000	1000	1000	1000	1000
SC_Otter<10	134	541		606	600		465	441	509		274		460	446	566				566
SC_Otter<24	2800	11261		12606	12486	12875	9683	9171	10603	11777	5695	15441	9574	9281	11777	11777		11777	11777
SC_Otter>=24	2420	9732	9240	10895	10791	11127	8368	7926	9164	10178	4922	13344	8274	8021	10178	10178	10178	10178	10178
SC_Static	2482	9981		11173	11066	11411	8582	8128	9398		5048	13685	8485	8226					10438
SW_Otter	850	3417		3825	3789		2938	2783	3218							3574			3574
SW_Static	226	908		1017	1007		781		855										

Table 7.7. [FIDES results presented for information]. Effort by stock corresponding in the range scenarios for the Dutch fleets [values in italic and bold are the chock species)

	NL_Beam<24	NL_Beam>=40	NL_Beam24-40
cod.27.47d20	631	4643	812
had.27.46a20	2539	18675	3266
ple.27.7d		***17731***	
ple.27.420	2843	20905	3656
pok.27.3a46	***2816***	***20706***	
sol.27.4	***2903***	***21350***	***3734***
tur.27.4	2183	16057	2808
whg.27.47d	2068	15208	2660
wit.27.3a47d	2391	17584	3075
nep.fu.5	2656	19529825	3416
nep.fu.6			
nep.fu.7			
nep.fu.8			
nep.fu.9			
nep.fu.10			
nep.fu.32		19529825	
nep.fu.33	2656	19529825	3416
nep.fu.34			
nep.27.4outFU	2656	19529825	3416

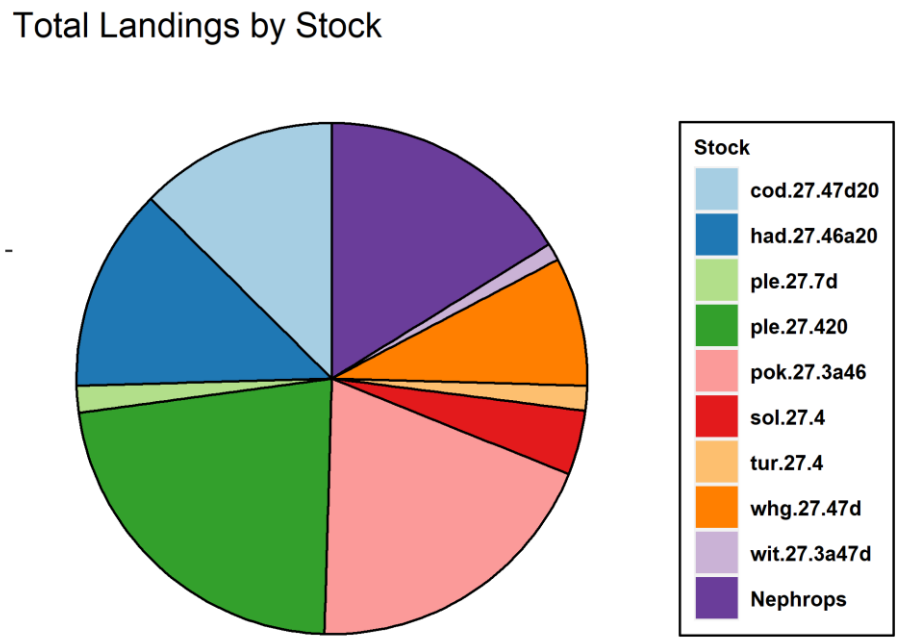


Figure 7.1. Distribution of 2019 landings of those stocks included in the mixed fisheries projections.

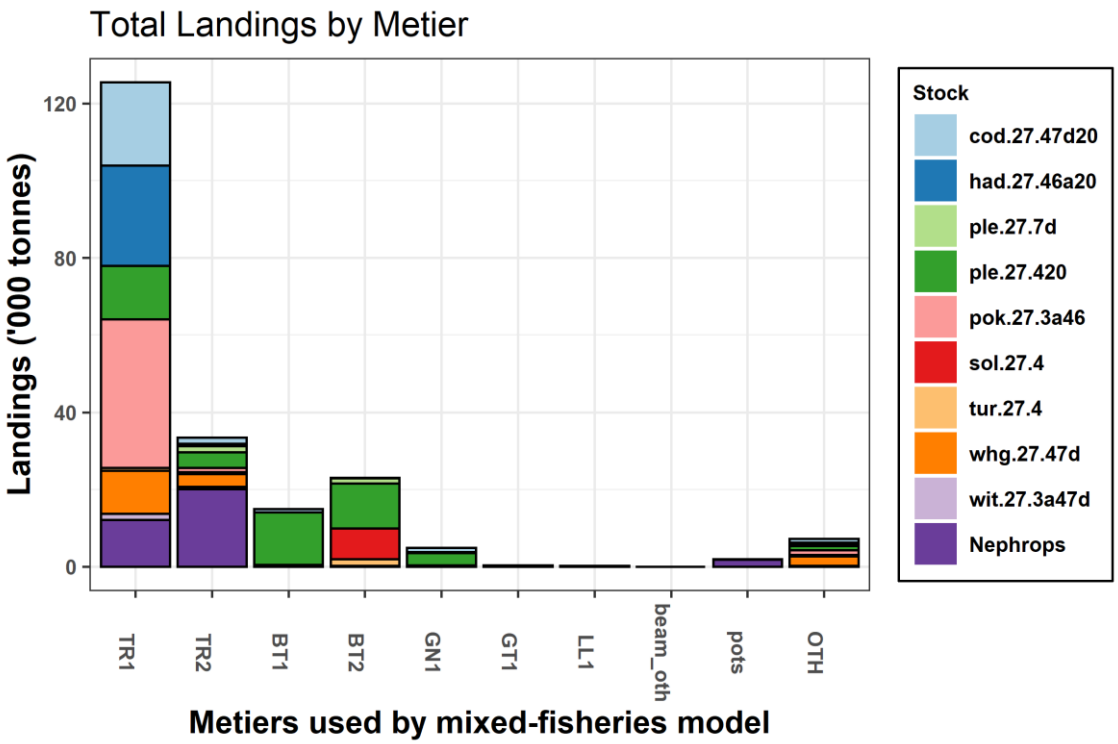


Figure 7.2. 2019 landings distribution of species by métier with landings consisting of ≥1% of any of the stocks. Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings <1% of any of the stocks.

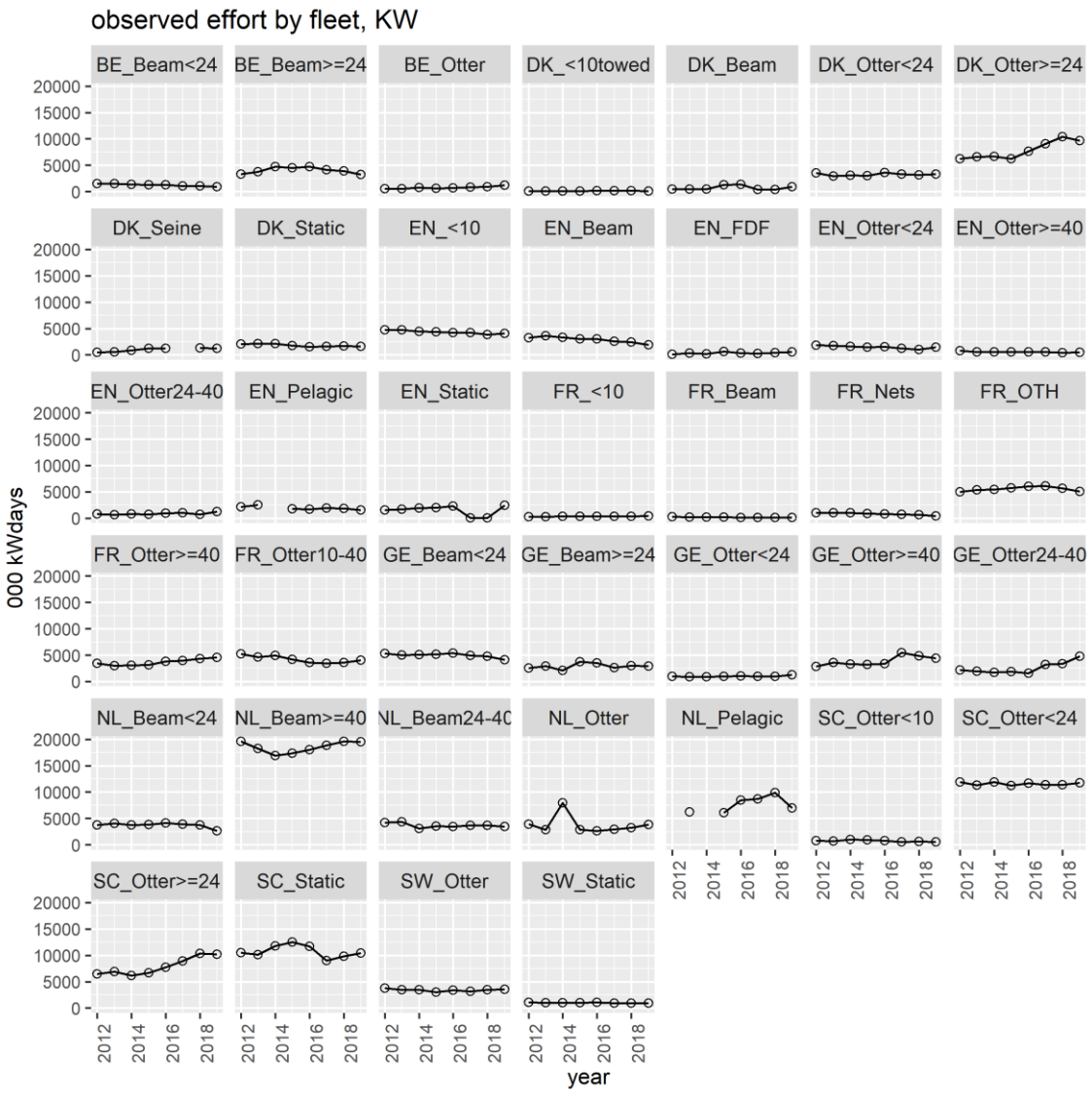


Figure 7.3. Effort by fleet and year for the North Sea demersal fleets, in '000 KWdays.

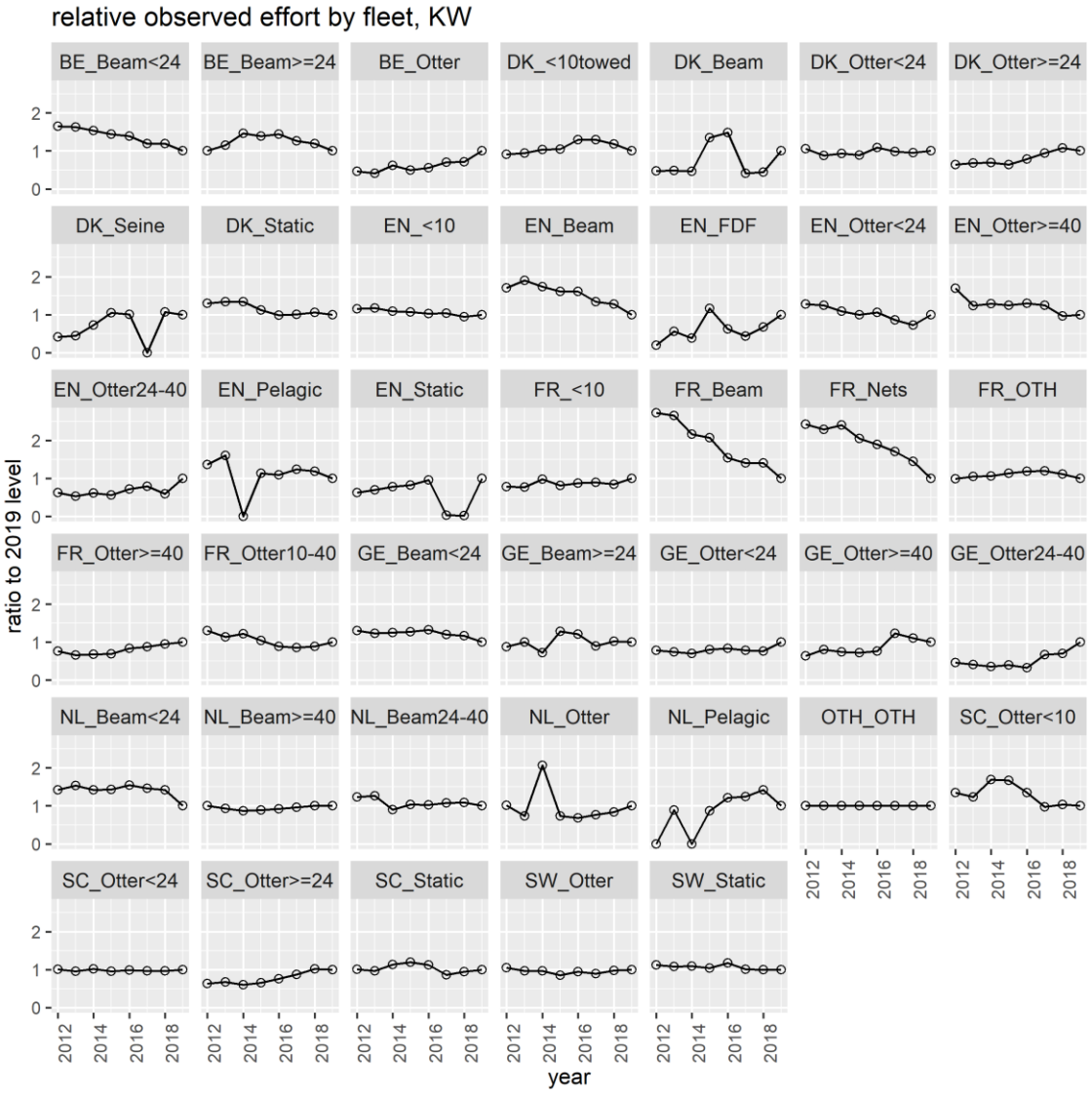


Figure 7.4. Relative trends (compared to the 2019 value) in effort (KW Days) by fleet and year for the North Sea demersal fleets.

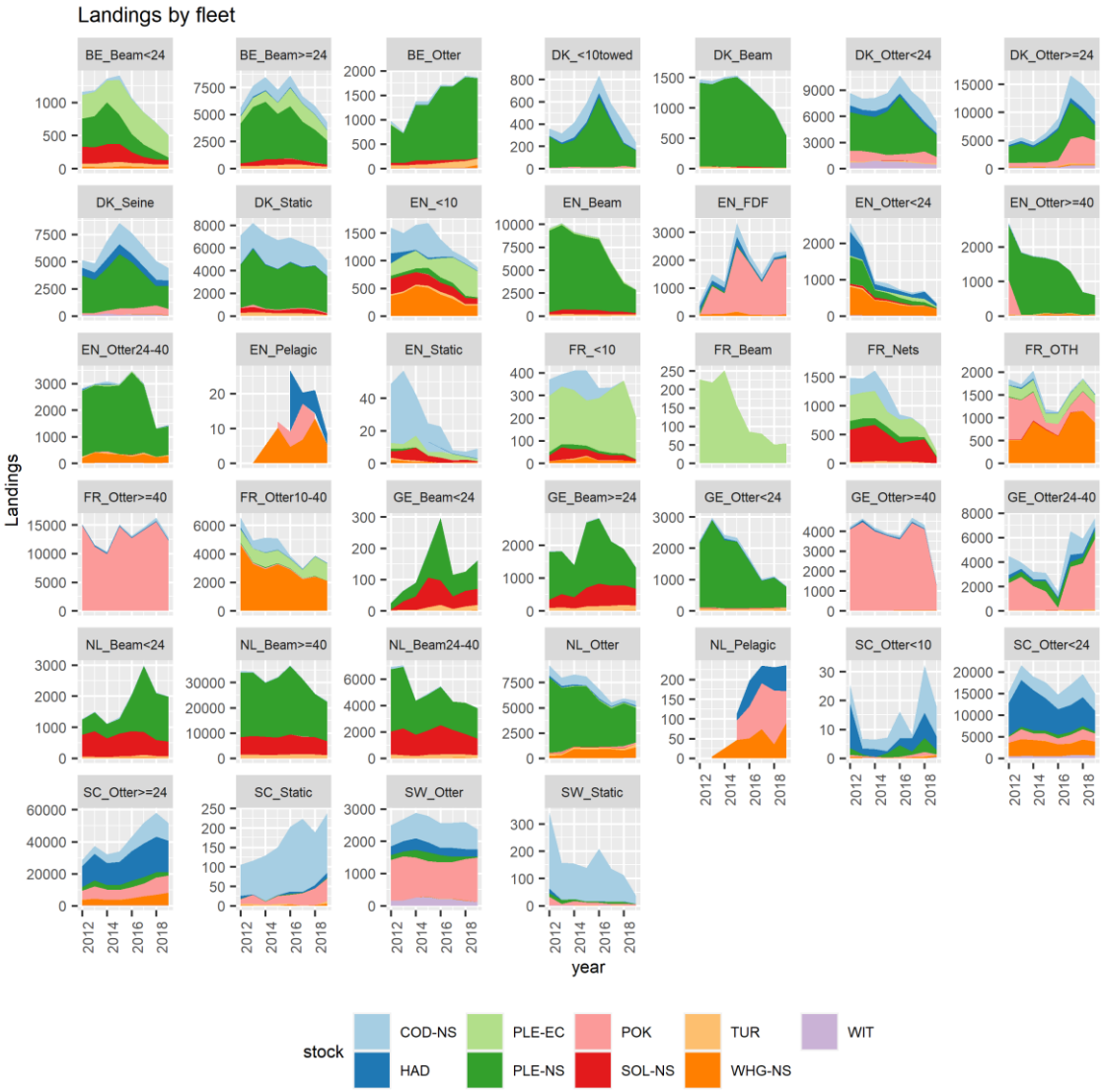


Figure 7.5. Landings by fleet, stock and year.

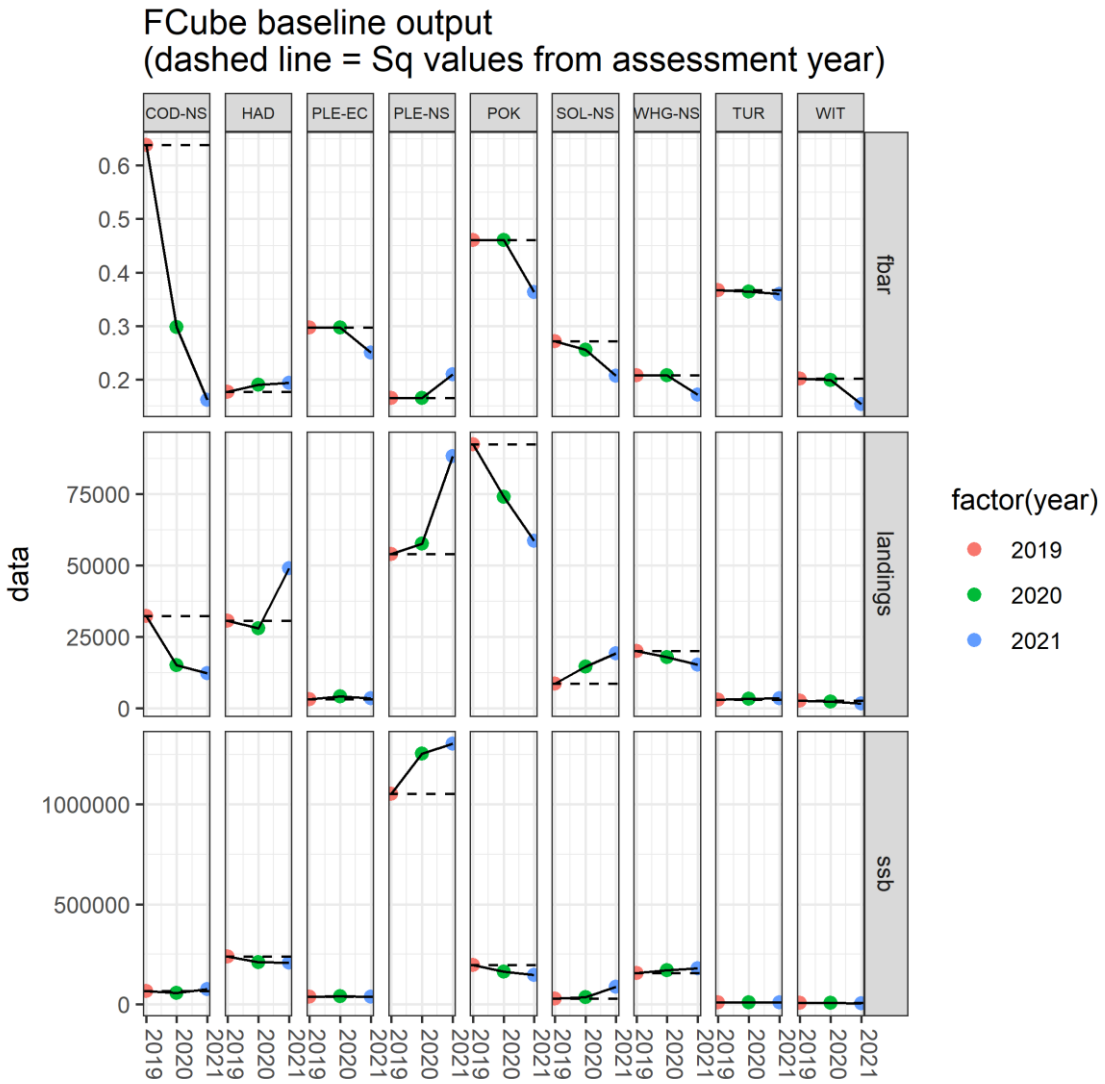


Figure 7.6. Summary of the relative changes in the single-stock advice for 2020 and 2021 compared to the situation in 2019.

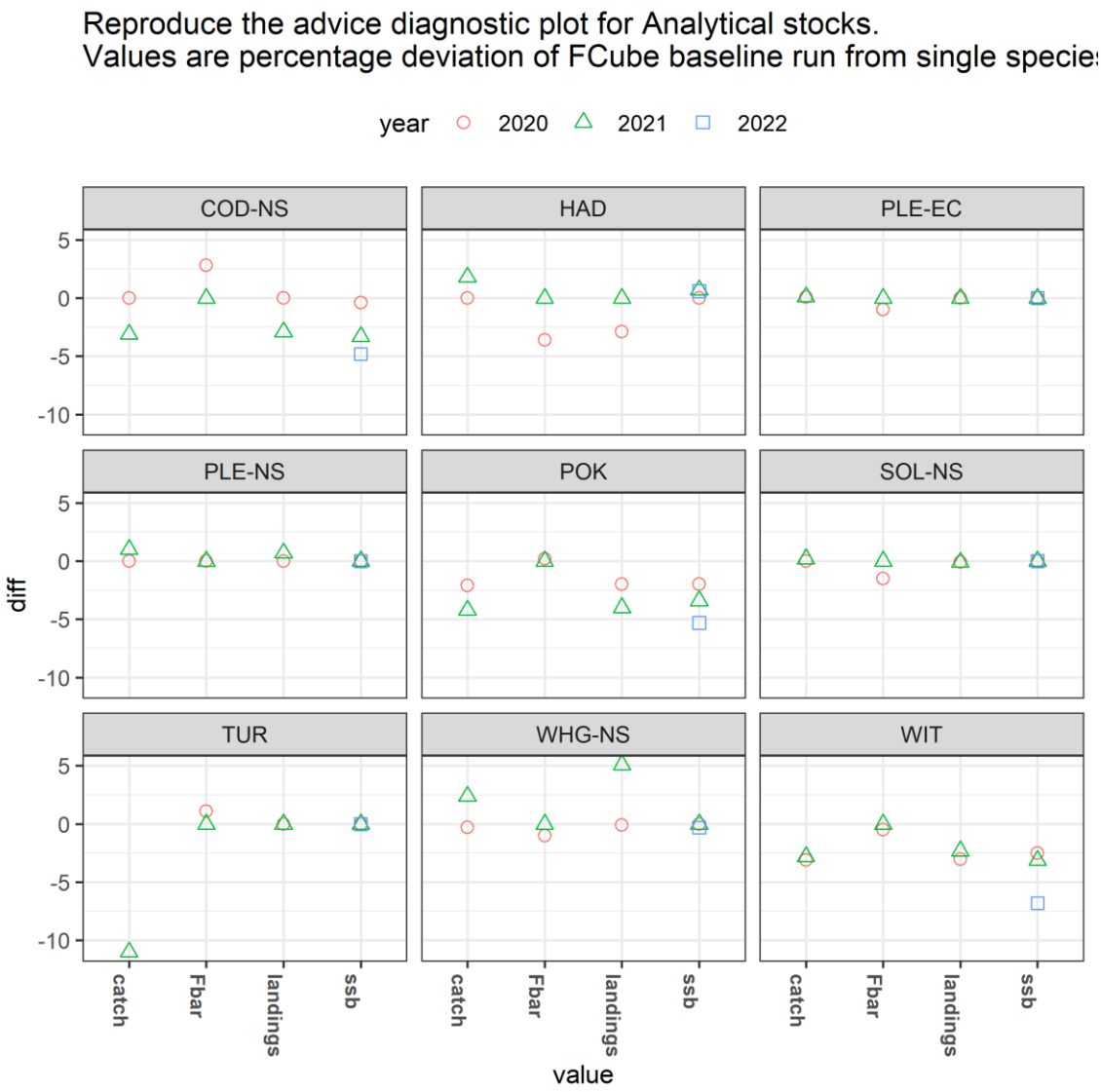


Figure 7.7. Difference between FCube baseline run and Single-species advice for finfish stocks, showing Fbar (2020—2021), landings (2020—2021) and SSB (2020—2022).

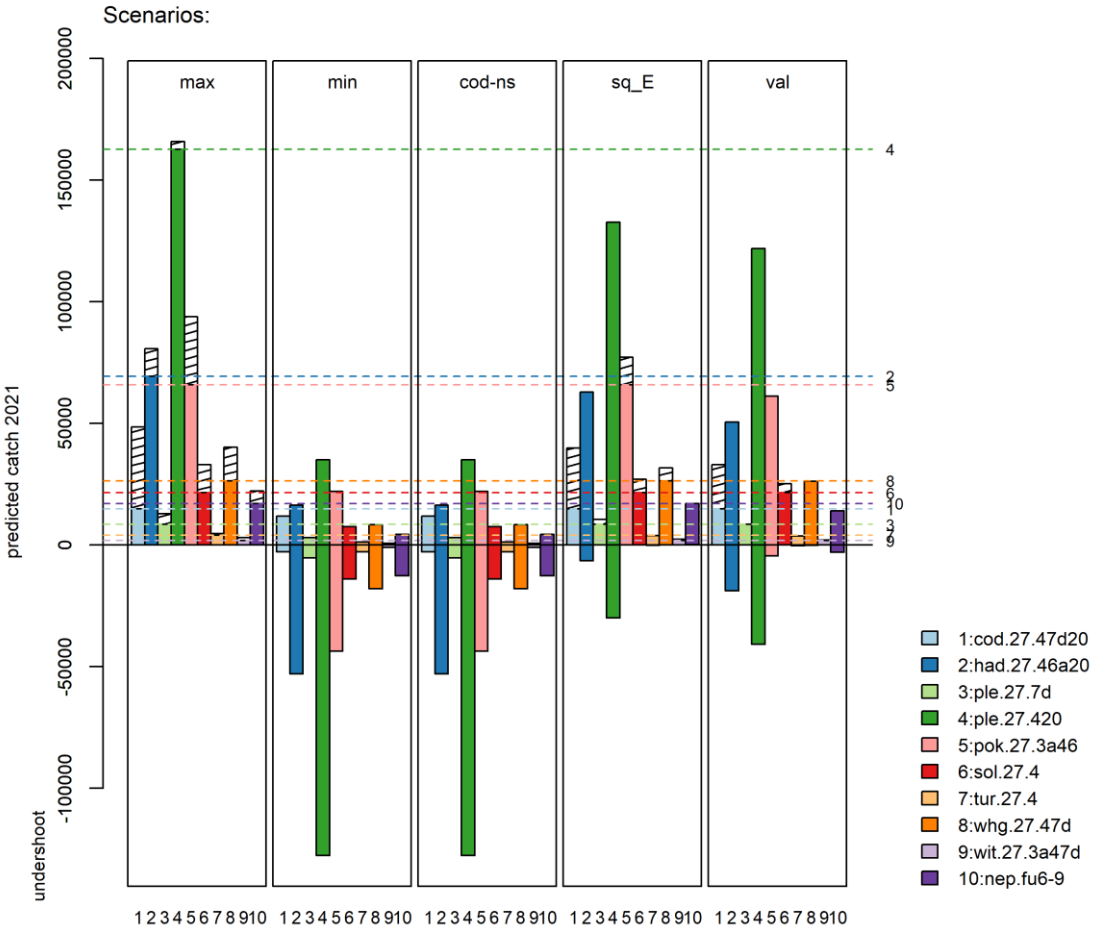


Figure 7.8. Mixed-fisheries projections. Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2021. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

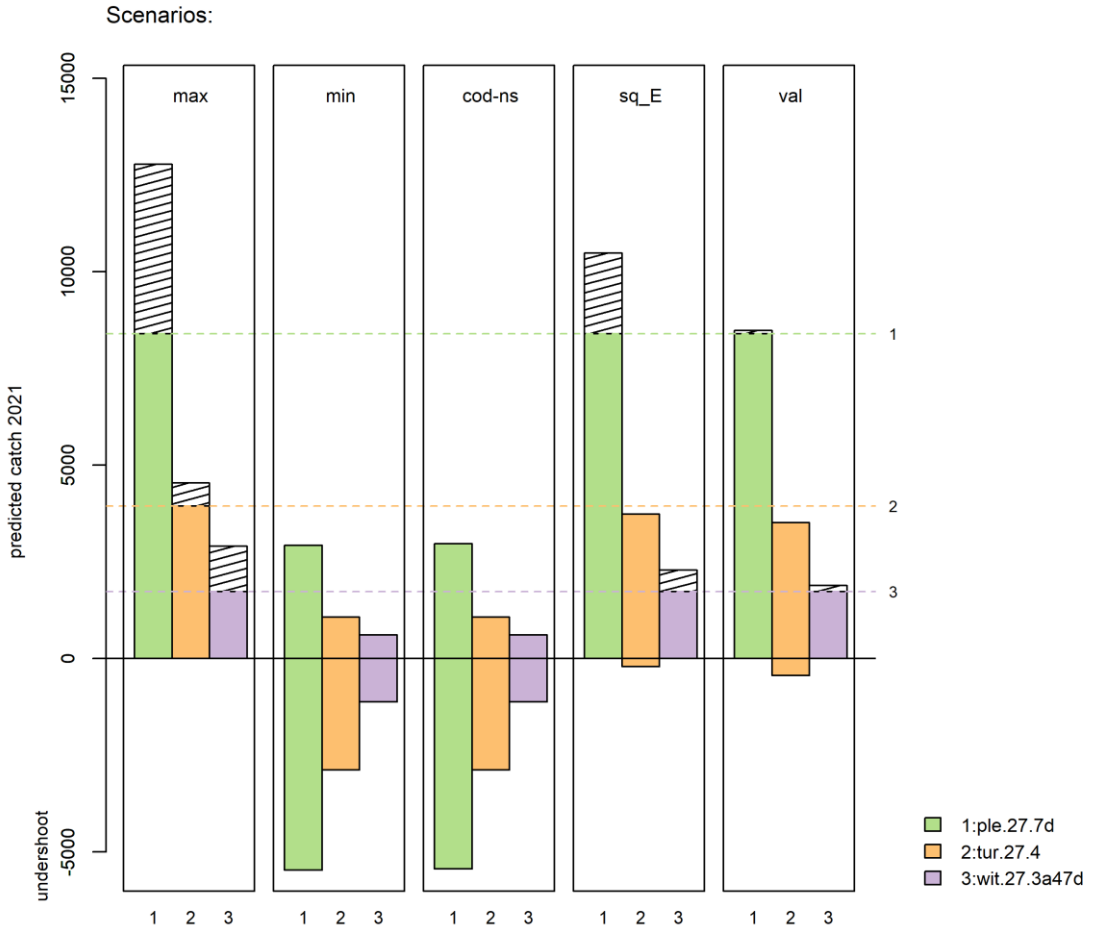


Figure 7.9. Mixed fisheries projections results for the stocks subject to lower landings (detail from Figure 7.8). Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2021. Bars below the value of zero show undershoot (com-pared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

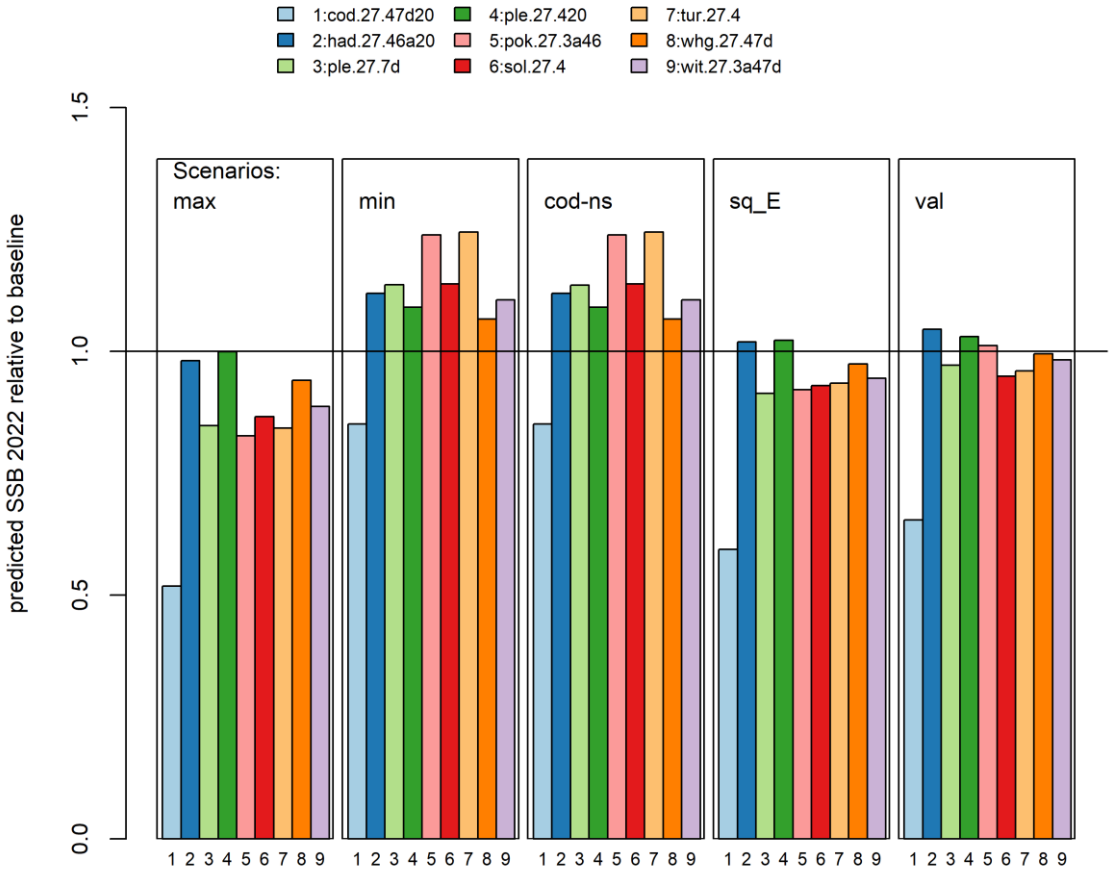


Figure 7.10. Mixed fisheries for the North Sea. Estimated SSB at the start of 2022 by stock after applying the mixed-fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line corresponds to the SSB resulting from the single-stock ad-vice. Norway lobster are not included as the abundance was not forecasted in the mixed-fisheries model.

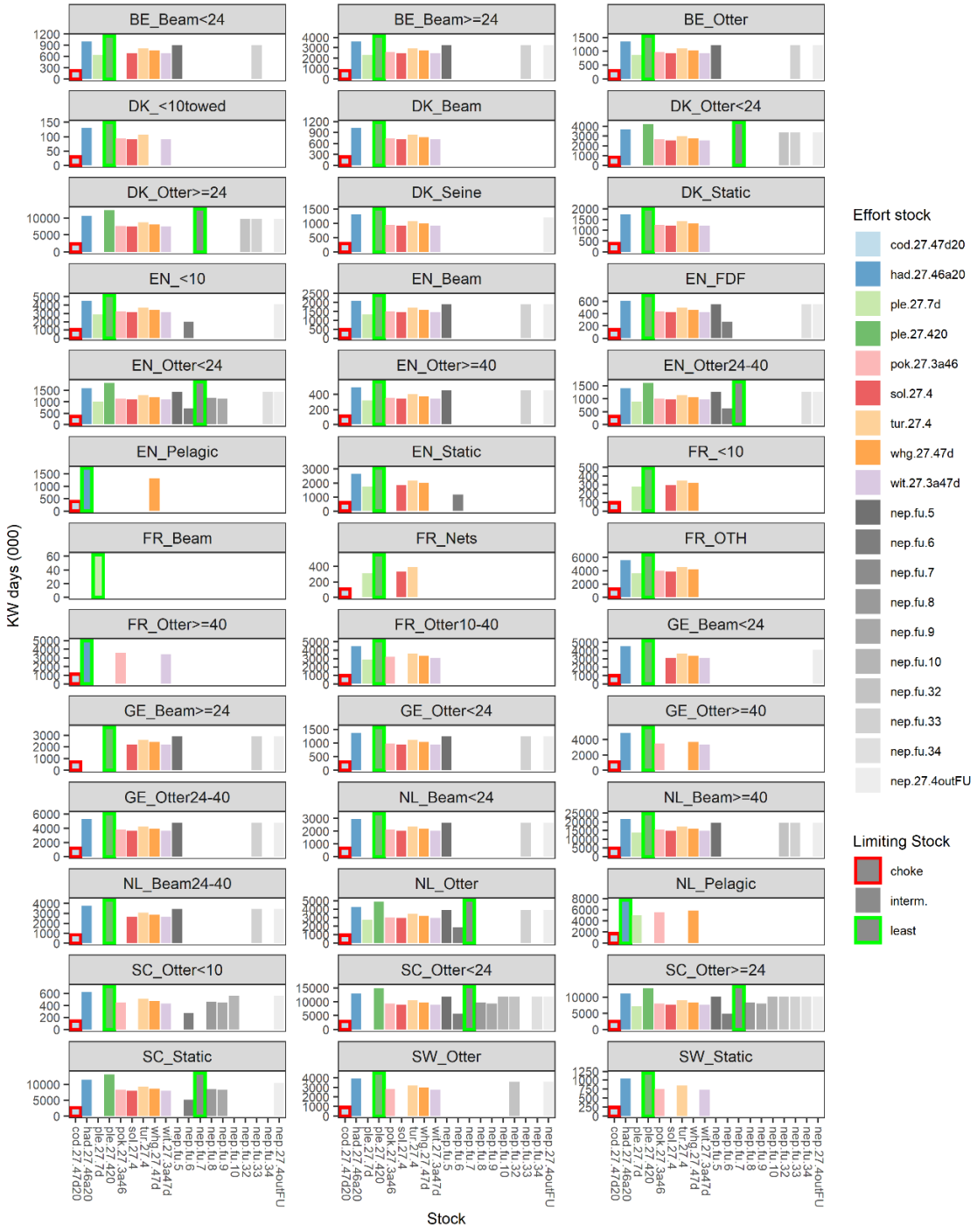


Figure 7.11. Mixed fisheries for the North Sea. Estimates of effort by fleet needed to reach each single-stock advice. Red triangles highlight the most limiting species for that fleet in 2021 ("choke species"), whereas the green triangles highlight the least limiting species. (1: cod.27.47d20, 2: had.27.46a20, 3.1: nep.fu.5, 3.2: nep.fu.6, 3.3: nep.fu.7, 3.4: nep.fu.8, 3.5: nep.fu.9, 3.6: nep.fu.10, 3.7: nep.fu.32, 3.8: nep.fu.33, 3.9: nep.fu.34, 3.10: nep.27.4outFU, 4: ple.27.7d, 5: ple.27.420, 6: pok.27.3a46, 8: sol.27.4, 9: tur.27.4, 10: whg.27.47d, 11: wit.27.3a47d). Fleet names are given by country (BE = Belgium, DK = Denmark, EN = England, FR = France, GE = Germany, IE = Ireland, NI = Northern Ireland, NL = the Netherlands, SC = Scotland, SW = Sweden, OTH = Others) and by meaningful combinations of main gear and vessel size differing across countries and based on homogeneous average fishing patterns. FDF = Fully Documented Fisheries vessels. Vessels in the various fleet segments can engage in several fisheries (métiers) over the year.

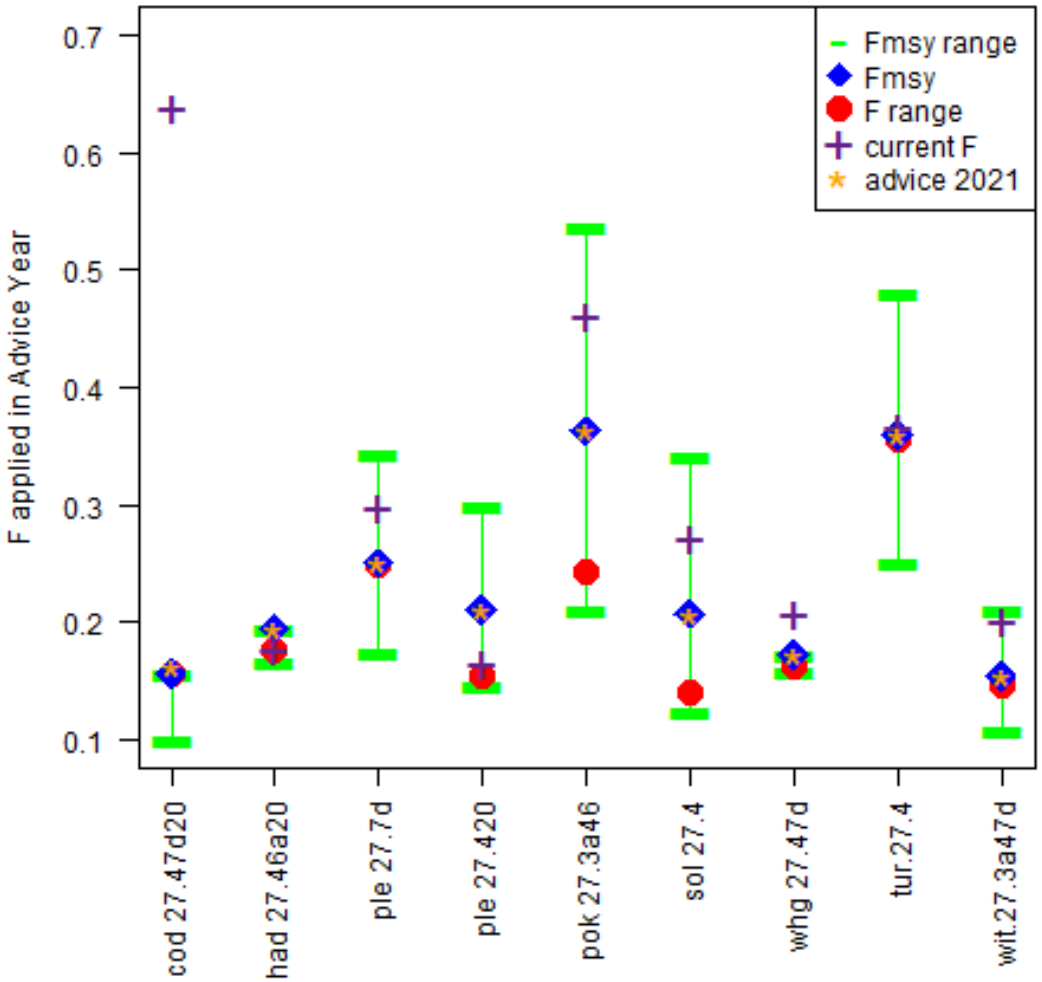


Figure 7.12. North Sea mixed-fisheries 2021 "range" fishing mortality within the F_{MSY} range, compared with F_{MSY}, the current F (F in 2019), and F in the single-stock advice for 2021. The "range" F is the one giving the lowest difference in tonnage between the "max" and the "min" scenario across all stocks and fleets. For cod in the North Sea, F_{MSY} ranges are limited in accordance with the MSY approach and the MAP when below MSY $B_{trigger}$.

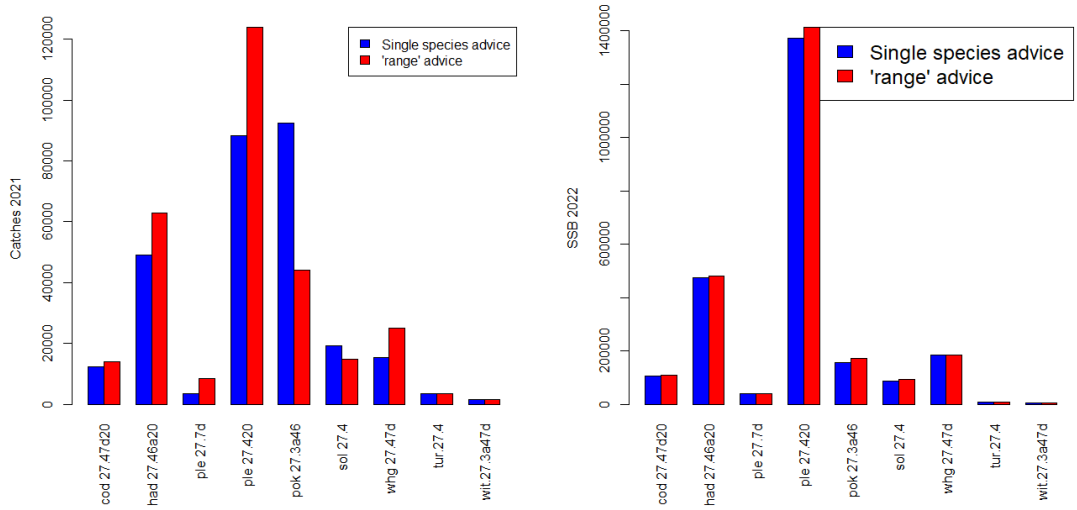


Figure 7.13. Comparison of the outcomes in terms of total catches in 2021 (left) and SSB in 2022 (right) between the F_{MSY}-based single-stock advice and the Frange-based forecast.

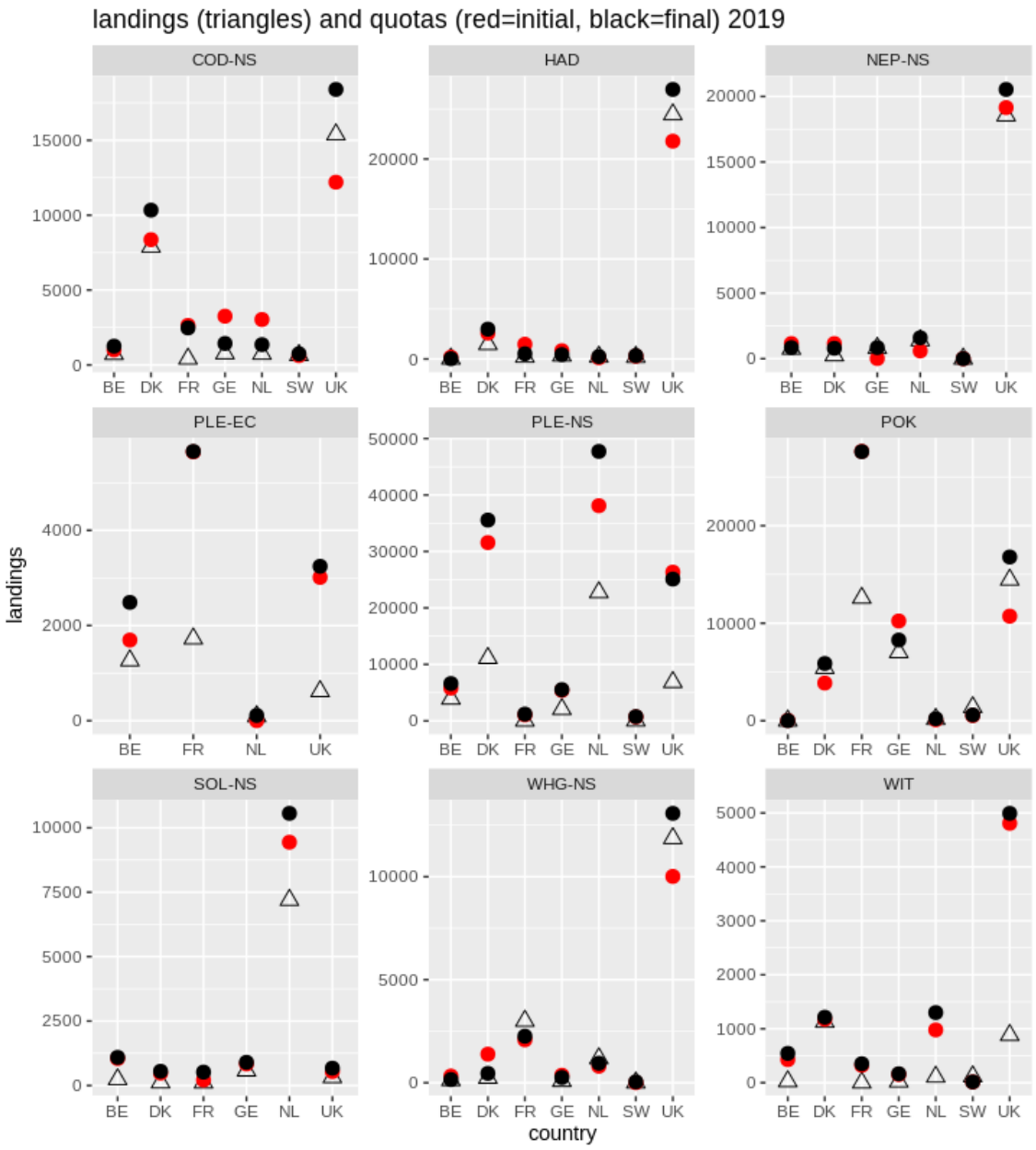


Figure 7.14. [FIDES results presented for information]. Quotas uptakes in 2019 by species and countries from FIDES database.

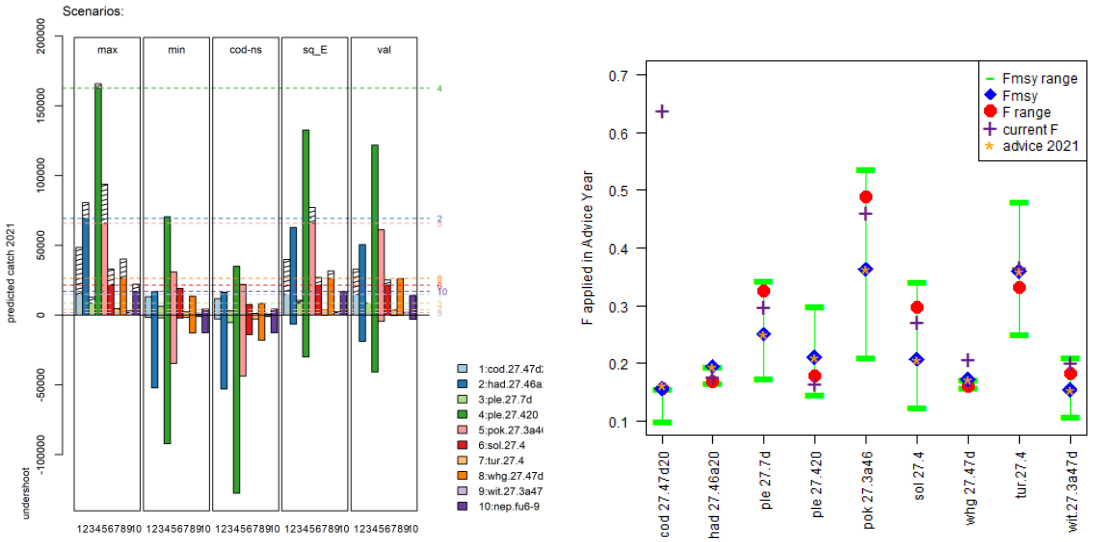


Figure 7.15. [FIDES results presented for information]. Left: Mixed-fisheries FIDES projections. Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2021. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice. Right: North Sea mixed-fisheries 2021 "range" fishing mortality within the F_{MSY} range, compared with F_{MSY}, the current F (F in 2019), and F in the single-stock advice for 2021. The "range" F is the one giving the lowest difference in tonnage between the "max" and the "min" scenario across all stocks and fleets. For cod in the North Sea, F_{MSY} ranges are limited in accordance with the MSY approach and the MAP when below MSY $B_{trigger}$.

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8 WGMIXFISH-METHODS planning

8.1 Bay of Biscay

There are several issues in the modelling process to provide mixed fisheries advice for Bay of Biscay that need to be addressed in future meetings.

- Investigate the differences obtained in the short term forecast between that carried out for mixed fisheries advice and that of the assessment working groups, especially for white anglerfish, seabass, and mackerel.
- Analyse the option of including fleet-dependent age structure in the conditioning of the model for some stocks.
- Improve fleet structure based on this year fleet configuration, e.g. consider removing some of them with low contribution to the catch, remove stocks that are only caught occasionally or where only caught in the past.
- Include blue whiting.
- Analyse stability of main model parameters, i.e. catchability, total effort, effort share and quota share. Based on the analysis consider the best way of conditioning the model at fleet/metier level, recent years average or last year value.
- Analyse the relevance of existing scenarios and identify new relevant ones.

8.2 Celtic Sea

- TAF – continued development of the repository. The current repository is working with the TAF framework but the structure could be further improved to be more in-line with the TAF philosophy.
- Data – continued refining of data processing procedures.
- Methodology - Transition to FLBEIA the current year's methodology now includes the option to condition an age-disaggregated FLfleet object for use in FLBEIA. Thus, using a common data conditioning procedure, Fcube and FLBEIA will be able to be compared in preparation for a transition to FLBEIA.

8.3 Iberian Waters

Continued development of all processes in this new region of advice.

8.4 North Sea

The following topics have been identified for future work in the North Sea case study:

- TAF – The current repository is working with the TAF framework but the structure could be further improved to be more in-line with the TAF philosophy. Improvements could include:
    - Improved organization or removal of created subdirectories (created within the standard data/, model/, output/, and report/ directories).
    - Improved separation of model and output routines. Model routines would be more focused on the actual model runs, while output routines would extract those results (e.g. as summary data objects).

  - Full documentation of all required package versions within SOFTWARE.bib. TAF coordinators have provided somewhat conflicting information here, which needs to be resolved; e.g. commonly used packages (e.g. FLCore, ggplot) are assumed to be on the TAF server and need not be included. This can still, however, be an issue if the advice has relied on an older, specific package version.

- Diagnostics
  - Revision and expansion of diagnostic tables and figures to evaluate the model conditioning and outcomes. Further figures illustrating the mixed fisheries intermediate year assumptions would be helpult (e.g. comparison of SSB at the beginning of the advice year versus the single species advice)
- Data
  - The stock objects for *Nephrops* FUs have historically been created and maintained by WGMIXFISH by extracting annual values from the advice documents. This procedure is inefficient and prone to errors. We suggest asking WGNSSK *Nephrops* stock coordinators to provide FLStock objects directly.
- Methodology
  - FIDES – The current advice year has elucidated some possible issues with how we use FIDES data to update the choking behaviour of fleets; specifically, the removal of choking stocks for countries who did not fully utilize their TAC is the last data year resulted in unrealistic forecasts with too few restrictions to fishing effort. A review of this process should be done to explore other possible adaptions to the procedure. The group agrees that the FIDES data is still a valuable data source for create more realistic short-term forecasts.
  - Intermediate year assumptions – This is a discussion that should be had across case studies. Also, should the same intermediate year assumptions be used among all scenarios (including "range").
- Report & Stock Annex
  - Several RMarkdown-produced Word documents are now used to create advice- and report-ready tables and figures. These will be further maintained and streamlined into a single RMarkdown script.
- Transition to FLBEIA
  - The current year's methodology now includes the option to condition an age-disaggregated FLfleet object for use in FLBEIA. Thus, using a common data conditioning procedure, Fcube and FLBEIA will be able to be compared in preparation for a transition to FLBEIA.

8.5 Irish Sea

The following areas would be useful to address in order to improve the mixed fisheries assessment methods in the Irish Sea

- Methods for the inclusion of stochastic assessment methods (e.g. SAM) into the FLR FCube framework. Improvements for the inclusion of SAM assessment methods have been demonstrated by the North Seas and Celtics Seas subgroups in 2020. The Irish Sea subgroup aims to implement such methods in the mixed fisheries assessment of Plaice and Sole in Division 7.a

- Methods for the inclusion of category 3 and other data poor stocks. The Irish Sea subgroup are developing code for the replication of the currently Irish Sea Cod single-species assessment in their mixed fisheries model. This species is assessed using a trends based assessment which uses a biomass index derived from the NI-GFS scientific survey.
- Potential improvements to the methods for the inclusion of *Nephrops* stocks in the mixed fisheries assessments. For example, whether the spatial aspects of *Nephrops* fisheries can be better accounted for (e.g. via fleet objects), and the potential merits of dividing TACs within regions based on single-species advice rather than recent landings.
- The use of FIDES information on quota uptake by member states to inform 'min' and 'range scenarios
- Improvements to fleet and metier structures to best reflect Irish Sea fisheries practices and technical interactions

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Annex 1: Recommendations

No recommendations

Annex 2: List of participants

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Annex 3: Audit Reports

Audit of the Mixed-fisheries advice for the Bay of Biscay ecoregion

Date: 10/11/2020
Auditor: Lionel Pawlowski

Summary of the advice

1) **Assessment type:** update

2) **Single stock Assessments used as basis**

STOCK	ICES CODE	ASSESSMENT	FORECAST
White anglerfish	mon.27.78abd	a4a	FLR
Mackerel	mac.27.nea	SAM	FLR
Sea bass	bss.27.8ab	Stock Synthesis	R
Sole	sol.27.8ab	FLXSA	FLR
Hake	hke.27.3a46-8abd	Stock Synthesis	R
Western horse mackerel	hom.27.2a4a5b6a7ace-k8	Stock Synthesis	FLR
Megrim	meg.27.7b-k8abd	Bayesian statistical catch at age	R
Norway lobster	nep.fu.2324	Underwater TV survey	Excel
Black-bellied anglerfish	ank.27.78abd	Landings, survey-based trends	NA
Whiting	whg.27.89a	Precautionary reduction of catches	NA
Smooth-hound	sdv.27.nea	Landings, survey-based trends	NA
Undulate ray	rju.27.8ab	Precautionary reduction of catches	NA
Thornback ray	rjc.27.8	Landings, survey-based trends	NA
Cuckoo ray	rjn.27.678abd	Landings, survey-based trends	NA

3) **Framework used for mixed fisheries forecasts**:
FLBEIA (FLR) (Garcia *et al.*, 2017; ICES, 2018).

4) **Data issues:**
There are some differences between the single-stock fishing mortality and SSB values, and the values obtained from the mixed-fisheries scenarios, where all fleets are considered to set their effort corresponding to their quota shares for each given species. Some explanation are provided for hake but the differences for the other stocks is unknown.

5) **Consistency:**

This year's advice is based from last year's advice with the inclusion of additions of new species of commercial interest (notably sole, seabass, mackerel and horse mackerel) and conservation value (elasmobranch) and removal of four spotted megrim. The Bay of Biscay case study is still relatively new therefore the list of species may still change substantially from year to year.

6) **Mixed fisheries situation**:
Last year for 2020, hake was considered the most limiting stock for most fleets and the stock of black anglerfish was seens as the least limiting stock for most fleets. This year had new species added and for 2021, the results in none of the mixed-fisheries scenarios are similar to the "min" scenario, indicating that the limiting stock varies from fleet to fleet. Horse mackerel and undulate ray generate the highest loss of fishing opportunities, indicating that they are among the most limiting stocks. Similarly, the least limiting stock varies from fleet to fleet. Norway lobster, the anglerfishes and smooth-hound generate the highest overshooting of the TACs, indicating that they are among the less limiting stocks.

7) **Management Plan**:
In the context of the new CFP, the EU has developed a Multiannual management plan (MAP) for the management of the Western Waters demersal mixed fisheries, which has been in force since 2019 with a unique framework defining objectives and constraints for both target and bycatch demersal species. Several stocks are either shared between the EU and non EU member states (which are not involved in the EU MAP) or not included in the EU-MAP. In those cases ICES gives advice based on the ICES MSY approach.

General comments
The audit has been carried out over a short period of time while report and stock annex were not fully finalized. I was unable to run the model due to R issues (see technical comments) but had a close reading through the code which is written in a clean way and well commented which is helpful to understand how the processing of the data and model is done.

The advice can be seen as an update from last year but it is actually not totally true considering the amount of changes that has been done in terms of species list. I suspect, given the diversity of species added this year, that the outcome and behavior of the whole framework are impacted by those changes. While this makes any attempt to compare with last year's advice a bit pointless, it is very positive to see to how this case study is growing notably in terms of range of species and methods.

Technical comments
It could be interesting given the number of stocks and related ICES WGs to have consistent naming in the data sets like stock_wgname_year.csv for example so it might be easier to pick-up single stock information quick from WG reports. Loading data directly from XLSX file requires additional R packages I wasn't unable to install (XLSconnect) because of Java issues therefore I couldn't rerun the full assessment on my own.

What is missing a bit in the various documents are the rational for the selection of the set of species. Are they the most landed ones, the most technically integrable into FLBEIA ? If time was allowing to do such exercise, it would be nice to see what are the effects for the runs and scenarios of removing/adding some species.

Given the number of stocks involved and for many of them some spatial extension outside of the Bay of Biscay, it would be nice to summarize somewhere the TAC/management measures in

place relevant for the Bay of Biscay and how the split by area/species were carried out for widely distributed stocks or stocks combining 2 species like megrim.

It is unclear why differences exists between SSB, F and their equivalent obtained from the mixed-fisheries scenarios, where all fleets are considered to set their effort corresponding to their quota shares for each given species. Those differences looks yet not critical for the advice and considering the diversity of species it is not clear from where it originates between data issues, deviation resulting from the assumption or other computing issues.

There is a minor error on tables 4 and 5 in the advice sheet referring to Iberian waters rather the Bay of Biscay.

Conclusions

Great amount of work has been carried out to develop the Bay of Biscay case study. While I have been unable to rerun the full script, I assume from reading the code that the assessment has been performed correctly. The change in the list of species makes comparison with last year a bit pointless but I have the overall feeling that things have been done correctly. The stock annex has been updated to reflect those changes.

Audit of the Mixed-fisheries advice for the Atlantic Iberian waters

Date: 7-11-2019
Auditor: Thomas BRUNEL

Summary of the advice

8) **Assessment type: update**
9) **Single stock Assessments used as basis** (stock/assessment model/EG forecast method)

Stocks	Assessment	Forecast
BLACK ANGLERFISH 8c9	Spict	NA
HAKE 8c9ac	GADGET	GADGET (script: predict.st.sh)
FOUR-SPOT MEGRIM 8c9a	XSA	MFDP
MEGRIM 8c9a9a	XSA	MFDP
WHITE ANGLERFISH 8c9a	SS3	SS3 (ad hoc R code)

10) **Framework used for mixed fisheries forecasts**:
FLBEIA (FLR) (Garcia et al., 2017; ICES, 2018e)
11) **Data issues:**
Discrepancies were found between the catch data used by the stock assessment EG and the data used by the mixed fisheries working group (up to -7% total catch in 2018 for the black anglerfish).
12) **Consistency**:
Same basis as last year's advice, except for the inclusion of an additional stock (black anglerfish)
13) **Mixed fisheries situation**:
Sourthern hake is the most limiting stock for most fleets and black anglerfish is the less limiting stock for most fleets.,
14) **Management Plan**:
The 5 stocks included in this advice are managed under the Multiannual Management Plan for Western Waters

General comments

Report and advice sheet are well written and are transparent about the limitations in the methods (e.g. various assumptions made), and identify the potential data related issues (i.e related to input catch data and to the effect of the changing framework between assessment EG and mixed fisheries EG).

As there is no stock annex equivalent for this advice (as for any mixed fisheries advice) and there is little description of the method in the report so it is difficult to judge whether the calculations were done according to procedure. However, the MIXFISH group's working procedure is based on a number of shared scripts, placed on a common repository, which guaranties that the same common procedures are applied across advice regions.

Within the time available to conduct this audit, it was not possible to check all calculations. Only the conformity of the results presented in the advice sheet and the report with the raw output of the mixed fisheries model was checked.

Differences where found between 1) the results of the forecasts for single stocks done at WGBIE, 2) the attempt to reproduced these forecasts in FLBEIA, 3) stock specific mixed fisheries scenarios.). Differences between 1 and 2 are mentioned in the report and on the advice sheet and can

be expected as a result of the change in framework between WGBIE and WGMIXFISH (convert GADGET output to FLR stock). Differences between 2 and 3 are not explained in the report, and it is difficult to understand why they arise. In principle a scenario in which all the fleets catch their quota of, for example, hake should give the same outcome, for hake, as the single stock short term forecast made using the same FLBEIA framework.

Technical comments

The magnitude of the discrepancies found between single stock projections done by stock assessment EG and the baseline run done by the mixed fisheries group is worrying. There seems to be some issues for hake in the transformation of the output of GADGET (seasonal and length-based) into an FLR object (annual and age-strucutred). In the historical period of the assessment, differences up to 30% are observed (although for the final assessment year the differences in only 1%).

Similarly, discrepancies (especially for monkfish) are found also in the fleet data (sum of catches per stocks in the mixed fisheries data can differ from the sum of catches used as input of the stock assessment models). This could have an effect on the mixed fisheries projections.

<u>Minor remarks on the report and advice sheet</u>

Advice sheet :

- The advice sheet is entitled "mixed-fisheries advice for the Bay of Biscay and the Atlantic Iberian waters". That does not match with the ICES subdivisions included in the analyses (8c9a). Most of the Bay of Biscay (8ab) is covered by another mixed fisheries model, which is currently under development.
- Figure 4 should show the gear code for each metier
- It could be usefull for the managers to have fleet based outcome (in effort or catches) of the mixed fisheries projection (e.g. rose plot presented on the North Sea advice sheet). The information on the consequences for each fleets is relevant.

Report :

- In section 4.3. (stock input data) it could be interesting to make a comparison of the stock trajectories (SSB and Fbar) from the stock assessment model (WGBIE) and from the assessment transformed to the annual age-structured format used for MixFish, at least for the stocks assessed with a length-based model. This would give an idea of the discrepany in the input data, and would be useful to understand discrepancies in forecasts. In fact, this would show that there are already large discrepancies in the historical part for hake SSB (up to 30%), although the discrepancy is small (1%) for the final assessment year (2018).

- Section 4.5.2.1. the baseline run is presented here as being "*the mixed-fisheries scenarios that consider all fleets set their effort corresponding to their quota shares for each given species*" (second paragraph). I think (after discussing with expert) that this is not exact : the baseline consists in 1) transferring assessment into the FLR format, and 2) run the forcast for each stock individually, with the same settings as in the expert groups, using the deterministic forecast function of FLR. There is no mixed fisheries calculation (i.e. effort) involved at this step.

- Also in this paragraph, the report provides a comparison of the baseline run and the single stock advice only for the landings. It would be usefull to give these results for SSB and Fbar as well.

Conclusions

The mixed fisheries projections have been performed correctly, but there are issues with the input data.

Qualitatively, the outcome of the projections makes sense : hake is the stock for which the single stock advice is decreasing the most, and is identified as the most limiting stock for these mixed fisheries. Because of the discrepancies discussed above, it is diffult to judge to what level of uncertainty is attached to the results presented, and to what extent they can be used quantitatively.

The causes for the discrepancies observed in the forecast between the length-structured model used in the stock assessment EG and the age-structure model used in the MixFish EG should be further investigated, in collaboration with stock assessors for the relevant stocks.

There should be a reflection within MIXFISH on what type of effect (e.g bias) these discrepancies can have on the outcome of the forecasts (at the first place, the figure put on the front page of the advice), and on which level of discrepancy can be considered acceptable.

Audit of the Mixed-fisheries advice for the Greater North Seas Ecoregion

Date: 06/11/2020
Auditor: Ruth Kelly

Summary of the advice

1) **Assessment type:** FCube mixed fisheries assessment
2) **Single stock Assessments used as basis** (stock/assessment model/EG forecast method)

SPECIES	ASSESSMENT	FORECAST
COD 4, 3.a and 7.d	SAM	SAM
HADDOCK 4, 3.a and 7.d	TSA	MFDP
PLAICE 4	AAP	AAP
SAITHE 4, 3.a and 6	SAM	SAM
SOLE 4	AAP	FLR 2.3, FLSTF
WHITING 4 and 7.d	FLR 2.x, FLXSA	MFDP
PLAICE 7.d	AAP	FLR 2.x, FLSTF
SOLE 7.d	XSA	MFDP
Nephrops FU's 5–10, 32, 33, 34 & other in Sub area 4	UWTV - analytical and non-analytical depending on FU	UWTV- analytical and non-analytical depending on FU

3) **Framework used for mixed fisheries forecasts**:
   The Fcube model coded in R, using the FLR framework (www.flr-project.org).
4) **Data issues:** None reported
5) **Consistency**:

Sole in 7d was not included in the mixed fisheries analysis this year because the assessment was downgraded to Category 3 and could not be included this year.
The assessment process had two other minor deviations from 2019, both were discussed at length by WGMixedFish, and are described in the WG report. Firstly, in order to achieve a better match better the mixed fishery projections and the single species advice for stocks assessed by WGNSSK using SAM assessments, the fwd() function, used in the forecast procedure of FCube, was modified to overwrite stock numbers in the intermediate year in cases where these are produced by the assessment model (e.g. SAM). This significantly reduced the differences between the FCube short-term forecast and the stochastic forecast procedure of SAM. Secondly, in 2019 FIDES data was used to inform the 'min' and 'range' scenarios in the FCube model. This FIDES data informs the model of the underuse of quotas by individual member states, and is then used to modify the 'min' scenario in cases where the member states have not utilized their for the 'choke' species. However, in 2020 the introduction of the FIDES information into the modelling procedure artificially inflated some of the values in the optimised 'range' scenario, suggesting higher F_{MSY} values for these species than could be fully justified by the working group on the basis of technical fisheries interactions alone. Therefore, the advice for 2020 is given without the inclusion of this additional FIDES information on quota uptake by individual member states.

6) **Mixed fisheries situation**:
   Cod is estimated to be the most limiting stock in the Greater North Sea mixed-fisheries model (for 39 out of 40 fleets). The assessment of cod has indicated that its SSB for 2020

is below B_{lim}, with advised catch rates for 2021 below F_{MSY} in order to achieve an SSB > B_{lim} in 2022.

7) **Management Plan**:
Demersal fisheries in the North Sea region are managed under a multi-annual plan for the North Seas region (Regulation (EU) 2018/973).

General comments
Report, advice and stock annex are clear and well-written, and have been made available on the ICES SharePoint. The code, data and R packages are available on the ICES Transparent Assessment Framework (TAF) and can be fully reproduced from this repository.

There are three minor deviations from the 2019 advice process (described above), these were all discussed at the WGMIXFISH 2020 advice meeting, and are adequately detailed in the stock annex, advice sheet and report.

Technical comments
Advice sheet
Nephrops needs to be added to the figure legend of figure 1 (currently NA in the legend). Minor comments by the North Seas subgroup in the margins need to be confirmed.

Code and reproducibility
The code runs fully reproduces the assessment process based on the data supplied on the ICES TAF repository. It is well explained and contains a Readme file to guide the user. One R package 'icesAdvice' needed to be installed separately, and should ideally be added to the software.bib file on the repository.

Stock Annex
Generally very well-written and clear. It may be useful to add further information on the FIDES procedure into sections C or D. I have added some minor comments on the text on the ICES sharepoint.

Conclusions
The assessment has been carried out appropriately, and is fully reproducible. There are some minor deviations from previous years, but these are fully justified. The alterations to the FLR function improve the model performance and fit to the single-species advice methods for stocks for which a SAM assessment is used.

Audit of the Mixed-fisheries advice for the Celtic Sea

Date: 13/11/2020
Auditor: Marieke Desender

General:
- Would be easier for first users if there was something in the readme file in github.
- Make sure latest PDFs from R markdown outputs are in place on github… so its easy to compare with new runs, also to check steps along the way. Maybe in this way, in case there is a difference in the end its easier to track down through the PDFS?

data_02_clean_accessions_effort_2020:
L125: rm(new_accession_effort, new_accessions_effort, accessions_effort): skipped this line…

model_01_Reproduce_the_advice_Celtic_Sea_2020.Rmd":
At first didn't work with R 3.5:
L25: RNGkind(sample.kind = "Rounding")
L57: trouble with installing packages or library (devtools), (ggplotFL), (formatR) and (stockassessment)
No problem anymore with getting the right packages installed after upgrading to R 3.6
differences in catch, ssb had and whiting for 2020-2022year in baseline Fcube
SSB22 had= 70134
SSBWHG2022= 37529
Due to SAM forecast?

model_02_Creating_the_fleet_object_Celtic_Sea_2020

model_03_Conditioning_Celtic_Sea_2020
plots differs with PDF on Github for example: haddock (log q) difference in French fleets split in below and above 24m?

model_04_FCube_Forecasts_Celtic_Sea_2020_SkipIntYear
there is a diff with the PDF on github, but least limiting effort % and number of fleets consistent with advice sheet!

model_05_optim_2020
sourceTAF: no problem
report outputs:
- report_03_FigAdvice_Celtic_Sea_2020.Rmd": L 230 barplot doesn't work: incorrect number of dimensions
- "report_04_advice_tables_2020.R":
- Haddock and whiting: different catch, SSB under all scenarios:
- Also low catches of haddock, whiting and sole in min scenario
- Rest of the outcome is exactly the same outcome as advice sheet
- Due to bug in SAM forecast!!! Advice sheet should be correct.

report_10_mixed_fisheries_overview
L472: All_years_spread_landings$OTM_SPF <-round (All_years_spread_landings$OTM_SPF/All_years_spread_landings$Total_tonnage,3)
-OTM_SPF doesn't exist? Double check, is mentioned in advice sheet
L861: All_years_spread_landings$Total_tonnage<-rowSums (All_years_spread_landings[,2:14])
Fm

Annex 4: List of stock annexes

The table below provides an overview of the WGMIXFISH Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication

Type "Stock Annexes".

Stock ID	Stock Name	Last updated	Link
mix.ns	North Sea Mixed Fisheries Annex	November 2020	mix.ns_SA
mix.ibw	Iberian Waters Mixed Fisheries Annex	October 2020	mix.ibw_SA
mix.cs	Celtic Sea Mixed Fisheries Annex	October 2020	mix.cs_SA
mix.bob	Bay of Biscay Mixed Fisheries Annex	October 2020	mix.bob_SA