WORKING GROUP ON MIXED FISHERIES ADVICE (WGMIXFISH-ADVICE)

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ICES International Council for the Exploration of the Sea
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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, Irish Sea 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 considers 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 Irish Sea, and the "FLBEIA" (Bio-Economic Impact Assessment using FLR) methodology for the Bay of Biscay, Iberian Waters and North Sea.

The Bay of Biscay mixed fisheries projections consider the single-species advice of 13 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, pol.27.89a, sdv.27.nea, sol.27.8ab, whb.27.1-91214, and whg.27.89a). Based on current fishing patterns and single-stock catch advice, the most limiting stock for Bay of Biscay demersal fisheries is horse mackerel (hom.27.2a4a5b6a7a-ce-k8), due to the zero-catch advice. The least limiting stock is whiting (whg.27.89a; 8 of 22 fleets). However, if horse mackerel was to be excluded as a restrictive stock due to the small contribution made by the demersal fleets to the total stock landings, the most limiting stock would be pollack (pol.27.89a) whose quota is first reached for 8 of 22 defined fleets.

The Celtic Sea mixed fisheries projections consider the single-species advice for 15 stocks (cod.27.7e-k, had.27.7b-k, whg.27.7b-ce-k, nep.fu.16, 17, 19, 20–21, 22, and outside FUs, sol.27.7e, sol.27.7fg, mon.27.78abd, ank.27.78abd, meg.27.7b-k8abd, and hke.27.3a46-8abd). Based on current fishing patterns and single-stock catch advice, cod is the most limiting stock for Celtic Sea demersal fisheries. This is due to the zero-catch advice for cod and because almost all fisheries operating with demersal gears catch cod.

The Iberian waters mixed fisheries projections consider the single-species advice for 5 stocks (ank.27.8c9a, hke.27.8c9a, lbd.27.8c9a, meg.27.8c9a and mon.27.8c9a). Based on current fishing patterns and single-stock catch advice, hake is the most limiting stock for Iberian waters demersal fisheries, corresponding to an undershoot of the advised catch for the other stocks considered in the mixed fisheries analysis and because almost all fisheries operating in the area with demersal gears catch hake. Black-bellied anglerfish is the least limiting stock in almost all the fleets considered in the mixed-fisheries analysis.

The Irish Sea mixed fisheries projections consider the single-species advice for 7 stocks (cod.27.7a, had.27.7a, ple.27.7a, sol.27.7a, whg.27.7a, nep.fu.14, and 15). Based on current fishing patterns and single-stock catch advice demersal fisheries in the Irish Sea are limited by the zero-catch advice for whiting and cod as almost all fleets within the mixed-fishery catch these stocks. The least limiting stock is haddock (12 of 14 fleets).

The North Sea mixed fisheries projections consider the single-species advice for 20 stocks (cod.27.47d20, had.27.46a20, ple.27.420, ple.27.7d, pok.27.3a46, sol.27.4, sol.27.7d, tur 27.4, whg.27.47d, wit.27.3a47d, nep.fu.5, 6, 7, 8, 9, 10, 32, 33, 34, and 4 outFU). Based on current fishing patterns and single-stock catch advice, the most limiting stock for North Sea demersal fisheries is witch, whose advised catch for 2023 is first reached for 36 of 46 defined fleets. Whiting is the least limiting stock in 35 of 46 fleets making it overall the least limiting stock.

Additional work included contributions to the fisheries overviews and two technical requests.

ii Expert group information

Expert group name	Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair(s)	Harriet Cole, UK
	Marc Taylor, Germany
Meeting venue and dates	3-7 October 2022, ICES Secretariat, Denmark

1 Introduction

This report documents WGMIXFISH-ADVICE 2022 meeting outputs. The ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) chaired by Marc Taylor, Germany and Harriet Cole, UK, met on 3–7 October 2022 to apply mixed fisheries forecasts to the 2021 single-species advice for the Bay of Biscay, Celtic Sea, Iberian waters, Irish Sea, and North Sea. This working group also contributed to the fisheries overviews for a number of regions and two technical requests.

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 FLBEIA. 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 Marc Taylor* (Germany) and Harriet Cole* (UK), will hold a hybrid meeting in Copenhagen, on 3–7 October 2022 to:

a) Carry out mixed fisheries projections for the Bay of Biscay taking into account the single species advice and the management measures in place for 2022 for anglerfish, megrim, sea bass, hake, sole, Norway lobster, whiting and pollack that is produced by WGBIE in May 2022; for mackerel, horse mackerel, and blue whiting produced by WGWIDE in September 2022 and rays and smooth hound produced by WGEF in October 2022.

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 2022 for cod, haddock, whiting, hake, megrim, monkfish, and *Nephrops norvegicus* that is produced by WGCSE and WGBIE in 2022.

c) Carry out mixed fisheries projections for Iberian waters taking into account the single species advice and the management measures in place for 2022 for hake, four-spot megrim, megrim and white anglerfish that is produced by WGBIE in May 2022.

d) Carry out mixed demersal fisheries projections for the Irish Sea (27.7.a) taking into account the single species advice for cod, haddock, whiting, plaice, sole, and *Nephrops norvegicus* that is produced by WGCSE in 2022.

e) Carry out mixed demersal fisheries projections for the North Sea taking into account the single species advice and the management measures in place for 2022 for cod, haddock, whiting, saithe, plaice, sole, turbot, *Nephrops norvegicus,* sole 7.d, plaice 7.d, and witch that is produced by WGNSSK in May 2022;

f) Produce draft mixed-fisheries sections for the ICES advisory report 2022 that includes a dissemination of the fleet and fisheries data and forecasts for the North Sea, Celtic Sea, Irish Sea, Bay of Biscay, and Iberian waters.

Supporting information

Priority:	The work is essential for the provision of ICES 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 fisheries

The Bay of Biscay covers ICES divisions 8.a-b and 8.d. These fisheries target a large range of species with different gears and in many cases are highly mixed. The trawl fisheries use otter, beam and pelagic trawls. Otter trawls are the main gear used in demersal fisheries in this ecoregion. The species caught depends on the area and on the range of depths fished, as well as on the cod-end mesh size. The main species caught in these fisheries are hake, anglerfish, megrim, Norway lobster, sole, horse mackerel, mackerel, blue whiting, sea bass, pollack, red mullet and cephalopods (cuttlefish and squid). Set net fisheries target sole, hake, pollack, sea bass, anglerfishes and crustacean species. While the 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.

Hake caught in ICES Division 3.a and Subareas 4, 6 and 7, megrim and anglerfishes in Subarea 7, pollack in 8.c and 9.a and mackerel, horse mackerel and blue whiting outside Bay of Biscay are also included in the current analysis to account for the whole fishing mortality on that species.

2.1.2 Management measures

In the context of the new Common Fisheries Policy (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 (EU, 2019), replacing the former single-stock long term management plans with an 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 or the precautionary approach (PA).

The EU landing obligation was introduced in 2016 (EU, 2015). This regulation prohibits the discarding of certain species on a fishery-by-fishery approach. Since 1 January 2019, catches of all quota species in the Bay of Biscay have been subject to the EU landing obligation rule, except if an exemption is in place.

2.2 FLBEIA

2.2.1 Software

The analysis was conducted using the FLR framework (Kell *et al.* (2007); www.flr-pro-ject.org; FLCore 2.6.18; FLAssess 2.6.3) and was run with R version 4.0 (R Core Team, 2021). All forecasts were projected using the FLBEIA package (version 4.0, 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. A total of 13 stocks were considered in the present analysis. 8 stocks are assessed as an ICES category 1 (with one Norway lobster stock assessed based on UWTV survey) and the 5 remaining stocks are assessed as ICES category 3, 5 and 6.

The list of species considered and the software used in the single-species assessments and forecasts are summarised in Table 2.1.

Table 2.1. Summary of stocks incorporated in this mixed fisheries analysis for the Bay of Biscay, the assessment model and forecast used to produce the single species advice.

Stocks	Assessment	Forecast
BLACK-BELLIED ANGLERFISH - 7, 8.a–b and 8.d	Length-based age-structured (Stock Synthesis)	FLR STF
SEA BASS - 8.a-b	Age- and length-based analytical (Stock Synthesis)	ad hoc R code
HAKE - 3.a, 4, 6, 7 and 8.a-b and 8.d	Length-based and sex-disaggregated (Stock Synthesis)	Stock Synthesis
HORSE MACKEREL - Northeast Atlantic	Length- and age-based analytical (Stock Synthesis)	FLR STF
MACKEREL - Northeast Atlantic and adjacent waters	Age-based analytical (SAM)	FLR STF
MEGRIM - 7.b-k and 8.a-b and 8.d	Statistical catch-at-age (a4a)	FLR STF
WHITE ANGLERFISH - 7, 8.a–b and 8.d	Length-based age-structured (Stock Synthesis)	FLR STF
NORWAY LOBSTER - FU 2324	Underwater television (UWTV) survey	Ad-hoc (excel sheet)
POLLACK - 8 and 9.a	None (Category 5)	No
SMOOTH-HOUND - Northeast Atlantic and adjacent waters	Landings survey-based trend (Category 3)	Ad-hoc (excel sheet)
SOLE - 8.a-b	Age-based analytical assessment (FLXSA) with only landings	FLR STF (including discards)
BLUE WHITING - Northeast Atlantic and adjacent waters	Age-based analytical assessment (SAM)	SAM forecast (deterministic version)
WHITING - 8 and 9.a	None (Category 6)	No

2.2.2 Scenarios

The basis of the model is to estimate the potential future levels of effort of 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 advice basis for stocks with analytical single species assessments was given in terms of 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, 5 and 6 stocks), the advice was based on the precautionary approach. A total of 16 scenarios were produced:

Table 2.2. Summary of scenarios produced for the mixed fisheries analysis of the Bay of Biscay.

Scenario code	Scenario
max	'Maximum': For each fleet, fishing in 2023 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 in 2023 stops when the catch for any one of the stocks meets the fleet's stock shares*. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks, and can highlight some potential 'choke species' issues.
min-exhom	'Minimum excluding horse mackerel': For each fleet, fishing in 2023 stops when the catch for any one of the stocks (excluding horse mackerel) meets the fleet's stock shares*. Horse mackerel is a potential choke species for most of the fleets included in the analysis (due to the zero-TAC advice for 2023). However, over 2019–2021 the fleets considered here account for less than 1% of stock landings.
ank	'Black-bellied anglerfish MSY approach': All fleets set their effort in 2023 corresponding to their black-bellied anglerfish quota share, regardless of other catches. This option causes overfishing of some stocks.
bss	'Sea bass MSY approach': All fleets set their effort in 2023 corresponding to their sea bass quota share, regardless of other catches. This option causes overfishing of some stocks.
hke	'Hake MSY approach': All fleets set their effort in 2023 corresponding to their hake quota share, regardless of other catches. This option causes overfishing of some stocks.
hom	'Horse mackerel MSY approach': All fleets set their effort in 2023corresponding to their horse mackerel quota share, regardless of other catches. This option causes underutilisation of some stocks.**
mac	'Mackerel MSY approach': All fleets set their effort in 2023 corresponding to their mackerel quota share, regardless of other catches. This option causes overfishing of some stocks.
meg	'Megrim MSY approach': All fleets set their effort in 2023 corresponding to their megrim quota share, regardless of other catches. This option causes overfishing of some stocks.
mon	'White anglerfish MSY approach': All fleets set their effort in 2023 corresponding to their white anglerfish quota share, regardless of other catches. This option causes overfishing of some stocks.
nep	'Norway lobster MSY approach': All fleets set their effort in 2023 corresponding to their Norway lobster quota share, regardless of other catches. This option causes overfishing of some stocks.
pol	'Pollack PA approach': All fleets set their effort in 2023 corresponding to their Pollack quota share, regardless of other catches. This option causes overfishing of some stocks.
sdv	'Smooth-hound PA approach': All fleets set their effort in 2023 corresponding to their smooth-hound quota share, regardless of other catches. This option causes overfishing of some stocks.
sol	'Sole MSY approach': All fleets set their effort in 2023 corresponding to their sole quota share, regardless of other catches. This option causes overfishing of some stocks.

Scenario code	Scenario
whb	'Blue whiting MSY approach': All fleets set their effort in 2023 corresponding to their blue whiting quota share, regardless of other catches. This option causes overfishing of some stocks.
whg	'Whiting PA approach': All fleets set their effort in 2023 corresponding to their whiting quota share, regardless of other catches. This option causes overfishing of some stocks.
sq_E	'Status quo effort': The effort of each fleet in 2023 is set equal to the average effort in the most recent three years recorded for which landings and discard data are available (2019–2021). Except for the pelagic fleets that catch the remaining quota for mackerel, horse mackerel and blue whiting, for which we assume that they catch all their available quotas.

* Throughout this analysis, the term 'fleet's stock share' or 'stock share' is used to describe the share of the fishing opportunities for each particular fleet, which has been calculated based on the single-stock advice for 2022 and the historical proportion of the stock landings taken by the fleet (2019–2021).

2.3 Stock input data and recent trends

2.3.1 Stocks

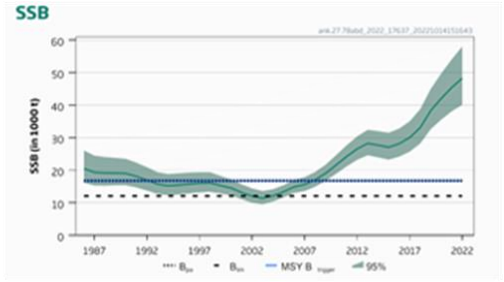
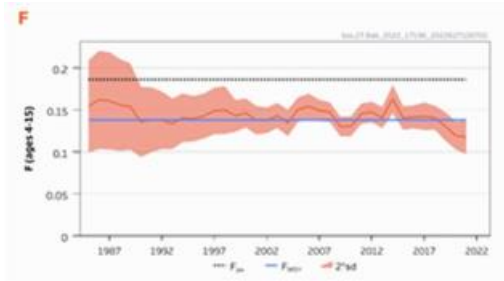
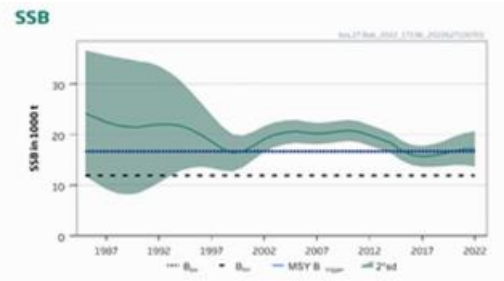
2.3.1.1 Data

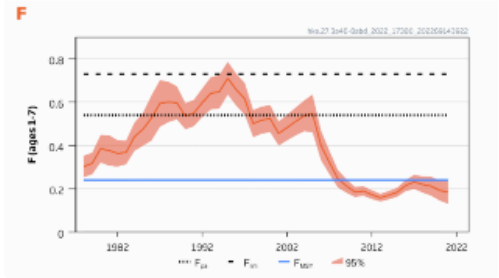
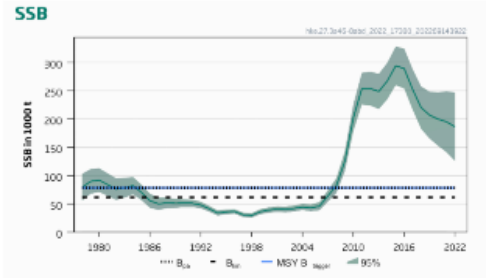
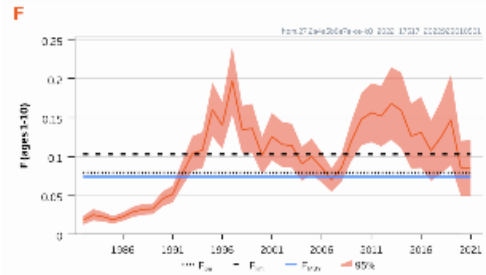
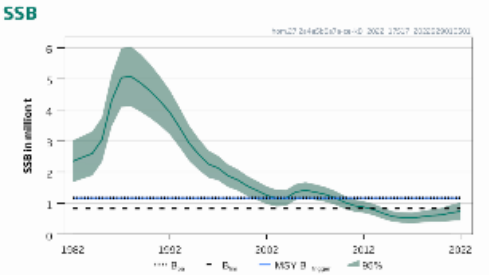
The single species assessment data for the different stocks were provided by the ICES Working Group for the Bay of Biscay and the Iberian Coast Ecoregion (WGBIE) (ICES, 2022a), ICES Working Group on Elasmobranch Fishes (WGEF) (ICES, 2022b) and ICES Working Group on Widely Distributed Stocks (WGWIDE) (ICES, 2022c). A number of the stocks considered within this mixed fisheries analysis are being assessed using stochastic assessments. Stock Synthesis (Methot and Wetzel, 2013), length-based age-structured, for the Northern hake stock (also sex-disaggregated), the anglerfishes' stocks in the southern Celtic Seas and the Bay of Biscay, the Northeast Atlantic horse mackerel and northern and central Bay of Biscay sea bass. SAM (Nielsen and Berg, 2014) for the Northeast Atlantic mackerel and blue whiting stocks. A Bayesian statistical catch at age model, a4a (Jardim *et al.*, 2015), for the stock of megrim in the west and southwest of Ireland 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 (Table 2.1). 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. Results are reasonably similar (see Section 2.5.1.1 below) and as such, WGMIXFISH does not consider these methodological differences to have a significant impact on the mixed fisheries advice and the projections.

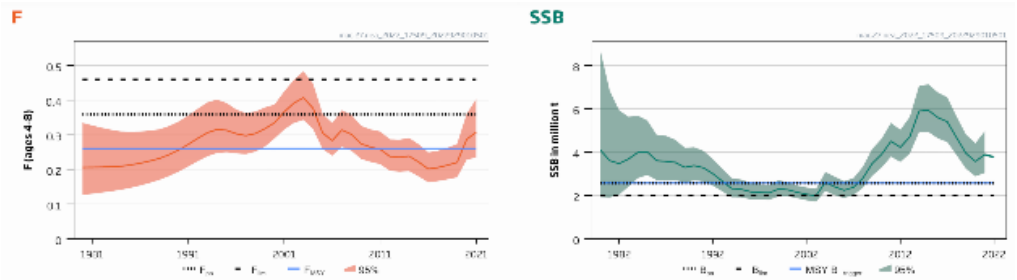
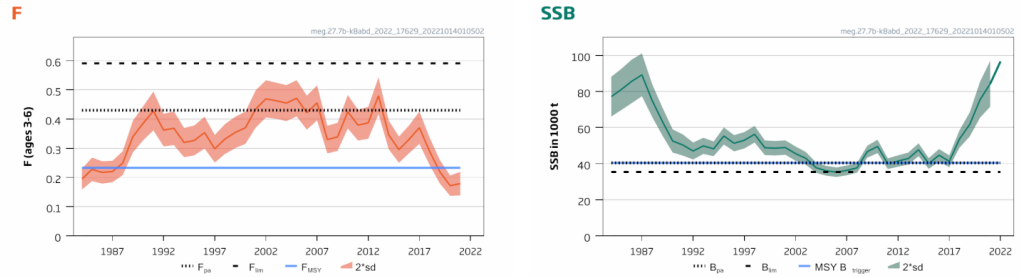
2.3.1.2 Trends and advice

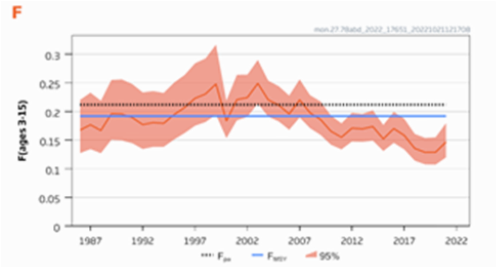
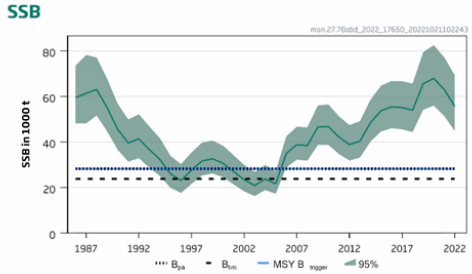
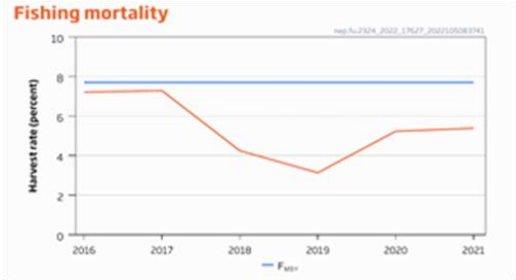
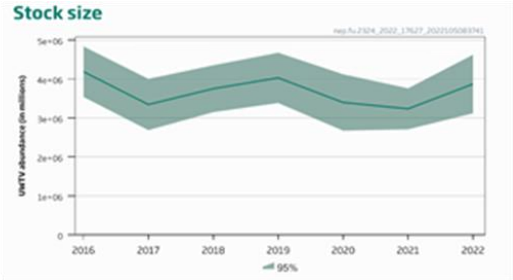
The advice for these stocks was drafted by the ICES WGBIE (ICES, 2022a), WGEF (ICES, 2022b) and WGWIDE (ICES, 2022c) under consideration by ACOM. In order to give a global overview of all Bay of Biscay demersal stocks of interest to this analysis, this information is summarised in the Table 2.3 based on the single species advice.

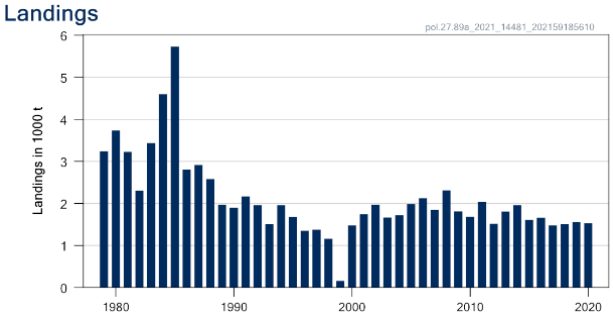
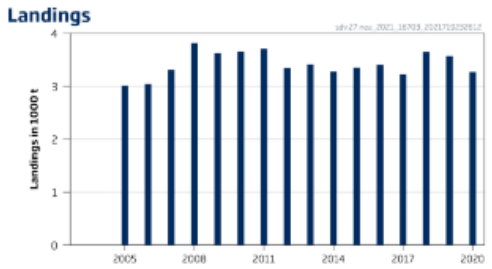
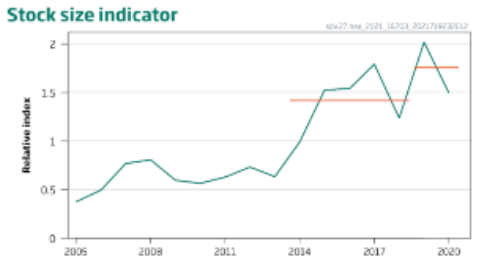
Table 2.3. Summary of stock status and ICES advice for the stocks included in the mixed fishery analysis.

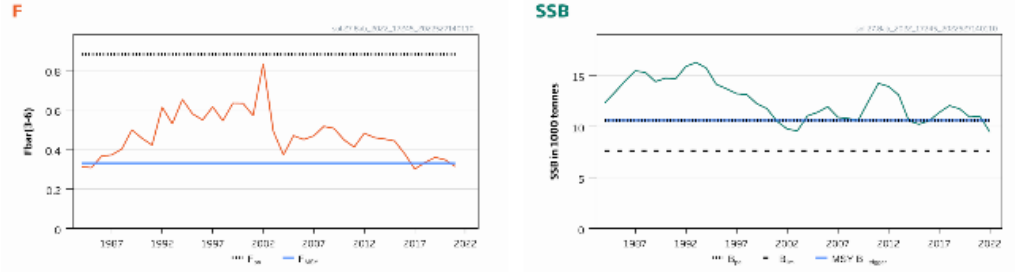
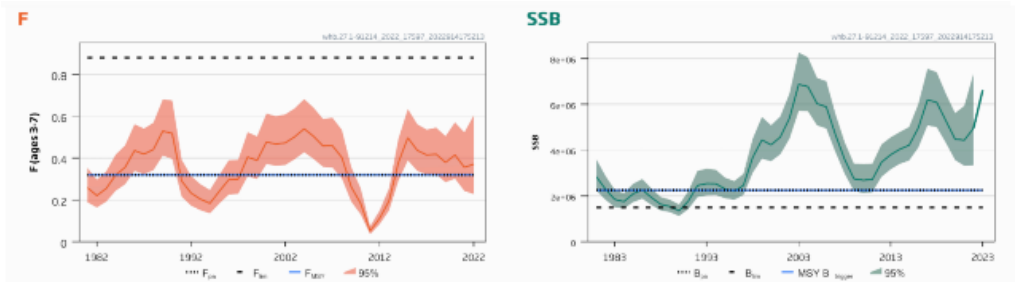
Species	Area	Stock status	Advice 2022
ank.27.78abd (Black-bellied anglerfish)	7, 8.a–b and 8.d	  **Summary:** Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 23 436 tonnes. ICES notes the existence of a precautionary management plan developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two anglerfish species – black-bellied anglerfish (Lophius budegassa) and white anglerfish (Lophius 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.
bss.27.8ab (Sea bass)	8.a-b	  **Summary:** Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, total removals in 2023 that correspond to the F ranges in the plan are between 2897 tonnes and 3398 tonnes.

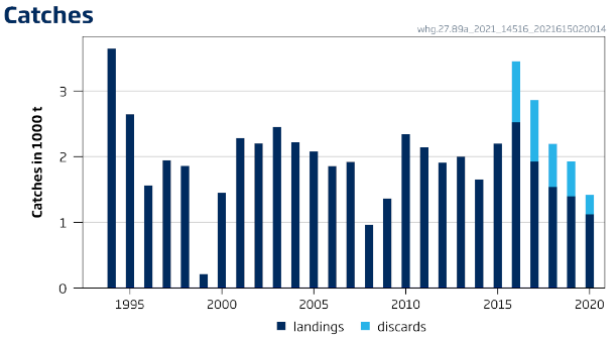
Species	Area	Stock status	Advice 2022
hke.27.3a46-8abd (Hake)	3.a, 4, 6, 7 and 8.a-b and 8.d	  **Summary:** Fishing pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 83 130 tonnes. ICES notes the existence of a precautionary management plan developed and adopted by one of the relevant management authorities for this stock.
hom.27.2a4a5b6a7a-ce-k8 (Horse mackerel)	Northeast Atlantic	  **Summary:** Fishing pressure on the stock is above FMSY and between Fpa and Flim; spawning-stock size is below MSY Btrigger, Bpa, andBlim.	ICES advises that when the MSY approach is applied there should be zero catch in 2023.

Species	Area	Stock status	Advice 2022
mac.27.nea (Mackerel)	Northeast Atlantic and adjacent waters	 **Summary:** Fishing pressure on the stock is above FMSY but below Fpa and Flim; spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 782 066 tonnes.
meg.27.7b-k8abd (Megrim)	7.b-k and 8.a-b and 8.d	 **Summary:** Fishing pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 23 596 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two megrim species—megrim (*Lepidorhombus whiffiagonis*) and four-spot megrim (*Lepidorhombus boscii*)—under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

Species	Area	Stock status	Advice 2022
mon.27.78abd (White anglerfish)	7, 8.a–b and 8.d	  **Summary:** Fishing pressure on the stock is below F_{MSY}; spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 34 540 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two anglerfish species—black-bellied anglerfish (*Lophius budegassa*) and white anglerfish (*Lophius 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.
nep.fu.2324 (Norway lobster)	FU 2324	  **Summary:** Fishing pressure on the stock is below F_{MSY}; no reference points for stock size have been defined for this stock.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 6734 tonnes, assuming recent discard rates.

Species	Area	Stock status	Advice 2022
pol.27.89a (Pollack)	8 and 9.a	 **Summary:** ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because the information needed to define reference points is not available.	ICES advises that when the precautionary approach is applied, commercial catches in each of the years 2022 and 2023 should be no more than 905 tonnes. All commercial catches are assumed to be landed. ICES cannot quantify the corresponding total catches because the recreational catches cannot be quantified.
sdv.27.nea (Smooth-hound)	Northeast Atlantic and adjacent waters	  **Summary:** ICES cannot assess the stock and exploitation status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points, because the reference points are undefined.	ICES advises that when the precautionary approach is applied, landings should be no more than 4441 tonnes in each of the years 2022 and 2023. ICES cannot quantify the corresponding catches.

Species	Area	Stock status	Advice 2022
sol.27.8ab (Sole)	8.a-b	 **Summary:** Fishing pressure on the stock is below FMSY and spawning-stock size is below MSY Btrigger and between Bpa and Blim.	ICES advises that when the EU multiannual plan (MAP) for the Western waters and adjacent waters is applied, catches in 2023 that correspond to the F ranges in the plan are between 1563 tonnes and 2685 tonnes.
whb.27.1-91214 (Blue whiting)	Northeast Atlantic and adjacent waters	 **Summary:** Fishing pressure on the stock is above FMSY and Fpa but below Flim; spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1 359 629 tonnes.

Species	Area	Stock status	Advice 2022
whg.27.89a (Whiting)	8 and 9.a	 **Summary:** Fishing pressure on the stock is below FMSY. No reference points for stock size have been defined for this stock.	ICES advises that when the precautionary approach is applied, catches should be no more than 2276 tonnes in each of the years 2022 and 2023.

2.4 Fleets and métiers

2.4.1 Catch and effort data

The WGMIXFISH data call requests landings and effort data consistent with the definition of DCF métiers and with data submitted to InterCatch (though with additional vessel length disaggregation), disaggregated 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 is assumed equal to the one used in the assessment for all métiers. However, the information by métier and area is now available in InterCatch and could be integrated in the MIXFISH data in future assessments. 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.

The fleet segments used in the mixed-fisheries analysis are defined by combining the country and the fishing gear group (Figure 2.2). These gear groupings differ to those used last year due to a change in the French data submission. Landings and effort provided this year were supplied at a more detailed métier level. This has resolved the inconsistency that resulted last year in more than half of French catch and effort being allocated to a miscellaneous fleet (FR_MIS [Figure 2.2]).

The suspected mislabelling of rays species by a number of member states is still unresolved and consequently it was not possible to include rays in this mixed fisheries analysis. These stocks are thornback ray (rjc.27.8abd), cuckoo ray (rjn.27.678abd), and undulate ray (rju.27.8ab).

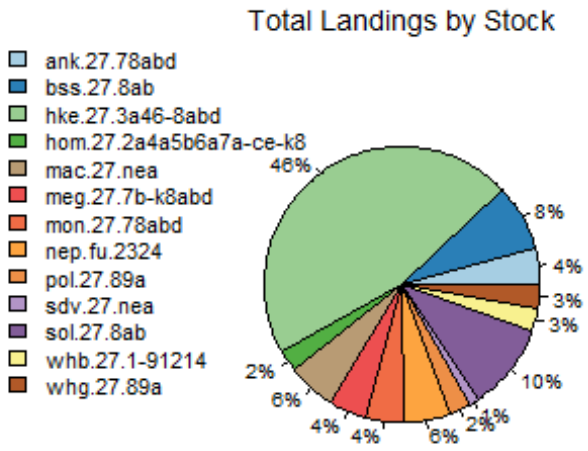


Figure 2.1. Bay of Biscay: Distribution of landings of the stocks included in the mixed fisheries projections (average 2019-2021).

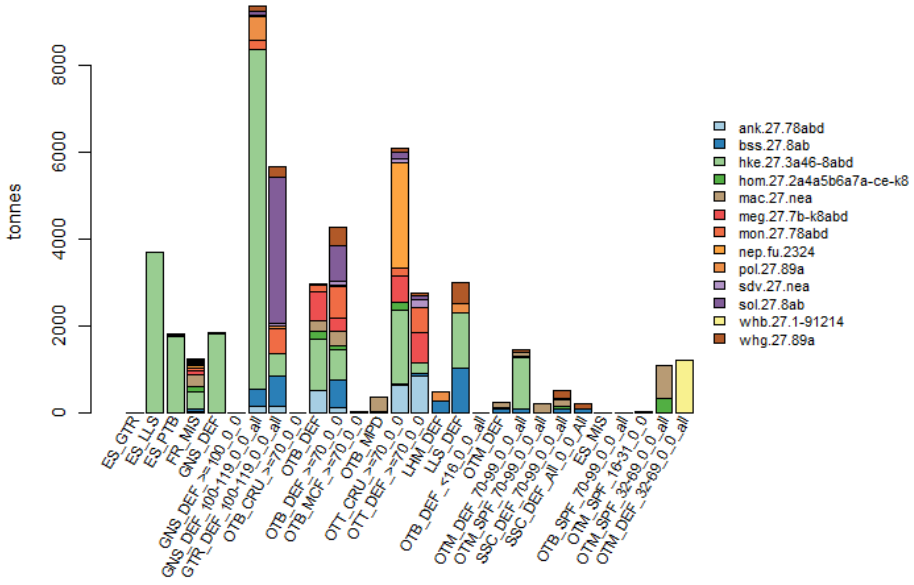


Figure 2.2. Bay of Biscay: Landings distribution of species by métier (average 2019-2021). The métiers used are described in Table 2.4. These fleets engage in one or several different métiers, among a total of 28 métiers (Table 2.4, according to the group of target species and the technical characteristics of the fishing gear.

2.4.2 Definition of fleets and métiers

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

1. Fleets were defined by aggregating landings and effort across country, gear group and vessel length (where applicable).
2. Fleets landing small amounts 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.

3. Effort and landing files were matched to ensure consistency, métiers with effort and no landing were aggregated to the "Other fleet".
4. 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 22 fleets, covering landing and effort inside the Bay of Biscay (8.a-b and 8.d) for the years 2019 to 2021. These fleets engage in one or several different métiers, among a total of 28 métiers (Table 2.4). Several fleets still represent a small amount of catches and could be combined in order to reduce the total number of fleets. Additionally, eight extra fleets were included to cover the landings of some stocks outside the Bay of Biscay (see Section 2.1.1).

The distribution of landings by stock and métier is presented in Figure 2.1 and Figure 2.2, respectively.

Table 2.4. Métier categories used in the Bay of Biscay mixed fisheries analysis.

Code	Definition
ES_GTR	Spanish trammel net
ES_LLS	Spanish longline
ES_MIS	Other gear types (Spanish)
ES_PTB	Spanish bottom pair trawl directed to demersal fish (mesh sizes larger than 70 mm)
FR_MIS	Other gear types (French)
GNS_DEF	Set gillnet targeting demersal fish
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish (mesh sizes larger than 100 mm)
GNS_DEF_100-119_0_0_all	Set gillnet targeting demersal fish (mesh sizes between 100 amd 119 mm)
GTR_DEF_100-119_0_0_all	Trammel net targeting demersal fish(mesh sizes larger than 100 mm)
LHM_DEF	Handline targeting demersal fish
LLS_DEF	Set longline targeting demersal fish
OTB_CRU_>=70_0_0	Norway lobster bottom otter trawl (at least 70 mm)
OTB_DEF	Bottom otter trawl directed to demersal fish
OTB_DEF_<16_0_0_all	Bottom otter trawl directed to demersal fish (mesh sizes smaller than 16 mm)
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 (mesh sizes of at least 70 mm)
OTB_MPD	Bottom otter trawl directed to mixed pelagic and demersal fish

Code	Definition
OTB_SPF_70-99_0_0_all	Bottom otter trawl directed to pelagic fish (mesh sizes between 70 and 99 mm)
OTM_DEF	Medium water otter trawl directed to demersal fish
OTM_DEF_32-69_0_0_all	Medium water otter trawl directed to demersal fish (mesh sizes between 32 and 69 mm)
OTM_DEF_70-99_0_0_all	Medium water otter trawl directed to demersal fish (mesh sizes between 70 and 99 mm)
OTM_SPF_16-31_0_0	Medium water otter trawl directed to pelagic fish (mesh sizes between 16 and 31 mm)
OTM_SPF_32-69_0_0_all	Medium water otter trawl directed to pelagic fish (mesh sizes between 32 and 69 mm)
OTM_SPF_70-99_0_0_all	Medium water otter trawl directed to pelagic fish (mesh sizes between 70 and 99 mm)
OTT_CRU_>=70_0_0	Twin otter trawl directed to crustacean (mesh sizes larger than 70 mm)
OTT_DEF_>=70_0_0	Twin otter trawl directed to demersal fish (mesh sizes larger than 70 mm)
SSC_DEF_70-99_0_0_all	Fly shooting seine (mesh sizes between 70 and 99 mm)
SSC_DEF_All_0_0_All	Fly shooting seine
MIS	All gears outside 8.a-b and 8.d

2.4.3 Trends

Analyses of trends by fleet were carried out on 2019-2021 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 2.26.

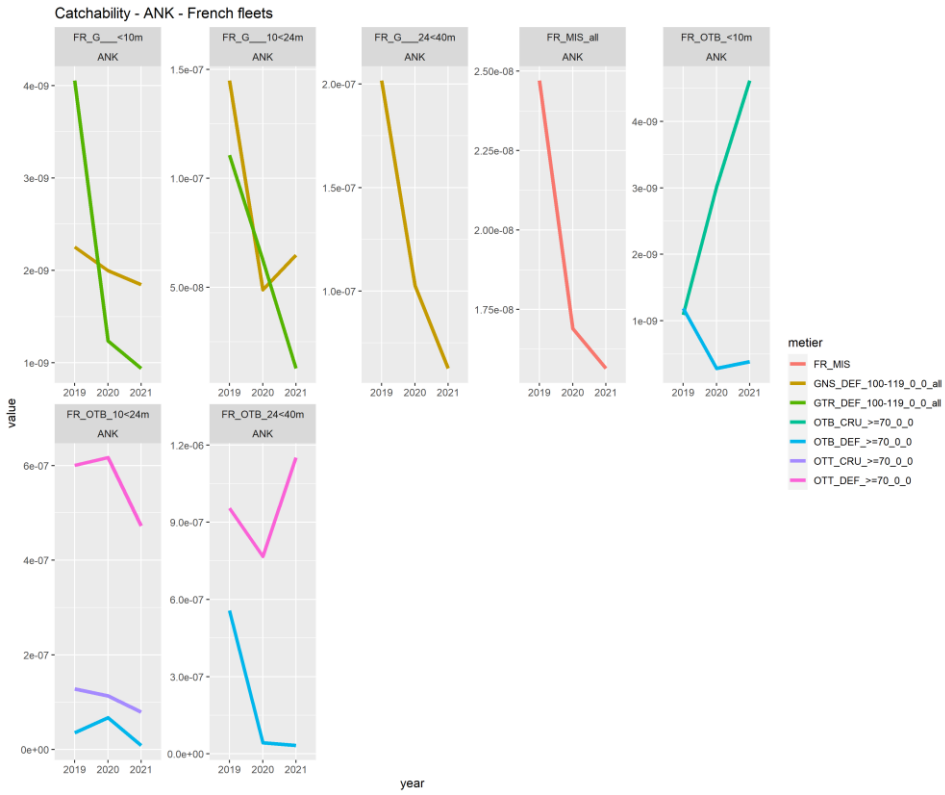


Figure 2.3. Bay of Biscay: trends of French catchability for black-bellied anglerfish (ank) by fleet and métier.

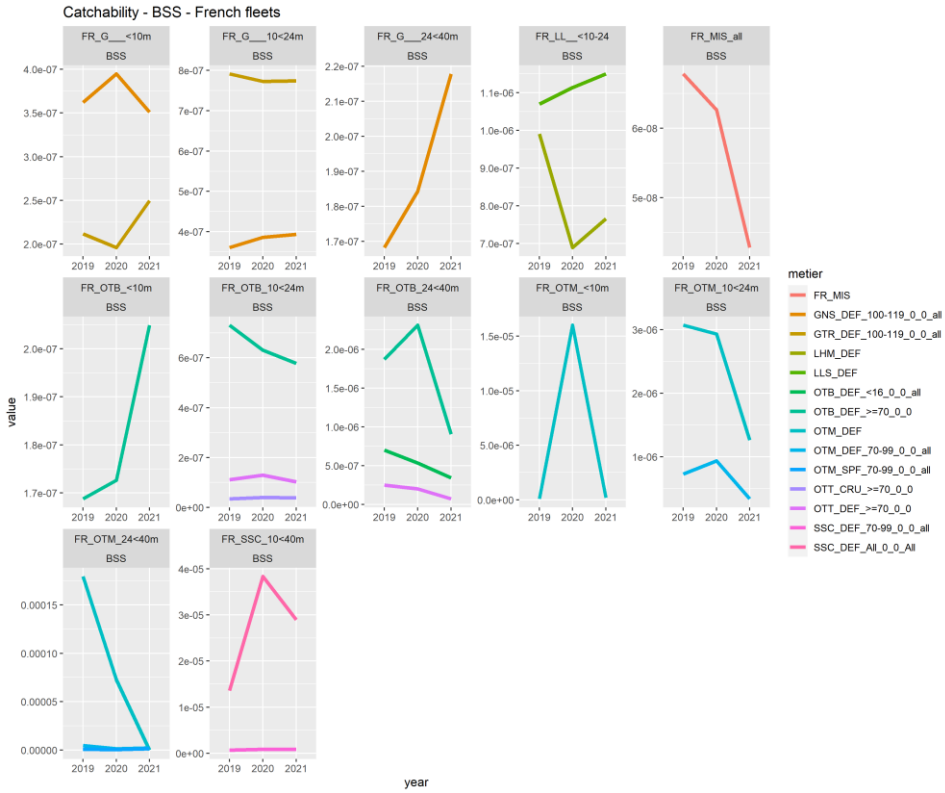


Figure 2.4. Bay of Biscay: trends of French catchability for sea bass (bss) by fleet and métier.

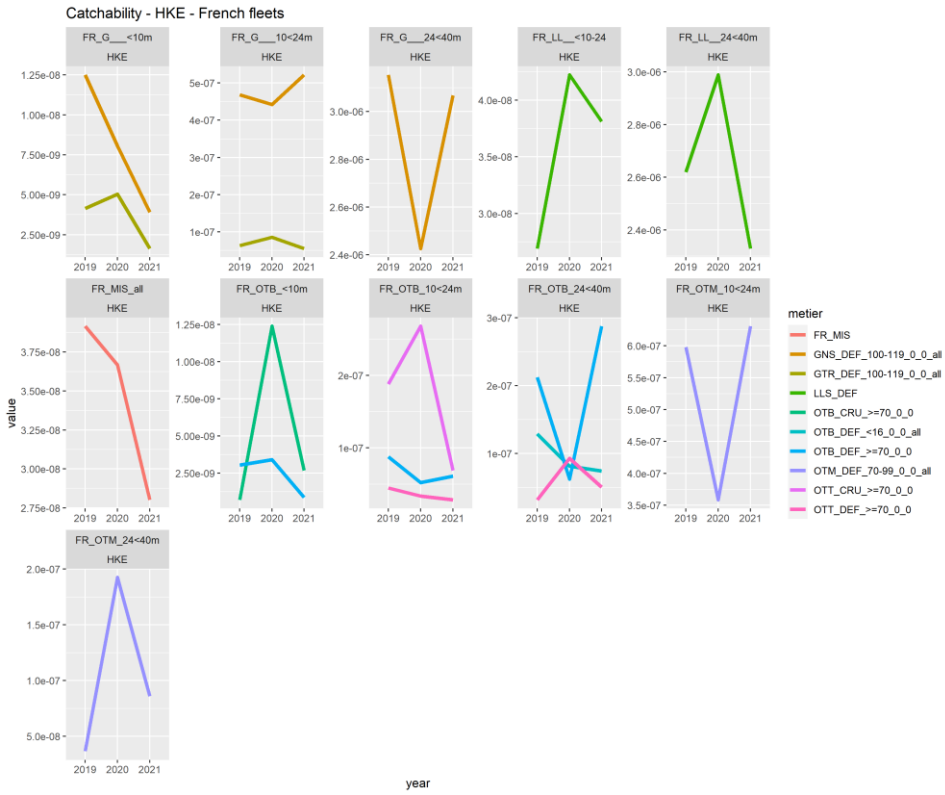


Figure 2.5. Bay of Biscay: trends of French catchability for hake (hke) by fleet and métier.

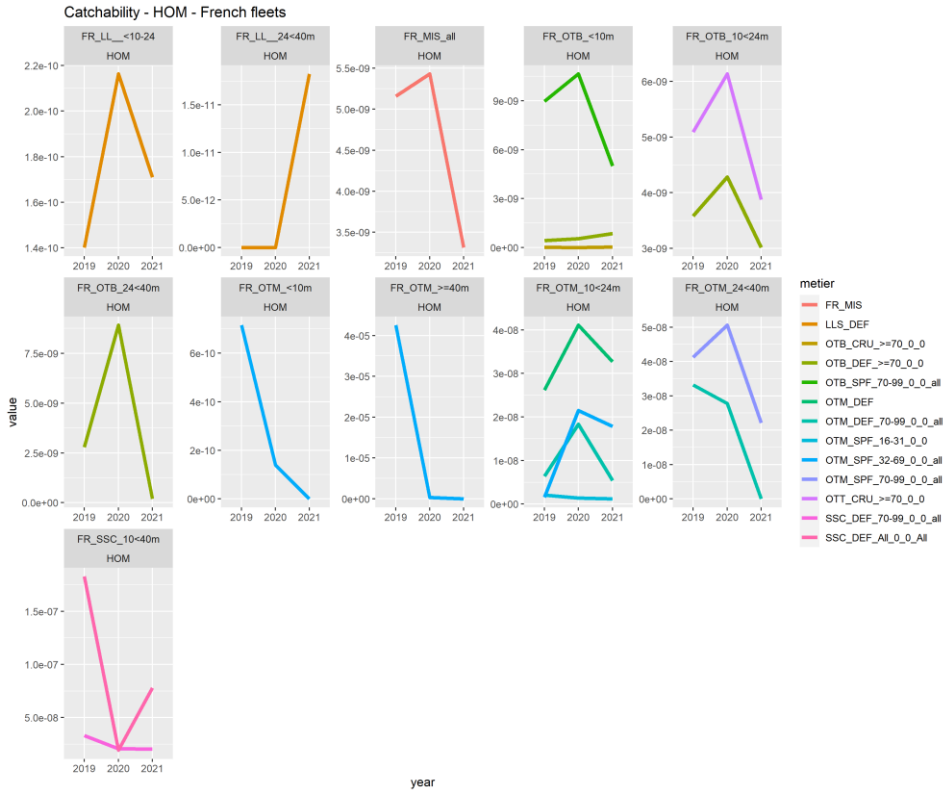


Figure 2.6. Bay of Biscay: trends of French catchability for horse mackerel (hom) by fleet and métier.

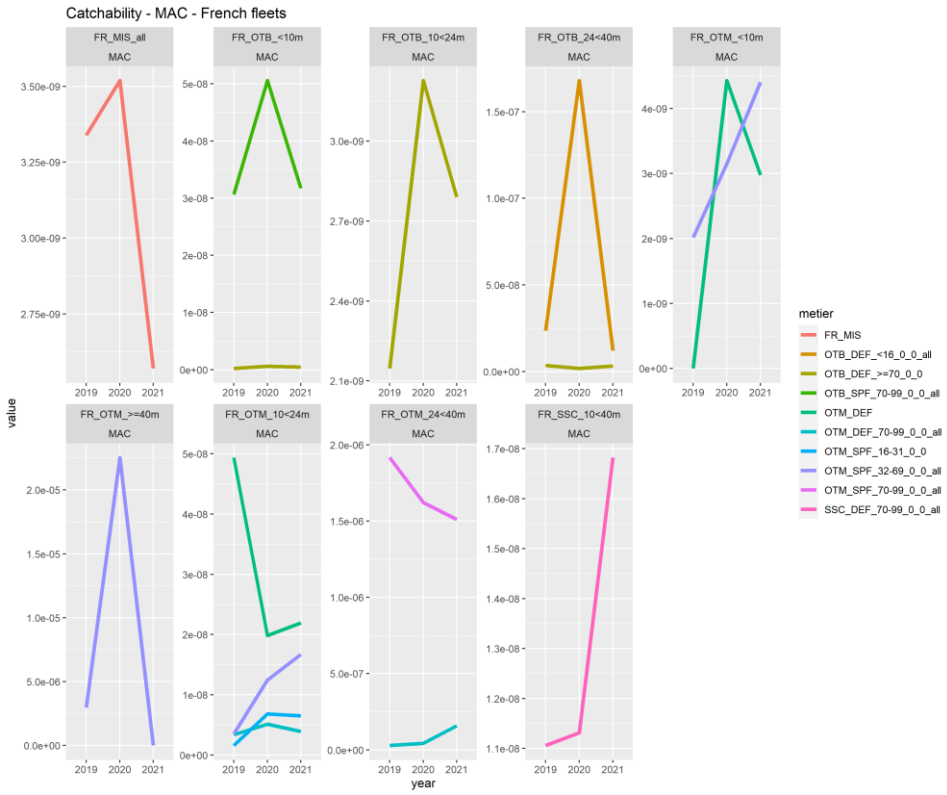


Figure 2.7. Bay of Biscay: trends of French catchability for mackerel (mac) by fleet and métier.

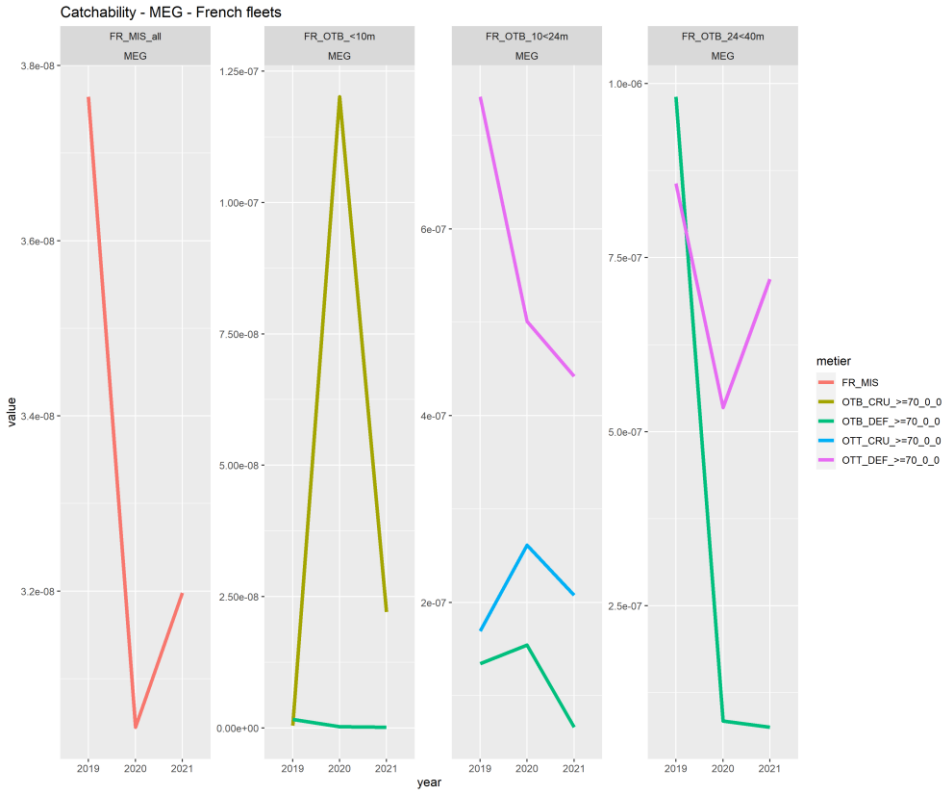


Figure 2.8. Bay of Biscay: trends of French catchability for megrim (meg) by fleet and métier.

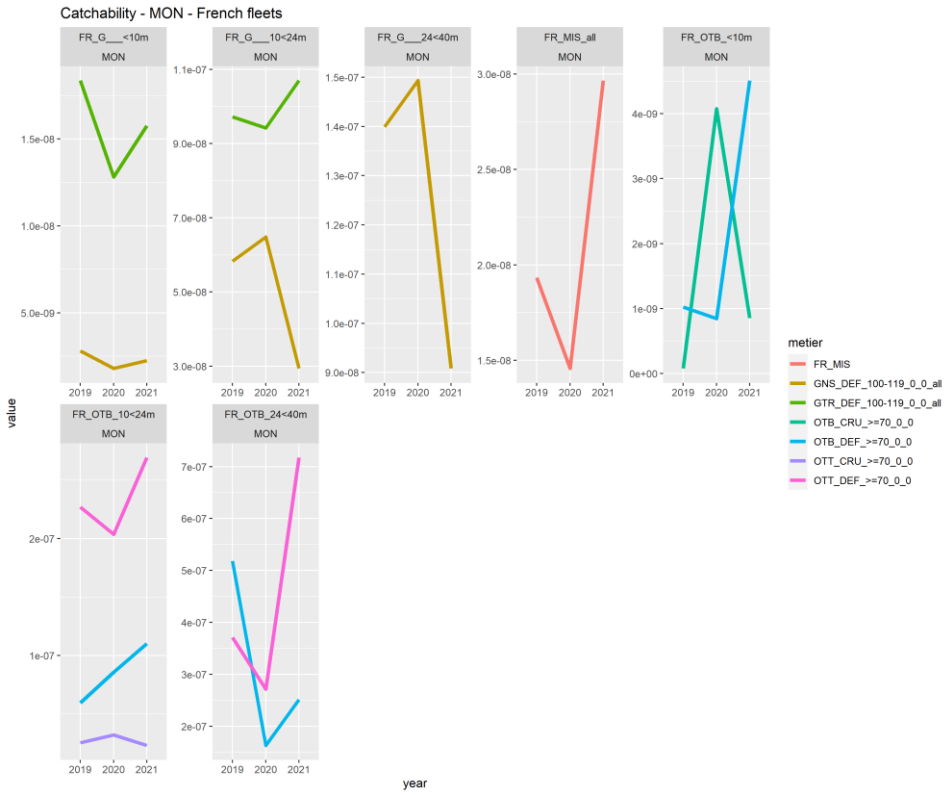


Figure 2.9. Bay of Biscay: trends of French catchability for white anglerfish (mon) by fleet and métier.

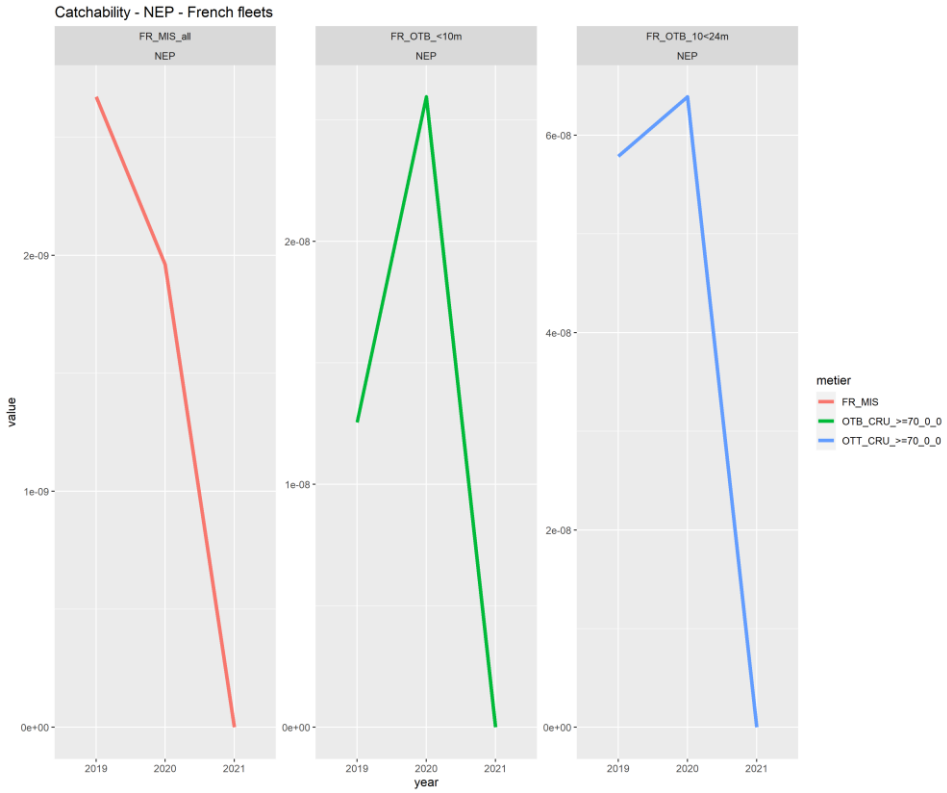


Figure 2.10. Bay of Biscay: trends of French catchability for Norway lobster (nep) by fleet and métier.

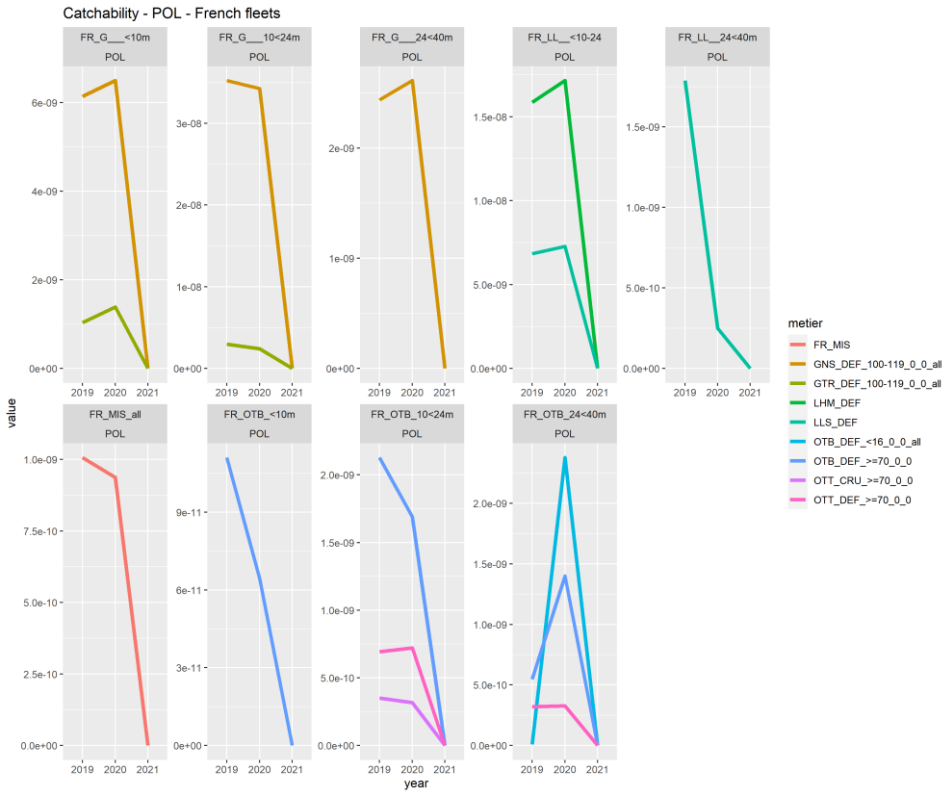


Figure 2.11. Bay of Biscay: trends of French catchability for pollack (pol) by fleet and métier.

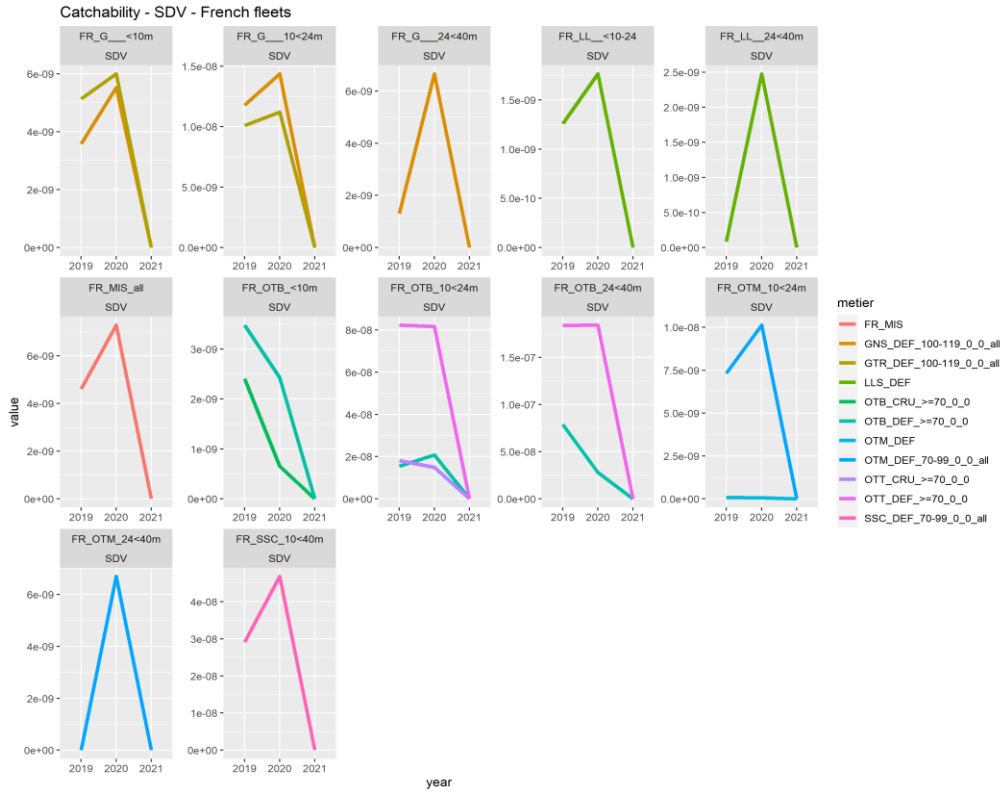


Figure 2.12. Bay of Biscay: trends of French catchability for smooth-hound (sdv) by fleet and métier.

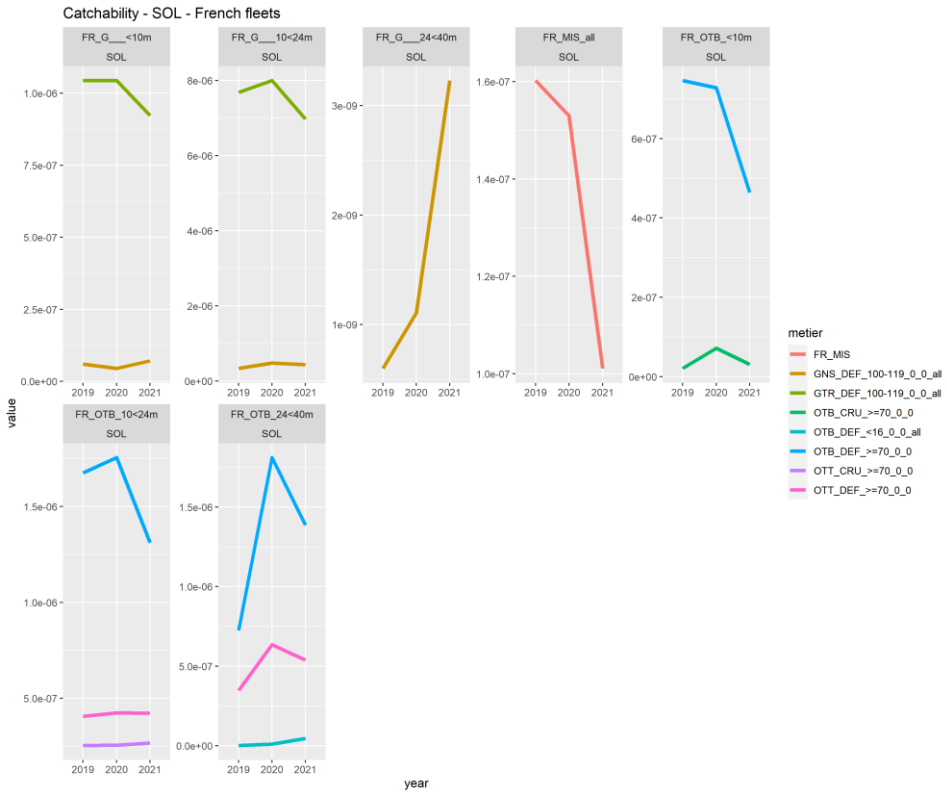


Figure 2.13. Bay of Biscay: trends of French catchability for sole (sol) by fleet and métier.

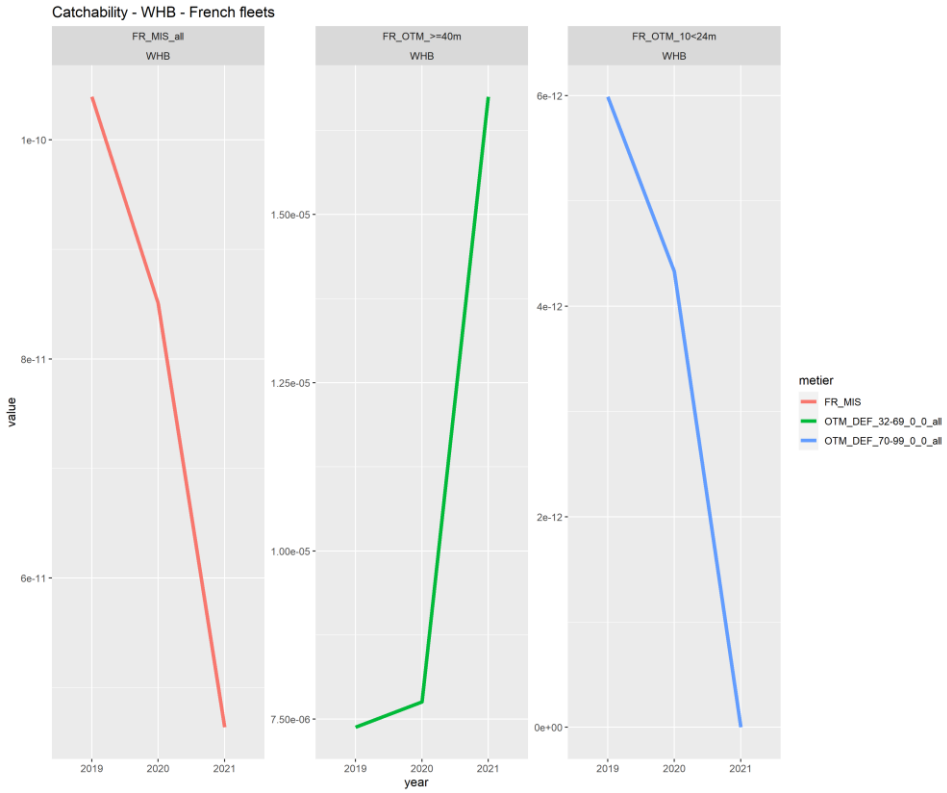


Figure 2.14. Bay of Biscay: trends of French catchability for blue whiting (whb) by fleet and métier.

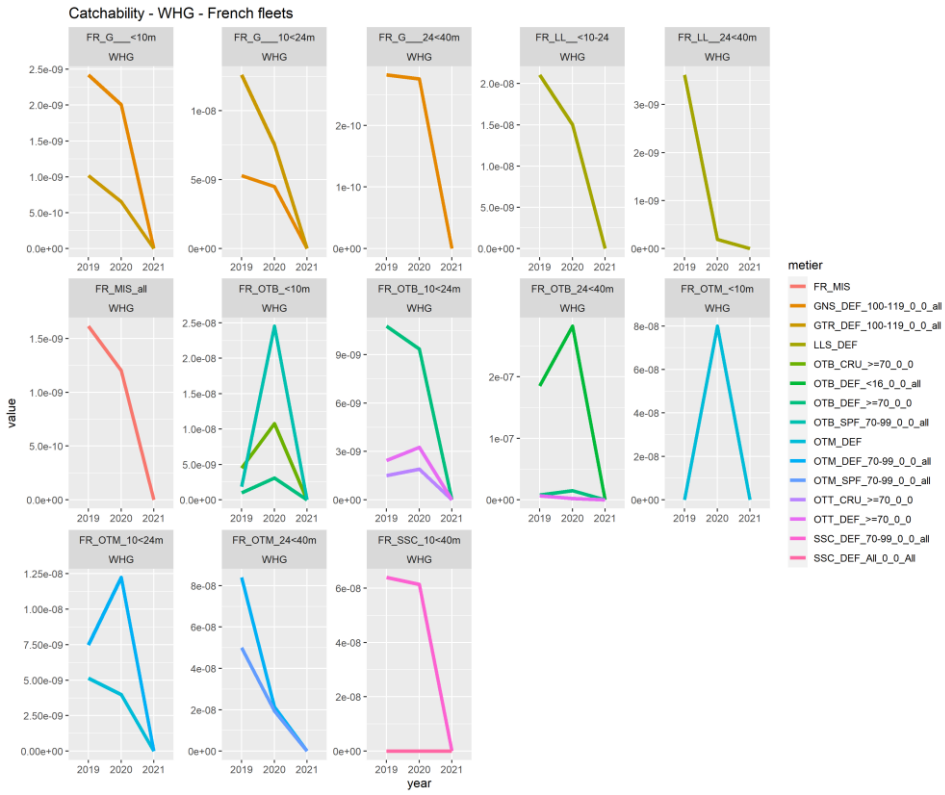


Figure 2.15. Bay of Biscay: trends of French catchability for whiting (whg) by fleet and métier.

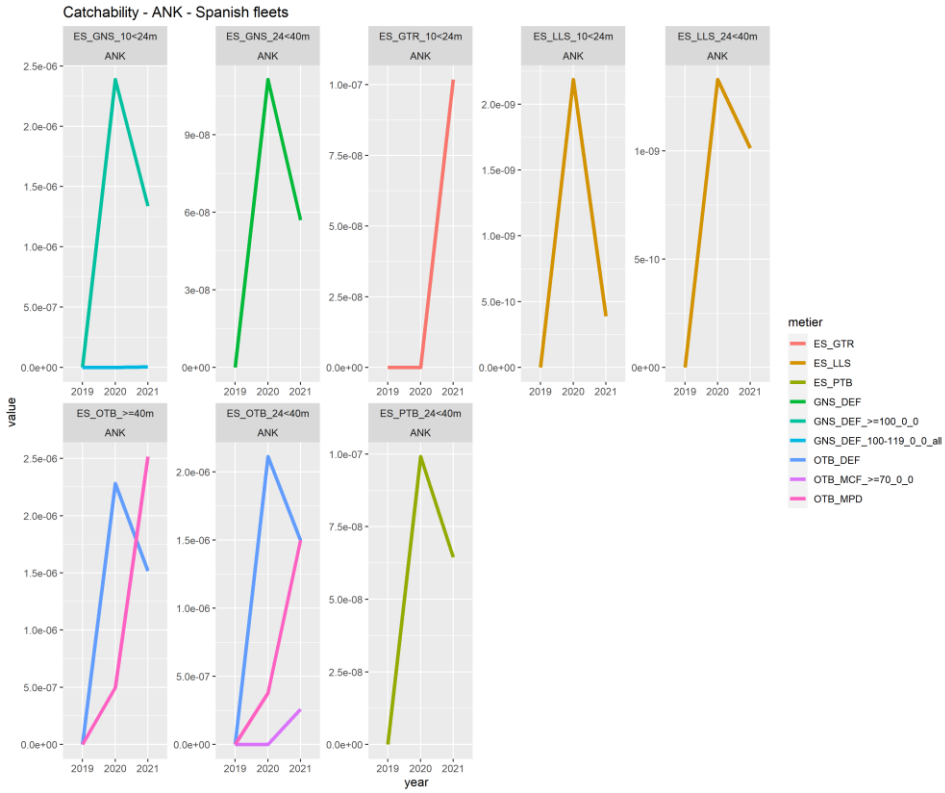


Figure 2.16. Bay of Biscay: trends of Spanish catchability for black-bellied anglerfish (ank) by fleet and métier.

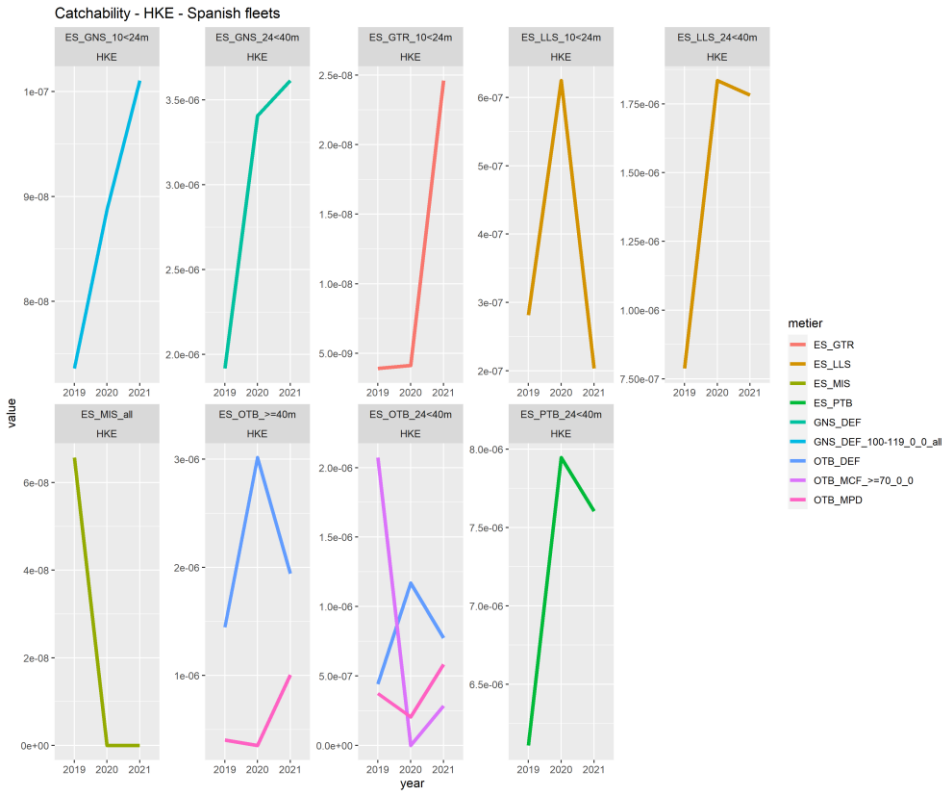


Figure 2.17. Bay of Biscay: trends of Spanish catchability for hake (hke) by fleet and métier.

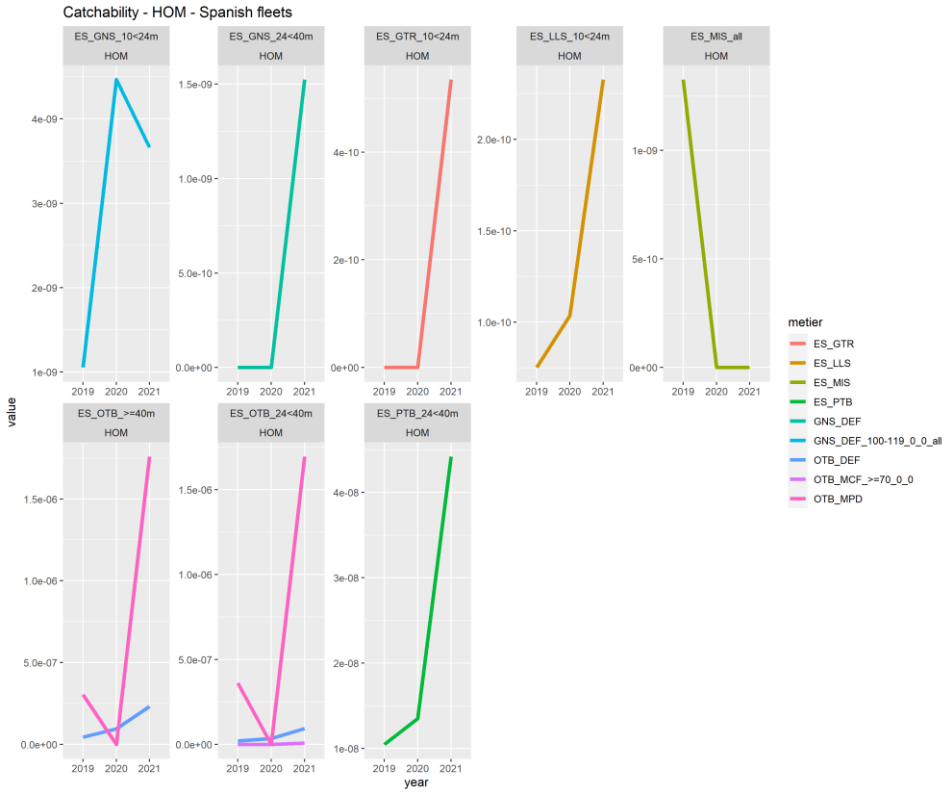


Figure 2.18. Bay of Biscay: trends of Spanish catchability for horse mackerel (hom) by fleet and métier.

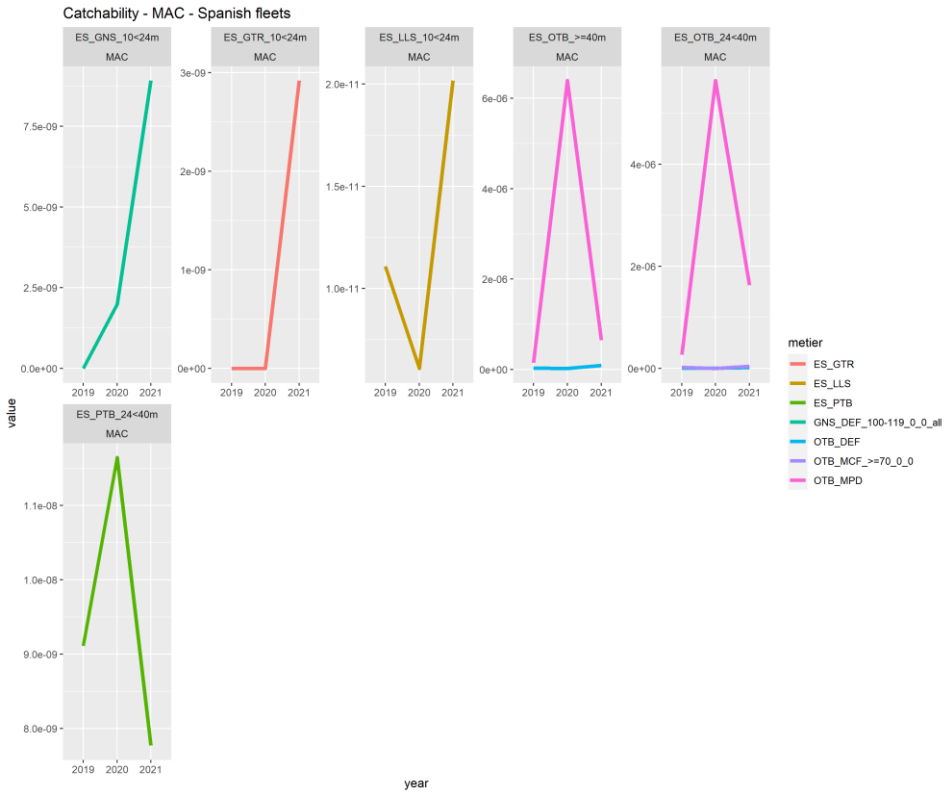


Figure 2.19. Bay of Biscay: trends of Spanish catchability for mackerel (mac) by fleet and métier.

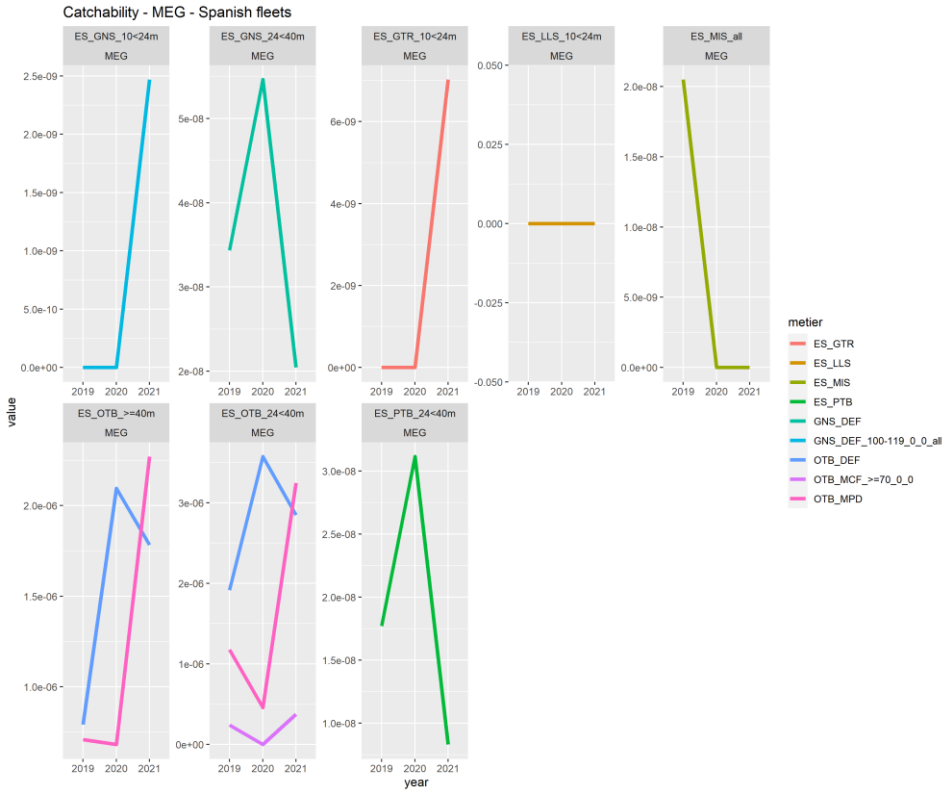


Figure 2.20. Bay of Biscay: trends of Spanish catchability for megrim (meg) by fleet and métier.

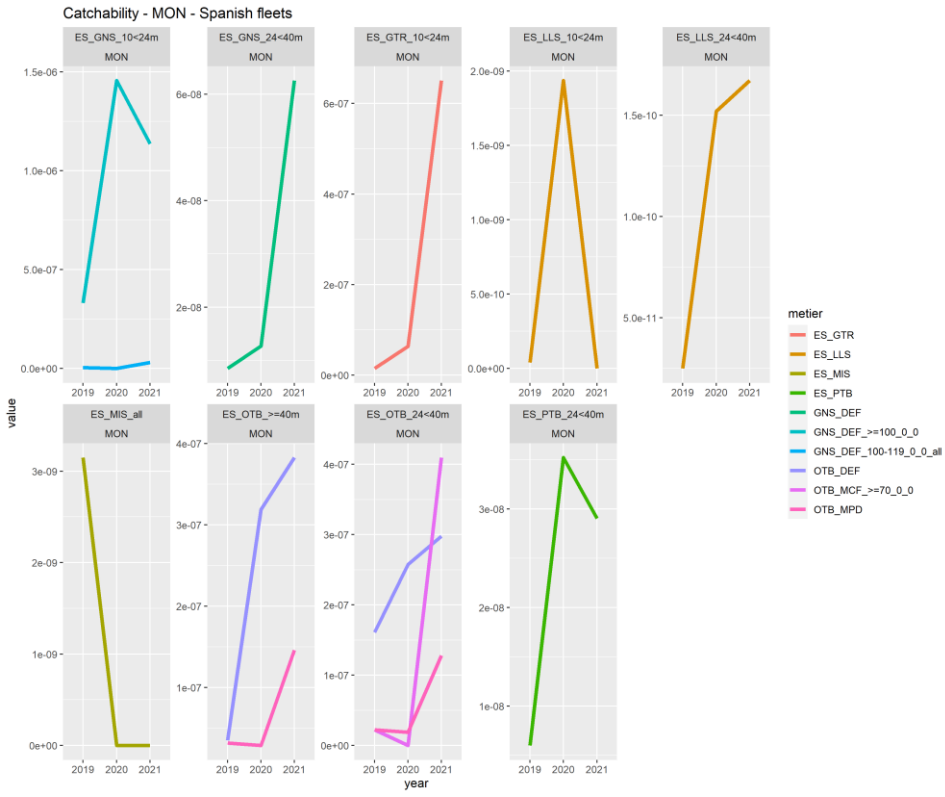


Figure 2.21. Bay of Biscay: trends of Spanish catchability for white anglerfish (mon) by fleet and métier.

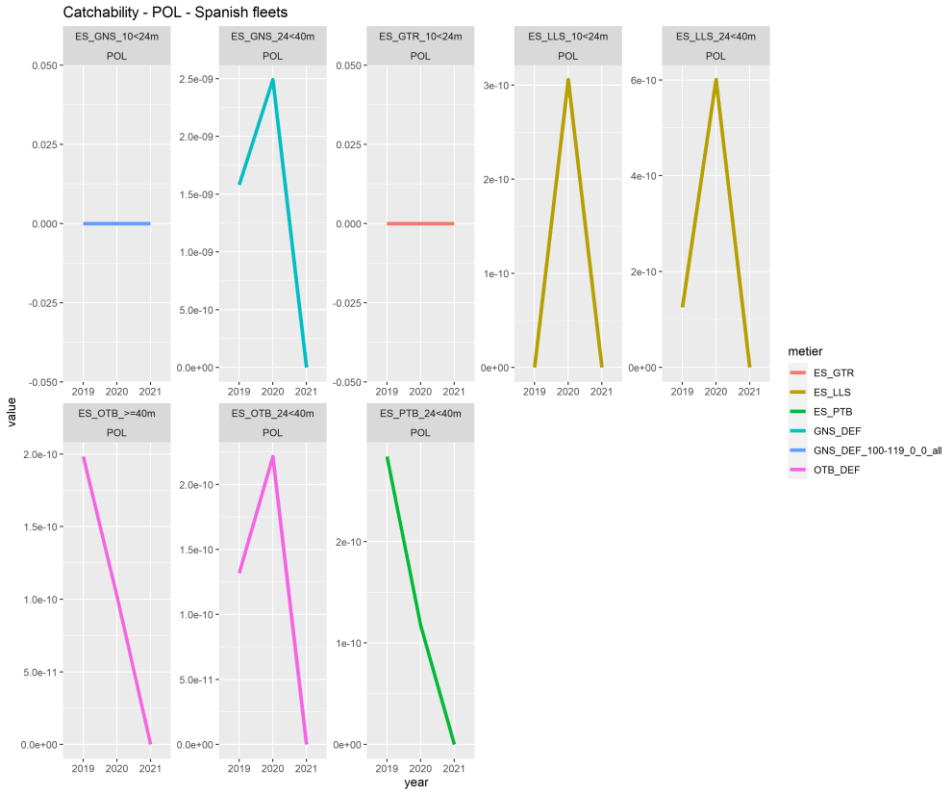


Figure 2.22. Bay of Biscay: trends of Spanish catchability for pollack (pol) by fleet and métier.

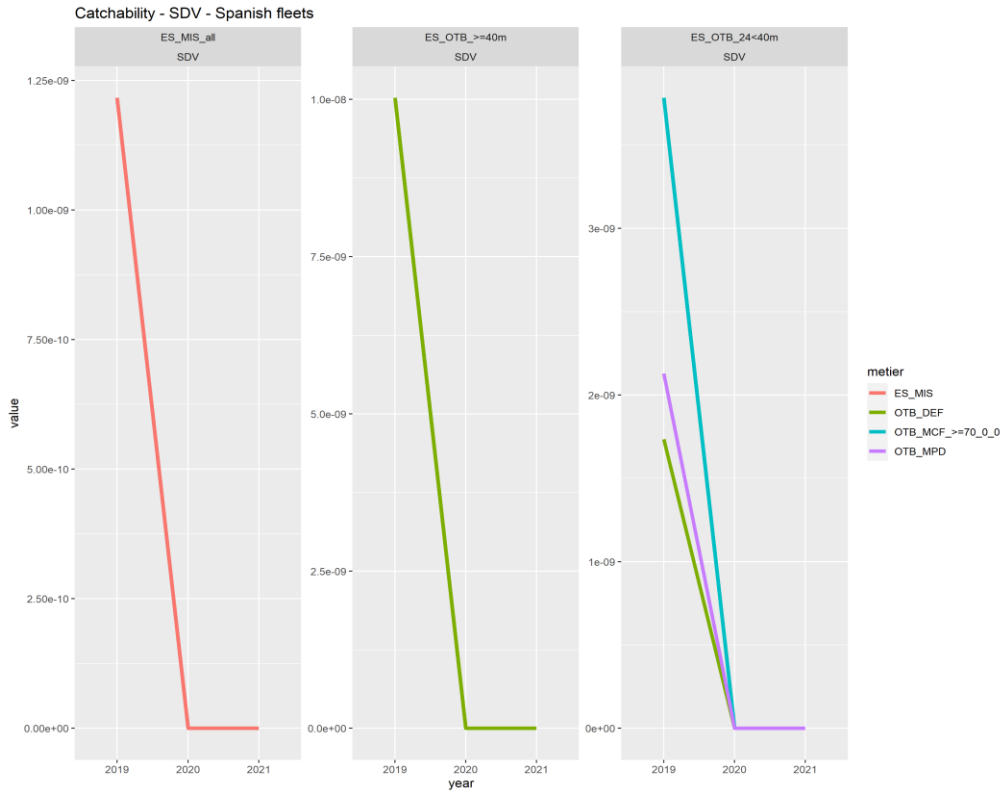


Figure 2.23. Bay of Biscay: trends of Spanish catchability for smooth-hound (sdv) by fleet and métier.

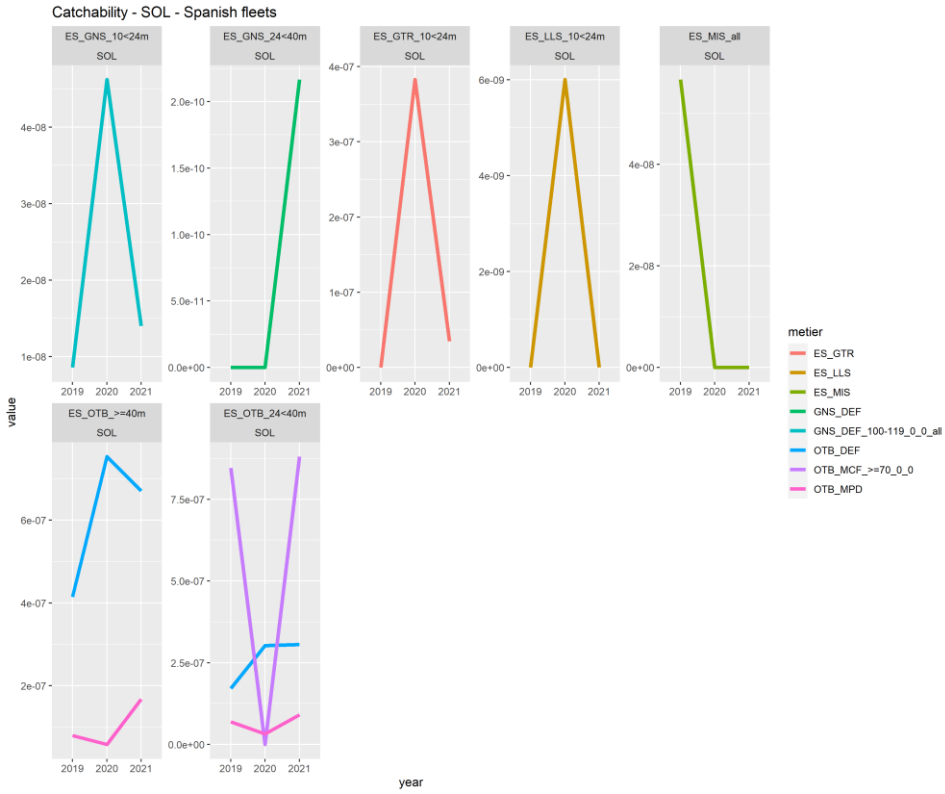


Figure 2.24. Bay of Biscay: trends of Spanish catchability for sole (sol) by fleet and métier.

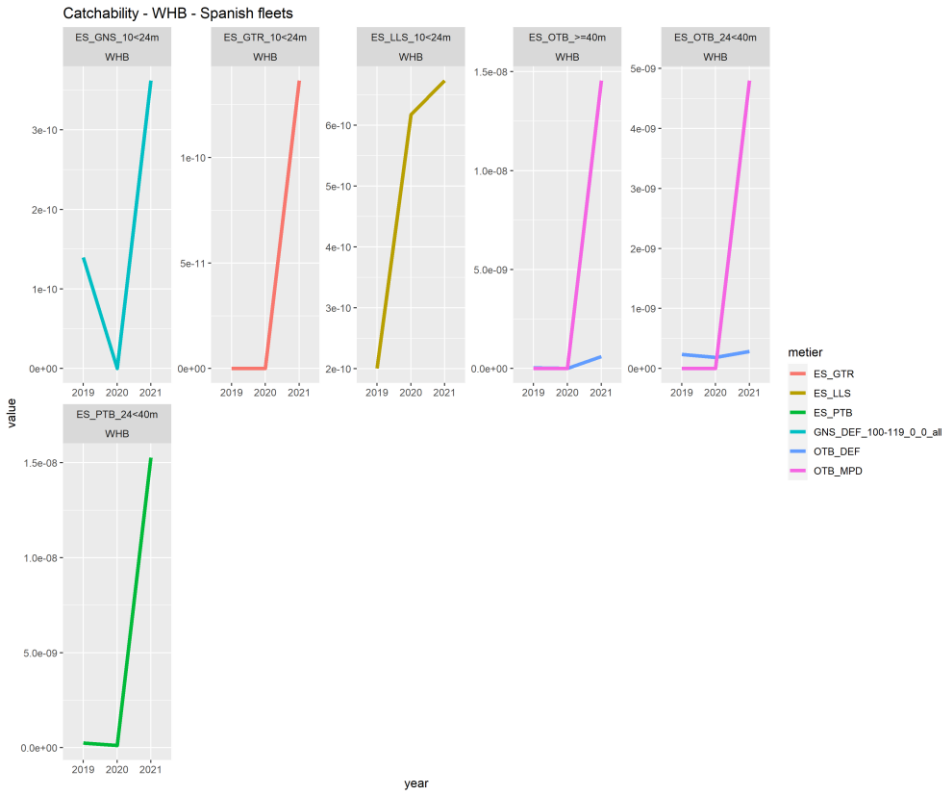


Figure 2.25. Bay of Biscay: trends of Spanish catchability for blue whiting (whb) by fleet and métier.

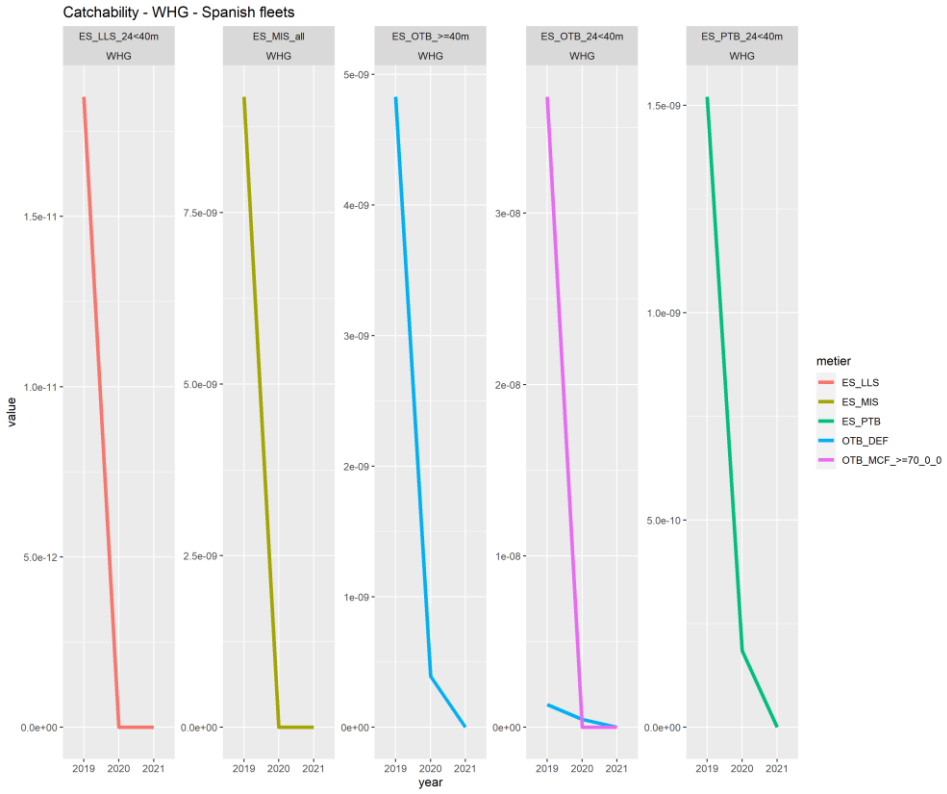


Figure 2.26. Bay of Biscay: trends of Spanish catchability for whiting (whg) by fleet and métier.

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 and WGWIDE are performed using different software and setups (see Section 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 the assessment working group (WGBIE or WGWIDE) are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions made for the intermediate year (2022) and basis for advice (MSY approach). Using these settings, and not introducing any mixed fisheries interactions, short-term forecasts are carried out at WGMIXFISH. This baseline run is then compared to the estimates provided in the ICES advice sheets (Table 2.5).

2.5.1.2 Mixed fisheries runs

Mixed-fisheries advice considers the implications of mixed fisheries operating under single-stock catch advice regimes based on the fishing patterns of the various fleets (i.e. catchability by stock and métier and effort share by métier) in recent years (2019–2021).

The mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2022) for all the fleets, except for the other fleets taking up the remaining catches for a single pelagic stock ("OT_HOM_-9", "OT_MAC_-9" and "OT_WHB_-9"), which assume effort required for full quota uptake in the intermediate year. 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.

For the TAC year (2023), the FLBEIA scenarios are used for catches in the Bay of Biscay, whereas the catches outside of the Bay of Biscay are associated with a single additional fleet per stock ("OT_*_-9"), assuming that they catch their full quota share.

The projections were run assuming a full 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:

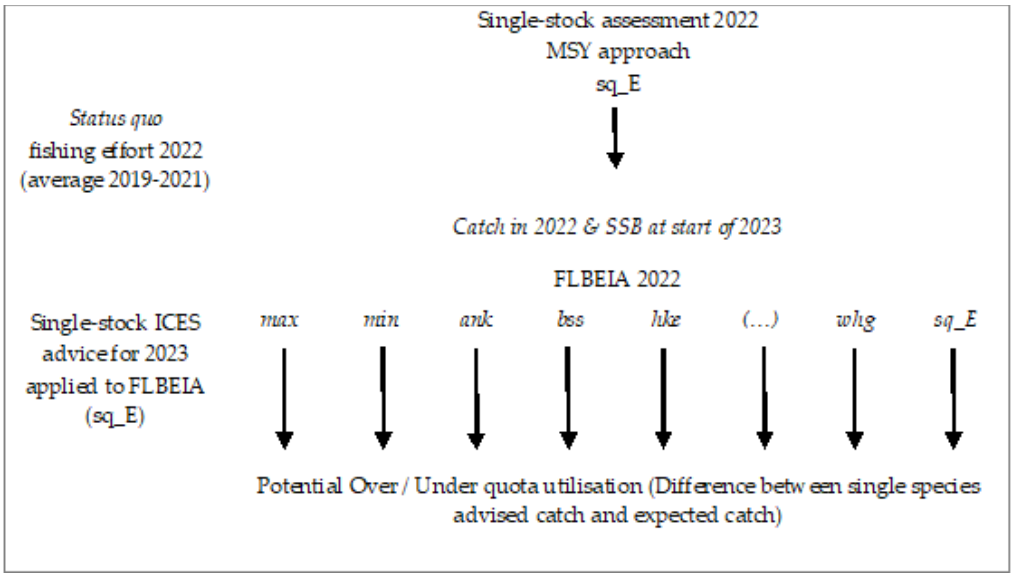


Table 2.5. Bay of Biscay: Summary of the 2023 landings and target Fs, resulting from the Advice Approaches considered by ICES.

Stock	Total catch advice 2023	F 2023	SSB 2024	Rational
Black-bellied anglerfish 7, 8.a–b and 8.d	23 436	0.163	50 314	MSY
Sea bass 8.a-b	3213	0.135	16 568	MAP
Hake 3.a, 4, 6, 7 and 8.a-b and 8.d	83 130	0.24	148 841	MSY
Horse mackerel Northeast Atlantic	0	0.00	805 946	MSY
Mackerel Northeast Atlantic and adjacent waters	782 066	0.26	3 649 119	MSY
Megrim 7.b-k and 8.a-b and 8.d	23 596	0.23	90 976	MSY
White anglerfish 7, 8.a–b and 8.d	34 540	0.192	53 140	MSY
Sole 8.a-b	2685	0.31	10 062	MAP
Blue whiting Northeast Atlantic and adjacent waters	1 359 629	0.32	7 781 444	MSY

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 2.6, 2.7 and 2.8). The replicated forecast for the majority of stocks were almost identical to the single-stock advice (differences lower than 5%). Discrepancies were larger for hake, white anglerfish, mackerel and blue whiting (with maximum differences of 6%,10%, 9%, and 10%, respectively).

Discrepancies in fishing mortality (F) were expected for hake because the length-based, seasonal models used in the stock assessments were approximated with annual age-based models in the mixed fisheries analysis. Differences in F for the stocks assessed using SAM (Nielsen and Berg, 2014), mackerel and blue whiting, are explained by differences in the F estimation methodology. On the one hand, FLBEIA estimates F by approximating values from the Baranov equation, whereas in SAM it is calculated based on the changes in numbers-at-age from one year to the following and the natural mortality. However, the reasons of discrepancies for white anglerfish are unknown and need to be investigated further.

Discrepancies in estimated discards were large for some stocks, specifically for hake, megrim and white anglerfish (Table 2.7). The discrepancies observed are probably related to the stock assessment used (Stock Synthesis), but WGMIXFISH has not been able to properly explain what is the specific factor that causes it. Nevertheless, these differences are not expected to affect the outcomes of the mixed-fisheries simulations as the TAC is assumed to constrain the total catches and these are satisfactorily reproduced.

In general, the differences observed this year were small ($\leq$10%) for all stocks. Consequently, the WGMIXFISH deterministic forecast was considered close enough to the single-stock advice to be used as a basis for the mixed-fisheries projections.

Previously observed differences in sea bass, were due to the way forecast discards are calculated. Although discards are presented in the advice sheet for the stock, these are not calculated in the short-term forecast, but calculated afterwards as a fixed proportion of the landings (5.45%).

Table 2.6. Bay of Biscay: Baseline run outputs from the FLBEIA package.

	ANK	BSS	HKE	HOM	MAC	MEG	MON	SOL	WHB
2022_Fbar	0.098	0.117	0.198	0.072	0.36	0.190	0.135	0.28	0.37
2022_Fmult	1	1	1	1	1	1	1	1	1
2022_Landings	10 557	2731	65 983	71 138	1 130 792	16157	20 822	2284	1 107 417
2022_SSB	45 430	16 474	195 117	693 992	4 087 820	84327	63 046	11 008	4 440 379
2023_Fbar	0.163	0.135	0.24	0	0.26	0.23	0.192	0.31	0.32
2023_Fmult	2	1	1	0	1	1	1	1	1
2023_Landings	18 874	3398	72 196	0	782 066	19 765	30 290	2685	1 359 629
2023_SSB	51 018	16 505	162 649	753 601	3 917 199	96 984	56 697	9338	6 297 180
2024_SSB	48 244	16 566	180 490	739 503	4 066 651	98 089	55 679	9443	4 748 904

Table 2.7. Bay of Biscay: Comparison between baseline run and ICES advice. Values for 2022 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	SOL	WHB
2022_Catch Baseline	15 093	2906	77 868	71 460	1 130 792	19 507	23 198	2725	1 107 422
2022_Catch ICES	14 606	2731	74 934	71 138	1 131 416	19 412	24 770	2284	1 107 529
2022_% diff catch	1.03	1.06	1.04	1	1	1	0.94	1.19	1
2023_Catch Baseline	23 436	3398	83 130	0	782 066	23 596	34 540	2685	1 359 629
2023_Catch ICES	23 436	3398	83 130	0	782 066	23 596	34 540	2685	1 359 629
2023_% diff catch	1	1	1		1	1	1	1	1
2022_Landings Baseline	10 557	2731	65 983	71 138	1 130 792	161 57	20 822	2284	1 107 417
2022_Landings ICES	10 458	2731	69 563			16 611	21 440	2233	1 107 529
2022_% diff land	1.01	1	0.95			0.97	0.97	1.02	1
2023_Landings Baseline	18 874	3398	72 196	0	782 066	19 765	30 290	2685	1 359 629
2023_Landings ICES	18 793	3200	76 360	0	782 066	20 264	30 103	2625	1 359 629
2023_% diff land	1	1.06	0.95		1	0.98	1.01	1.02	1
2022_Discards Baseline	4536	175	11 885	322	0	3350	2375	441	6
2022_Discards ICES	4148	0	5371	0	0	2800	3330	51	0
2022_% diff disc	1.09	0	2.2	0	0	1.20	0.71	8.6	0
2023_Discards Baseline	4562	0	10 934	0	0	3831	4250	0	0
2023_Discards ICES	4643	0	6770	0	0	3332	4437	60	0
2023_% diff disc	0.98		1.62			1.15	0.96	0	

Table 2.8. Bay of Biscay: FLBEIA baseline run outputs for SSB and F relative to ICES advice.

	SSB_2022	SSB_2023	SSB_2024	F_2021	F_2022	F_2023
ANK	1.00	1.04	1.04	1.00	0.97	0.97
BSS	0.96	1.02	1.02	1.00	0.99	1.03
HKE	0.97	0.97	1.01	0.99	0.95	0.94
HOM	1.00	1.00	1.00	1.00	1.00	
MAC	0.98	0.99	1.06	1.09	1.08	1.07
MEG	0.99	1.01	1.00	1.00	1.00	1.00
MON	1.00	1.00	0.98	1.00	1.07	1.10
SOL	1.00	1.00	0.99	1.01	0.98	1.03
WHB	1.00	1.00	0.90	0.95	1.00	1.10

2.5.2.2 Mixed fisheries analysis

The full overview of the FLBEIA projections to 2024 is presented in Table 2.9 and Figures 2.27 – 2.29. The results for 2023 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 (Table 2.9 and Figure 2.28).

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 (2019-2021). The scenarios, therefore, do not assume any amount of quota balancing through adaptation of fishing behaviour. Mixed-fisheries catch scenario results show that it is not possible to achieve all advised single stock catches simultaneously under the current fishing patterns. For instance, if decreasing fishing mortality for pollack is the major objective and fleets stop fishing after exhaustion of their pollack catch advice, this would mean that the catch advice for other species in the mixed fisheries may not be fully utilized. As a consequence, scenarios that result in under- or overutilization are useful in identifying the main mismatches between the fishing opportunities for the various stocks, where limiting catch advice can create potential "choke species" effects at fleet level. Such scenarios indicate the direction in which fleets may have to adapt to more fully utilize these catch opportunities without increasing the risk of unwanted catch.

The "min" scenario is based on the assumption that the fishery stops for a fleet once one of the stock quotas is exhausted, representing a full implementation of the EU's landings obligation. For 2023, the results of the "min" scenario, indicate that horse mackerel is the most limiting stock in the Bay of Biscay mixed-fisheries model due to its zero TAC advice, constraining 16 of the 22 modelled fleets.

However, the horse mackerel quota share of the stock for the demersal mixed-fisheries is lower than 1% and consequently this stock was not included as a restricting stock in the "min-exhom" scenario. When excluding horse mackerel ("min-exhom" scenario), pollack becomes the most limiting stock constraining eight out of 22 fleet segments (Figure 2.30). The catch advice for this pollack stock has shown a 39% reduction in 2022-2023 relative to 2021.

The "max" scenario is included to demonstrate 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 economic viability, legality, or fleet capacity. For 2023, the results in none of the scenarios are similar to the "max" scenario, indicating that the least limiting stock varies from fleet to fleet. Whiting, smooth-hound, hake and Norway lobster would be the least limiting stocks for eight, five, and three fleet segments, respectively (Figure 2.30). Corresponding to an overshoot of the advised catch for the other considered stocks.

The *status quo* "sq_E" scenario sets the effort of each fleet in 2022 and in 2023 equal to the average of the effort in the most recently recorded three years for which data are available (2019-2021). For the pelagic fleets that catch the remaining quota for mackerel, horse mackerel and blue whiting, we assume that they catch all their available quotas. 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 2023 catch advice overshoot for pollack and horse mackerel.

Horse mackerel, mackerel, and blue whiting are included in these analyses as they are potential choke species for some demersal fleets. Catches taken by these fleets represent very low proportions of the overall catches from these stocks, so the impact of these fleets on the dynamics of the stocks of mackerel, blue whiting, and horse mackerel is negligible even though they are economically important for these fleets.

Table 2.9. Results of running FLBEIA scenarios on the TAC year (2022). Comparison of the single-stock ICES advice and potential landings in the various FLBEIA scenarios.

Stock	Single stock catch advice 2023	max	min	min-exhom	ANK	BSS	HKE	HOM	MAC	MEG	MON	NEP	POL	SDV	SOL	WHB	WHG	sq_E
ANK	23 436	1.35	0.78	0.89	1	0.93	0.93	0.78	0.90	0.94	0.99	1.28	0.89	1.08	0.91	0.91	1.05	0.64
BSS	3398	2.3	0.24	0.78	1.13	1	1.02	0.27	0.87	0.92	1.13	1.55	0.79	1.76	0.89	0.88	1.84	0.89
HKE	83 130	1.32	0.82	0.92	1.04	0.99	1	0.85	0.96	0.98	1.05	1.12	0.93	1.16	0.97	0.96	1.13	0.87
HOM	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0	0
MAC	782 066	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MEG	23 596	1.40	0.83	0.95	1.05	0.99	0.99	0.83	0.96	1	1.05	1.31	0.96	1.15	0.97	0.97	1.09	0.84
MON	34 540	1.17	0.90	0.95	1.01	0.97	0.97	0.90	0.95	0.97	1	1.13	0.95	1.04	0.96	0.96	1.04	0.67
NEP	6734	1	0	0.193	0.38	0.25	0.25	0	0.21	0.27	0.34	1	0.193	0.44	0.22	0.22	0.45	0.22
POL	905	2.2	0.67	1	1.36	1.22	1.23	0.72	1.10	1.12	1.39	1.37	1	1.95	1.10	1.10	2	1.13
SDV	4441	1.94	0.084	0.44	0.81	0.57	0.57	0.093	0.48	0.58	0.76	1.80	0.44	1	0.50	0.50	1.03	0.51
SOL	2685	2.6	0.67	0.89	1.49	1.14	1.15	0.75	0.99	1.05	1.53	1.85	0.89	1.97	1	1	2	1
WHB	1 359 629	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WHG	2276	1.33	0.099	0.42	0.62	0.54	0.55	0.110	0.47	0.51	0.61	0.94	0.43	0.96	0.48	0.48	1	0.48

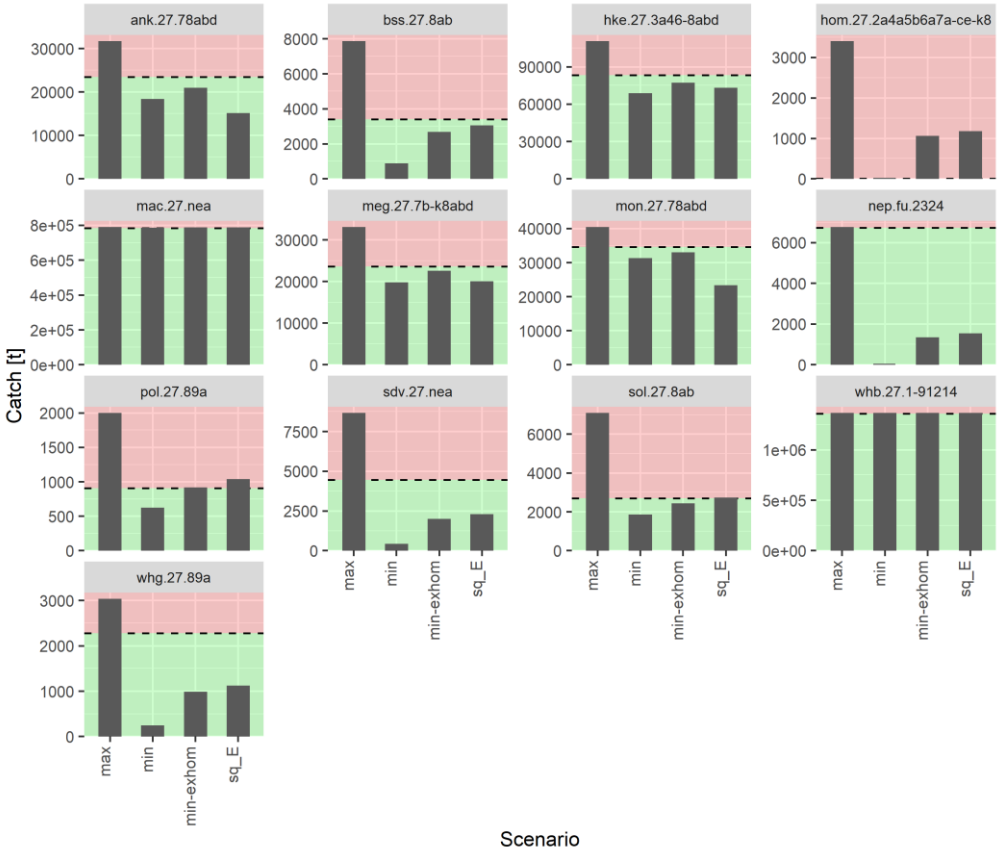


Figure 2.27. Bay of Biscay mixed fisheries forecast: Estimates of 2024 catches (in tonnes) by stock and scenario (Table 2.2). The horizontal dashed lines correspond to the single-stock catch advice, with areas above and below the line representing potential over and undershoot, respectively.

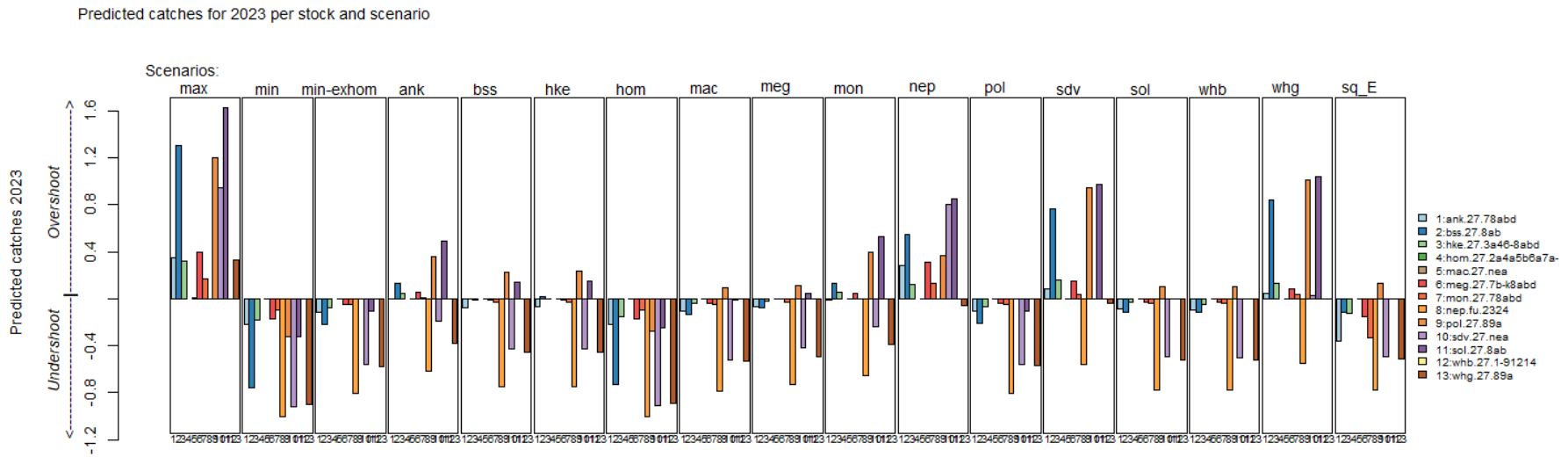


Figure 2.28. Bay of Biscay mixed fisheries forecasts: TAC year results (2023). FLBEIA estimates of potential percentage of catches change by stock (relative to the TAC advice) and scenario (Table 2.2). Horizontal line corresponds to the the single-stock advice for 2023. Bars below the value of zero show the percentage of undershoot (compared to the single species catch advice) in cases where catches are predicted to be lower when applying the scenario.

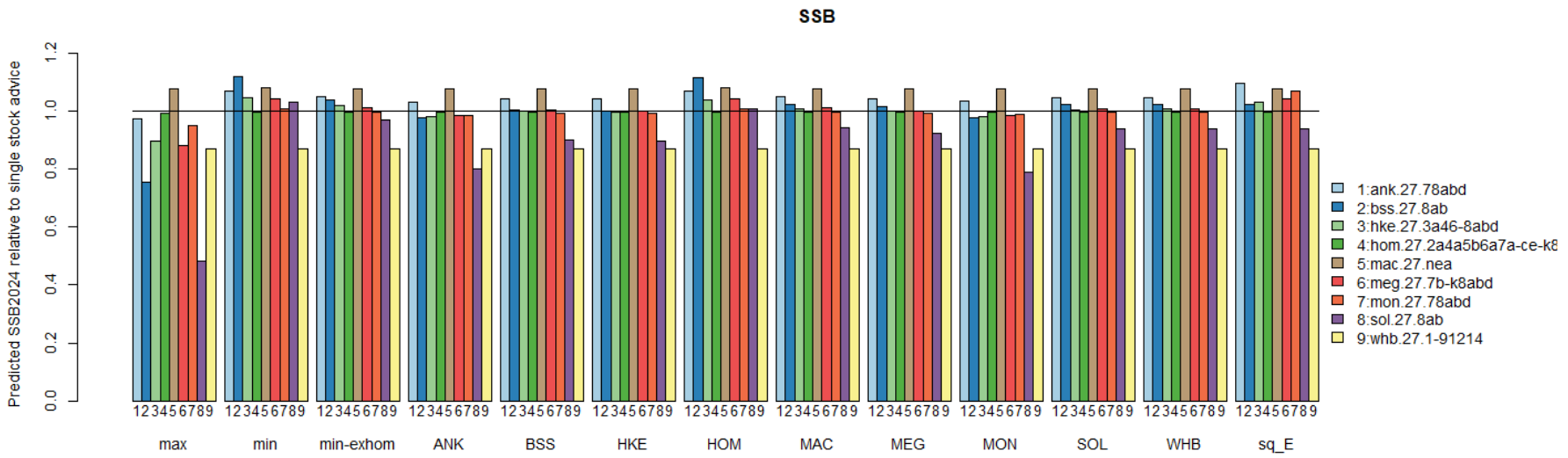


Figure 2.29. Bay of Biscay mixed fisheries forecasts: Estimates of potential SSB at the start of 2024 by stock and scenario (Table 2.2), expressed as a ratio to the single-species advice forecast (Table 2.5). Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2024).

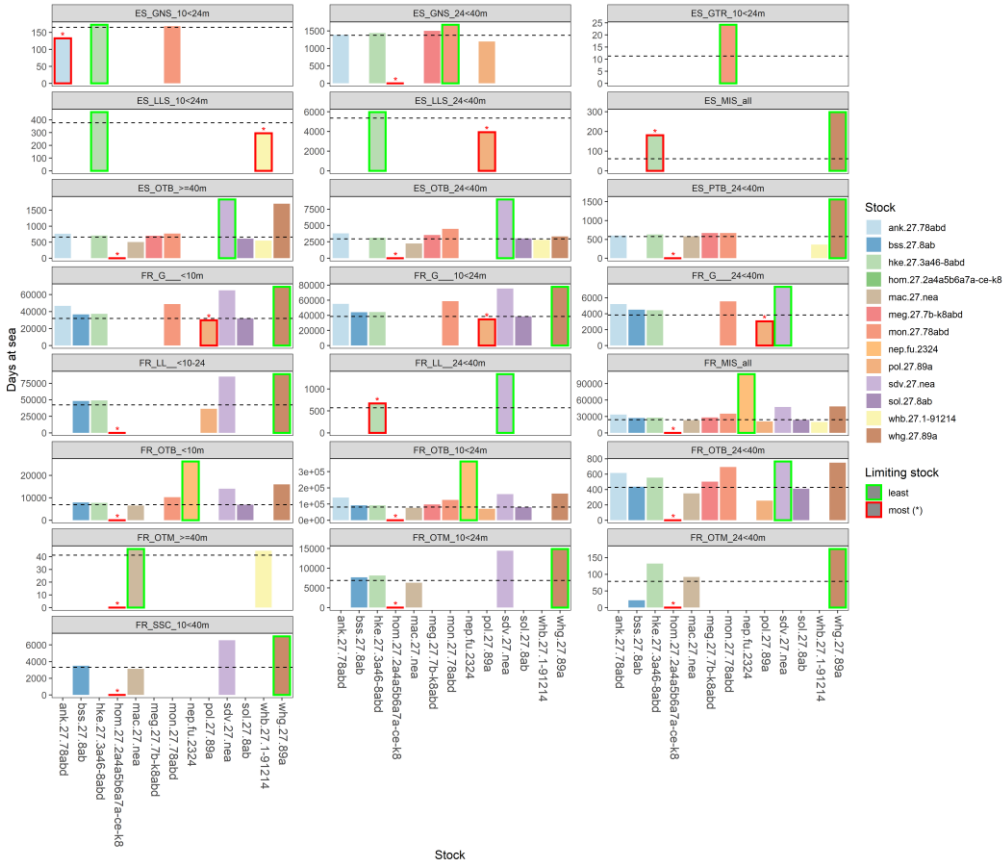


Figure 2.30. Estimates of effort by fleet needed to reach the advice for the single stocks. Stocks are coded by colour, with the most limiting stock ("choke species") for each fleet in 2023 highlighted with a red border and the least limiting species highlighted with a green border. Fleet names are given by country (FR = France, ES = Spain) and by 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. The *status quo* effort for each fleet (average 2019-2021) is shown as a dashed line for reference.

2.6 References

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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 2022, the ICES advice for all stocks considered in this model was given in terms of terms the ICES MSY approach. A multiannual management plan (MAP) for Western and adjacent waters has been adopted by the EU for stocks covered by this advice (Council Regulation (EC) 2019/472) which ICES considers to be precautionary. However, there is no agreed shared management plan with UK for these stocks. 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 EU 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 (https://bim.ie/fisheries/advisory-services/fisheries-management-chart)

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. Another area closure was in place for EU fisheries in FU16 (the Porcupine bank) between 1 May – 31 July 2010-2012; however,

the period of the EU regulatory close was reduced to only May between 2013 and 2019 (Council Regulation 2019/124), and has not been in force since 2020 (Council Regulation 2020/123).

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. Since 1 January 2019, catches of all quota species in the Celtic Seas have been 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 2021

Species	Exemption type	Area	Gear	Maximum de minimis exemption (% of total annual catch)
Albacore tuna	De minimis	7	Midwater pair trawls	5
Whiting	De minimis	7b -7k	Bottom trawls and seines ≥ 80 mm, Pelagic and beam trawls 80-119 mm	5
Sole	De minimis	7a, 7d -7h	Beam trawl 80-119 mm with Flemish Panel	3
Sole	De minimis	7d,e,f & g	Trammel nets and gillnets	3
Haddock	De minimis	7b,c & 7e-k	Bottom trawls and seines ≥ 100 mm, catches comprising ≤30% Nephrops	5
Haddock	De minimis	7b,c & 7e-k	Vessels using ≥ 80 mm, with catches comprising more than 30% Nephrops	5
Haddock	De minimis	7b,c & 7e-k	Beam trawls ≥ 80 mm with Flemish Panel	5
Haddock [1]	De minimis	6a	Nephrops bottom trawls using <119mm with HSG	3
Megrim [2]	De minimis	7	Beam Trawls 80-119mm & Bottom trawls	4
Horse mackerel	De minimis	6 & 7b-k	Bottom trawls, seines & beam trawls	3
Mackerel	De minimis	6 & 7b-k	Bottom trawls, seines & beam trawls	3
Boarfish	De minimis	7b,7c,7f-7k	Bottom trawls	0.5
Argentine	De minimis	EU 5b & 6	Bottom trawls ≥ 100 mm	0.6
Species	**Exemption Type**	**Area**	**Gear**	**Discard Release Notes**
Nephrops	Survivability	6 & 7	Pots, creels or traps	immediately & where caught
Nephrops	Survivability	7	Bottom trawls 70-99mm with HSG* or ≥100mm	immediately & where caught
Nephrops	Survivability	6a (<12nm)	Bottom trawls 80-110 mm	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	7d -7g	Beam Trawls with flip up rope or benthic release panel (vessels > 221kW)	Released immediately
Plaice	Survivability	7a-7g	BT2 (vessels ≤221 kW or ≤24 m) inside 12 nm, tows ≤ 1:30 hour	Released immediately
All Species	Survivability	EU 5b; 6 & 7	Pots, creels and traps	Released immediately

[1] Applies ony to haddock <MCRS (30cm), [2] Applies ony to megrim <MCRS (20cm)
* See list of highly specific gears for Nephrops. ** Bottom trawls:70 to 99mm in 7f,7g, 7h North of 49.5°N & 7j East of 11°W - catches must comprise 55% whiting or anglerfish, hake & megrim combined; ≥100mm in the rest of 7

Reference: Commission Delegated Regulation (EU) 2020/2015

3.2 Model

3.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.*, 2007; FLCore 2.6.16, FLFleet 2.6.1, FLAssess 2.6.3, Flash 2.5.11) running with R4.1.0 (R Development Core Team, 2020). All forecasts were projected using the same fwd() function in the Flash Package. The FCube method was 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	Statistical catch-at-age model (A4A)	FLR STF

Stock	Assessment	Forecast
mon.27.78abd	Statistical catch-at-age model (SS3)	FLR STF
ank.27.7-8abd	Length-based age-structured Stock Synthesis model (SS3)	FLR STF
sol.27.e	Age-based analytical assessment (XSA)	FLR STF
sol.27.7fg	Age-based stochastic analytical assessment (SAM)	SAM
hke.27.3a46-8abd	Length-based and sex-disaggregated model (SS3)	FLR STF
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 several mixed fisheries scenarios. The basis of the model is to estimate the potential future levels of effort by a fleet corresponding to the fishing opportunities (catches 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 six options (or scenarios) were included in the advice:

Scenario code	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 of 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.
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.
cod.27.7e-k	**"Cod MSY approach":** All fleets set their effort corresponding to that required to catch their cod stock share, regardless of other catches.
sq_E	**"*Status quo* effort":** The effort of each fleet in the TAC year (2022) is set equal to the average effort in the most recent 3 years (2019-2021) for which catch and effort data are available.

***Note that 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 2022 and the historical proportion of the stock landings taken by the fleet.**

A "range" scenario as described in Ulrich et al. (2017) has been implemented in previous years. This scenario searches for the minimum sum of differences between potential catches by stock under the "min" and "max" scenarios within the F_{MSY} ranges. It estimates fishing mortality by stock which, if used for setting single-stock fishing opportunities for the next TAC year, may reduce the gap between the most and least restrictive TACs, thus reducing the potential quota over- and undershoot. This scenario is run using reduced F_{MSY} ranges when stock size is below MSY $B_{trigger}$ (for example, cod (F_{MSY} range 0.040–0.068) and whiting (F_{MSY} range 0.191–0.228) and the full range for other stocks. Norway lobster is not included in the "range" scenario.

During this year's advice meeting, it became apparent that the optimization routine could only derive stable solutions for F values of the most- and least-limiting stocks, and not for all stocks. In order to avoid misinterpretation, it was decided to remove this scenario from the advice until a more appropriate approach can be developed.

3.3 Data compilation

Following IBPMIXFISH 2021 (ICES 2021a), the data compilation R scripts were significantly revised to improve workflow, readability, and reproducibility. These revisions have been thoroughly detailed in the IBP report and annex. The input data source to these scripts remains the same, bar the inclusion of standard assessment graph data retrieved directly from ICES.

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

5. Stock data: Stock abundance, age-structure, reference points, catch advice, and trends. This data is supplied by the single species assessment working groups, the data is also retrieved from the ICES Standard Assessment Graph (SAG) server on a stock by stock basis and used to validate data submissions to WGMIXFISH.

6. Fisheries dependent data: fleet and métier trends in landings and effort. This data is sourced from the WGMIXFISH data call ("accessions data").
7. Discard rates: InterCatch.

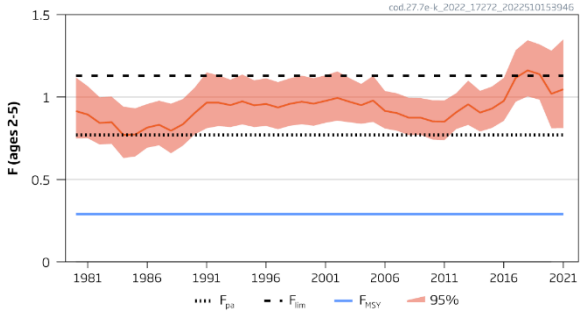
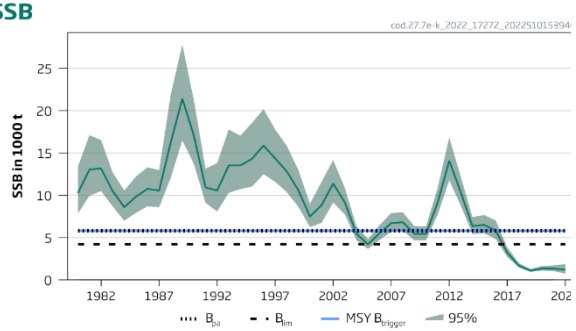
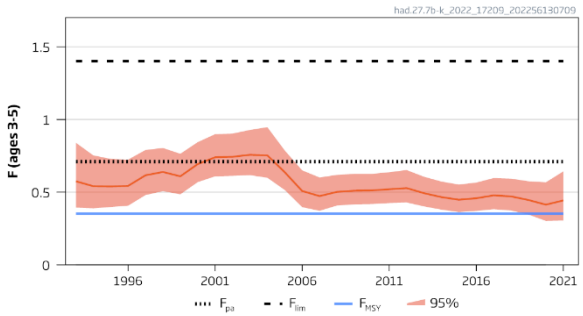
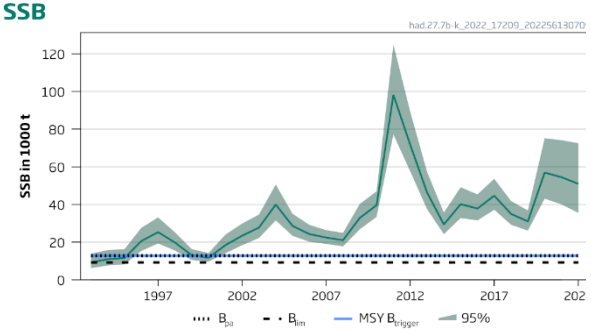
Details on the collection, structure and implementation of these data sources can be found in the stock annex (ICES 2022a). Below specific details of the data sources in 2022 have been described.

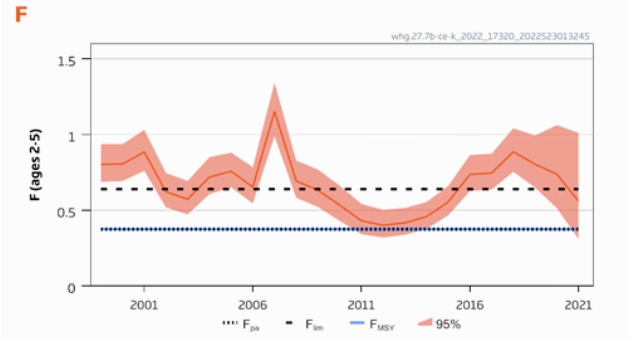
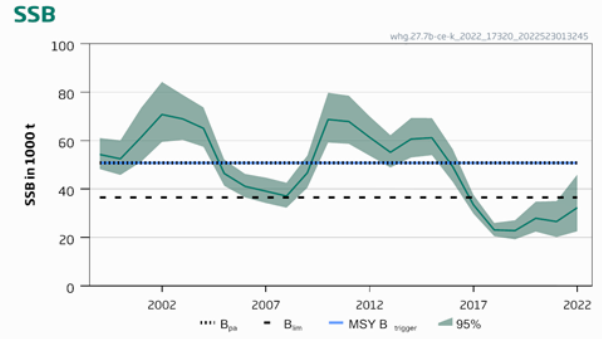
3.3.1 Stock data

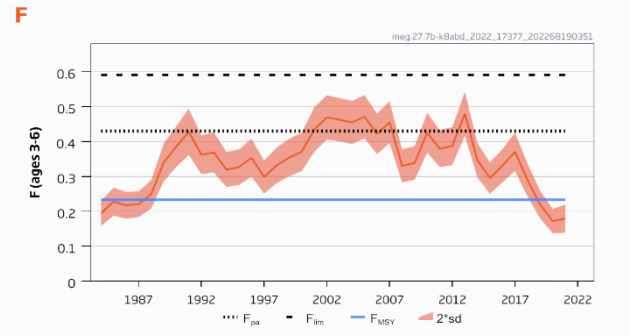
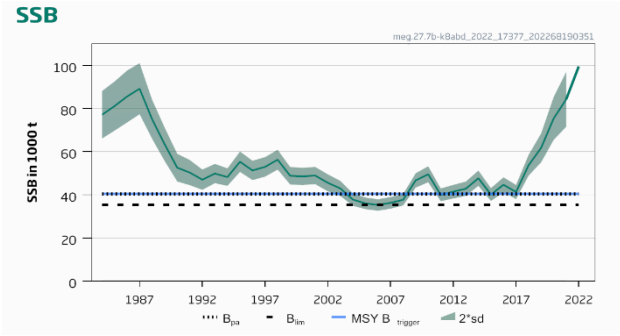
Single species stock assessment outputs including abundance, fishing mortality, biological parameters (maturity, natural mortality) and age-structure was supplied by WGCSE (ICES 2022b) and WGBIE (ICES 2022c) in the form of FLR stock objects. Details of reference points, advice for 2023, TAC and trends in stock status were taken from the advice sheets. The consistent support and cooperation from the chairs and single species stock assessors has greatly eased the workload of WGMIXFISH in 2022. An overview of the trends and advice for demersal stocks included in Celtic Sea mixed fisheries analysis from the single species advice for these stocks is described below (ICES 2022b, 2022c) (Table 3.).

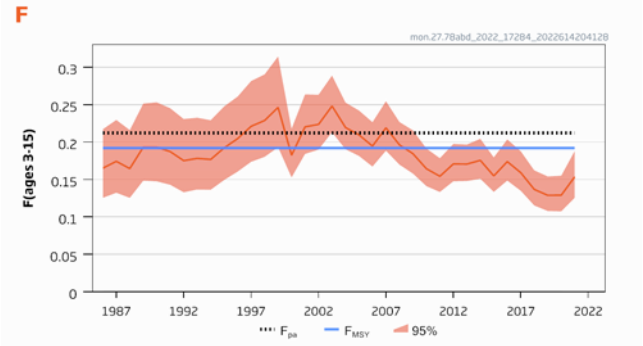
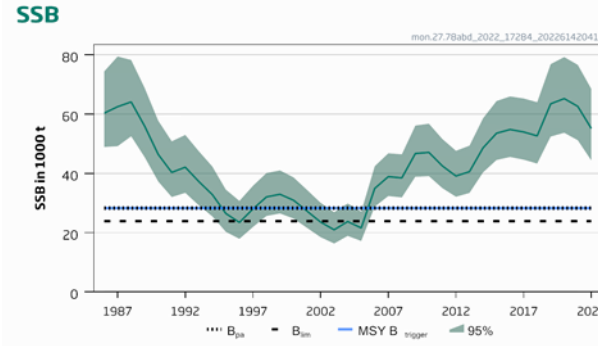
Table 3.1. Summary of advice and stock trends for the stocks included in the Celtic Sea mixed fisheries model (ICES 2022b, 2022c)

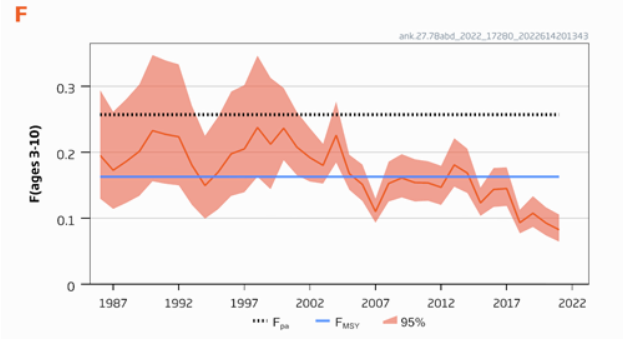
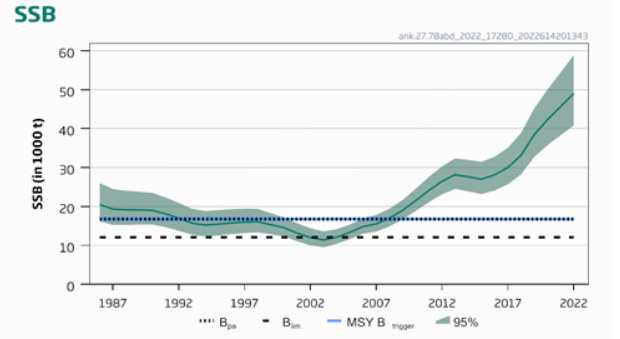
Analytical stocks

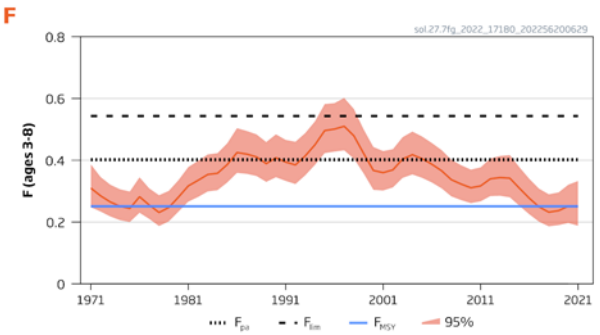
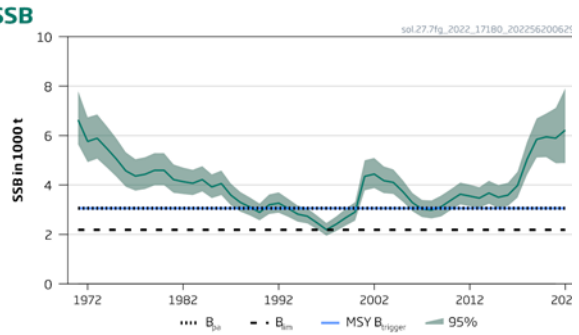
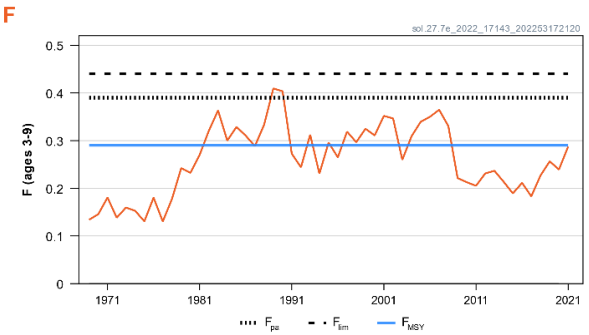
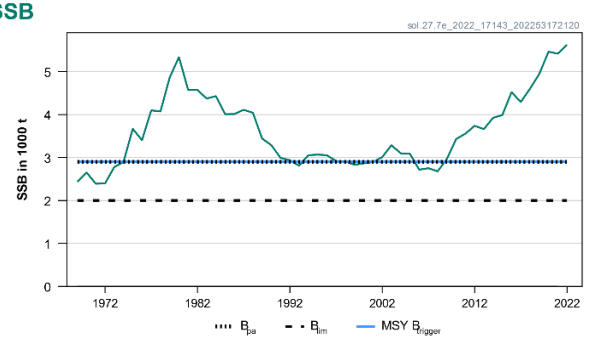
Species	Area	Stock status	Advice 2022
cod.27.7e–k (Cod)	Divisions 7. e–k (western English Channel and southern Celtic Seas)	F  SSB  **Summary**: Fishing pressure on the stock is above FMSY and between Fpa, and Flim, and spawning-stock size is below MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach and precautionary considerations are applied, there should be zero catch in 2023. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.
had.27b–k (Haddock)	Divisions 7.b–k (southern Celtic Seas and English Channel)	F  SSB  **Summary**: Fishing pressure on the stock is above FMSY and below Fpa and Flim, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 11 901 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

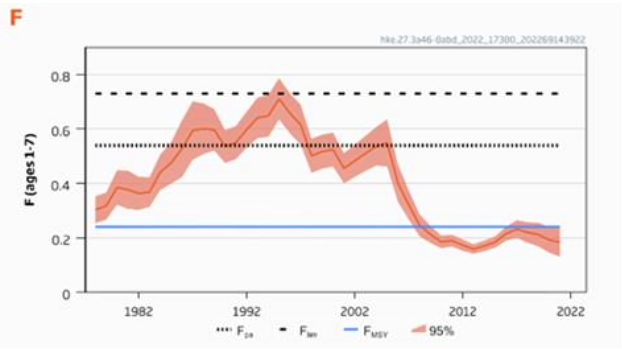
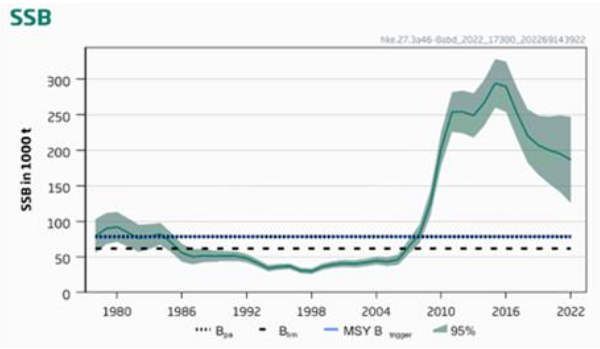
Species	Area	Stock status	Advice 2022
whg.27.b–c, e–k (Whiting)	Divisions 7.b–c and 7.e–k (southern Celtic Seas and western English Channel)	  **Summary:** Fishing pressure on the stock is above FMSY and between Fpa and Flim, and spawning-stock size is below MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1715 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management should be implemented at the stock level.

Species	Area	Stock status	Advice 2022
meg.27.7b-k8abd (Megrim)	Divisions 7.b–k, 8.a–b, and 8.d (west and southwest of Ireland, Bay of Biscay)	  **Summary**: Fishing pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 24 176 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two megrim species—megrim (Lepidorhombus whiffiagonis) and four-spot megrim (Lepidorhombus boscii)—under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the over-exploitation of either species.

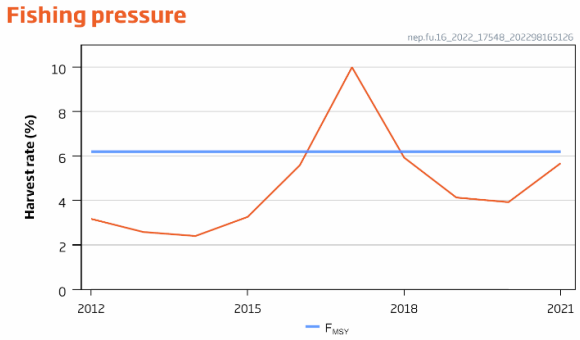
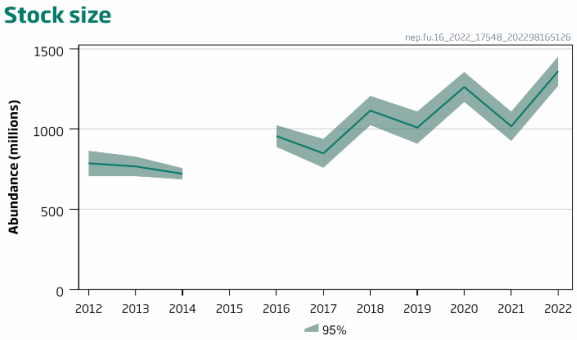
Species	Area	Stock status	Advice 2022
mon.27.78 abd (White anglerfish)	Subarea 7 and in divisions 8.a–b and 8.d (southern Celtic Seas, Bay of Biscay)	  **Summary**: Fishing pressure on the stock is below FMSY; spawning stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 34 476 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two anglerfish species—black-bellied anglerfish (Lophius budegassa) and white anglerfish (Lophius piscatorius)—under a combined species total allowable catch (TAC) prevents effective control of the single-species exploitation rates and could lead to the over-exploitation of either species.

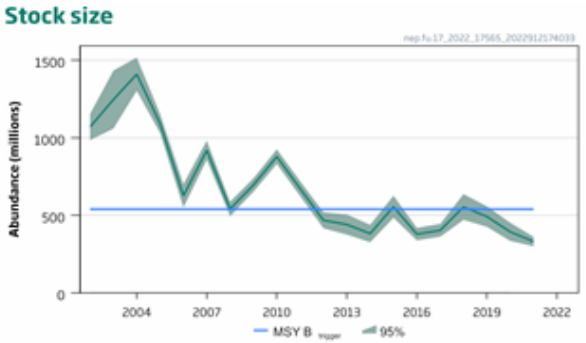
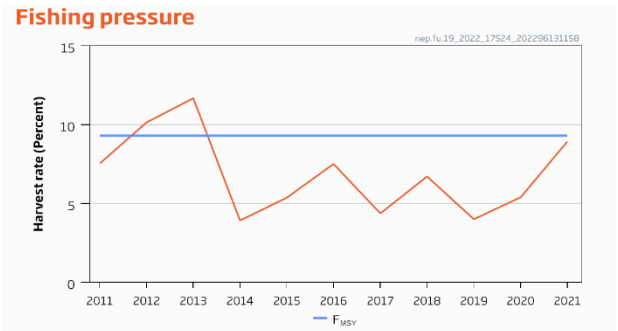
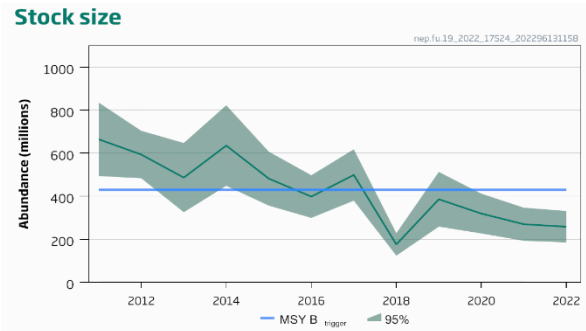
Species	Area	Stock status	Advice 2022
ank.27.7-8abd (Black-bellied anglerfish)	Subarea 7 and divisions 8.a–b and 8.d (Celtic Seas, Bay of Biscay)	  **Summary**: Fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 23 958 tonnes. ICES notes the existence of a precautionary management plan developed and adopted by one of the relevant management authorities for this stock. Management of catches of the two anglerfish species – black-bellied anglerfish (Lophius budegassa) and white anglerfish (Lophius 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.

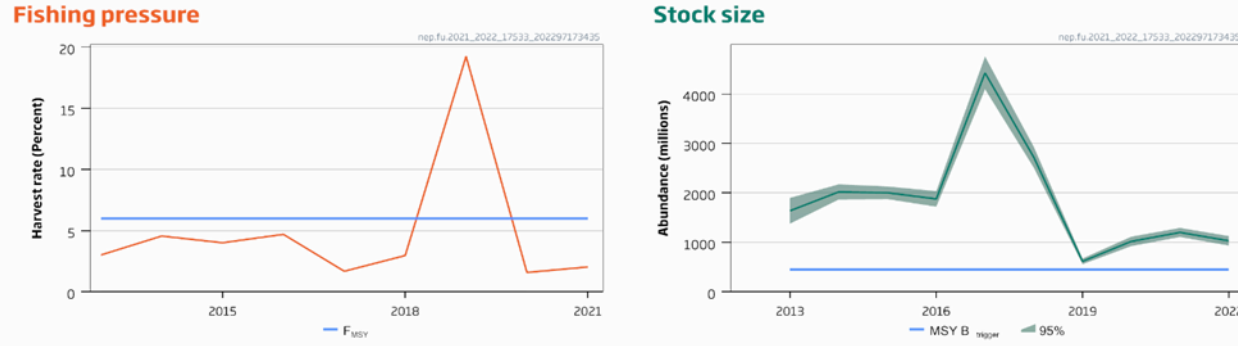
Species	Area	Stock status	Advice 2022
sol.27.7fg (Sole)	Divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	  **Summary**: Fishing pressure on the stock is at FMSY; spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1338 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.e (Sole)	Divisions 7.e (western English Channel)	  **Summary**: Fishing pressure on the stock is at FMSY; spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1394 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

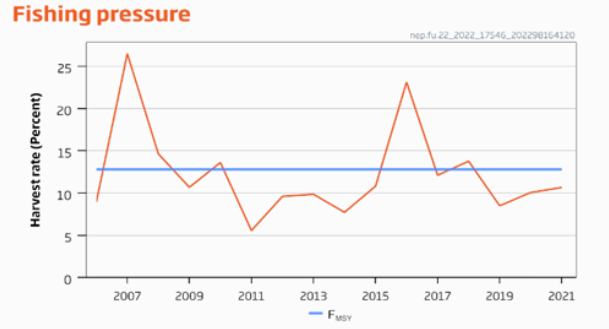
Species	Area	Stock status	Advice 2022
hke.27.3a46-8abd (Hake)	Subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea. Celtic Seas. and the northern	  **Summary**: pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 83 130 tonnes. ICES notes the existence of a precautionary management plan developed and adopted by one of the relevant management authorities for this stock.

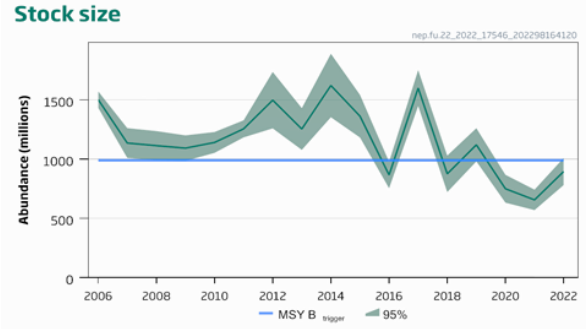
Nephrops stocks

Species	Area	Stock status	Advice 2022
nep.fu.16 (*Nephrops*)	Divisions 7.b–c and 7.j–k, Functional Unit 16 (west and southwest of Ireland, Porcupine Bank)	  **Summary:** Fishing pressure on the stock is below FMSY, and no reference points for stock size have been defined for this stock.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, and assuming zero discards, catches in 2023 that correspond to the F ranges in the MAP are between 3054 and 3787 tonnes. The entire range is considered precautionary when applying ICES advice rule. To ensure that the stock in FU 16 is exploited sustainably, management should be continued at the FU level.

Species	Area	Stock status	Advice 2022
nep.fu.17 (*Nephrops*)	Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)	  **Summary:** Fishing pressure on the stock is at FMSY, and stock size unkown.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 that correspond to the F ranges in the MAP are between 316 and 363 tonnes. To ensure that the stock in Functional Unit (FU) 17 is exploited sustainably, management should be implemented at the FU level.
nep.fu.19 (*Nephrops*)	Divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of southwest of Ireland)	  **Summary:** Fishing pressure on the stock is below FMSY, and stock size is below MSY Btrigger.	ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 that correspond to the F ranges in the MAP are between 302 and 338 tonnes. To ensure that the stock in Functional Unit (FU) 19 is exploited sustainably, management should be implemented at the FU level.

Species	Area	Stock status	Advice 2022
nep.fu.2021 (*Nephrops*)	Divisions 7.g and 7.h, functional units 20 - 21 (Celtic Sea)	 **Summary:** Fishing pressure on the stock is below FMSY, and stock size is above MSY Btrigger.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 1803 tonnes. To ensure that the stock in functional units (FUs) 20–21 is exploited sustainably, management should be implemented at the level of the combined FU 20–21. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 7. ICES considers this plan to be precautionary when implemented at the FU level.

<table>
<tr><th>Species</th><th>Area</th><th>Stock status</th><th>Advice 2022</th></tr>
<tr>
<td>nep.fu.22
(Nephrops)</td>
<td>Divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)</td>
<td>




Summary: Fishing pressure on the stock is below FMSY, and stock size is below MSY Btrigger.
</td>
<td>ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns

do not change from the average of the years 2019–2021, catches in 2023 should be no more than 2548 tonnes.

To ensure that the stock in Functional Unit (FU) 22 is exploited sustainably, management should be implemented at the FU level.

ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 7. ICES considers this plan to be precautionary when implemented at the FU level.</td>
</tr>
<tr>
<td>nep.27.7outFU*
(Nephrops)</td>
<td>Subarea 7, outside the functional units (southern Celtic Seas, southwest of Ireland)</td>
<td>
<table>
<tr><th></th><th></th><th colspan="4">Fishing pressure</th><th></th><th colspan="4">Stock size</th></tr>
<tr><th></th><th></th><th>2018</th><th>2019</th><th colspan="2">2020</th><th></th><th>2018</th><th>2019</th><th colspan="2">2020</th></tr>
<tr><td>Maximum sustainable yield</td><td>F_{MSY}</td><td>?</td><td>?</td><td>?</td><td>Unknown</td><td>MSY $B_{trigger}$</td><td>?</td><td>?</td><td>?</td><td>Unknown</td></tr>
<tr><td>Precautionary approach</td><td>F_{pa},F_{lim}</td><td>?</td><td>?</td><td>?</td><td>Unknown</td><td>B_{pa},B_{lim}</td><td>?</td><td>?</td><td>?</td><td>Unknown</td></tr>
<tr><td>Management plan</td><td>F_{MGT}</td><td>–</td><td>–</td><td>–</td><td>Not applicable</td><td>B_{MGT}</td><td>–</td><td>–</td><td>–</td><td>Not applicable</td></tr>
<tr><td>Qualitative evaluation</td><td>-</td><td>?</td><td>?</td><td>?</td><td>Unknown</td><td>-</td><td>?</td><td>?</td><td>?</td><td>Unknown</td></tr>
</table>
</td>
<td>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.</td>
</tr>
</table>

*** Format of nep.27.7outFU differs from other stocks because the advice was published in 2020**

3.3.2 Fisheries dependent data

Information on fisheries is supplied according to the WGMXIFSH data call in the form of "accessions" data, which provides disaggregated fleet data at the level of métier which are consistent with the definitions outlined in the DCF. This includes landings (in tonnes) for defined species and fishing effort (in KW days). In 2019, 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 input from expert knowledge during the working group but will require a full resubmission during the 2023 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 accessions 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 Defining fleet and métier

The data sources described above 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 and 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). A similar aggregating procedure as for the fleets was performed, where any métier catching < 10% of a fleets catch of any stock was aggregated into an "OTH" métier. This results in a large number of fleets and métier due to the diversity of activity in the Celtic Sea. The data is therefore aggregated to ICES area-level groupings for the Celtics Sea (7bc; 7e; 7.fg; 7hjk), this has a useful benefit of reducing run time, but also reveals the net contribution of "smaller" fleets in a manner that is more comparable for end users.

The final data used contained 32 fleets (country * gear grouping * vessel length category), an "other" fleet (OTH), and four single stock fleets ("megrim", "anglerfish", "monkfish" and "hake") which account for the catches of these stocks that occur outside of the Celtic Sea region. (i.e. the Bay of Biscay). Each fleet engages in several of the 156 different métiers each catching the stocks incorporated into this model (Table 3., 3.3). The combination of stocks landed by each métier varies greatly (Figure 3.2).

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 3.4. 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 Discards
2019	ank.27.78abd	9244	3125	1.000	1.000	9244	3125
2020	ank.27.78abd	8590	2716	1.000	1.000	8590	2716
2021	ank.27.78abd	9015	4884	1.000	1.000	9015	4884
2019	cod.27.7e-k	1069	299	1.000	0.959	1069	312
2020	cod.27.7e-k	922	231	0.976	1.000	944	231
2021	cod.27.7e-k	914	580	1.000	1.000	914	580
2019	hke.27.3a46-8abd	83038	13030	1.000	1.000	83038	13030
2020	hke.27.3a46-8abd	73194	10208	1.000	1.000	73194	10208
2021	hke.27.3a46-8abd	69604	8657	1.000	1.000	69604	8657
2019	meg.27.7b-k8abd	12652	1984	1.000	1.000	12652	1984
20	meg.27.7b-k8abd	11749	2400	1.000	1.000	11749	2400

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
20							
2021	meg.27.7b-k8abd	12953	2935	1.000	1.000	12953	2935
2019	mon.27.78abd	19495	3159	1.000	1.000	19495	3159
2020	mon.27.78abd	19458	3087	1.000	1.000	19458	3087
2021	mon.27.78abd	22777	3796	1.000	1.000	22777	3796
2019	sol.27.7fg	1067	145	0.998	1.000	1069	145
2020	sol.27.7fg	1523	106	0.999	1.000	1524	106
2021	sol.27.7fg	1335	62	0.999	1.000	1337	62
2019	whg.27.7b-ce-k	6589	970	1.000	0.998	6589	972
2020	whg.27.7b-ce-k	5931	1266	0.999	0.987	5939	1283
2021	whg.27.7b-ce-k	6154	1223	1.000	0.979	6154	1249
2019	had.27.7b-k	7657	3584	0.989	0.975	7743	3676

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
2020	had.27.7b-k	7859	4260	0.996	0.846	7888	5035
2021	had.27.7b-k	9259	2280	1.000	0.942	9259	2419
2019	sol.27.7e	1185	0	1.000	NA	1185	0
2020	sol.27.7e	1219	0	1.000	NA	1219	0
2021	sol.27.7e	1392	0	1.000	NA	1392	0
2019	nep.out.7	216	0	1.000	NA	216	0
2020	nep.out.7	304	0	1.000	NA	304	0
2021	nep.out.7	346	0	1.000	NA	346	0
2019	nep.fu.22	2083	262	1.000	1.000	2083	262
2020	nep.fu.22	1518	288	0.996	0.996	1525	290
2021	nep.fu.22	1616	149	1.000	1.000	1616	149
20	nep.fu.2021	2723	539	1.000	1.000	2723	539

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
19							
2020	nep.fu.2021	413	34	1.000	1.000	413	34
2021	nep.fu.2021	736	49	1.000	1.000	736	49
2019	nep.fu.19	249	112	1.000	1.000	249	112
2020	nep.fu.19	249	136	1.000	1.000	249	136
2021	nep.fu.19	415	173	1.000	1.000	415	173
2019	nep.fu.16	2229	NA	1.000	NA	2229	0
2020	nep.fu.16	1899	NA	0.975	NA	1947	0
2021	nep.fu.16	2476	NA	0.999	NA	2479	0
2019	nep.fu.17	167	21	0.990	0.990	168	21
2020	nep.fu.17	222	54	0.996	0.996	223	54
2021	nep.fu.17	498	88	0.999	0.999	498	88

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
2019	ank.27.78abd	9244	3125	1.000	1.000	9244	3125
2020	ank.27.78abd	8590	2716	1.000	1.000	8590	2716
2021	ank.27.78abd	9015	4884	1.000	1.000	9015	4884
2019	cod.27.7e-k	1069	299	1.000	0.959	1069	312

). Some stock landings may not be accounted for in the fleets defined above due to issues such as landings from countries or areas not included in the Celtic Sea mode or national landings with missing logbook information that cannot be allocated to a specific fleet. The landings coverage for all fish stocks is very high (above 95% of landings of each fish stock for each of the years 2019–2021 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 an "OTH" fleet (both landings and discards). During data processing a difference in UK landings for *Nephrops* was noted for FU 16 and FU 20-21 in 2019 between the InterCatch and WGMIXFISH data. 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 for 2019. The issue has since been resolved and has not been a factor since the 2021 data submission.

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 2.6.16 package, and two forecast methods were used, stf() from the FLAssess (version 2.6.3) and fwd() from the Flash (version 2.5.11) packages. Stock objects were processed using Fla4a (version 1.8.2), FLXSA (version 2.6.4), stockassessment (version 0.11.0). As such, the input parameterisation as well as the stock projections are made externally using existing methods and

packages, while only 3 steps 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 either the FLR forecast method or the stockassessment forecast() method for SAM stocks. This ensured greater coherence between the single stock and mixed fishery forecasts.

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 act as a quality control procedure to ensure that the projections are 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

For the mixed fisheries runs, the following assumptions/settings are used.

Firstly, an effort based intermediate year assumption (average effort 2019-2021) is used instead of the single stock advice assumption. This is considered more consistent with a mixed-fishery fleet-based hypothesis for catch than using the divergent single stock approaches and provides the same functional link between fishing effort and fishing mortality across all stocks.

Secondly, for the stock targets in the FCube scenarios a fishing mortality consistent with the catch advice in the TAC year is used to drive the mixed fisheries scenarios rather than using the target F from the single stock catch advice. Using the advised fishing mortality as the target in the scenarios means that under a stock limiting scenario, it is possible to not achieve the single stock catch advice for that stock. This is because the stock size at the beginning of the TAC year can be different to the single stock forecast as a different intermediate year assumption is used in the mixed fisheries scenarios. Hence, a different catch in the TAC results from the advised F. Using an F consistent with the advised catch as the target in the scenario ensures that the catch advice is always achieved but it may result in a different fishing mortality to the single stock advice. This was considered more in line with a "implementation error" type approach, given the single stock catch advice is fixed and intermediate year uncertain and impacting the TAC year.

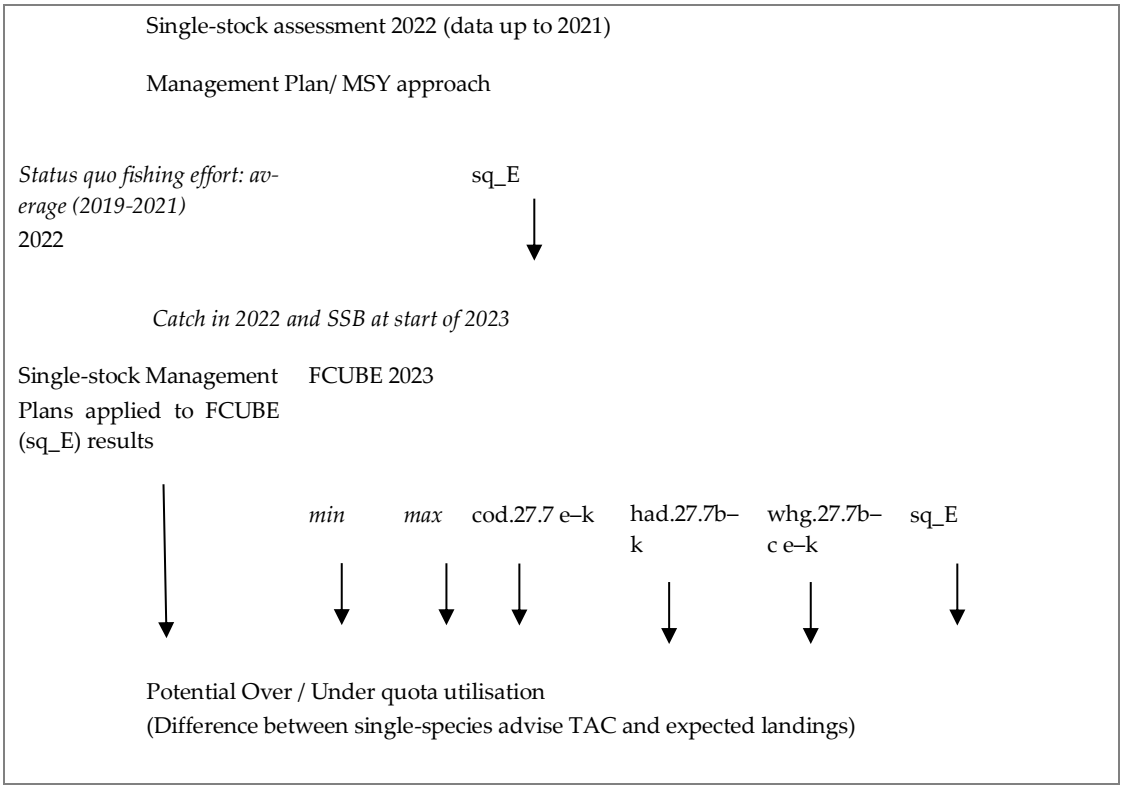
FCube analyses of the intermediate year (2022)

For the mixed fisheries advice, the intermediate year assumption used was status quo fishing effort (average (2019-2021)), with Fcube scenarios applied in the TAC year.

FCube analyses for the TAC year (2023)

Six scenarios were run, as outlined in Section 3.2.2 above.

In summary, the FCube runs followed the scheme below:



3.4.2 Results of FCube runs

3.4.2.1 Baseline run

summaries the result of the baseline runs for each of the stocks included in the model. Figure 3. shows the required change in fishing mortality for each stock. This trend shows that cod requires the biggest reduction in F, indicating that the zero catch advice would lead to a choke for all 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 3.6 and summarised in

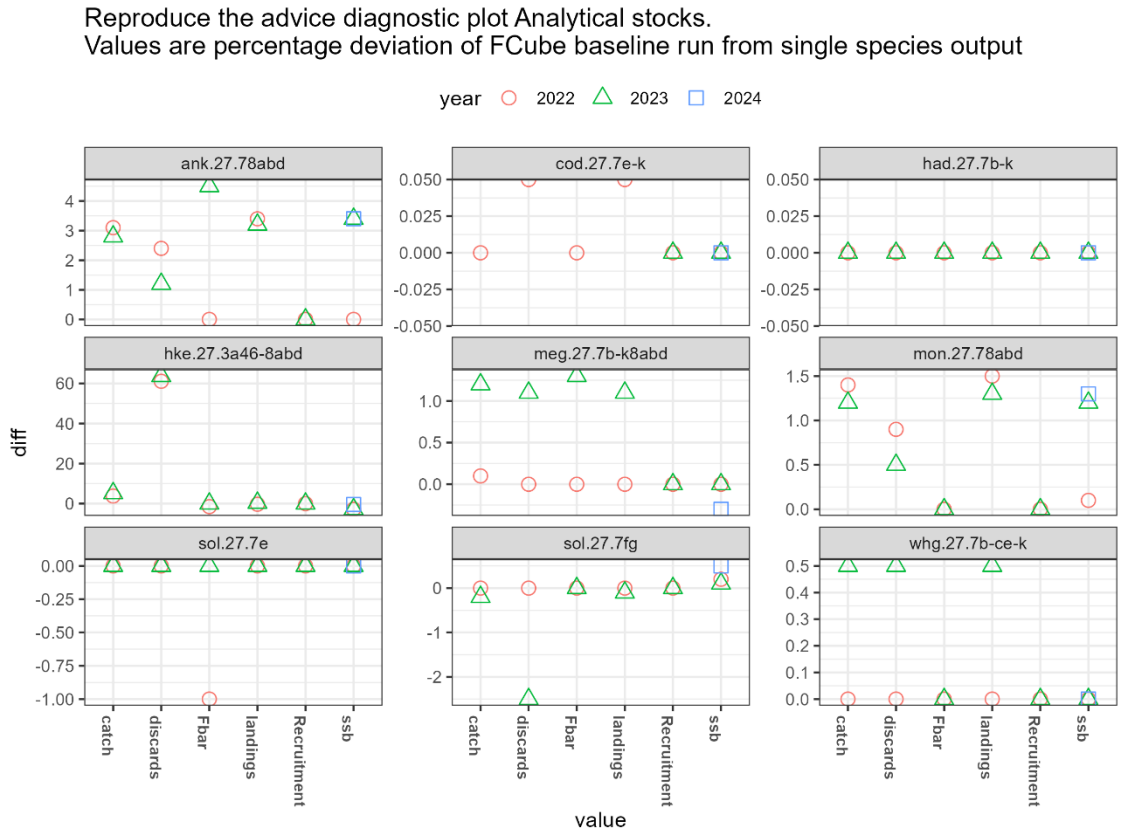


Figure 3.. The replicated forecast for all stocks were almost identical to the single-stock advice.

3.4.2.2 Mixed fisheries analyses

Intermediate year

The full overview of the FCube projections to 2024 is presented in **Error! Reference source not found.**-3.8, Figure 3., and Figure 3.. The results for 2024 can be compared to each other as in a single-species option table. For all baseline scenarios, WGMIXFISH assumed *status quo effort* in 2023.

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.). In 2023, the "min" scenario shows that cod limits 29 of the 32 fleets due to the zero-catch advice for cod and that almost all fleets catch cod to a greater or lesser extent. The three remaining fleets had no cod landings, with the remaining fleets limited by haddock, hake and white anglerfish respectively.

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 3.7, Figure 3.9), 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 2023, the 'max' scenario indicated that fleets have different least limiting stocks which results in over-quota catches of all other stocks (Figure 3.10). Black-bellied anglerfish (23 fleets), hake (three fleets), white anglerfish (one fleets) and Norway lobster (three fleets over two different functional units [FUs]), and western English channel sole (two fleets) are the least limiting stocks.

The *status quo* effort scenario ("sq_E") results in a small overshoot of haddock, a large overshoot of cod and whiting, and a small undershoot of white and black-bellied anglerfish, hake, megrim, and Norway lobster.

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 2023 is not considered precautionary as the stock is estimated to be and remain below B_{lim} (Table 3.9). The 'max' and 'Sq_E' scenarios result in whiting and haddock being fished above F_{MSY} in 2023 (Table 3.8). 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 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.

Of the presented scenarios, the 'min' scenario 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 2023 due to the cod stock being < B_{lim} in 2024, even with a zero cod catch in 2023 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.

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 (2019-2021) landing share by fleet and stock. As a crosscheck, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input (

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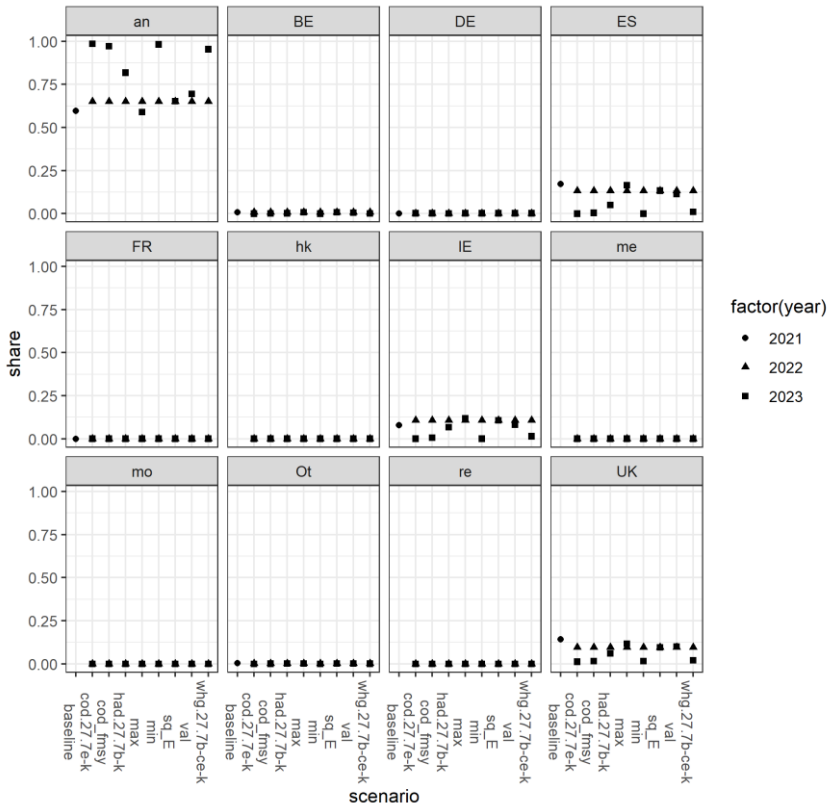

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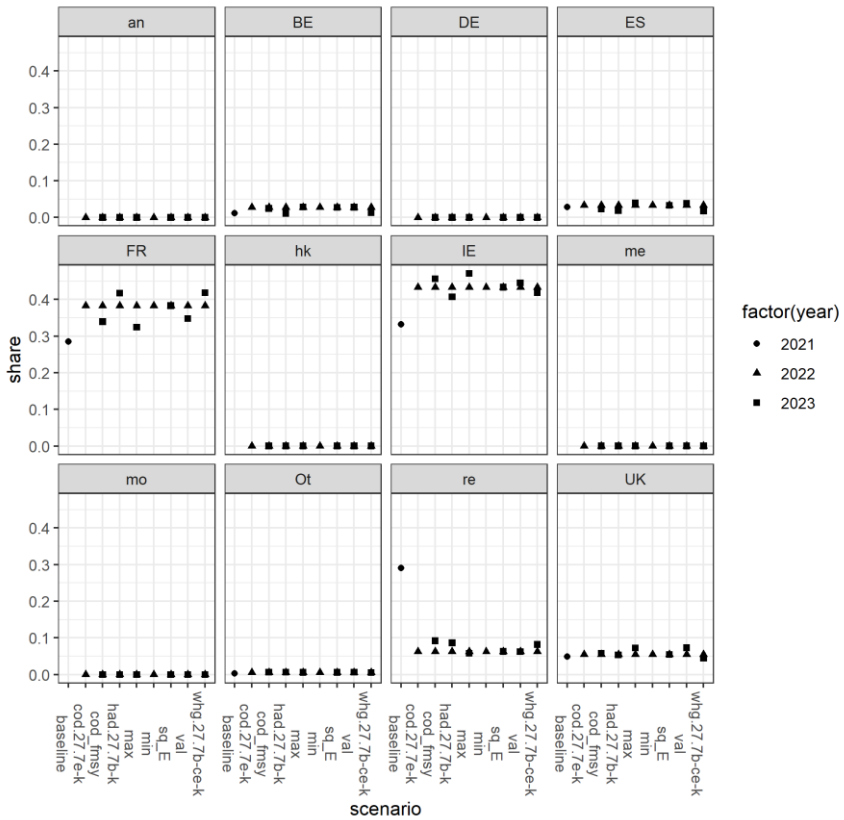

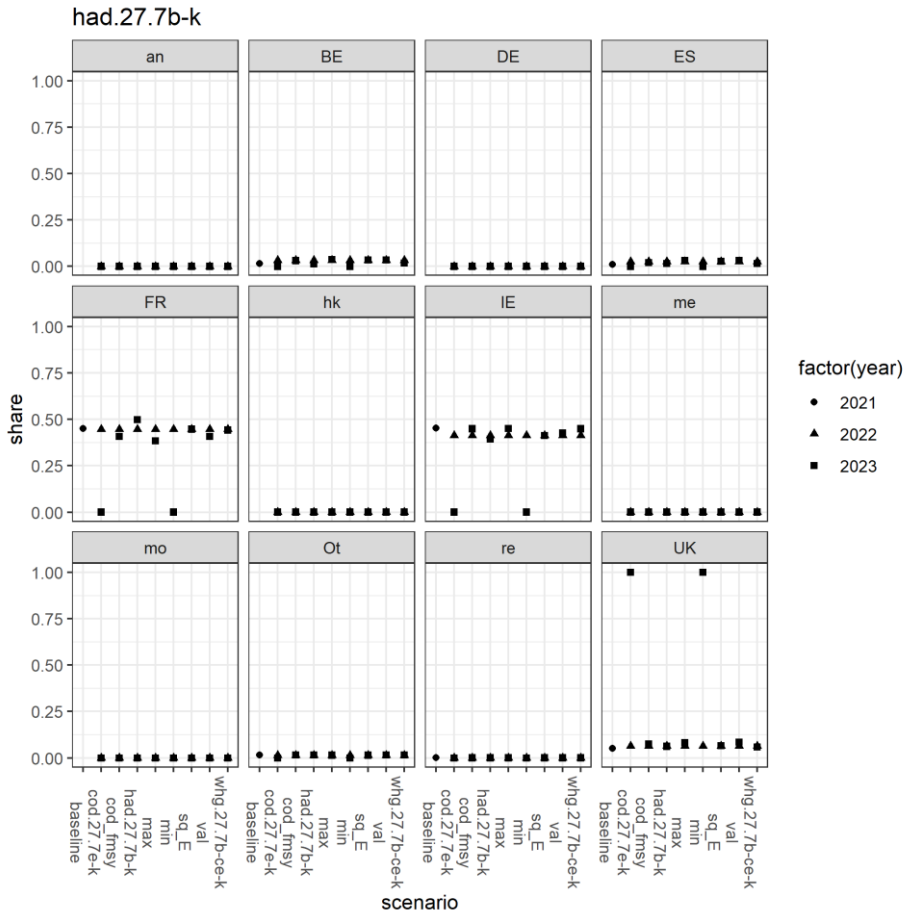
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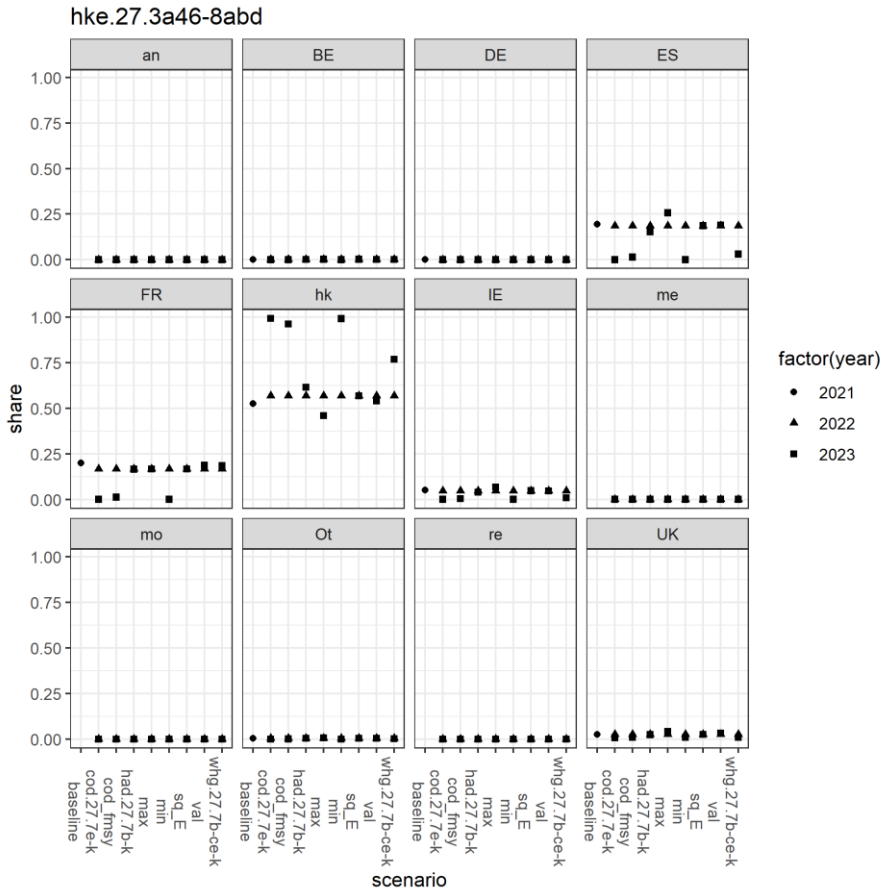
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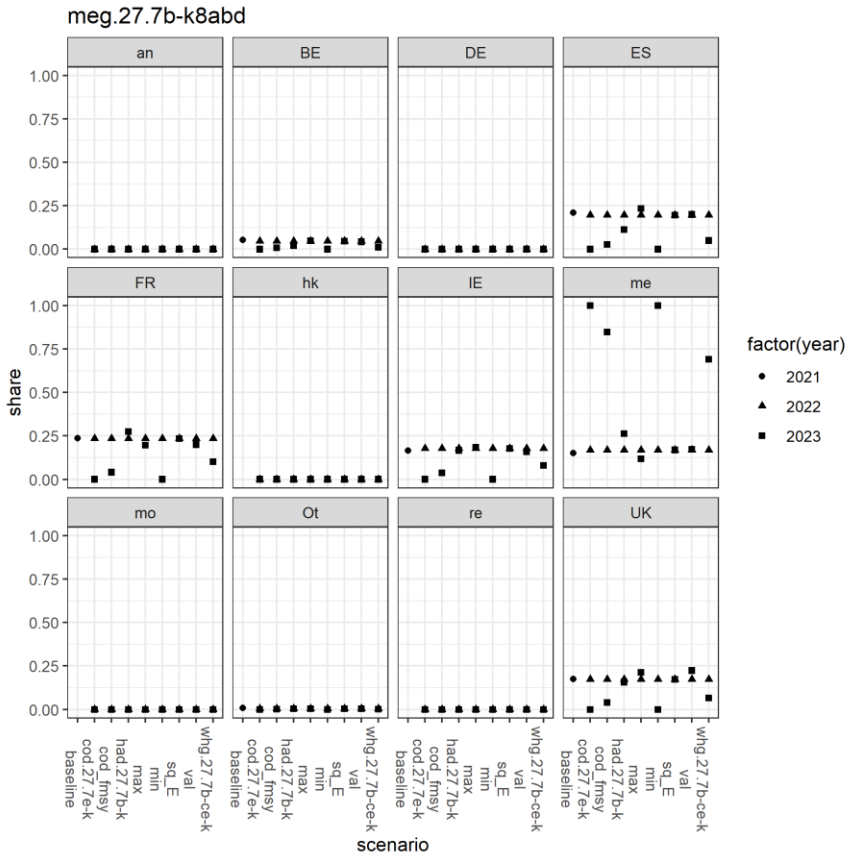
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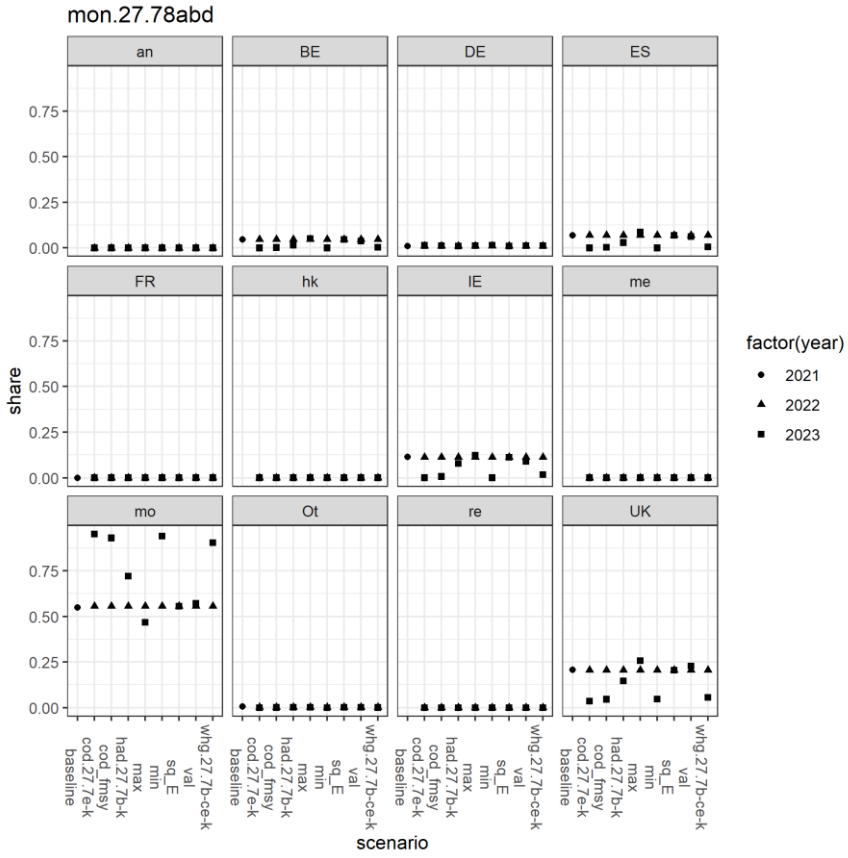
2023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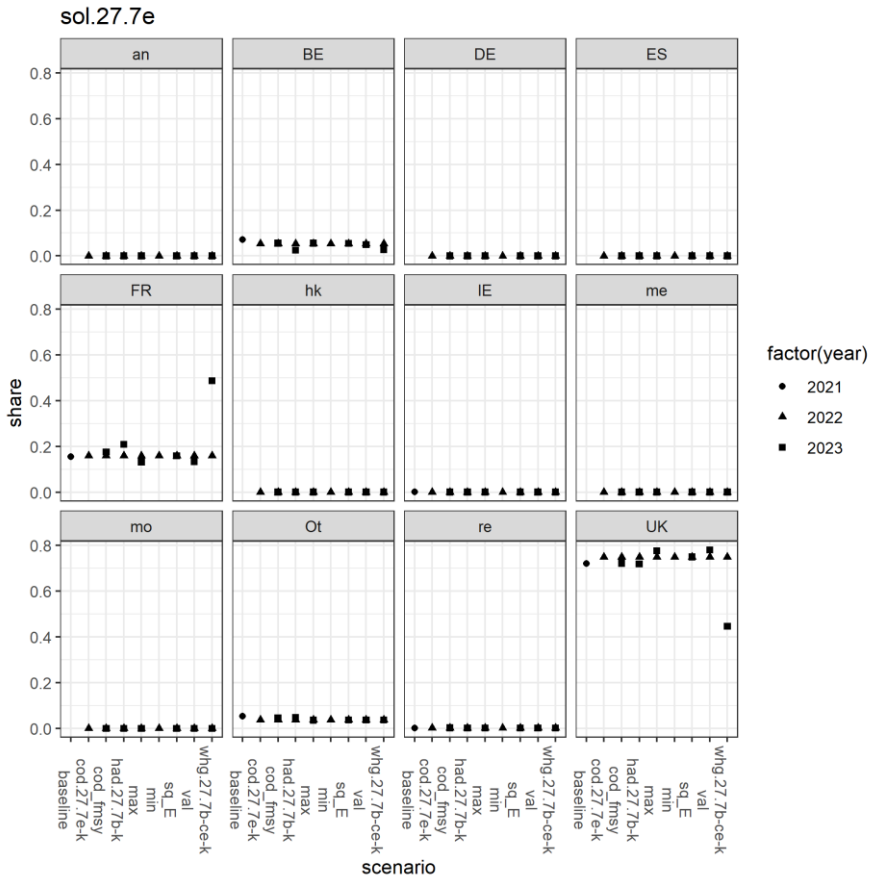
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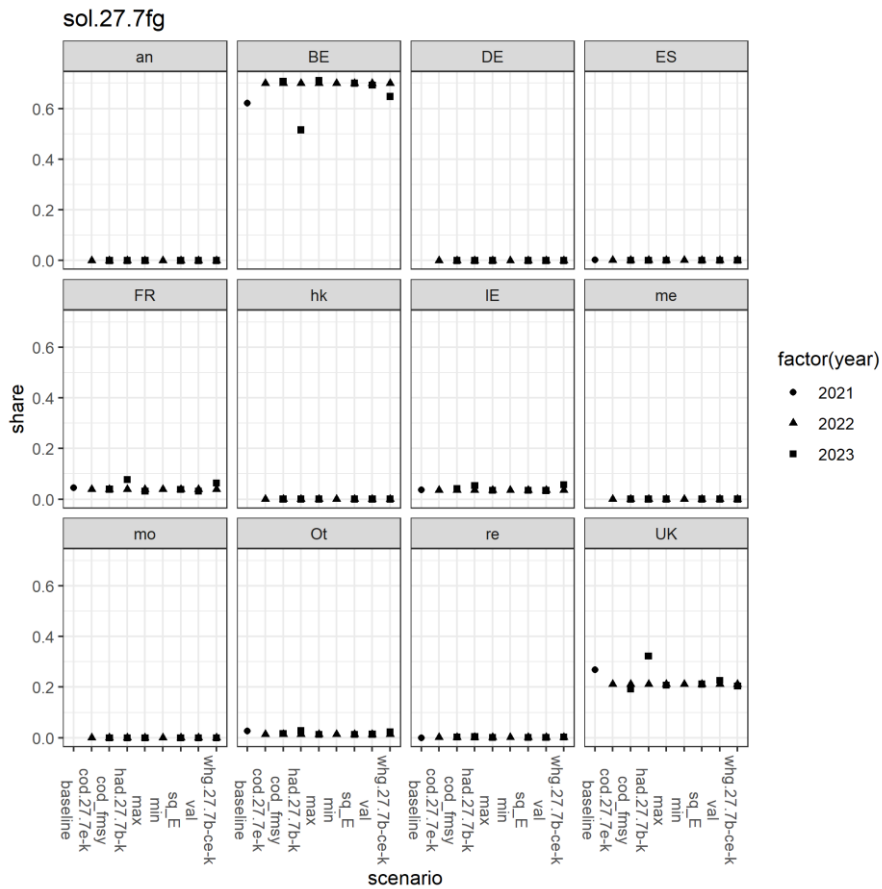
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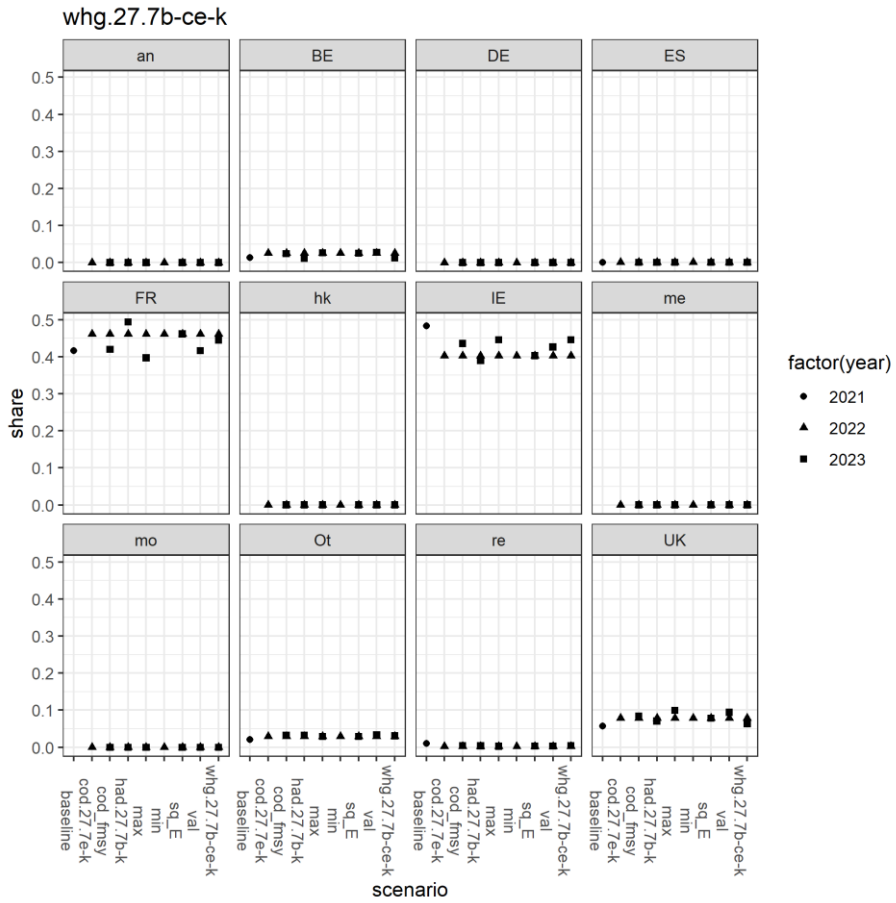


Figure 3.). The results show some deviations across all scenarios which arise because (under the assumption of a full discard ban), fleets with a small share of a stock but high discard rate have their fishing activity limited by that stock, resulting in underutilization of their target stock(s). This 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.

3.4.3 EU Technical request for zero catch advice stocks

In addition to the standard mixed fisheries scenarios ICES are asked to provide advice on potential catches of zero catch advice stocks given fishing opportunities for target stocks. For Celtic Sea cod, three additional scenarios were provided using the Celtic Sea mixed fishery model. Including catches:

1. Based on haddock fished at F_{MSY}
2. Based on haddock fished at F_{MSY} lower
3. Based on haddock fished at an intermediate level between F_{MSY} and F_{MSY} lower

The level of catches (2023), fishing mortality (2023) and spawning stock biomass (2024) under each of these scenarios are provided in Tables 3.9-3.11.

Table 3.2. Celtic Sea. Summary of the ICES single-species advice for 2023. Where a stock/Functional Unit does not have a management plan the landings follow ICES advice.

Species	Agreed TAC (summed TACs) 2022	Total Catch-advice for 2023	Projected landings-advice for 2023	F_{total}/Harvest ratio for 2023	F_{wanted}/ Harvest ratio for 2023	SSB 2023	SSB 2024	Rational
Cod 7. e–k	644*	0	0	0	0	1053	2754	MSY
Haddock 7.b–k	15000**	11901	9064	0.353	0.31	47157	48517	MAP
Whiting 7.bc, 7. e–k	8352***	1715	1512	0.090	0.079	30343	36571	MSY
Megrim 7.b–k, 8.a–b, 8.d	20786****	24176	20782	0.23	n/a	98527	92640	MSY
White anglerfish 7, 8.a-b, 8.d	52205^^	34476	30053	0.192	0.190	55576	52524	MSY
Black-bellied anglerfish 7, 8.a-b, 8.d	52205^^	23958	18867	0.163	0.142	50317	50837	MSY
Sole 7.e	1810	1394	1388	n/a	0.29	5052	4541	MSY
Sole 7.fg	1337	1338	1258	0.251	0.23	6120	5903	MAP
Hake 3.a, 4, 6, 7, 8.a–b, 8.d	78926	83130	76360	0.24	0.223	168765	148841	MAP
Nephrops FU16	5196*****	3787	3787	6.2^	n/a	1363		MAP
Nephrops FU17	17038******	363	312	5.2^	n/a	331		MAP
Nephrops FU19	17038******	338	311	5.6^	n/a	259		MAP
Nephrops FU20-21	17038******	1803	1757	6.0^	n/a	1032		MSY
Nephrops FU22	17038******	2548	2473	11.6^	n/a	895		MSY
Nephrops 7 outside FU	17038******	150	150					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

^^ applies to both Lophius species combined.

Table 3.3. Celtic Sea. Métiers consistent with DCF métier level 5 and additional metiers in the model

Mixed-fisheries métiers	Gear	Target species
LLS_DEF	Longline trawls	Demersal fish
LLS_FIF	Longline trawls	Fin fish
OTB_DEF	Otter trawls	Demersal fish
OTT_DEF	Twin otter trawls	Demersal fish
OTB_CRU	Otter trawls	Crustaceans
OTT_CRU	Twin otter trawls	Crustaceans
GNS_DEF	Gillnets	Demersal fish
GTR_DEF	Trammel nets	Demersal fish
SSC_DEF	Scottish seines	Demersal fish
SDN_DEF	Danish seines	Demersal fish
TBB_DEF	Beam trawls	Demersal fish
FPO_CRU	Static pots	Crustaceans
OTH / MIS_MIS	Other miscellaneous gears	Any
Outside (of 7bc,e-k)	All gears	Any

Table 3.4. 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 Discards
2019	ank.27.78abd	9244	3125	1.000	1.000	9244	3125
2020	ank.27.78abd	8590	2716	1.000	1.000	8590	2716
2021	ank.27.78abd	9015	4884	1.000	1.000	9015	4884
2019	cod.27.7e-k	1069	299	1.000	0.959	1069	312
2020	cod.27.7e-k	922	231	0.976	1.000	944	231
2021	cod.27.7e-k	914	580	1.000	1.000	914	580
2019	hke.27.3a46-8abd	83038	13030	1.000	1.000	83038	13030
2020	hke.27.3a46-8abd	73194	10208	1.000	1.000	73194	10208
2021	hke.27.3a46-8abd	69604	8657	1.000	1.000	69604	8657
2019	meg.27.7b-k8abd	12652	1984	1.000	1.000	12652	1984
2020	meg.27.7b-k8abd	11749	2400	1.000	1.000	11749	2400
2021	meg.27.7b-k8abd	12953	2935	1.000	1.000	12953	2935
2019	mon.27.78abd	19495	3159	1.000	1.000	19495	3159
2020	mon.27.78abd	19458	3087	1.000	1.000	19458	3087

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
2021	mon.27.78abd	22777	3796	1.000	1.000	22777	3796
2019	sol.27.7fg	1067	145	0.998	1.000	1069	145
2020	sol.27.7fg	1523	106	0.999	1.000	1524	106
2021	sol.27.7fg	1335	62	0.999	1.000	1337	62
2019	whg.27.7b-ce-k	6589	970	1.000	0.998	6589	972
2020	whg.27.7b-ce-k	5931	1266	0.999	0.987	5939	1283
2021	whg.27.7b-ce-k	6154	1223	1.000	0.979	6154	1249
2019	had.27.7b-k	7657	3584	0.989	0.975	7743	3676
2020	had.27.7b-k	7859	4260	0.996	0.846	7888	5035
2021	had.27.7b-k	9259	2280	1.000	0.942	9259	2419
2019	sol.27.7e	1185	0	1.000	NA	1185	0
2020	sol.27.7e	1219	0	1.000	NA	1219	0
2021	sol.27.7e	1392	0	1.000	NA	1392	0
2019	nep.out.7	216	0	1.000	NA	216	0
2020	nep.out.7	304	0	1.000	NA	304	0
2021	nep.out.7	346	0	1.000	NA	346	0

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
2019	nep.fu.22	2083	262	1.000	1.000	2083	262
2020	nep.fu.22	1518	288	0.996	0.996	1525	290
2021	nep.fu.22	1616	149	1.000	1.000	1616	149
2019	nep.fu.2021	2723	539	1.000	1.000	2723	539
2020	nep.fu.2021	413	34	1.000	1.000	413	34
2021	nep.fu.2021	736	49	1.000	1.000	736	49
2019	nep.fu.19	249	112	1.000	1.000	249	112
2020	nep.fu.19	249	136	1.000	1.000	249	136
2021	nep.fu.19	415	173	1.000	1.000	415	173
2019	nep.fu.16	2229	NA	1.000	NA	2229	0
2020	nep.fu.16	1899	NA	0.975	NA	1947	0
2021	nep.fu.16	2476	NA	0.999	NA	2479	0
2019	nep.fu.17	167	21	0.990	0.990	168	21
2020	nep.fu.17	222	54	0.996	0.996	223	54
2021	nep.fu.17	498	88	0.999	0.999	498	88
2019	ank.27.78abd	9244	3125	1.000	1.000	9244	3125

Year	Stock	Working Group Landings (WGCSE, WGBIE)	Working Group Discards (WGCSE, WGBIE)	Ratio of Landings	Ratio of Discards	WGMIXFISH Landings	WGMIXFISH Discards
2020	ank.27.78abd	8590	2716	1.000	1.000	8590	2716
2021	ank.27.78abd	9015	4884	1.000	1.000	9015	4884
2019	cod.27.7e-k	1069	299	1.000	0.959	1069	312

Table 3.5. Comparison between the outputs from the reproduction of the advice and ICES advice. Values for 2022 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	% difference
2022	ank.27.78abd	catch	15058	14606	3.1
2022	ank.27.78abd	discards	4249	4148	2.4
2022	ank.27.78abd	Fbar	0.098	0.098	0
2022	ank.27.78abd	landings	10811	10458	3.4
2022	ank.27.78abd	Recruitment	146922	146922	0
2022	ank.27.78abd	ssb	48273	48272	0
2022	cod.27.7e-k	catch	1174	1174	0
2022	cod.27.7e-k	discards	235	0	Inf
2022	cod.27.7e-k	Fbar	1.069	1.069	0
2022	cod.27.7e-k	landings	939	0	Inf
2022	cod.27.7e-k	Recruitment	1305	1305	0
2022	cod.27.7e-k	ssb	1196	1196	0
2022	had.27.7b-k	catch	15320	15320	0
2022	had.27.7b-k	discards	3012	3012	0
2022	had.27.7b-k	Fbar	0.443	0.443	0
2022	had.27.7b-k	landings	12308	12308	0
2022	had.27.7b-k	Recruitment	275943	275943	0
2022	had.27.7b-k	ssb	50999	50999	0
2022	hke.27.3a46-8abd	catch	77809	74935	3.8
2022	hke.27.3a46-8abd	discards	8650	5371	61.1
2022	hke.27.3a46-8abd	Fbar	0.195	0.198	-1.5
2022	hke.27.3a46-8abd	landings	69383	69563	-0.3
2022	hke.27.3a46-8abd	Recruitment	898602	898602	0
2022	hke.27.3a46-8abd	ssb	181048	186358	-2.8
2022	meg.27.7b-k8abd	catch	19422	19412	0.1
2022	meg.27.7b-k8abd	discards	2800	2800	0
2022	meg.27.7b-k8abd	Fbar	0.19	0.19	0
2022	meg.27.7b-k8abd	landings	16611	16612	0
2022	meg.27.7b-k8abd	Recruitment	221058	221058	0
2022	meg.27.7b-k8abd	ssb	96645	96645	0
2022	mon.27.78abd	catch	25109	24770	1.4
2022	mon.27.78abd	discards	3361	3330	0.9
2022	mon.27.78abd	Fbar	0.135	0.135	0
2022	mon.27.78abd	landings	21760	21440	1.5
2022	mon.27.78abd	Recruitment	107677	107677	0
2022	mon.27.78abd	ssb	55783	55742	0.1
2022	sol.27.7e	catch	1507	1507	0
2022	sol.27.7e	discards	7	7	0
2022	sol.27.7e	Fbar	0.287	0.29	-1
2022	sol.27.7e	landings	1500	1500	0
2022	sol.27.7e	Recruitment	4077	4077	0
2022	sol.27.7e	ssb	5624	5624	0
2022	sol.27.7fg	catch	1337	1337	0

Year	Stock	Value	FCube.baseline	Single.Spp.Advice	% difference
2022	sol.27.7fg	discards	79	79	0
2022	sol.27.7fg	Fbar	0.246	0.246	0
2022	sol.27.7fg	landings	1258	1258	0
2022	sol.27.7fg	Recruitment	5111	5111	0
2022	sol.27.7fg	ssb	6231	6221	0.2
2022	whg.27.7b-ce-k	catch	10741	10741	0
2022	whg.27.7b-ce-k	discards	1513	1513	0
2022	whg.27.7b-ce-k	Fbar	0.701	0.701	0
2022	whg.27.7b-ce-k	landings	9228	9228	0
2022	whg.27.7b-ce-k	Recruitment	400108	400108	0
2022	whg.27.7b-ce-k	ssb	32346	32346	0
2023	ank.27.78abd	catch	24093	23436	2.8
2023	ank.27.78abd	discards	4698	4643	1.2
2023	ank.27.78abd	Fbar	0.163	0.156	4.5
2023	ank.27.78abd	landings	19398	18793	3.2
2023	ank.27.78abd	Recruitment	147092	147092	0
2023	ank.27.78abd	ssb	51133	49454	3.4
2023	cod.27.7e-k	catch	0	0	NA
2023	cod.27.7e-k	discards	0	NA	NA
2023	cod.27.7e-k	Fbar	0	0	NA
2023	cod.27.7e-k	landings	0	0	NA
2023	cod.27.7e-k	Recruitment	1305	1305	0
2023	cod.27.7e-k	ssb	1053	1053	0
2023	had.27.7b-k	catch	11901	11901	0
2023	had.27.7b-k	discards	2837	2837	0
2023	had.27.7b-k	Fbar	0.353	0.353	0
2023	had.27.7b-k	landings	9064	9064	0
2023	had.27.7b-k	Recruitment	275943	275943	0
2023	had.27.7b-k	ssb	47157	47157	0
2023	hke.27.3a46-8abd	catch	87479	83130	5.2
2023	hke.27.3a46-8abd	discards	11083	6770	63.7
2023	hke.27.3a46-8abd	Fbar	0.24	0.24	0
2023	hke.27.3a46-8abd	landings	76701	76360	0.4
2023	hke.27.3a46-8abd	Recruitment	891837	891837	0
2023	hke.27.3a46-8abd	ssb	164029	168765	-2.8
2023	meg.27.7b-k8abd	catch	23883	23596	1.2
2023	meg.27.7b-k8abd	discards	3370	3332	1.1
2023	meg.27.7b-k8abd	Fbar	0.233	0.23	1.3
2023	meg.27.7b-k8abd	landings	20494	20264	1.1
2023	meg.27.7b-k8abd	Recruitment	221058	221058	0
2023	meg.27.7b-k8abd	ssb	96184	96184	0
2023	mon.27.78abd	catch	34949	34540	1.2
2023	mon.27.78abd	discards	4461	4437	0.5
2023	mon.27.78abd	Fbar	0.192	0.192	0
2023	mon.27.78abd	landings	30505	30103	1.3
2023	mon.27.78abd	Recruitment	107829	107829	0

Year	Stock	Value	FCube.baseline	Single.Spp.Advice	% difference
2023	mon.27.78abd	ssb	56892	56201	1.2
2023	sol.27.7e	catch	1394	1394	0
2023	sol.27.7e	discards	6	6	0
2023	sol.27.7e	Fbar	0.29	0.29	0
2023	sol.27.7e	landings	1388	1388	0
2023	sol.27.7e	Recruitment	4077	4077	0
2023	sol.27.7e	ssb	5052	5052	0
2023	sol.27.7fg	catch	1335	1338	-0.2
2023	sol.27.7fg	discards	78	80	-2.5
2023	sol.27.7fg	Fbar	0.251	0.251	0
2023	sol.27.7fg	landings	1257	1258	-0.1
2023	sol.27.7fg	Recruitment	5111	5111	0
2023	sol.27.7fg	ssb	6128	6120	0.1
2023	whg.27.7b-ce-k	catch	1723	1715	0.5
2023	whg.27.7b-ce-k	discards	204	203	0.5
2023	whg.27.7b-ce-k	Fbar	0.09	0.09	0
2023	whg.27.7b-ce-k	landings	1519	1512	0.5
2023	whg.27.7b-ce-k	Recruitment	400108	400108	0
2023	whg.27.7b-ce-k	ssb	30343	30343	0
2024	ank.27.78abd	ssb	52006	50314	3.4
2024	cod.27.7e-k	ssb	2754	2754	0
2024	had.27.7b-k	ssb	48157	48157	0
2024	hke.27.3a46-8abd	ssb	148277	148841	-0.4
2024	meg.27.7b-k8abd	ssb	90695	90976	-0.3
2024	mon.27.78abd	ssb	53815	53140	1.3
2024	sol.27.7e	ssb	4541	4541	0
2024	sol.27.7fg	ssb	5932	5903	0.5
2024	whg.27.7b-ce-k	ssb	36563	36571	0
2023	nep.fu.16	catch	3787	3787	0
2023	nep.fu.16	discards	0	0	NA
2023	nep.fu.16	discards.dead	0	0	NA
2023	nep.fu.16	discards.surviving	0	0	NA
2023	nep.fu.16	Fbar	0.062	0.062	0
2023	nep.fu.16	landings	3787	3787	0
2023	nep.fu.17	catch	363	363	0
2023	nep.fu.17	discards	50	51	-2
2023	nep.fu.17	discards.dead	38	38	0
2023	nep.fu.17	discards.surviving	13	13	0
2023	nep.fu.17	Fbar	0.052	0.052	0
2023	nep.fu.17	landings	312	312	0
2023	nep.fu.19	catch	338	338	0
2023	nep.fu.19	discards	108	108	0
2023	nep.fu.19	discards.dead	81	81	0
2023	nep.fu.19	discards.surviving	27	27	0

Year	Stock	Value	FCube.baseline	Single.Spp.Advice	% difference
2023	nep.fu.19	Fbar	0.056	0.056	0
2023	nep.fu.19	landings	230	230	0
2023	nep.fu.2021	catch	1803	1803	0
2023	nep.fu.2021	discards	183	183	0
2023	nep.fu.2021	discards.dead	137	137	0
2023	nep.fu.2021	discards.surviving	46	46	0
2023	nep.fu.2021	Fbar	0.06	0.06	0
2023	nep.fu.2021	landings	1620	1620	0
2023	nep.fu.22	catch	2548	2548	0
2023	nep.fu.22	discards	300	300	0
2023	nep.fu.22	discards.dead	225	225	0
2023	nep.fu.22	discards.surviving	75	75	0
2023	nep.fu.22	Fbar	0.116	0.116	0
2023	nep.fu.22	landings	2248	2248	0
2023	nep.out.7	catch	150	150	0
2023	nep.out.7	discards	0	NA	NA
2023	nep.out.7	discards.dead	NA	NA	NA
2023	nep.out.7	discards.surviving	NA	NA	NA
2023	nep.out.7	Fbar	NA	NA	NA
2023	nep.out.7	landings	150	150	0

Table 3.6 Mixed-fisheries advice in the Celtic Sea. Catch (in tonnes) per mixed-fisheries scenario 2022, in absolute values.

Stock	Single-stock catch advice (2023)^	Catch per mixed-fisheries scenario (2023)					
		max	min	sq_E	cod-cs	had-cs	whg-cs
ank.27.78abd	23436	23466	14478	15113	14421	17233	14890
cod.27.7e-k	0	1505	0	1153	0	1001	229
had.27.7b-k	11901	21175	0.28	14544	0.260	11801	2107
hke.27.3a46-8abd	83130	95320	47661	74128	47608	73758	60390
meg.27.7b-k8abd	23596	31017	4301	20151	4301	15451	6167
mon.27.78abd	34540	38644	20310	25481	20068	26035	21058
sol.27.7e	1394	1974	0	1273	0	914	186
sol.27.7fg	1338	2063	0	1317	0	602	108
whg.27.7b-ce-k	1715	14517	0	10388	0	8859	1703
nep.fu.16	3787	5290	0	2871	0	2159	381
nep.fu.17	363	428	0	239	0	188	33
nep.fu.19	338	397	0	233	0	205	35
nep.fu.2021	1803	3072	0	1698	0	1370	242
nep.fu.22	2548	3491	0	1927	0	1519	272
nep.27.7outFU	150	232	0	128	0	100	18

^ Advised catches of no more than the indicated value.

Table 3.7. Mixed-fisheries advice in the Celtic Sea. Fishing mortality per mixed-fisheries scenario 2023, in absolute values.

Stock	Single-stock F advice (2023)	F(2023) resulting from mixed-fisheries scenarios					
		max	min	sq_E	cod-cs	had-cs	whg-cs
ank.27.78abd*	0.156	0.159	0.095	0.099	0.095	0.114	0.098
cod.27.7e-k	0	1.774	0	1.081	0	0.868	0.148
had.27.7b-k	0.353	0.731	0.000007538834	0.451	0.000007050179	0.352	0.056
hke.27.3a46-8abd	0.24	0.266	0.123	0.2	0.123	0.199	0.159
meg.27.7b-k8abd	0.23	0.318	0.038	0.193	0.038	0.144	0.055
mon.27.78abd*	0.192	0.215	0.107	0.136	0.106	0.139	0.111
sol.27.7e	0.29	0.424	0	0.252	0	0.174	0.033
sol.27.7fg	0.251	0.421	0	0.248	0	0.106	0.018
whg.27.7b-ce-k	0.09	1.147	0	0.704	0	0.57	0.089
nep.fu.16**	0.062	0.087	0	0.047	0	0.035	0.006
nep.fu.17**	0.052	0.065	0	0.036	0	0.028	0.005
nep.fu.19**	0.056	0.075	0	0.044	0	0.038	0.007
nep.fu.2021**	0.06	0.107	0	0.059	0	0.048	0.008
nep.fu.22**	0.116	0.167	0	0.092	0	0.073	0.013

Legend

$F_{2023} \leq F_{MSY}$

$F_{MSY} < F_{2023} \leq F_{pa}$

$F_{pa} < F_{2023} \leq F_{lim}$

$F_{2023} > F_{lim}$

***ank.27.78abd and mon.27.78abd have no F_{lim}.**

****Norway lobster stocks have no F_{pa} or F_{lim} limits, and so colours relate to above (black) or below (white) F_{MSY} harvest ratios.**

Table 3.8. Mixed-fisheries advice in the Celtic Sea. Spawning Stock Biomass per mixed-fisheries scenario 2024, in absolute values.

Stock	Single-stock advice	SSB (2024) resulting from mixed-fisheries scenarios					
		max	min	sq_E	cod-cs	had-cs	whg-cs
ank.27.78abd	50314	52166	55590	55347	55611	54539	55432
cod.27.7e-k	2754	587	2735	1051	2735	1264	2390
had.27.7b-k	48157	37997	60799	45058	60799	48037	58544
hke.27.3a46-8abd	148841	143788	166468	153829	166493	154005	160376
meg.27.7b-k8abd	90976	82999	111048	94351	111048	99287	109074
mon.27.78abd	53140	52463	58676	56923	58758	56736	58423
sol.27.7e	4541	4141	6075	4825	6075	5176	5891
sol.27.7fg	5903	5128	7307	5912	7307	6669	7192
whg.27.7b-ce-k	36571	25991	38090	29294	38090	30527	36564

Legend

	$SSB_{2024} > B_{pa}$ or MSY $B_{trigger}$
	$SSB_{2024} > B_{lim}$, no B_{pa} defined
	B_{pa} or MSY $B_{trigger} \geq bSSB_{2024} > B_{lim}$
	$SSB_{2024} \leq B_{lim}$

Table 3.9. Mixed-fisheries advice in the Celtic Sea (Technical request). Catch (in tonnes) per mixed-fisheries scenario 2023, in absolute values.

Stock	Single-stock catch advice (2023)	Catch per mixed-fisheries scenario (2023)		
		Haddock F_{MSY}	Haddock $F_{MSY\ lower}$	Haddock $F_{MSY\ lower} – F_{MSY}$
ank.27.78abd	23958	17628	16566	17098
cod.27.7e-k	0	1002	717	869
had.27.7b-k	11901	11829	7820	9883
hke.27.3a46-8abd	83130	75967	70049	73022
meg.27.7b-k8abd	23596	15521	11503	13535
mon.27.78abd	34476	26254	23977	25119
sol.27.7e	1394	916	617	769
sol.27.7fg	1338	604	385	495
whg.27.7b-ce-k	1715	8879	6069	7535
nep.fu.16	3787	2165	1355	1760
nep.fu.17	363	189	118	153
nep.fu.19	338	205	128	167
nep.fu.2021	1803	1374	860	1117
nep.fu.22	2548	1523	954	1238
nep.out.7	150	100	63	81

Table 3.10. Mixed-fisheries advice in the Celtic Sea (Technical request). TAC year (2023) fishing mortality per mixed-fisheries scenario 2023, in absolute values.

Stock	Single-stock F advice (2023)	Fishing mortality per mixed-fisheries scenario (2023)		
		Haddock F_{MSY}	Haddock $F_{MSY\ lower}$	Haddock $F_{MSY\ lower} – F_{MSY}$
ank.27.78abd	0.117	0.11	0.113	0.101
cod.27.7e-k	0.87	0.55	0.71	0.15
had.27.7b-k	0.353	0.221	0.287	0.056
hke.27.3a46-8abd	0.206	0.188	0.197	0.166
meg.27.7b-k8abd	0.145	0.105	0.125	0.055
mon.27.78abd	0.141	0.128	0.134	0.112
sol.27.7e	0.174	0.114	0.144	0.033
sol.27.7fg	0.106	0.067	0.086	0.018
whg.27.7b-ce-k	0.572	0.358	0.465	0.09
nep.fu.16	0.035	0.022	0.029	0.006
nep.fu.17	0.028	0.018	0.023	0.005
nep.fu.19	0.039	0.024	0.031	0.007
nep.fu.2021	0.048	0.03	0.039	0.009
nep.fu.22	0.073	0.046	0.059	0.013

Table 3.11. Mixed-fisheries advice in the Celtic Sea (Technical request). TAC year + 1 (2024) SSB per mixed-fisheries scenario 2023, in absolute values.

Stock	Single-stock advice SSB (2024)	Spawning-stock biomass (2024)		
		Haddock F_{MSY}	Haddock $F_{MSY\ lower}$	Haddock $F_{MSY\ lower} - F_{MSY}$
ank.27.78abd	23958	54388	54793	54590
cod.27.7e-k	0	1261	1671	1450
had.27.7b-k	11901	48009	52262	50083
hke.27.3a46-8abd	83130	152955	155770	154355
meg.27.7b-k8abd	23596	99213	103443	101303
mon.27.78abd	34476	56662	57433	57046
sol.27.7e	1394	5174	5468	5319
sol.27.7fg	1338	6668	6898	6782
whg.27.7b-ce-k	1715	30512	32838	31612

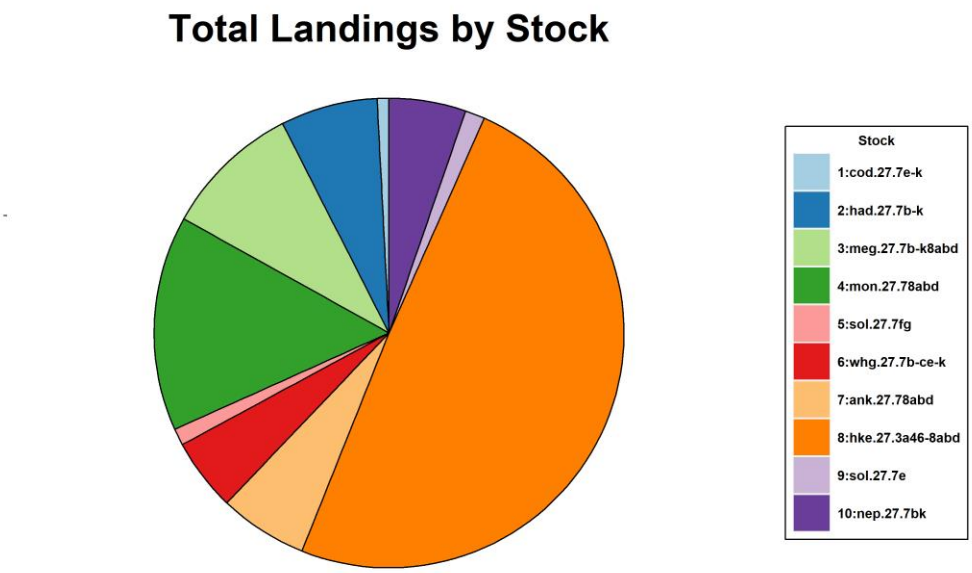


Figure 3.1. Celtic Sea. Distribution of landings of those stocks included in the mixed fisheries projections.

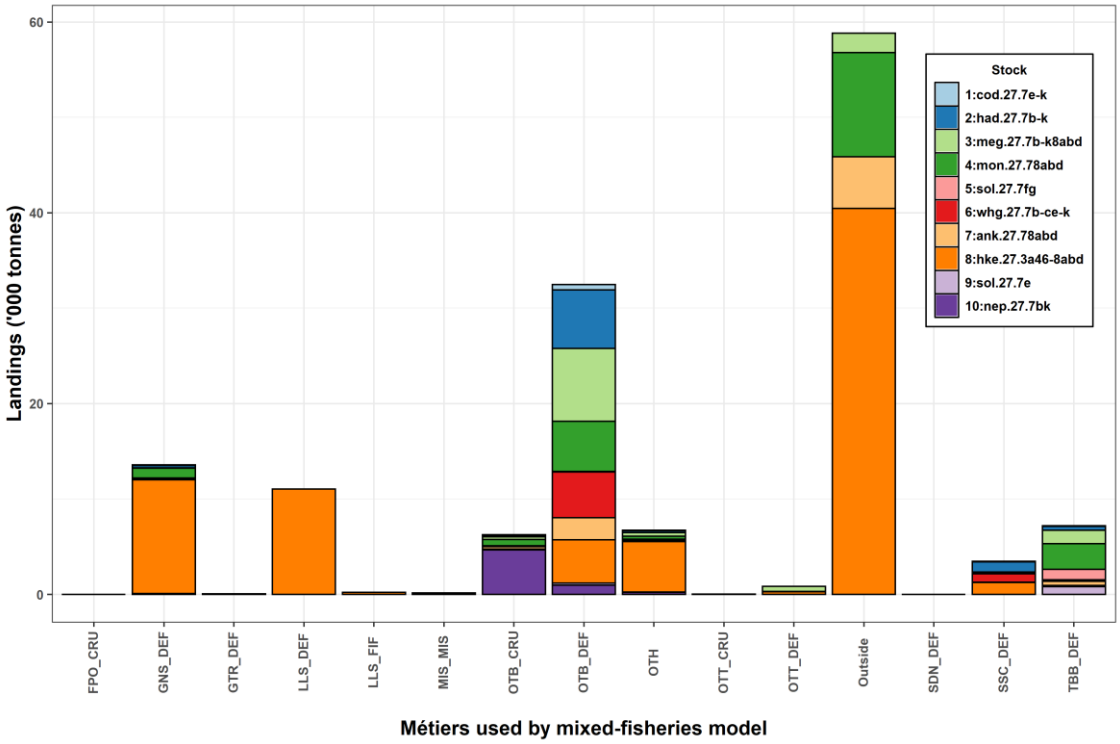


Figure 3.2. Celtic Sea. Landings distribution of species by métier with landings consisting of ≥ 1% of any of the stocks (1-7) (average from 2019-2021) Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks (1–7) (average from 2019-2021).

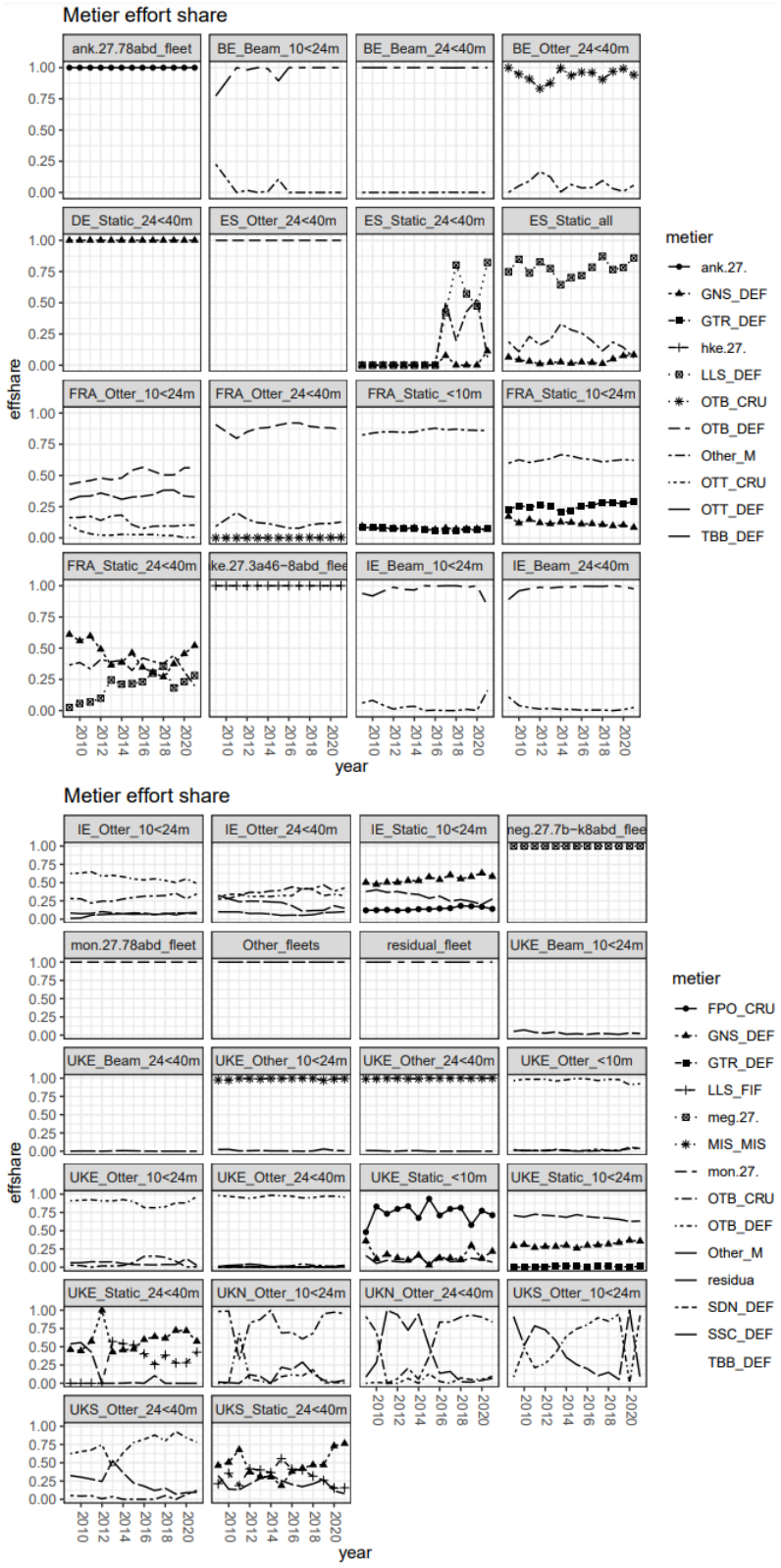


Figure 3.3. Effort share (in proportion) by métier and by year for each fleet.

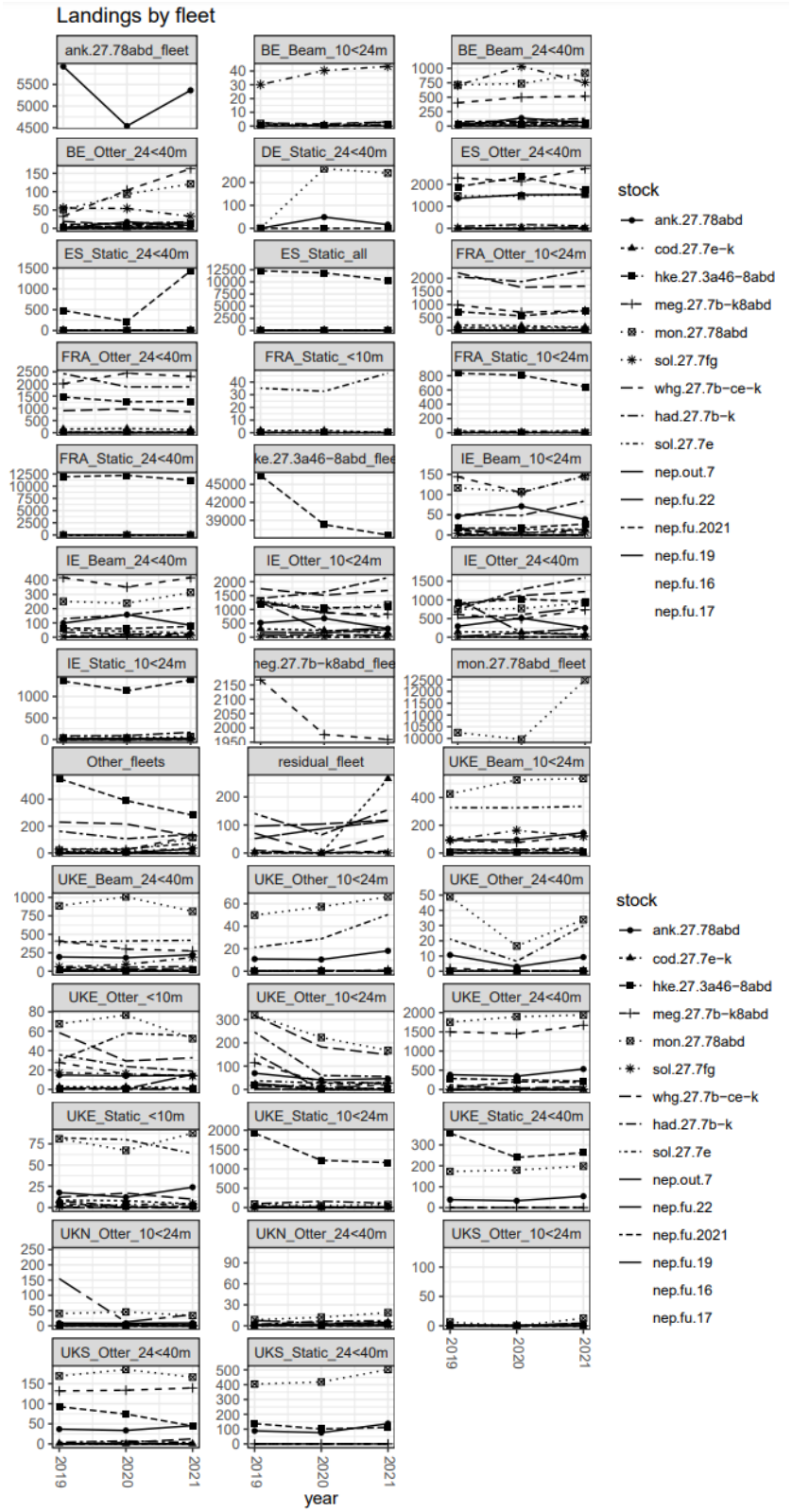


Figure 3.4. Landings by fleet, stock and year. Note: different scales on the y-axis.

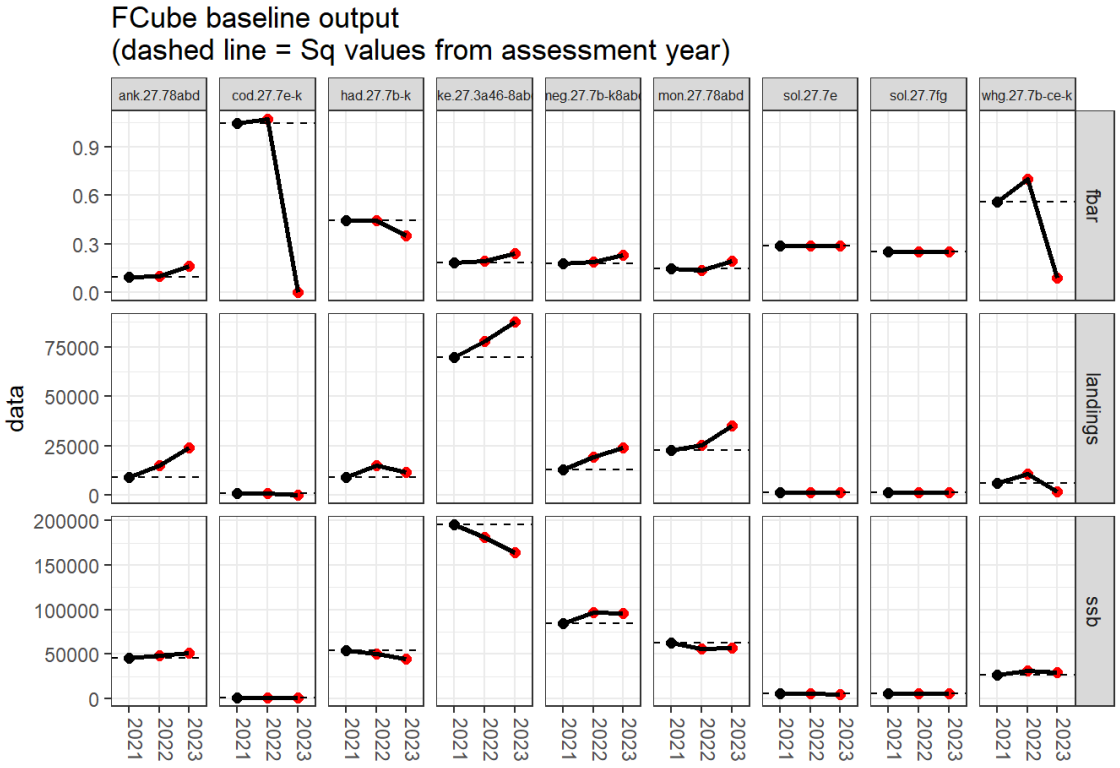


Figure 3.5. Change in fishing mortality (Fbar), landings (tonnes) and SSB (tonnes) assumed in the intermediate year (2022) and required for the TAC year (2023) under the single-stock forecast assumptions consistent with the MSY approach.

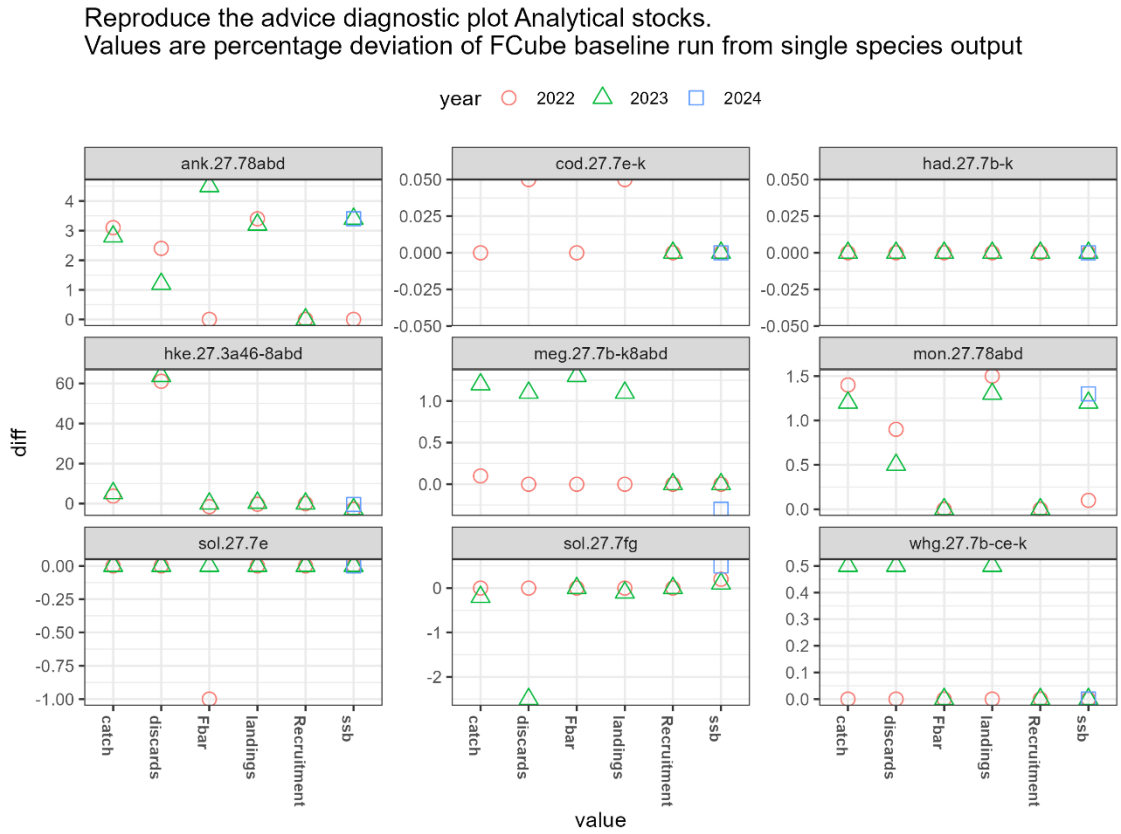


Figure 3.6. Celtic Sea. Difference between FCube baseline run and single-species advice for finfish stocks, showing Fbar (2022–2023), catch, discards and landings (2022–2023) and SSB (2021–2024).

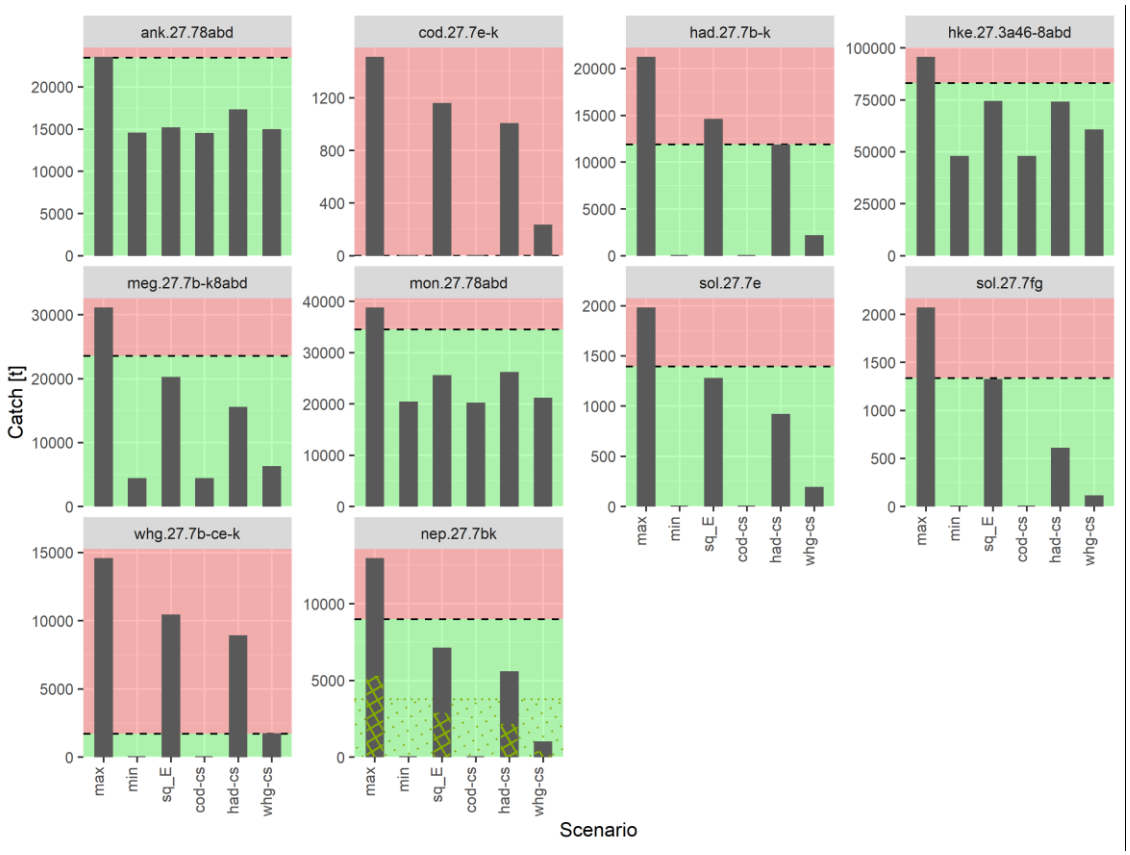


Figure 3.7. Celtic Sea. TAC year results (2023). FCube estimates of potential landings by stock after applying the status quo effort scenario to all stocks in the intermediate year followed by the FCube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value 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. The hashed bars in nep.27.7bk indicate the proportion of catches of Norway lobster caught in FU16 and the dotted line indicates the catch limit which applies in this FU.

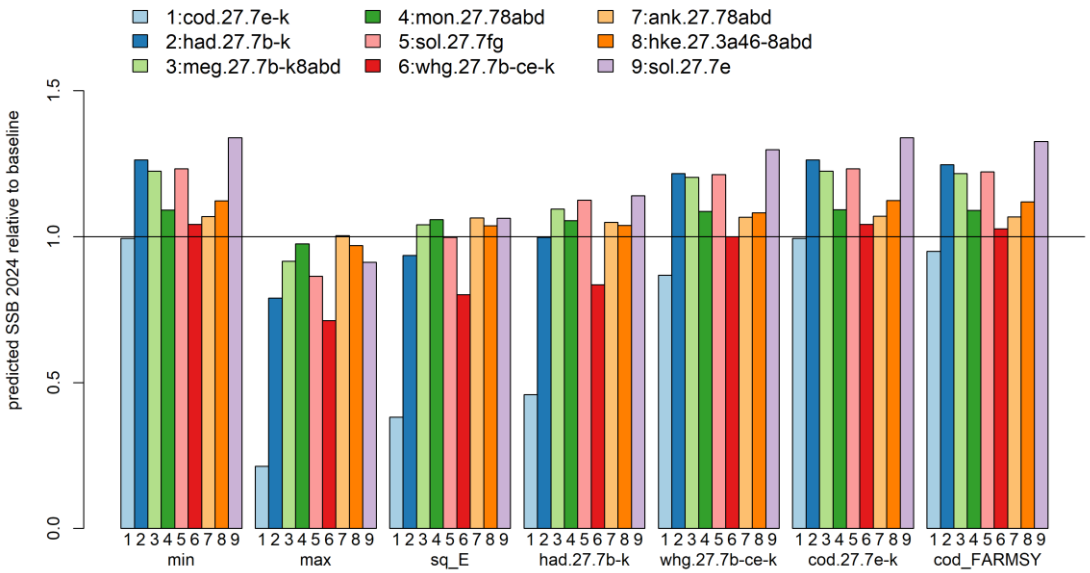


Figure 3.8. Mixed fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential SSB at the start of 2024 by stock after applying the mixed fisheries scenarios, relative to SSB resulting from the single-stock advice forecast (the horizontal line).

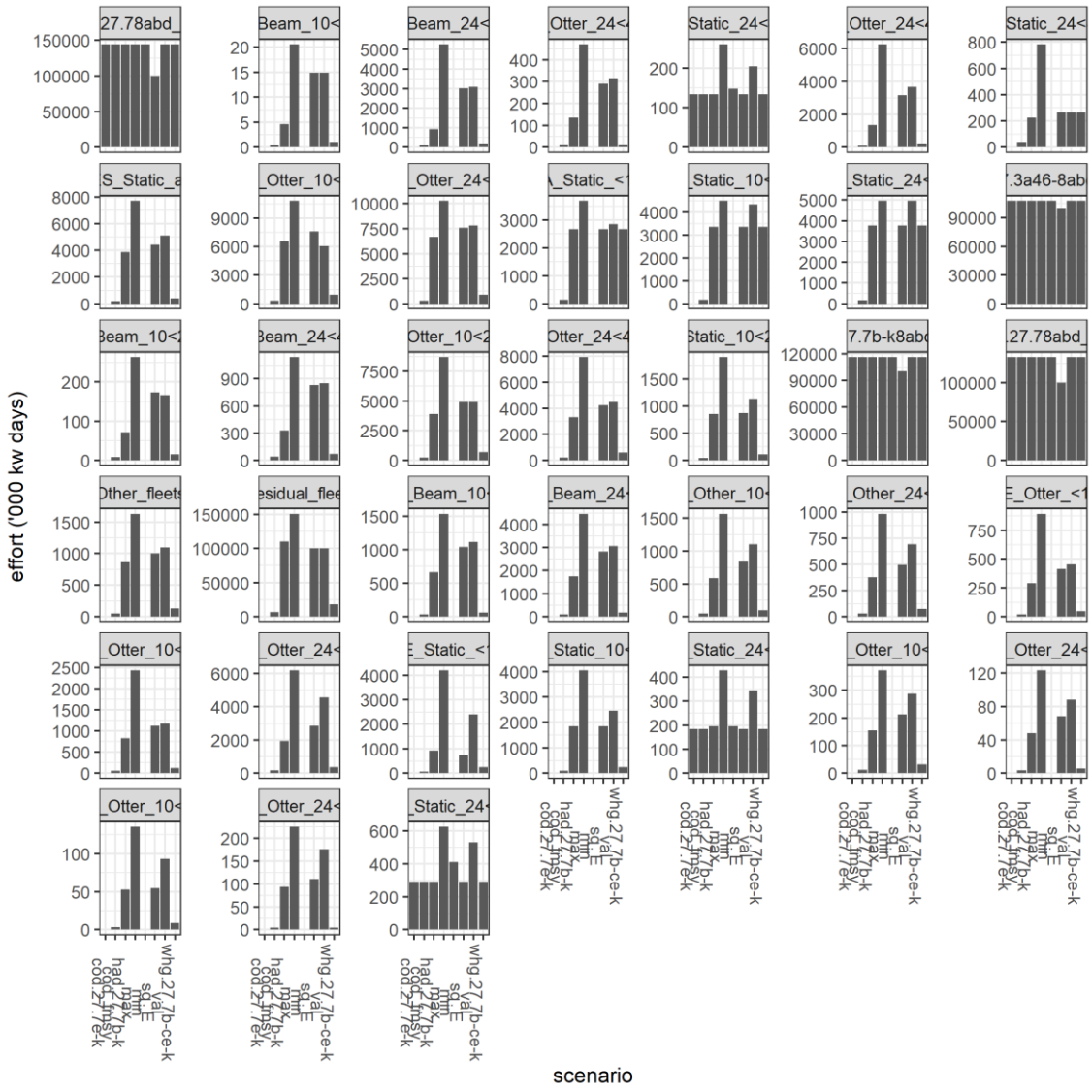
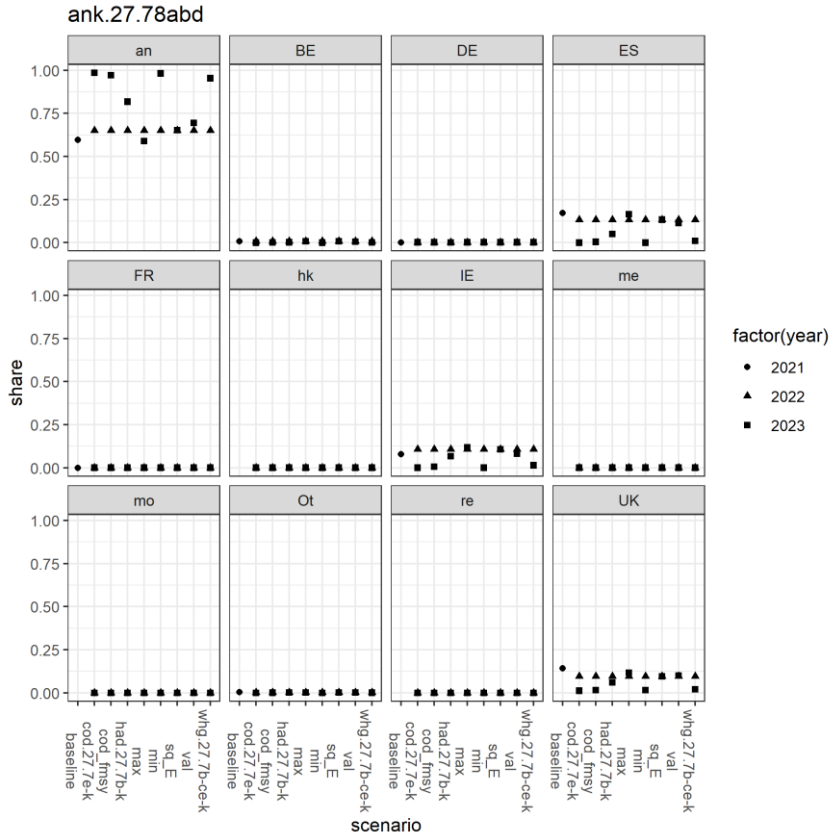


Figure 3.93. Celtic Sea. FCube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2023 (baseline run).

Figure 3.4. Mixed fisheries for the Celtic Sea. Estimates of effort by fleet needed to reach each single-stock advice. The stocks are coded by colour, with the bar for the most limiting stock ("choke species") for each fleet in 2023 highlighted with a red border and the bar for the least limiting species highlighted with a green border. Fleet names are given by country, main gear, and vessel length (m). The status quo effort for each fleet (average 2019-2021) is shown as a dashed line for reference.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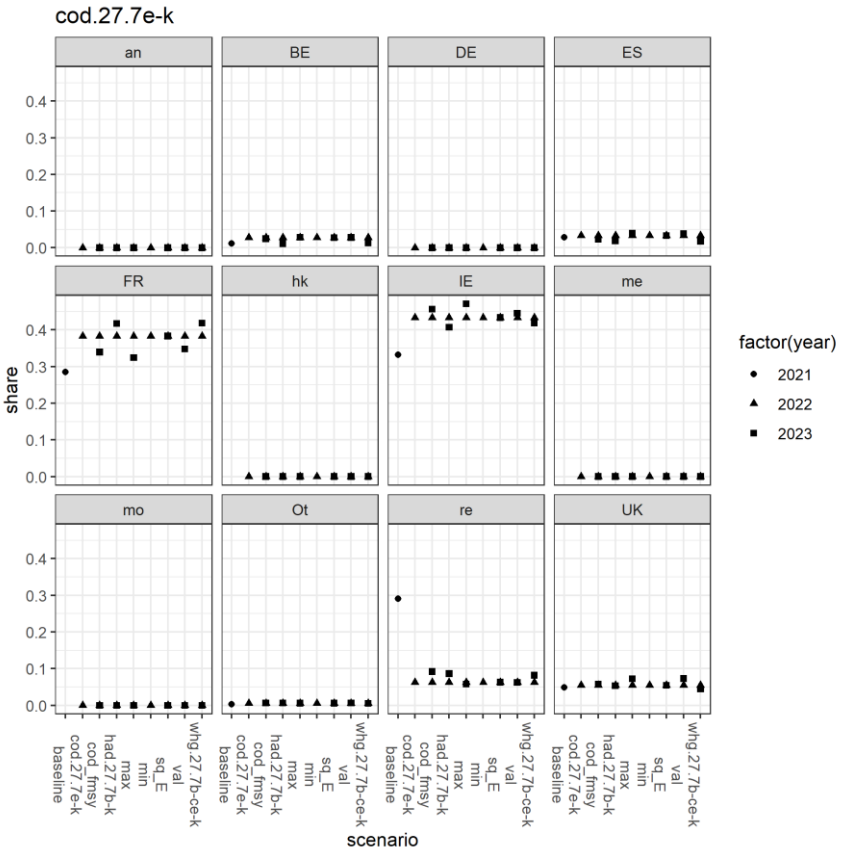
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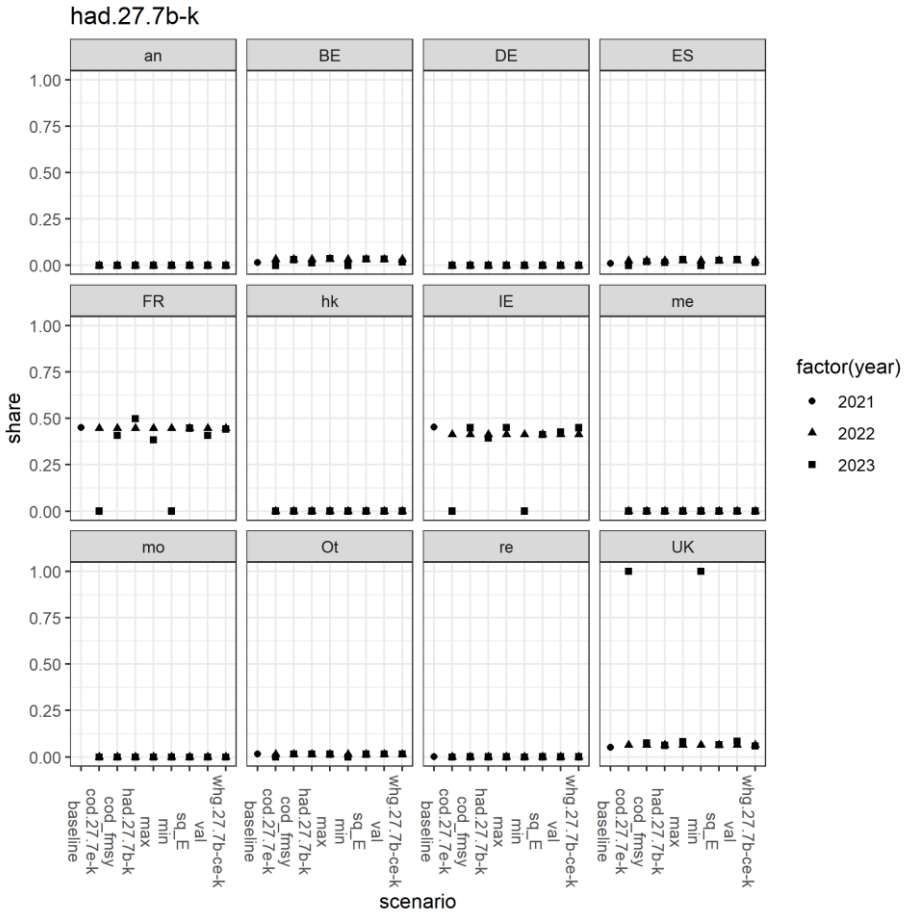
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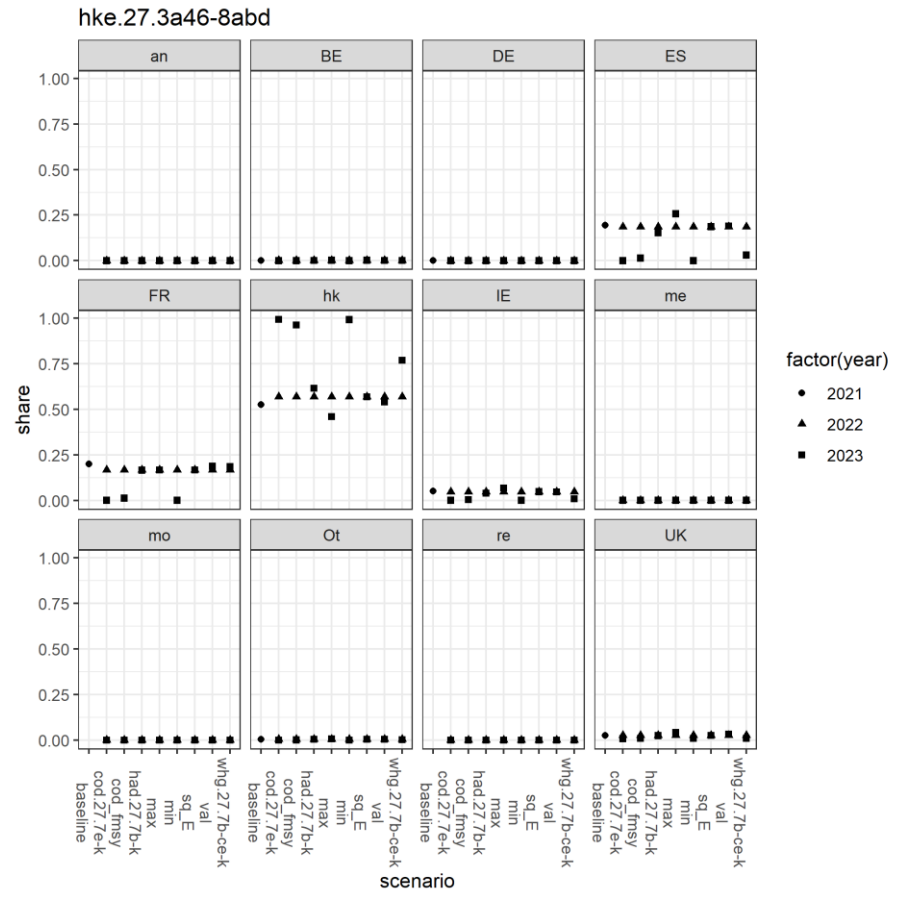
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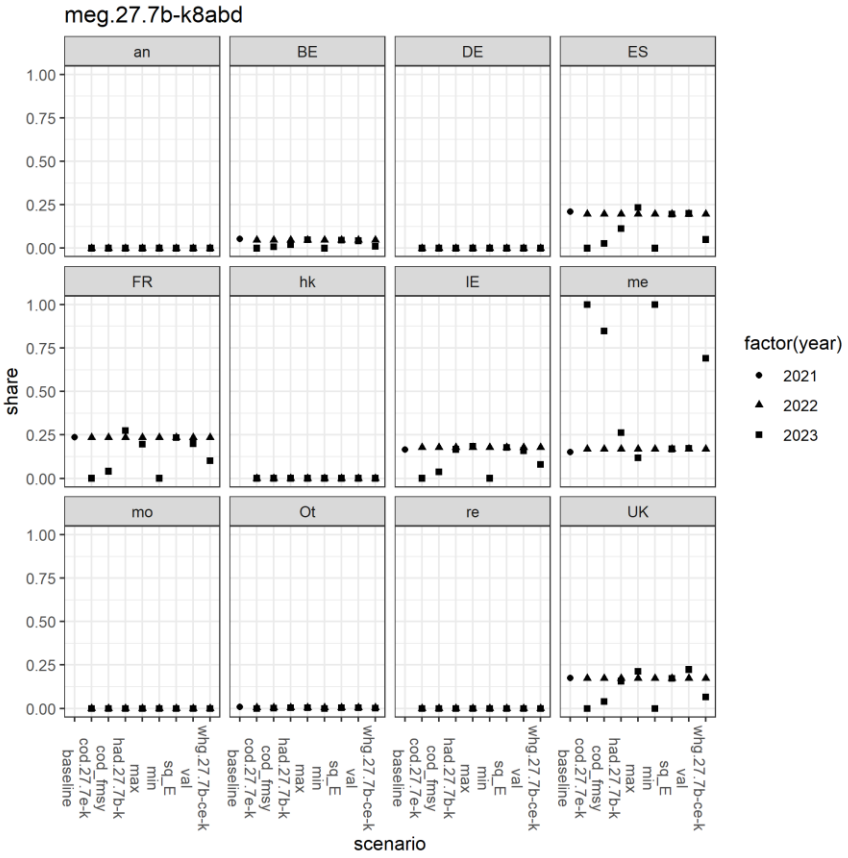
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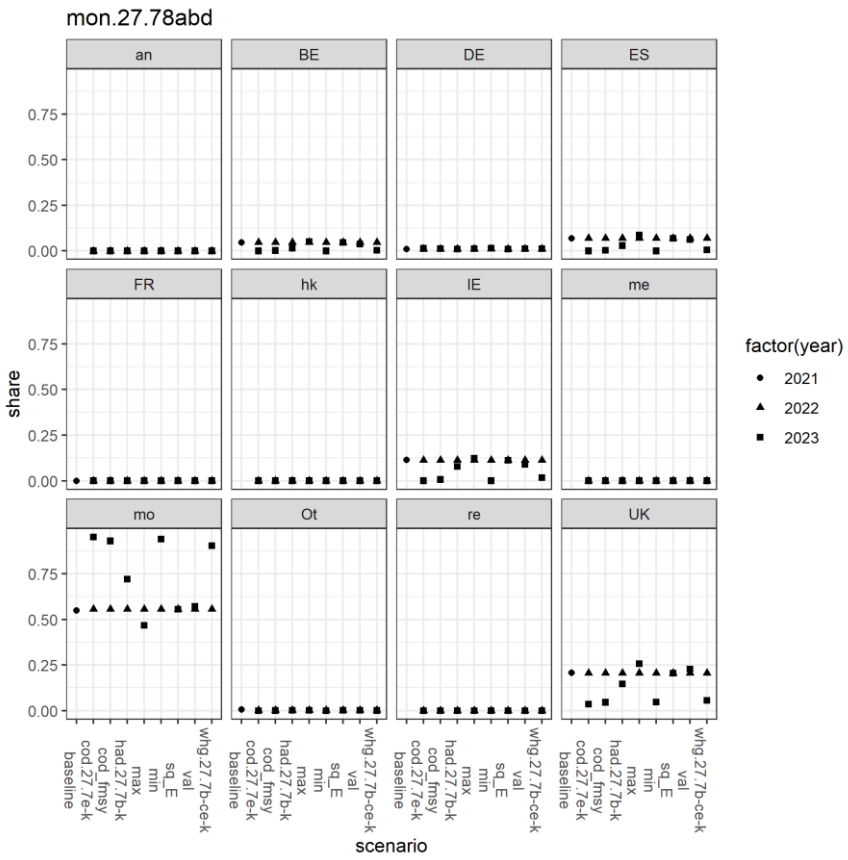
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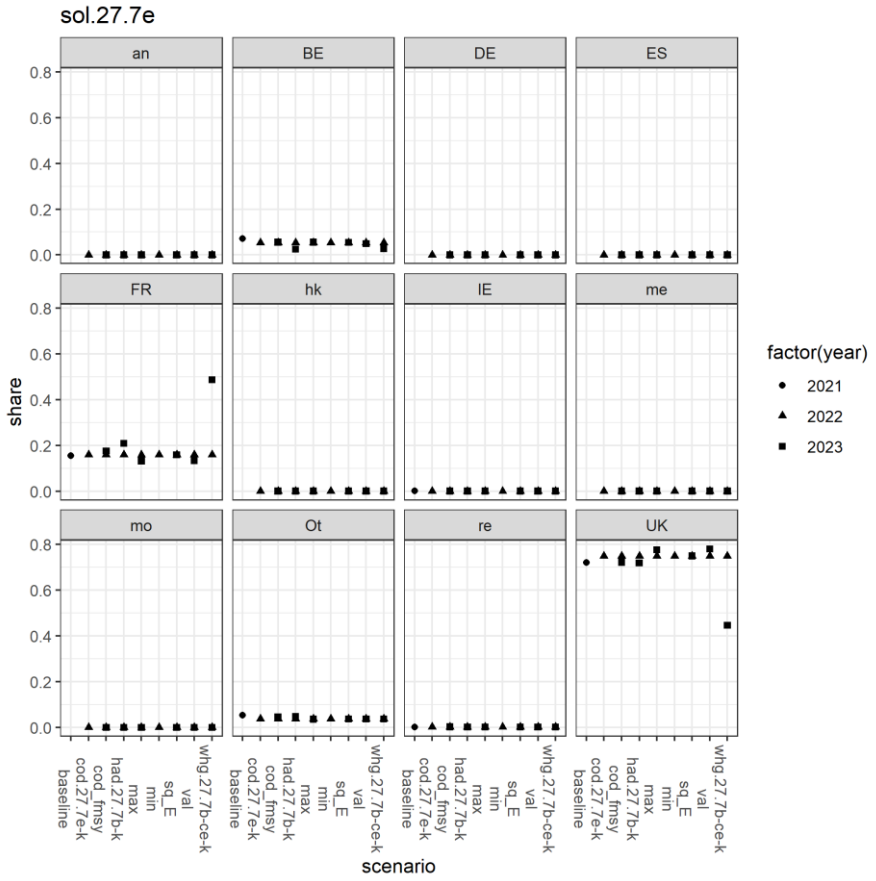
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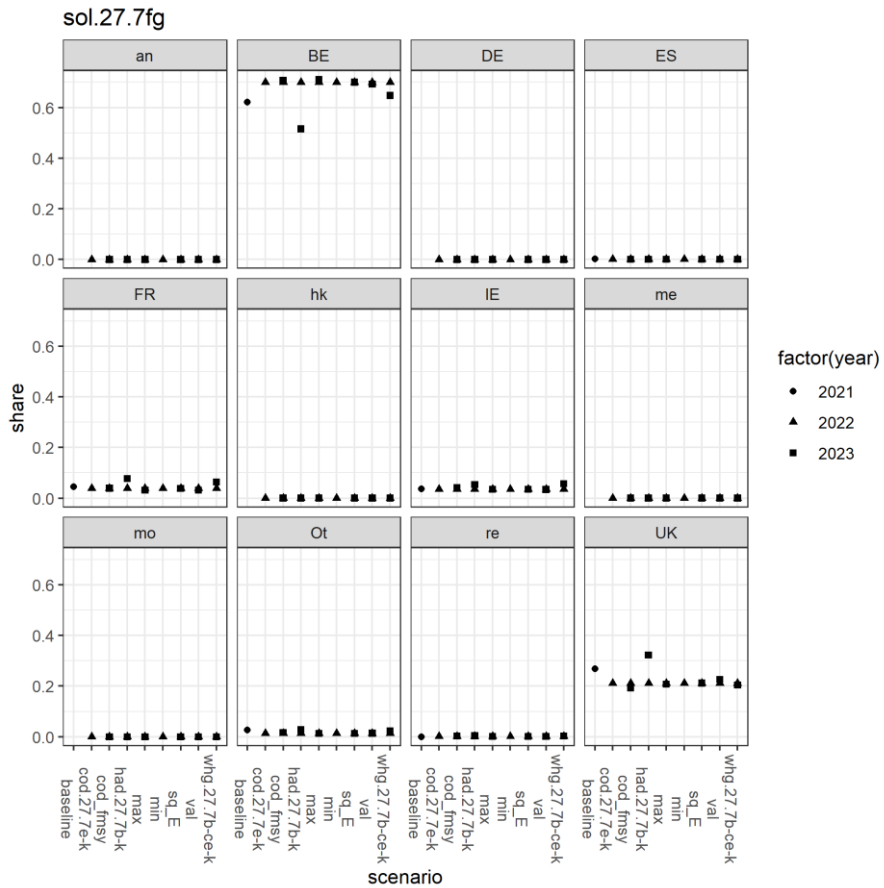
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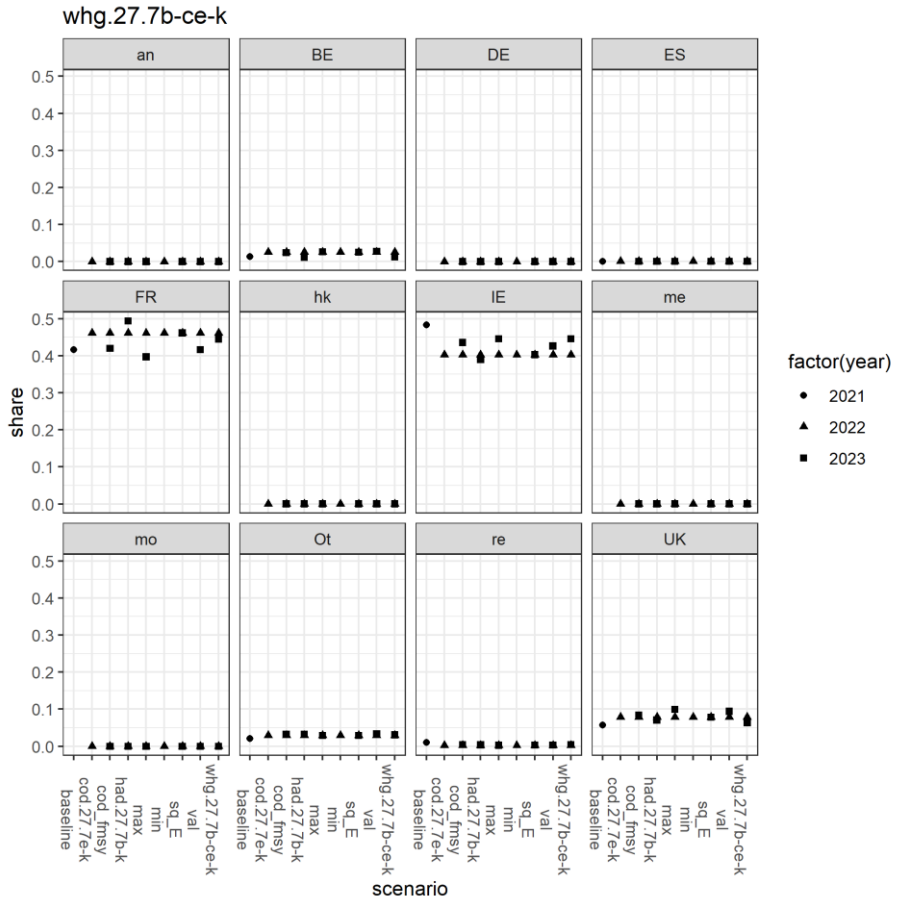

Figure 3.5. Test for relative stability. Changes of relative share of species' landings by country in 2021 and 2023 compared to the 2022 share, for the 'baseline' and 7 FCube scenarios.

3.5 References

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4 Iberian waters

4.1 Background

Fisheries operating within the Atlantic Iberian Coast Ecoregion catch a wide range of different species, including those considered to be demersal, pelagic, wide-ranging and deep sea. Various elasmobranch species are also caught.

Portuguese and Spanish demersal fisheries are typically mixed, catching a wide variety of species, reflecting the biological diversity of the areas they exploit. These fisheries are executed using a number of different gear types. Trawl fisheries (using otter or pair trawls) land *Nephrops*, hake, anglerfishes, megrims, blue whiting, mackerel, horse mackerel as well as cephalopods (cuttlefish and squid). Gillnet fisheries target sole, hake, pollack and anglerfishes, while a longline fishery targets mainly hake. Analyses of the Spanish demersal fleets in divisions 8.c and 9.a show that the main target species are blue whiting, mackerel, hake, horse mackerel, anglerfishes and megrims. Three pelagic/semi-pelagic species (blue whiting, mackerel, and horse mackerel) constitute 61% of the total landings in these demersal métiers. In the Portuguese demersal métiers the most important species caught by the demersal fish trawlers are horse mackerel, mackerel, hake and blue whiting. The three pelagic/semi-pelagic species (blue whiting, mackerel, and horse mackerel) constitute 41% of the total landings in these demersal métiers. The Portuguese crustacean trawlers target mainly Norway lobster, rose shrimp, and blue whiting. Hake, anglerfishes, sole, and rays are present in trawl catches but they are mainly caught by artisanal métiers using gill- and trammelnets.

There is a large small-scale multi-gear fleet operating in the area which uses a diversity of gears that allow exploitation of ecological communities in different habitat types, depths, and substrata. The composition of the landings depends largely on the fishing gear used and on the ecological community of the fishing grounds visited, which may change seasonally. Fleet segmentation of this large small-scale fleets presents a challenge in the area.

The fisheries are mainly carried out by Portuguese and Spanish vessels, with a small participation of French vessels

This mixed fisheries analysis will consider finfish species in the ICES Divisions 8.c (Bay of Biscay – South) and 9.a (Portuguese waters - East). The species considered are part of the demersal mixed fisheries of the Atlantic Iberian Waters, and include hake (hke.27.8c9a), four-spot megrim (ldb.27.8c9a), megrim (meg.27.8c9a), black-bellied anglerfish (ank.27.8c9a) and white anglerfish (mon.27.8c9a). As mentioned above there are other stocks in the area that could be relevant to describe the effort allocation and technical interactions in the area. The introduction of new species will improve the scope and relevance of this mixed fisheries analysis.

4.1.1 Management measures

Total allowable catch (TAC) is the main fishery management tool in this region. These were introduced for most stocks in the 1980s, but the TACs (and quotas) were generally not restrictive until the early 1990s. The 2013 reform of the Common Fisheries Policy aimed to eliminate discarding through the introduction of the EU landing obligation (LO). The LO was introduced for pelagic species in 2015 and has been phased in for demersal TAC species since 2016. Since 2019 the LO has applied to all TAC species, although there are some exemptions. Delegated Regulation (EU) 2019/2237 included a *de minimis* exemption for hake caught with trawls and seines, megrims caught with gillnets, trawls and seines and anglerfishes caught with gillnets, trawls and

seines in ICES subareas 8 and 9. A large number of technical measures are in place. These include measures to improve the selectivity of towed gears (partly in order to reduce bycatch) and gear restrictions (ICES, 2020).

Spatial management also occurs, both for fisheries and for ecosystem reasons. Closed areas/seasons are used to protect spawning and juvenile fish, for example. Protected areas have also been designated for habitats and species listed by EU Nature Directives (ICES, 2020). Fishery regulations are in place to restrict certain fisheries that may affect vulnerable habitats.

The Regulation (EU) 2019/472 of the European Parliament and of the Council, published on 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. Fishing opportunities for 2020 were presented in EU Reg. 2020/123. The new multiannual management plan (MAP, EU Regulation 2019/472) includes 36 demersal and deep-sea stocks including 15 Norway lobster FUs in Western Waters, 7 of those stocks (FUs) are caught in ICES division 8c and 9a. The five stocks considered in the mixed fisheries analysis of Iberian Waters; hake (hke.27.8c9a), megrim (meg.27.8c9a), four-spot megrim (ldb.27.8c9a), black-bellied (ank.27.8c9a) and white anglerfishes (mon.27.8c9a) are included in this new multiannual management.

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 4.0.1 (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-BELLIED ANGLERFISH ank.27.8c9a	Surplus Production model (SpiCT)	NA
HAKE hke.27.8c9a	Length-based age-structured Stock Synthesis model (SS3)	SS3
FOUR-SPOT MEGRIM ldb.27.8c9a	Statistical catch-at-age model (a4a)	FLR STF
MEGRIM meg.27.8c9a	Statistical catch-at-age model (a4a)	FLR STF
WHITE ANGLERFISH mon.27.8c9a	Length-based age-structured Stock Synthesis model (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 2022, ICES single-stock catch advice was given according to the EU MAP for the Western Waters and adjacent waters (MSY level) for hake, megrims and white anglerfish and the MSY approach for black-bellied anglerfish (stock summaries in **Error! Reference source not found.**). T he same basis was retained in the current mixed fisheries framework, in which the following eight scenarios are considered in the advice:

Scenario code	Scenarios
max	**"Maximum":** For each fleet, fishing stops when all stocks have been caught up to the fleet 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 stock share. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks.
ank	**"Black-bellied anglerfish":** All fleets set their effort corresponding to that required to catch their black-bellied anglerfish stock share, regardless of other catches.
hke	**"Hake":** All fleets set their effort corresponding to that required to catch their hake stock share, regardless of other catches.
ldb	**"Four-spot megrim":** All fleets set their effort corresponding to that required to catch their four-spot megrim stock share, regardless of other catches.
meg	**"Megrim":** All fleets set their effort corresponding to that required to catch their megrim stock share, regardless of other catches.
mon	**"White anglerfish":** All fleets set their effort corresponding to that required to catch their white anglerfish stock share, regardless of other catches.
sq_E	***"Status quo* effort":** The effort of each fleet in the catch advice year (2023) is set equal to the average effort in the most recent three years (2019–2021) for which catch and effort data are available.

4.3 Stock input data and recent trends

4.3.1 Stock data

The assessment data for the different stocks is taken each year from the ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (ICES, 2022a). For hake and both megrims, total catches (landings and discards) are included in the single-stock assessment. The assessment of white anglerfish and black-bellied anglerfish just include landings, as discards are almost negligible for these species.

The assessment data for the stocks with analytical assessment were directly provided by the respective stock coordinators, as an FLStock object for white anglerfish, megrims and hake. White anglerfish and hake are assessed using a Stock Synthesis length and/or seasonal based statistical assessment. However, the implementation of FLBEIA requires an annual and age-based dynamics and the assumption made in the assessment model for these two species cannot be fully

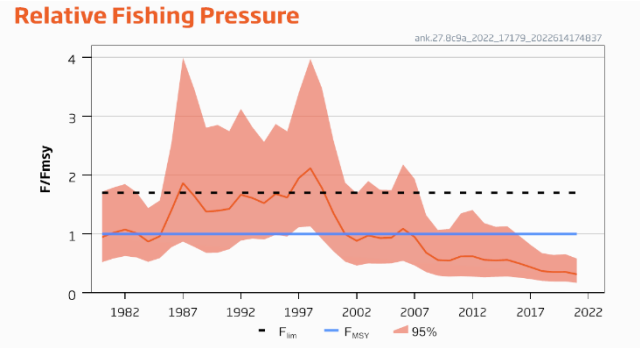
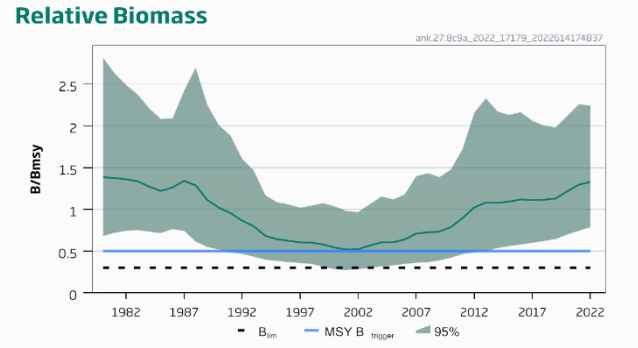
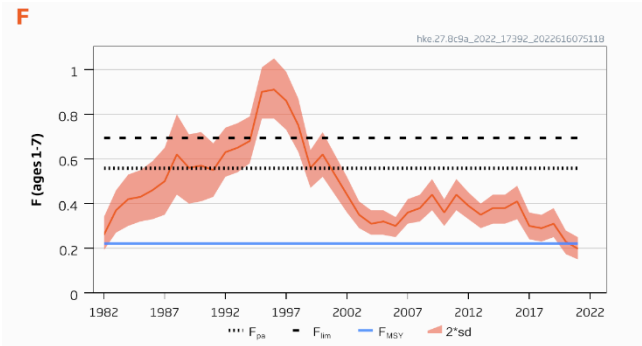
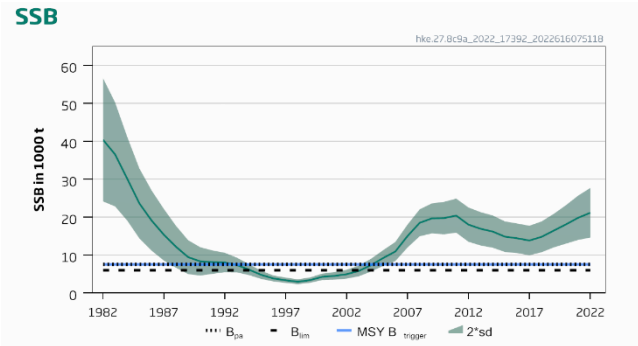
replicated. This can lead to differences in the projections carried out with both approaches mainly due to the difference between the length-based model used for this stock and the age-based model applied in the mixed-fisheries analysis. The projections carried out with FLBEIA are routinely compared to those carried out in the single-species assessment working group to assess the potential impact of using different approaches. The black-bellied anglerfish stock is assessed with a surplus production model (SPiCT). The single-stock advice for black-bellied anglerfish is provided following the ICES guidelines for category 2 stocks (ICES, 2022b).

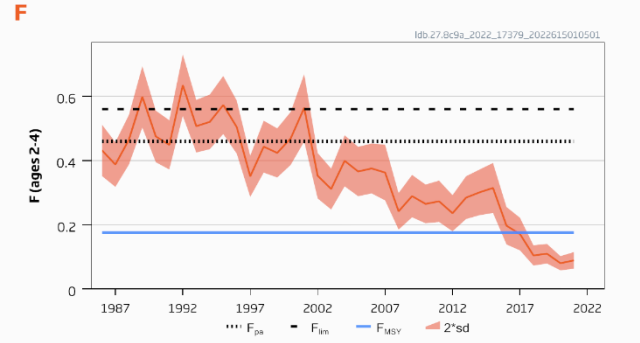
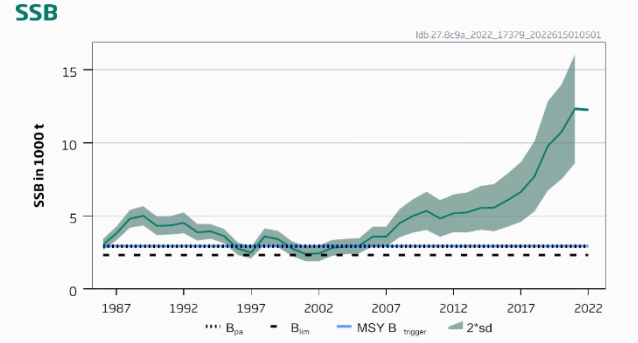
This year, hake and megrim stocks were benchmarked and assessment models and forecast methodologies changed. The updated single-species assessment and forecast methods are outlined in section 4.5.1.1.

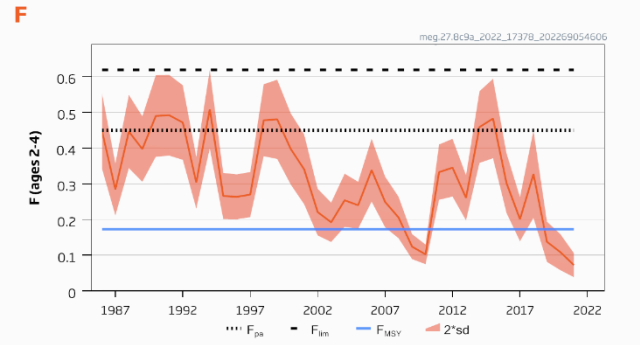
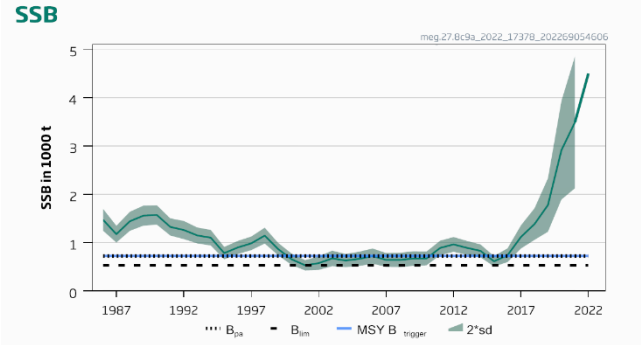
4.3.2 Stock trends and advice

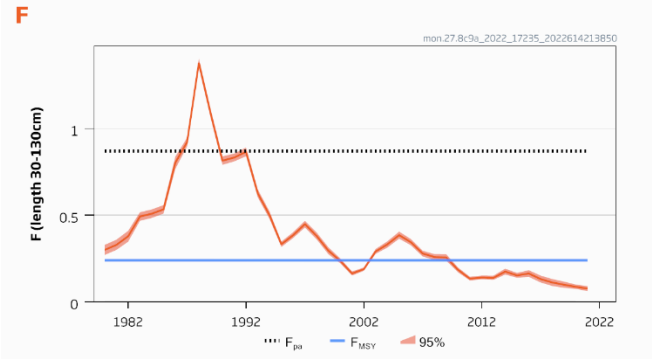
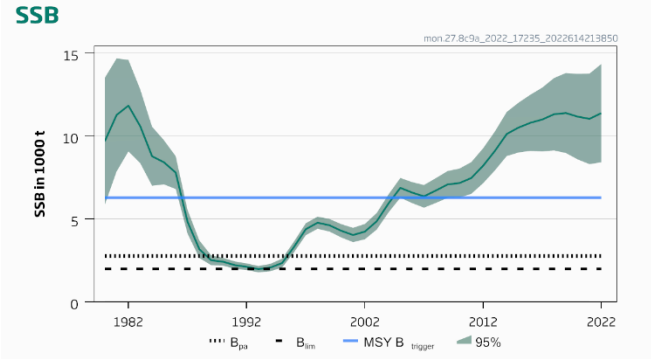
Recent trends in SSB, F and recruitment are described on a stock-by-stock basis in ICES (2022a), and latest advice for 2023 by stock is available on the ICES website. In order to give a global overview of the Iberian demersal stocks included in this analysis, this information is summarised below. Table 4.1 provides an overview of the F and SSB trends for the stocks included in the mixed-fisheries advice and summarizes the advice, SSB and target Fs resulting from the advice approaches considered by ICES (ICES, 2022a).

Table 4.1. Summary of stocks included in the mixed-fisheries advice.

Species	Area	Stock status	Advice 2023
ank.27.8c-9a (black-bellied anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 	**Summary:** Fishing pressure on the stock is below F_{MSY} and biomass is above MSY $B_{trigger}$ and B_{lim}. **Advice:** ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 2064 tonnes.
hke.27.8c-9a (Hake)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 	**Summary:** Fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim **Advice**: ICES advises that when the EU multiannual plan (MAP) is applied catches in 2023 that correspond to the F ranges in the plan are between 8322 and 15925 tonnes. Catches higher than those corresponding to F_{MSY} (11791 tonnes) can only be taken under conditions specified in the MAP.

Species	Area	Stock status	Advice 2023
ldb.27.8c-9a. (Four-spot Megrim)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 	**Summary:** The fishing pressure on the stock is below FMSY; spawning-stock size is above MSY Btrigger, Bpa, and Blim. **Advice:** ICES advises that when the EU multiannual plan (MAP) is applied catches in 2023 that correspond to the F ranges in the plan are between 1595 and 3421 tonnes. Catches higher than those corresponding to F_{MSY} (2282 tonnes) can only be taken under conditions specified in the MAP.

Species	Area	Stock status	Advice 2023
meg.27.8c-9a (Megrim)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 	**Summary:** Fishing pressure on the stock is below FMSY; spawning stock size is above MSY Btrigger, Bpa, and Blim.. **Advice:** ICES advises that when the EU multiannual plan (MAP) is applied catches in 2023 that correspond to the F ranges in the plan are between 654 and 1456 tonnes. Catches higher than those corresponding to F_{MSY} 968 tonnes) can only be taken under conditions specified in the MAP

Species	Area	Stock status	Advice 2023
mon.27.8c-9a (white anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	 	**Summary:** Fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim. **Advice:** ICES advises that when the EU multiannual plan (MAP) is applied catches in 2023 that correspond to the F ranges in the plan are between 1613 and 2986 tonnes. Catches higher than those corresponding to F_{MSY} 2271 tonnes) can only be taken under conditions specified in the MAP

4.4 Fleets and métiers

4.4.1 Catch and effort data

The mixed-fisheries assessment is based on catch and effort data provided by the National laboratories and administrations to the annual ICES data calls (InterCatch database: discards and landings by stock, area and metier, consistent with the DCF definition of métiers), and data collected by STECF for the evaluation of the effort regime (Accessions data, that contains information on landings and fishing effort by area, quarter and metier). These fishery data, structured by DCF fleet segments and métiers, are used as inputs together with ICES single-stock data and advice, in the integrated FLBEIA framework.

The final dataset extracted from InterCatch for use by WGBIE includes discards estimates for all stocks and some métiers, which are used to estimate the discard ratio for the mixed-fisheries fleets in the assessment of hake and both megrims (anglerfish stocks discards are considered negligible). InterCatch files also provided non-reported landings (ICES WGBIE estimates) 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 provides a small number of landings that are considered negligible (less than 1% of the total catch) and not considered for WGMIXFISH analysis in this area. Discards and non-reported landings are added from the respective InterCatch files.

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.

Portugal provided a new series of effort and landings for the period 2015-2021, using a new algorithm for métier classification, different from those previously used. Some outdated métiers who had no catches in the last years were removed in the new series. The two megrims and anglerfish species are not usually landed separately for the majority of the commercial categories and they are recorded together. Therefore, estimates of species-specific landings are derived from their relative proportions in market samples and applied to correct Portuguese landings at the species level.

For the period 2009-2016, Spain sent effort and official landings as a unique series. Data for the period 2017-2021 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. Time series of landings and discards were checked between single stock assessment and the data compiled by the WGMIXFISH from data call and InterCatch.

Proportion of landings in 2021 for stocks considered in the mixed fisheries projections is presented in **Error! Reference source not found.**. Hake (hke.27.8c9a) was the dominant species, comprising of 78% of total landings, followed by black-bellied anglerfish (ank.27.8c9a, 7%), four spot megrim (ldb.27.8c9a ,7%), white anglerfish (mon.27.8c9a, 6%) and megrim (meg.27.8c9a, 2%).

Southern hake stock provides the highest catches in almost all fisheries operating in the area with demersal gears. Megrims are mainly caught by the bottom otter trawl targeting demersal fish and anglerfishes by several bottom otter trawl and gillnets (Figure 4.2).

4.4.2 Definition of fleets and métiers

Fleet and métier categories used in the mixed-fisheries analysis are based on the EU Data Collection Framework (DCF) level 6 categories provided by Spain, Portugal and France.

In 2021, 56 métiers were reported through the ICES Data Accessions. InterCatch data included 25 fleet categories with catches on the species considered in the mixed fisheries analysis. 14 fleet segments were aggregated based on their relevance for the Portuguese and Spanish fisheries, gear group and on the species, catchability considered in mixed fisheries advice (Table 4.2). The classification of fleet segments did not include vessel size for Spanish trawlers as the disaggregation by métier already captures this information. In the case of Portugal, the contribution of the small vessels was minor, and their catch profile was similar to the largest vessels profile, hence a single fleet was used for the three trawl size categories. Within the fleet segments, métiers were defined by combining the country, fishing gear and mesh size of both Portuguese and Spanish fleets. The "MIS" métier represents the artisanal multi-gear fleet occurring in the area. These multi-gear fleets use a wide diversity of gears that allows exploitation of different fish communities in different habitats and depths. In 2022, the "Other" metier only included French small métiers which accounts for less than 1% of the catch. Table 4.3 describes the main gear, country, mesh size and target assemblage of the final métier categories used in the mixed-fisheries analysis.

The procedure for defining fleets and métiers was not revised in 2022, and has therefore been the same in the last few years. In order to improve harmonization between the Portuguese and Spanish fleets, which have different technical characteristics in both active and static gears, further analysis should be done on the method for matching and aggregating the métiers used for mixed-fisheries analysis.

4.4.3 Trends

Analyses of trends by fleet were carried out for 2019–2021 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 the Spanish and Portuguese fleet segments are presented in Figure 4.3 and 4.4, respectively. The key assumption in the projections is that catchability by stock and métier and effort distribution (share) in 2022 and 2023 is the average of the last three years (2019-2021). In reality, fishing patterns have slight changes over time but no assessment has been made on the impact of this variability on the simulations.

4.5 Mixed fisheries forecasts

4.5.1 Description of scenarios

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, and
2. 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. 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). Some of the assessments are length based and/or seasonal and this cannot be fully replicated in the

deterministic FLBEIA software. 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 2 black-bellied anglerfish, assessed with surplus production model (SPiCT), the catch estimates in the ICES advice sheet under status quo F/F_{MSY} was used. The Fsq estimates provided in the ICES advice sheets were used for the stocks with analytical assessment.

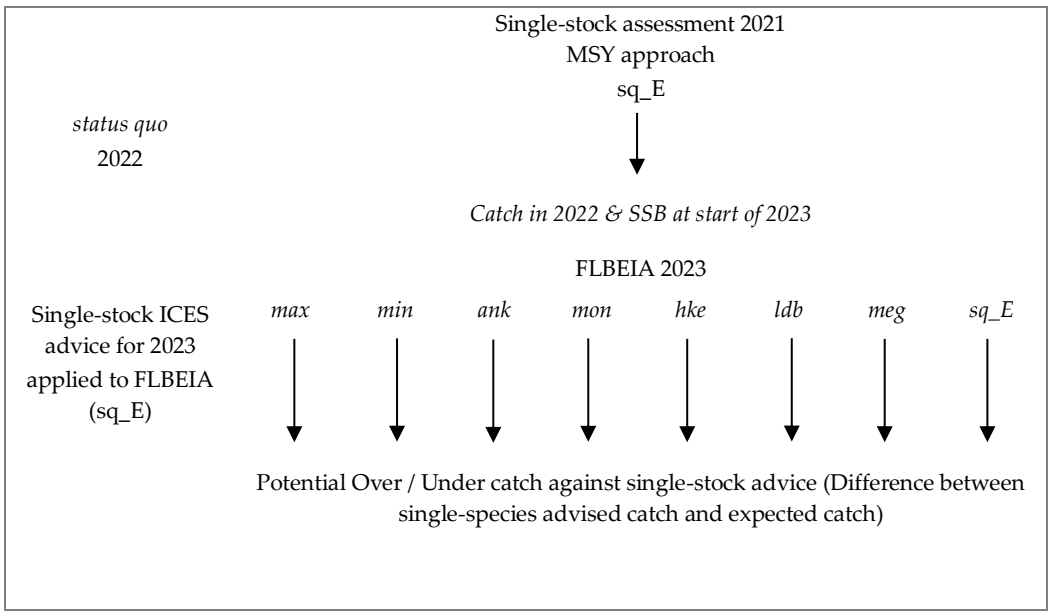
The same forecast settings as in the stock annex for each stock with dynamics (i.e. not including the fixed dynamics used for Category 2 black-bellied anglerfish) are outlined in the table below:

Stocks	Assessment	Forecast	Fbar (range)	Fsq	Weight-at-age	Recruitment	Discards proportion
HAKE 8c9ac	(SS3)	SS3	Age 1-7	Average F (2019–2021)	Time invariant	Estimated BevHolt in SS3	Estimated (fixed)
FOUR-SPOT MEGRIM 8c9a	(a4a)	FLR STF	Age 2-4	Average F (2019–2021)	Average (2017–2021)	GeoMean (1990–2019)	Average (2017–2021)
MEGRIM 8c9a	(a4a)	FLR STF	Age 2-4	Average F (2019–2021)	Average (2017–2021)	GeoMean (1998–2019)	Average (2017–2021)
WHITE ANGLERFISH 8c9a	(SS3)	SS3	30-130cm	Average F (2019–2021)	Time invariant	GeoMean (2003–2021	Discards negligible

Mixed fisheries runs

The mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2022), with the FLBEIA scenarios used for the advice year (2023). 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

Baseline runs

The rationale behind the single-species baseline runs is given in the previous Section **Error! Reference source not found.**. The ICES single-stock advice for category 2 black-bellied anglerfish is based on the MSY approach and for hake, megrims and white anglerfish in 2022 (ICES, 2022a) is based on F ranges in accordance with the EU multiannual plan (MAP) for demersal stocks in the western waters (Regulation (EU) 2019/472). The results from baseline runs (Table 4.4) are compared with the results from the corresponding ICES runs in Table 4.5 (Catch differences) and **Error! Reference source not found.**4.6 (SSB and F differences).

Due to methodological differences between the forecasts conducted in single-species assessments and the deterministic forecast done within WGMIXFISH (section 4.5.1), some discrepancies are to be expected between the baseline run reproducing the assessments. Despite these methodological differences, the differences observed this year were small (< 6%) for all species, except for hake (<12% for F in forecast years). Differences in hake are attributable to the simplified age-based model applied in the mixed-fisheries versus the more complex multi season, sex separated, length-based SS3 model used in this stock. However, the WGMIXFISH deterministic forecast was considered close enough to the single-stock advice to be used as a basis for the mixed-fisheries projections. The issues and problems encountered in replicating the single-species advice for each species are identified below.

White anglerfish: Assessment with length-based SS3 model. The F_{sq}(30-130cm) use in the assessment forecast was defined in FLBEIA as F_{sq}(age1-age10) based on age-length analysis. Discrepancies of 2% in the final assessment year and <3% in the end interim year 2022 and end advice year 2023. Fsq differences of 6% (because of the age range instead of the length range used in the assessment) and 7% in the interim and advice year.

Hake: Assessment with multi season, sex separated, length-based SS3 model. The approach used is summarized in table 4.9. No discrepancies for SSB and F in the final assessment year. <4% SSB differences in the forecast years and below 12% in the F´s.

Four-spot megrim: Assessment with a4a. Discrepancies in SSB were below 2% and 4% in F between FLBEIA run and single stock advice forecast years.

Megrim: Assessment with a4a. below 3% discrepancies in the SSB in the forecast years and <5% in F´s at 2022 between FLBEIA runs and single stock advice forecast.

Black-bellied anglerfish: Category 2 stock, assessment with surplus production model. F and biomass projections are relative to F_{MSY} and B_{MSY}. 2% differences in catch 2022 and no discrepancies in catch 2023.

The outputs of the scenarios at the start of the advice year were all consistent with the single-stock forecasts with minor differences considering the adjusted methods used for the FLBEIA unified framework and each single-species stock methodology. The differences were considered acceptable for modelling the technical interactions between stocks and fleets in the mixed-fisheries scenarios.

Mixed fisheries analyses

The full overview of the FLBEIA scenarios catch and SSB projections is presented in **Error! Reference source not found.**7 and 4.8 and Figure 3..5-4.7. Figures 4.5 to illustrate trade-offs in catches and the potential for quota overshoot and undershoot linked to the most and the least restrictive single-stock fishing opportunities for 2023, for ease of comparison, the landings

relative to the single-stock advice are also presented. Figure 4.6 very similar and shows the estimates of potential 2023 catches by stock and by scenario, the horizontal dashed line corresponds to the single-stock catch advice, with areas above and below the line representing potential over and undershoot respectively. Figure 4.7 illustrates the estimates of potential SSB by stock in the mixed-fisheries scenarios, for ease of comparison, the SSB is expressed as a ratio to the single-stock advice forecast.

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 landing obligation. This scenario reflects the constraints that result from a strictly implemented discard ban. On average, the fishing effort for all fleets should be reduced in 10 % of its 2021 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. For 2023, the **"min"** scenario results are very similar to those of the **"hke"** scenario, indicating that hake is the most limiting stock for all fleets. This scenario shows potential loss of fishing opportunities for black-bellied and white anglerfish and, to a lesser extent, the two megrims stocks (Figure 1).

The **"max"** scenario is included to demonstrate the upper bound of potential fleet effort and stock catches because it assumes that all fleets continue fishing until all the stock shares are exhausted, irrespective of the economic viability of such actions. In 2023, the "max" scenario results in overquota catches for hake, megrim stocks and white anglerfish. The "max" scenario is also very similar to the "ank" scenario and, to a lesser extent, to the "mon" scenario, indicating that anglerfish stocks are the least limiting for most fleets . In these scenarios, the F estimates in 2023 are above the F_{MSY} levels for hake, megrim and four-spot megrim. For white anglerfish, the estimated F is above F_{MSY} in the "max" and "ank" scenarios.

The status quo **"sq_E"** scenario sets the effort of each fleet in 2022 and in 2023 equal to the average of the effort in the most recently recorded three years for which data are available (2019–2021). This scenario investigates the mixed fisheries outcomes if the situation remains the same in terms of total effort and effort allocation among métiers. This scenario shows 2023 advised catch overshoot for hake of 20% and a advised catch undershoot for all other stocks These results are in agreement with the observed ratio of catch to TAC in recent years for the considered stocks.

Within the scenarios based on each of the stocks, the results of **"ank"** and **"mon"** scenario are similar to those of the "**max**" scenario indicating that both anglerfish would be the least limiting stocks. In these scenarios, SSB is estimated to be lower than the single stock advice because of large TAC overshoot. The largest differences in SSB were found in the **"max", "ank" and "mon"** where SSB was estimated to be considerably lower than the single stock advice because of large TAC overshoot. The reduction of SSB is more noticeable in hake and megrims stocks because of the increased effort in these scenarios and technical interaction between these species and the anglerfish stocks (mainly from the bottom trawl gears). The "**mon**" scenario estimates effort levels slightly lower 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 increases by half the advice for both megrims. black-bellied anglerfish is the least limiting stock in 10 fleets of the 11 considered in this analysis (Figure 4.8).

The "**hke**" scenario gives the same result as the **"min"** scenario, showing hake as the choke species in this group and across all fleets considered in mixed fisheries analysis (Figure 4.8)

The "**ldb**" and "**meg**" scenarios provide a similar perspective, increasing the fishing opportunities of both stocks in comparison with the **"hke"** scenario. The "**meg**" scenario, by definition, is also in agreement with the observed average ratio of catch to TAC for this species, very close to 1 in recent years. With the exception of hake (80% above advice), this scenario estimates an undershoot for four-spot megrim and anglerfish stocks very similar to the observed 2016-2021

average ratio of catch to TAC in these species. This could be a consequence of megrims and anglerfishes being caught by the same bottom otter trawl gears, while hake occurs in the catches of almost all the Iberian métiers.

The estimates of effort by fleet are presented in Figure 4.8 showing the most limiting stock ('choke species') and the least limiting species for each fleet in 2023. The status quo effort for each fleet (average 2019-2021) is shown as a dashed line for reference. As expected hake is the most limiting stock for all 11 fleets considered in mixed-fisheries analysis and the black-bellied anglerfish is the least limiting stock in 10 fleets and the four-spot megrim in 1 fleet (SP_MIS).

4.6 References

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Table 4.2. Detailed description of the fleet categories with relevant catches in the species considered in the Iberian waters mixed fisheries analysis and final mixed fisheries metier group.

Acronym	DCF definition	Description	Mixed fisheries métier
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 8c with mesh size of 280 mm	GN1
GNS_DEF_0_0_0	Set gillnet targeting demersal fish	Artisanal Portuguese fleet using set gillnets	GN_GT_LL
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	GN_GT
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	GN2
GTR_DEF_0_0_0	Trammel net targeting demersal fish	Artisanal Portuguese fleet using trammel nets	GN_GT_LL

Acronym	DCF definition	Description	Mixed fisheries métier
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	GN_GT
LLS_DEF_0_0_0	Set longline targeting demersal fish	Spanish set longline targeting a variety of demersal fish in Spanish Iberian waters	GN_GT_LLS
MIS_MIS_0_0_0_HC	Miscellaneous	Portuguese and Spanish artisanal fleet not covered by other métiers	MIS
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	OT_CRU
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 8c and 9a	OT_DEF
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 9a	OT_DEF
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)	OT_MCD
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	OT_PT_MPD
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	OT_PT_MPD

Table 4.3. Final métier categories description used in mixed-fisheries analysis.

Acronym	Gear / country	Mesh size / main target assemblage
GN1	Gillnets / SP	≥ 100 mm / demersal fish
GN2	Gillnets / SP	≥ 80 mm and < 99 mm / demersal fish
GN_GT	Gillnets, trammel nets / SP:PT	≥ 60 mm and < 79 mm / demersal fish
LL_GN_GT	Longlines, gillnets, trammel nets / PT; SP	Any / demersal fish
OT_CRU	Otter trawls / PT	≥ 55 mm / crustaceans
OT_DEF	Otter trawls / PT; SP	≥ 65 mm / demersal fish
OT_MCD	Otter trawls / SP	≥ 55 mm / crustacean; demersal fish
OT_PT_MPD	Otter and pair trawls / SP	≥ 55 mm / pelagic; demersal fish
MIS	Miscellaneous / PT;SP	Any
Others	Other gears	Any

PT- Portugal; SP-Spain

Table 4.4. Baseline run outputs from the FLBEIA package.

Year and Value	ANK* ank.27.8c9a	HKE hke.27.8c9a	LDB ldb.27.8c9a	MEG meg.27.8c9a	MON mon.27.8c9a
2022_Fbar	NA	0.25	0.093	0.106	0.088
2022_Landings	718	8370	1134	267	619
2022_SSB	0	20320	12073	4450	11745
2023_Fbar	NA	0.22	0.176	0.173	0.24
2023_Landings	2064	9659	2091	926	2271
2023_SSB	0	21399	11984	4573	12306
2024_SSB	0	24643	10129	4021	11436

***category 2 B/B_{MSY}**

Table 4.5. Comparison between baseline run and ICES estimated catches for intermediate and advice years. Figures for 2022 compare results from the baseline run - that use the same forecast assumptions in the intermediate year as the forecasts leading to ICES advice

Year and Value	ANK* ank.27.8c9a	HKE hke.27.8c9a	LDB ldb.27.8c9a	MEG meg.27.8c9a	MON mon.27.8c9a
2022_Catches Baseline	732	11738	1218	553	792
2022_Catches ICES	720	11738	1218	553	792
2022_% diff	1.02	1	1	1	1
2023_Catches Baseline	2064	11791	2282	968	2271
2023_Catches ICES	2064	11791	2282	968	2271
2023_% diff	1	1	1	1	1

***category 2 stock**

Table 4.6. Comparison of SSB and F forecasts between FLBEIA baseline run outputs and single stock assessment.

Stock	SSB_2022	SSB_2023	SSB_2024	F_2022	F_2023
ank.27.8c9a*	NA	0	0	0	0
hke.27.8c9a	0.96	0.98	1.03	0.89	0.88
ldb.27.8c9a	0.98	0.99	0.98	0.99	1.04
meg.27.8c9a	0.99	0.98	0.97	1.03	1.05
mon.27.8c9a	1.03	1.03	1.02	0.93	0.93

*F/F_{MSY}; B/B_{MSY}

Table 4.7. Results of running FLBEIA scenarios on the advice year (2023). Comparison of the single-stock ICES advice and potential catches in the various FLBEIA scenarios (test for details).

Stock	Single-stock Catch(2023)	max	min	ank	hke	ldb	meg	mon	sq_E
ank.27.8c9a	2064	2065	605	2064	609	1317	1123	1845	732
hke.27.8c9a	11791	37599	11731	37586	11791	26238	21411	34918	14368
ldb.27.8c9a	2282	3441	980	3441	980	2282	1956	3121	1233
meg.27.8c9a	968	1560	482	1560	482	1129	968	1495	605
mon.27.8c9a	2271	2641	755	2640	761	1675	1374	2271	905

Table 4.8. Results of running FLBEIA scenarios on the advice year. Comparison of the Spawning-stock biomass (SSB) results in 2024 (end 2023) from single-stock advice. Weights are in tonnes.

Stock	Single-stock SSB(2024)	max	min	ank	hke	ldb	meg	mon	sq_E
ank.27.8c9a	NA	0	0	0	0	0	0	0	0
hke.27.8c9a	23936	6104	23660	6111	23631	13368	16912	7567	21840
ldb.27.8c9a	10295	5390	11397	5390	11397	9992	10343	6746	11125
meg.27.8c9a	4140	1774	4610	1774	4610	3442	4017	2093	4460
mon.27.8c9a	11163	11021	13068	11022	13062	12070	12396	11423	12905

Table 4.9. Description of the approach used to approximate the SS3 southern hake model to FLBEIA/FLR

Southern hake SS model description:

- No age data are available for this stock. This is a length-based model although growth is estimated following a von Bertalanffy model and age results for population and catches can be provided by SS output system.
- The model has quarterly time steps. Catch are implemented quarterly and population dynamic follow also quarterly steps.
- Total landings and discards by quarter are estimated by the model. Landing estimation seems to be quite accurate although discards are underestimated (see figure 1)
- Recruitment happens in 2 settlement assignments in months 1 and 7.
- There are two sexes with different natural mortality and growth (Figure 2)
- Maturity at length ogive is provide only from female data and SSB (1st Jan) correspond to females only too.
- Catches are split in 4 pseudo fleets (groups of fleets with similar catch length distribution)
- Only the trawlers fleet group have discards in the model. Minor and partial discards are also available for other fleets although not implemented into their fleets in the SS model. All discards in weight are assigned to the trawlers fleet.
- Selectivity for the 4 fleets is estimated at length.

FLBEIA/FLR simplified approach:

- Population at age are reported at 1st Jan and quarterly catches are collapsed to annual catches
- Recruitment (age 0) at 1st Jan is the sum of the recruitment in the two settlements (month 1 and 7). To keep consistency M at age 0 is corrected to deliver abundance at age 1 (1st Jan) equal the SS reported abundance.
- M -at-age is the weighting mean of males and females (except age zero. See previous point)
- Weight-at-age is the weighted mean of males and females.
- Maturity-at-age was reduced with the sex ratio-at-age to allow FLR SSB be comparable with SS female only SSB.
- Catch-at-age for all fleets and quarters are collapsed in a yearly catch at age with landings and discards separated.
- Weight at age for landings and discards are estimated in a similar way than weight in the population.

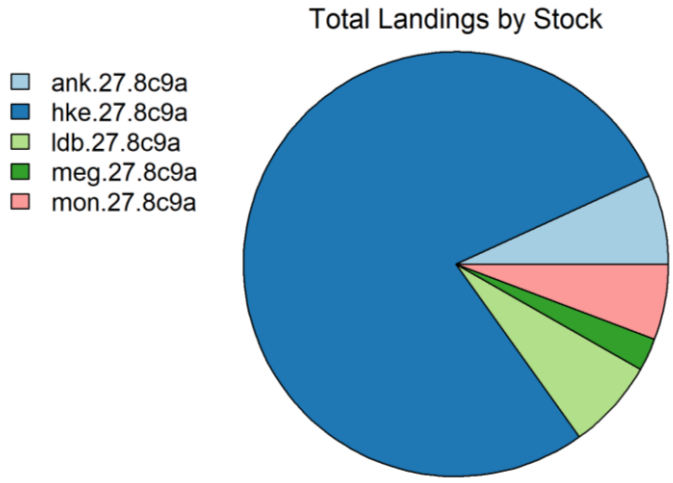


Figure 4.1. Catch distribution in 2021 by the stocks included in the mixed fisheries projections: Hake (78%), black-bellied anglerfish (7%), white anglerfish (6%), four spot megrim (7%) and megrim (2%)

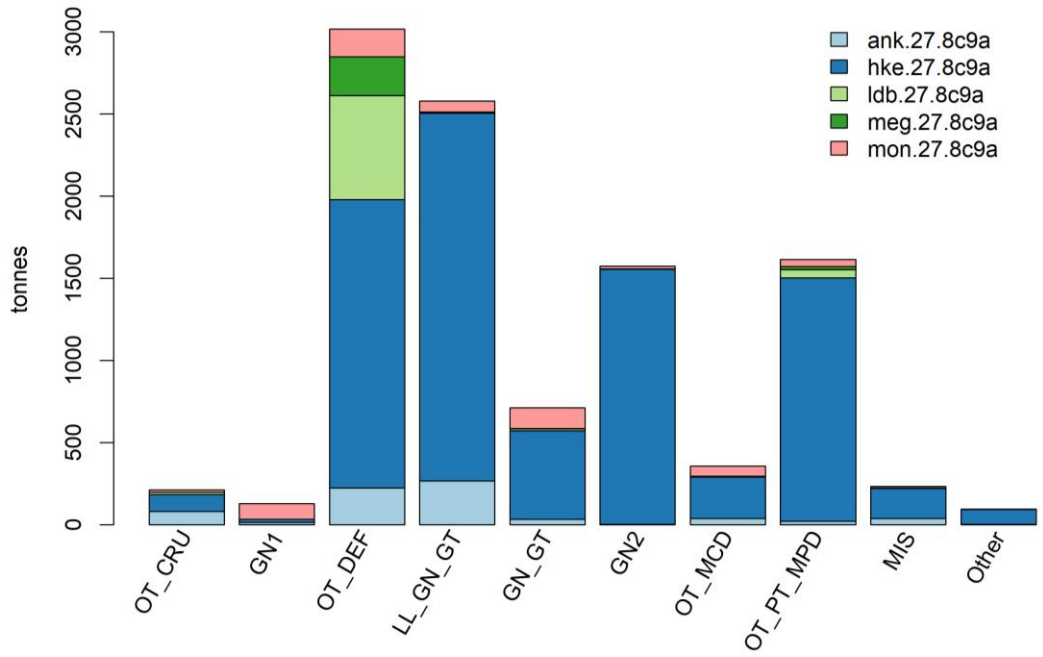


Figure 4.2. Landings distribution of species by mixfish gear group in 2021. Description of the technical characteristics of each gear group available in Table 4.3.

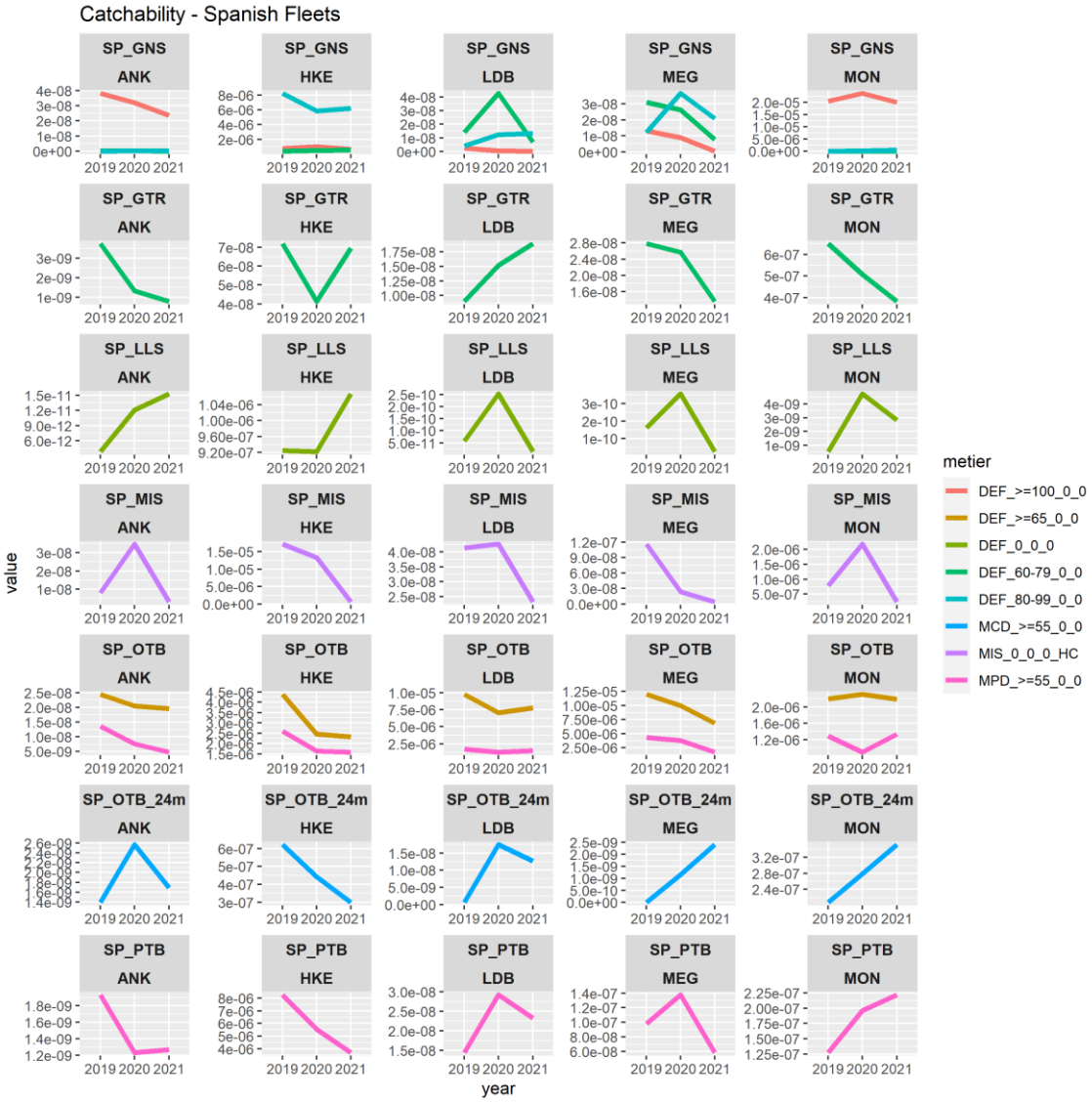


Figure 4.3. Trends of Spanish catchability by stock, fleet and métier from 2019-2021.

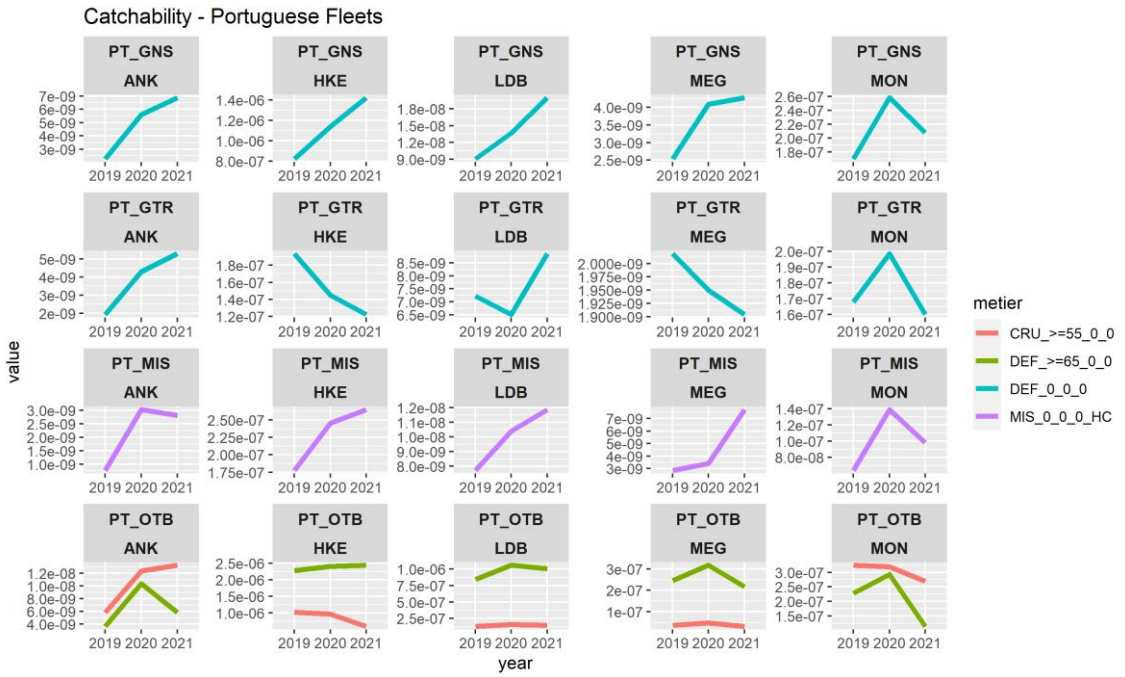


Figure 4.4. trends of Portuguese catchability by stock, fleet and metier from 2019-2021.

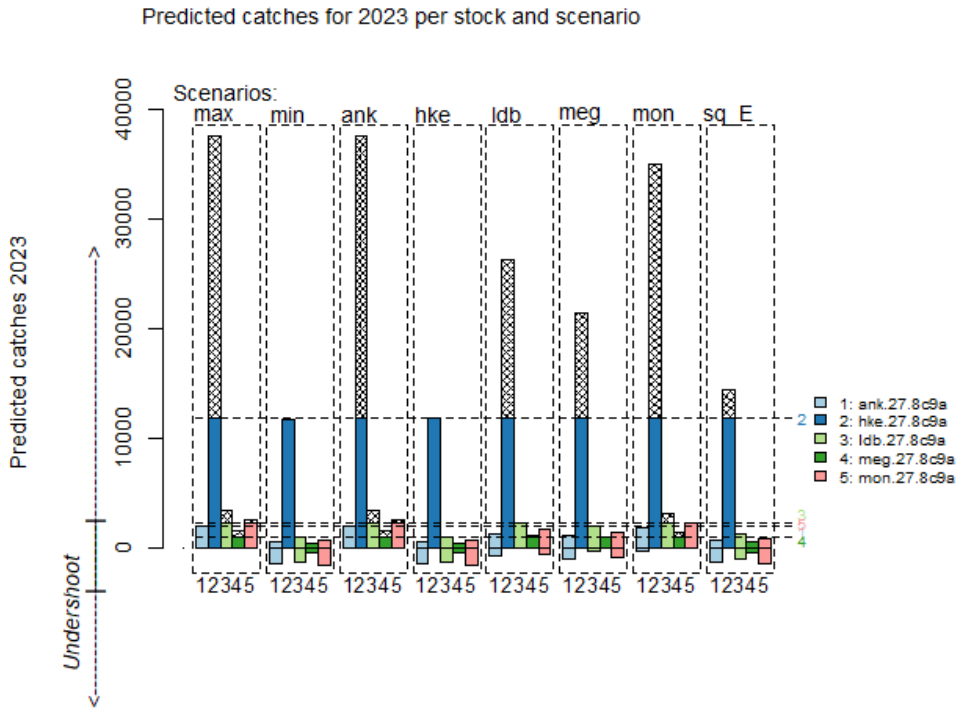


Figure 4.5. Mixed fisheries forecasts for catches in 2023. FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year 2022, followed by the FLBEIA scenarios. Horizontal lines correspond to the catch set by the single-stock advice. 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.

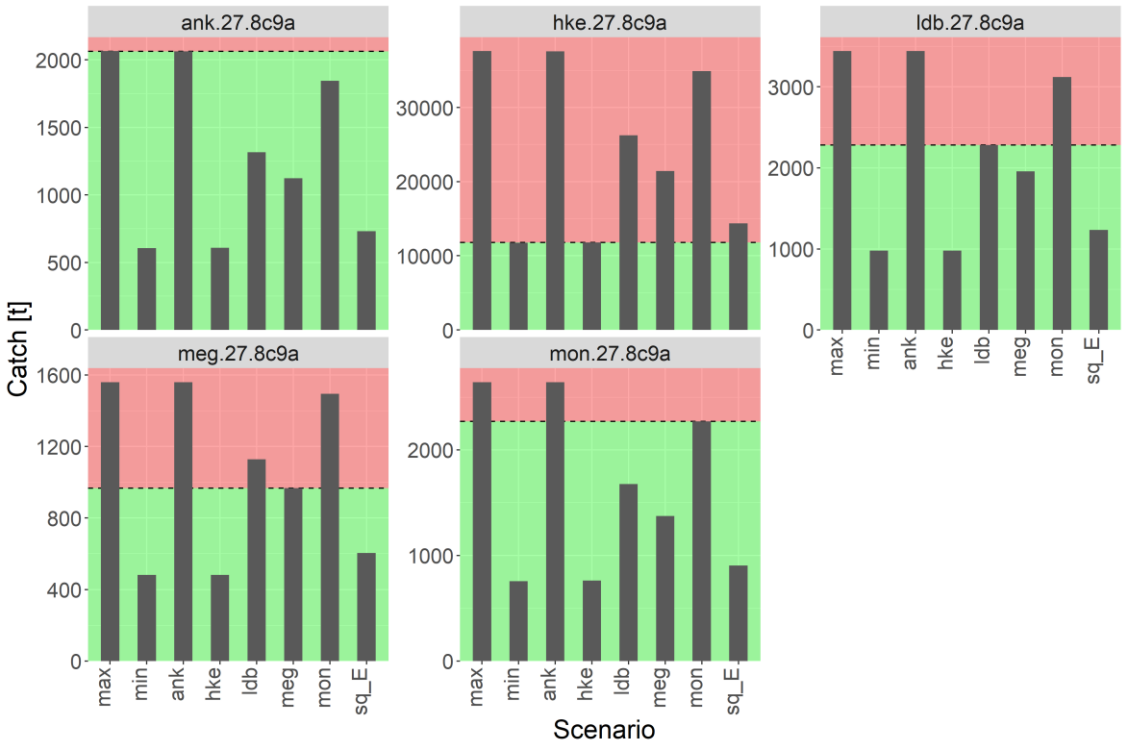


Figure 4.6. Mixed fisheries forecasts for catches in 2023 (in tonnes) by stock and scenario. The horizontal dashed line corresponds to the single-stock catch advice, with areas above and below the line representing potential over and undershoot respectively.

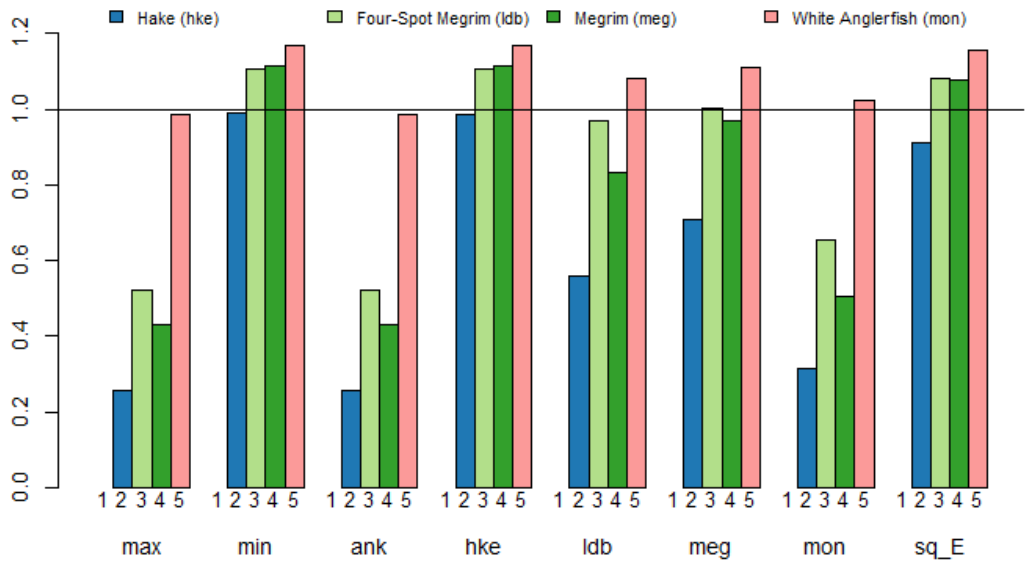


Figure 4.7. Mixed fisheries forecasts for estimates of potential SSB at the start of 2024 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2024).

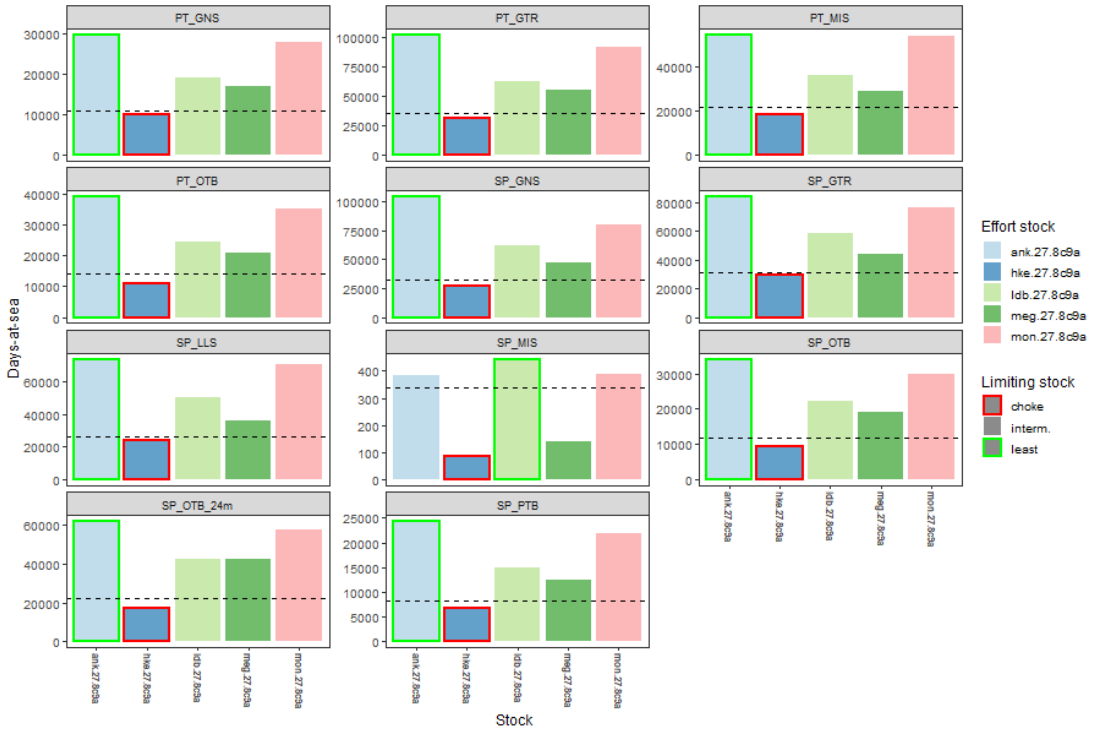


Figure 4.8. Estimates of effort by fleet needed to reach the single-stock advice catches. The bar for the most limiting stock ('choke species') for each fleet in 2023 highlighted with a red border and the bar for the least limiting species highlighted with a green border. The *status quo* effort for each fleet (average 2019-2021) is shown as a dashed line for reference.

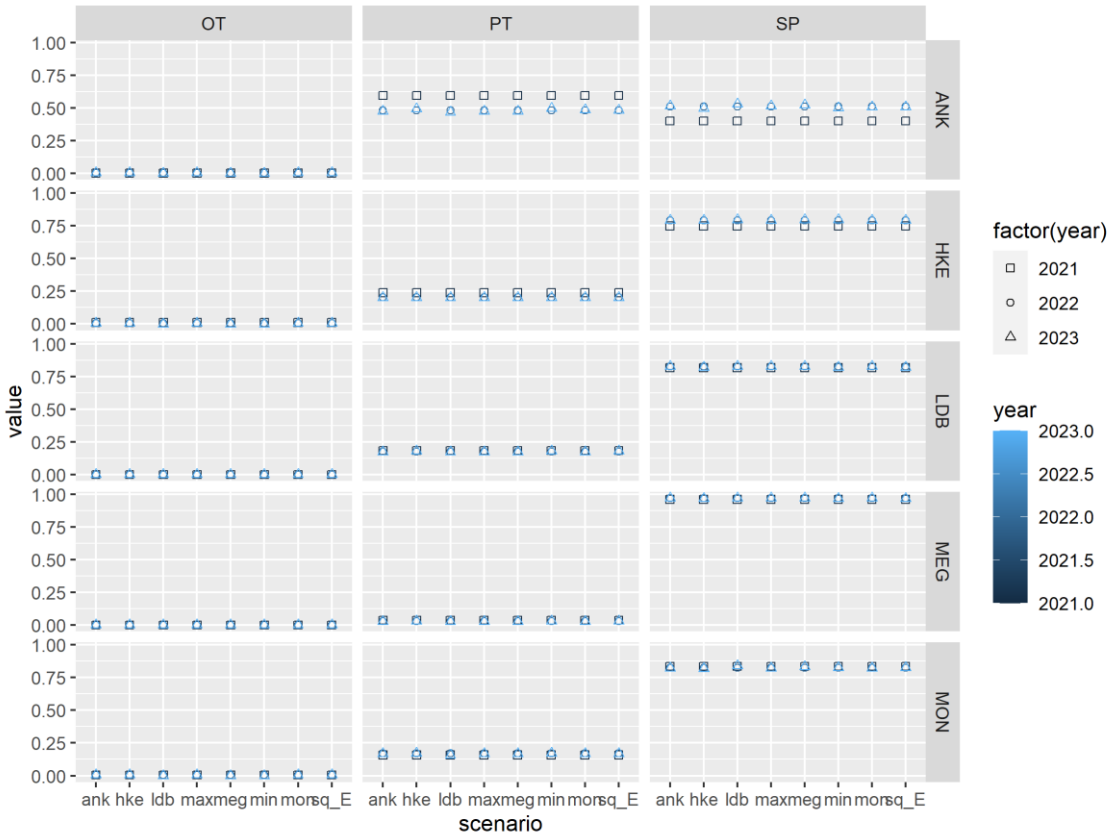


Figure 4.9. Iberian waters mixed fisheries forecasts: Test for relative stability. Changes of relative share of landings by country in 2022 and 2023 compared to the 2021 share for the eight FLBEIA scenario.

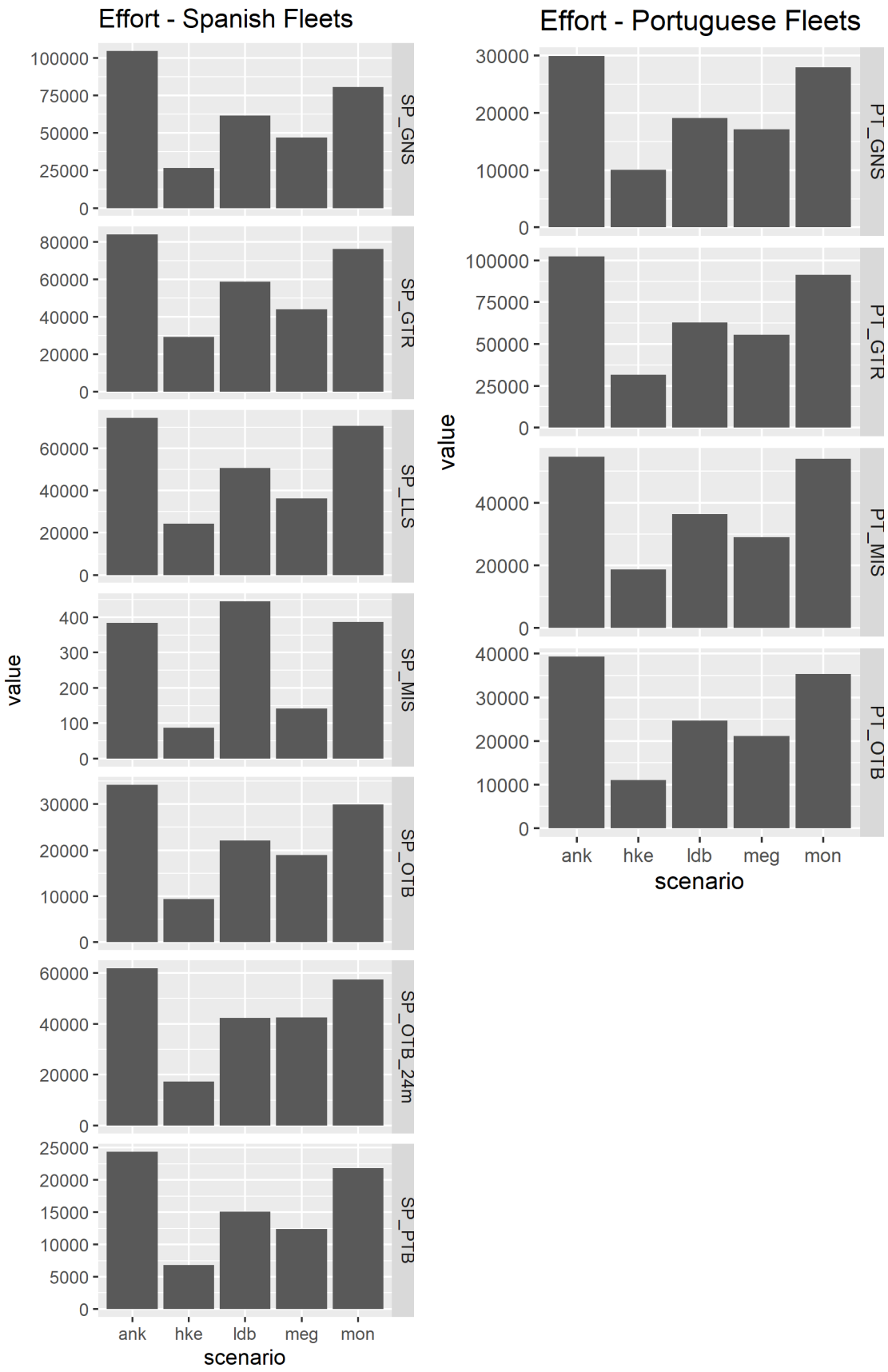


Figure 4.10. FLBEIA estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2023 (baseline run).

5 Irish Sea

5.1 Background

The Irish Sea, ICES Division 7.a, is a relativity enclosed sea basin situated between Ireland/Northern 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 contains a deeper channel in the west with a maximum depth exceeding 275 m, and 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; Figure 5.1).

Nephrops is the main demersal species landed by Irish Sea fisheries. *Nephrops* is mainly targeted using otter trawls (OTB) with mesh size in the range 70–99 mm. This fishery is primarily focused in the north west of the Irish Sea, with >90% of landings in 2021 caught in FU 15. Of demersal species haddock accounts for the second highest landings and is mainly caught in otter trawls (OTB) and mid-water otter trawls (OTM). Sole accounts for the third highest landings in the Irish Sea, and is mainly targeted by beam trawls (TBB).

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 carry out most of fishing activity in the Irish Sea, namely: Northern Ireland, Republic of Ireland, England and Belgium. There is variation in the landings profiles of each country reflecting different fishing patterns, practices, and quota shares (Figure 5.2 and 5.3).

5.1.1 Management measures

Fishing opportunities Irish Sea (ICES division 7.a) are managed by TACs for six demersal species: cod, haddock, plaice, sole, whiting, and *Nephrops.* 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. *Nephrops* stocks are assessed using UWTV based stock assessment models at the FU level.

A multiannual management plan (MAP) for Western and adjacent waters has been adopted by the EU for cod, haddock and whiting in the Irish Sea, and *Nephrops* in FU's 14 and 15 (Council Regulation (EC) 2019/472) which ICES considers to be precautionary. Plaice in the Irish Sea is taken into account under the EU multiannual plan (MAP) as a bycatch species. However, there is no agreed shared management plan with UK for these stocks. ICES is not aware of any agreed precautionary management plan for sole in this area. A single *Nephrops* TAC is issued for Subarea 7 (with an 'of which' provision for FU16). ICES notes that to ensure that each stock is exploited sustainably, management should be implemented at the FU level.

Cod and whiting are managed as by-catch only in the Irish Sea, with no directed fishery of either species permitted in the area. As such they are likely to have considerable mixed fisheries

implications, and catches may be impacted by adjusting the fishing opportunities permitted for other species in addition to technical measures such as area closures and technical devices such as highly selective gears. For a summary of current technical measures in the region see: (https://bim.ie/fisheries/advisory-services/fisheries-management-chart). Catches of whiting are primarily observed in *Nephrops* directed otter-trawl fisheries, with a smaller proportion from finfish directed otter-trawls and other gears. Catches of cod are primarily observed in demersal fish directed otter-trawl fisheries (both OTB and OTM), with significant proportions from *Nephrops* directed otter trawls and beam trawls. Council Regulation (EC) No. 304/2000 and Regulation (EC) No. 2549/2000 introduced area closures on the cod spawning grounds for ten weeks from mid-February till the end of April. These area closures now occur annually, although there are some derogations in place for gears not targeting cod.

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 at sea of certain species on a fishery-by-fishery approach. An overview of the exemptions of the landings obligation in the Celtic Seas region can be found below:

Exemptions to the landing obligation in 2022

Species	Exemption type	Area	Gear	Maximum de minimis exemption (% of total annual catch)
Albacore tuna	De minimis	7	Midwater pair trawls	5
Whiting	De minimis	7b -7k	Bottom trawls and seines ≥ 80 mm, Pelagic trawls and beam trawls 80-119 mm	5
Sole	De minimis	7a, 7d - 7g	Beam trawl 80-119 mm with Flemish Panel	3
Sole	De minimis	7d,e,f & g	Trammel nets and gill nets	3
Haddock	De minimis	7b,c & 7e-k	Bottom trawls and seines ≥ 100 mm with catches comprising ≤30% Nephrops	5
Haddock	De minimis	7b,c & 7e-k	Vessels using ≥ 80 mm, with catches comprising more than 30% Nephrops	5
Haddock	De minimis	7b,c & 7e-k	Beam trawls ≥ 80 mm with Flemish Panel	5
Haddock [1]	De minimis	6a	Nephrops bottom trawls using <119mm with HSG*	3
Megrim [2]	De minimis	7	Beam Trawls 80-119mm & Bottom trawls**	4
Horse mackerel	De minimis	6 & 7b-k	DMF [3] using bottom trawls, seines & beam trawls	3
Mackerel	De minimis	6 & 7b-k	DMF [3] using bottom trawls, seines & beam trawls	3
Boarfish	De minimis	7b,7c,7f-7k	Bottom trawls	0.5
Argentine	De minimis	EU 5b & 6	Bottom trawls ≥ 100 mm	0.6
Species	**Exemption**	**Area**	**Gear**	**Discard Release Notes**
Nephrops	Survivability	6 & 7	Pots, creels or traps	immediately whole & where caught
Nephrops	Survivability	7	Bottom trawls 70-99mm with HSG* or ≥100mm	immediately whole & where caught
Nephrops	Survivability	6a (<12nm)	Bottom trawls 80-110 mm	immediately whole & where caught
Skates & rays	Survivability	6 & 7	All gears	Released immediately
Plaice	Survivability	7b -7k	Seines (SSC)	Released immediately
Plaice	Survivability	7d -7g	Trammel nets and otter trawls	Released immediately
Plaice	Survivability	7d -7g	Beam Trawls with flip up rope or benthic release panel (vessels > 221kW)	Released immediately
Plaice	Survivability	7a-7g	BT2 (vessels ≤221 kW or ≤24 m) inside 12 nm, tows ≤ 1:30 hour	Released immediately
All Species	Survivability	EU 5b; 6 & 7	Pots, creels and traps	Released immediately

[1] Applies only to haddock <MCRS (30cm), [2] Applies only to megrim <MCRS (20cm), [3] Demersal Mixed Fisheries

* See list of area-specific highly selective gears for Nephrops in table

** Bottom trawls: 70 to 99mm in 7f, 7g, 7h North of 49.5°N & 7j East of 11°W - catches must comprise 55% whiting or anglerfish, hake & megrim combined; ≥100mm in the rest of 7

Reference: Commission Delegated Regulations (EU) 2020/2015 (Consolidated)

5.2 Model

5.2.1 Software

The FCube model has been coded as a method in R 64bits (R Development Core Team, 2008), using 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 2.6.17 and FLFleet 2.6.1 packages. Stock objects were created using outputs from single stock assessment for each fish stock: FLa4a (version 1.8.2), FLXSA (version 2.6.4), and stockassessment (version 0.5.4). Forecasts for fish stocks with analytical assessments were projected using the fwd() function in the Flash package (version 2.5.11). *Nephrops* catch forecasts were calculated based on a combined FU14 and FU15 stock, with the same R approach used for individual FU's in the single stock advice. As such, the input

parameterisation as well as the stock projections are made externally using existing methods and packages, while only the FCube specific steps are internalised in the method, thus keeping full transparency and flexibility in the use of the model.

All code is stored on github at: https://github.com/ices-taf/2022_IrS_MixedFisheriesAdvice

Table 5.1. Software used by WGCSE in the single-species assessments and forecasts

Stock	Assessment	Forecast
cod.27.7a	Stock synthesis (SS3)	FLR STF
had.27.7a	ASAP (Age-Structured Assessment Programme; NOAA)	FLR STF
nep.fu.14	Underwater TV survey	NA
nep.fu.15	Underwater TV survey	NA
ple.27.7a	Age-based stochastic analytical assessment (SAM)	SAM
sol.27.7a	Age-based analytical assessment (XSA)	FLR STF
whg.27.7a	ASAP (Age-Structured Assessment Programme; NOAA)	FLR STF

5.2.2 Scenarios

FCube (Ulrich *et al.* 2008; 2011) was used to forecast seven mixed-fisheries scenarios (Table 5.2). The basis of the model is to estimate the future levels of effort for each fleet corresponding to the fishing opportunities available to that fleet, based on recent fleet effort distribution and catchability by stock and métier. This level of effort is then used to estimate the corresponding summed *F* of all fleets per stock, and catches are then forecast using the standard forecast procedures from the single-species assessment (with the exception of plaice which was forecast using FLR rather than SAM). The basis for each single-stock advice is retained in the current mixed fisheries framework.

The mixed fisheries model includes cod, haddock, plaice, sole, whiting and *Nephrops* FU14 and FU15. For fish stocks the stock objects used in the model were received directly from the single-stock coordinators and match those used in the single-stock advice (ICES, 2022a). *Nephrops* stocks in FU14 and FU15 were merged in the mixed fisheries model (see section 5.3.1 below for details), and a single scenario representing the sum of the advice for both FU14 and FU15 was used to represent the Irish Sea *Nephrops* fishery. Following model testing this was considered the best approach, because the landings and discards data in MIXFISH accessions and InterCatch for fish stocks is at the level of ICES division (7.a). Therefore, it is not currently possible to allocate catch compositions of fish stocks at the individual FU level. Furthermore, *Nephrops* targeting fleets move between FU's using the same métiers depending on fishing opportunities and conditions. Therefore, whilst *Nephrops* stocks are best assessed as separate FU's the behaviour and catch compositions of the fishery within the mixed fishery model (given the available data) are best captured by merging FU14 and FU15 stocks and advice within the model. Out of FU and FU19 catches are excluded from the model, as these are unlikely to reflect the main target areas of the Irish Sea *Nephrops* fishery and represent <1% of the landings.

The following scenarios are included in the mixed fisheries considerations:

Table 5.2. Mixed fisheries scenarios considered for the Irish Sea

Scenario code	Scenarios
max	**"Maximum":** For each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares*. This option results in overfishing of the single-stock advice of 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 results in underutilization of the single-stock advice possibilities of other stocks.
sq_E	**"*Status quo* effort":** The effort of each fleet in the catch advice year (2023) is set equal to the average effort in the most recent three years (2019–2021) for which catch and effort data are available.
cod-is	**"Cod MSY approach and precautionary considerations":** All fleets set their effort corresponding to that required to catch their advised cod stock share, regardless of other catches.
had-is	**"Haddock MSY approach":** All fleets set their effort corresponding to that required to catch their advised haddock stock share, regardless of other catches.
nep-is	**"*Nephrops* MSY approach":** All fleets set their effort corresponding to that required to catch their advised *Nephrops* stock share for FU14 and FU15 combined, regardless of other catches.
whg-is	**"Whiting MSY approach and precautionary considerations":** All fleets set their effort corresponding to that required to catch their advised whiting stock share, regardless of other catches.

*** Throughout this document, the term "stock share" is used to describe the share of the fishing opportunities for each fleet, calculated based on the single-stock advice for 2023 and the historical proportion of the landings of that stock taken by the fleet (average 2019-2021).**

5.3 Data compilation

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

3. Stock data: Stock abundance, structure, reference points and advice (ICES, 2022a).
4. Fisheries dependent data: fleet and métier trends in landings and effort (2019-2021), are from the WGMIXFISH data call.
5. Discard data: from the ICES InterCatch database, and individual WGCSE stock coordinators.

5.3.1 Stock data

Single species stock assessment outputs including biomass, fishing mortality, biological parameters (maturity, natural mortality) and age-structure for demersal fish stocks were supplied by WGCSE stock co-ordinators in the form of FLR stock objects (with the exception of plaice which was supplied as a SAM object). FLR stock objects for *Nephrops* FU14 and FU 15 were created based on landings, discard and stock numbers, mean weights and harvest rates in the WGCSE advice meeting report (ICES, 2022a). *Nephrops* stock objects were merged by summing their respective stock objects using the R package FLCore, to create a single Irish Sea *Nephrops* stock object within the mixed fisheries model (see section 5.2.2 above). This results in the annual landings, discards, catches and stock (tonnes and number) being the sum of those in the individual stocks. The individual weights in landings, discards, stock and catches, are calculated as the mean individual weight per year weighted by the numbers of each FU14 and FU15 in each year. The annual harvest rates of the merged stock object were calculated as the catch numbers divided by the stock numbers per year. The forecast harvest rate based on *Nephrops* advice was calculated

based on the sum of the advice for both FU's. Specifically, the advised harvest rate for catch in the advice year is calculated as:

$$Adviced\ catch\ numbers = \frac{Advised\ catch\ FU14\ (t) + Advised\ catch\ FU15\ (t)}{Mean\ catch\ weight\ (g)}$$

$$Harvest\ rate = \frac{Advised\ catch\ numbers}{Stock\ numbers}$$

Reference points, advice for 2023, TAC in 2022 and trends in stock status were from WGCSE advice sheets. The consistent support and cooperation from the chairs and single species stock assessors has greatly eased the workload of WGMIXFISH. An overview of the trends and advice for stocks included in Irish Sea mixed fisheries analysis from the single species advice sheets for these stocks is described below (ICES 2022a) (Table 5.3).

5.3.2 Fisheries dependent data

Information on fisheries is supplied according to the WGMIXFISH data call in the form of "accessions" data, this provides disaggregated fleet data at the level of métier which are consistent with the definitions outlined in the DCF. This includes landings (in tonnes) for defined species and fishing effort (in KW days). Landings and effort métiers for the model stocks were checked for consistency within countries and years, and effort data was available for all of the métiers for which landings were reported. For comparison of accessions data and other data sources see section 5.3.5 Quality Control.

5.3.3 Discard data

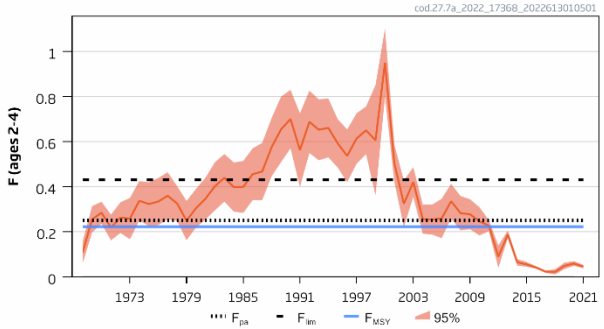
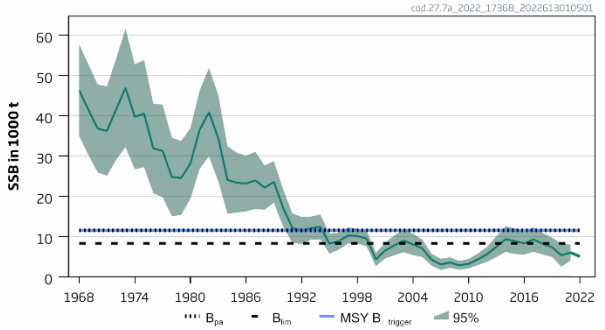
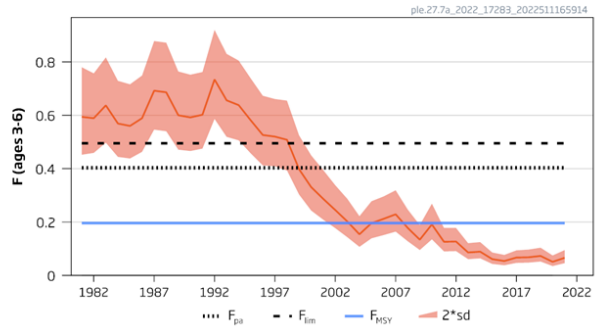
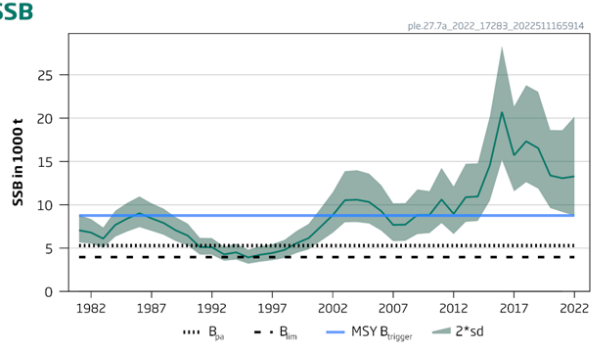
Discard ratios were calculated per stock, country, year and métier (DCF level 6 where possible e.g. OTB_CRU_70-99_0_0_all) from InterCatch data used in single-stock assessments. These ratios were applied to the landings data supplied in the WGMIXFISH accessions data call to calculate corresponding discard weights for the submitted landings.

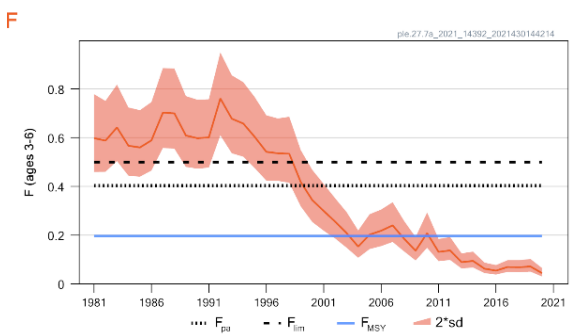
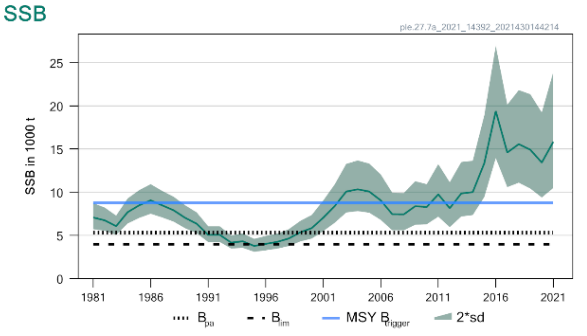
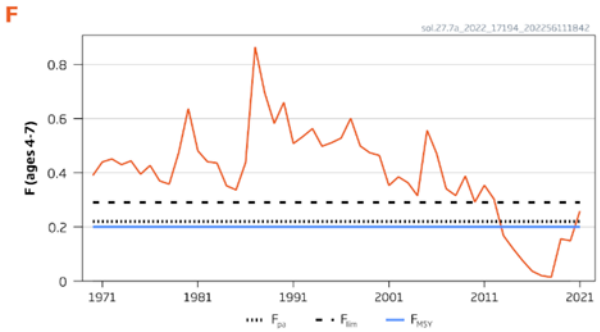
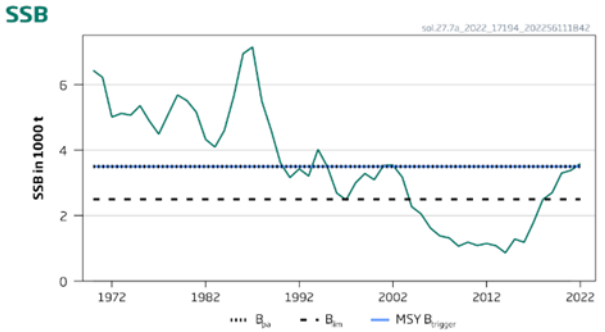
For some 7a stocks InterCatch discard data are not consistent with that used in the assessment (eg sol.27.7.a and whg.27.7.a), and in these cases discard data in InterCatch formats were sourced directly from the stock coordinators of these stocks. In the case of sol.27.7.a this is standard practice, whilst in the case of whg.27.7.a this related to changes in data processing to accommodate incorporation of other sampling sources in 2020 due to Covid-19 disruptions to sampling programmes. In *Nephrops* FU14 there was no discard data available in 2020 due to the Covid-19 pandemic. Therefore, discard rates were estimated as the mean value of the three preceding years (per country and métier), as per the WGCSE single-stock assessment for this stock. An adjustment was made to the discard estimate of ple.27.7a for the English OTB_CRU_70_99_0_0_all in 2021 to match the single-stock assessment as the discard raising for this fleet was conducted outside of InterCatch for that year.

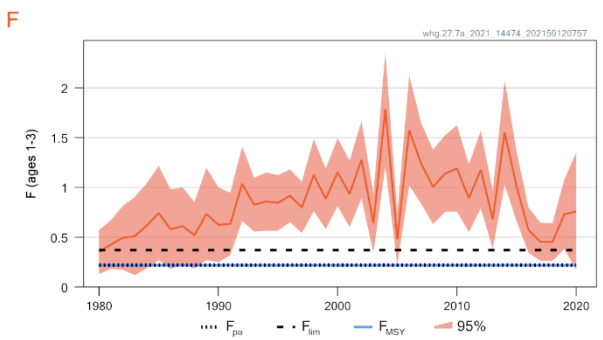
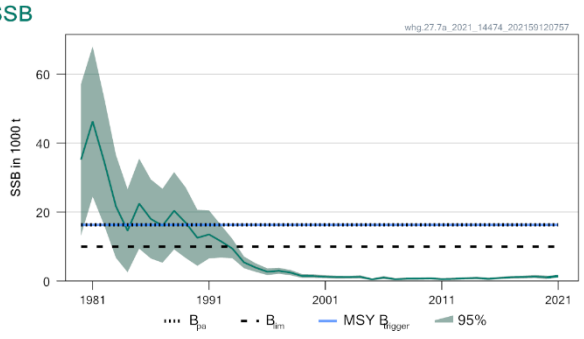
Overall, the conformity of métiers in MIXFISH and InterCatch was high, however, it would be desirable for countries to continue improving the consistency between data uploaded to InterCatch and data submitted to WGMIXFISH (for details see 5.3.7 Quality Control).

Table 5.3. Summary of advice, fishing pressure/harvest rate and stock trends for the stocks included in the Irish Sea mixed fisheries model (ICES 2021, ICES 2022a)

Fish stocks

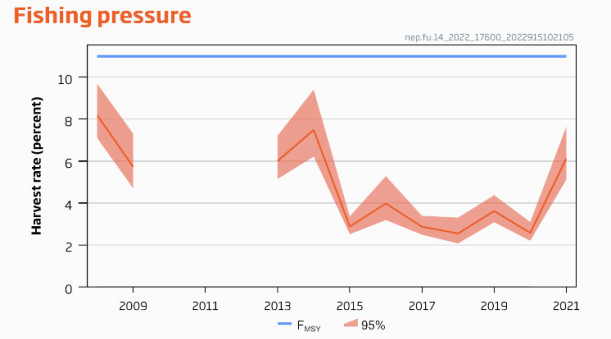
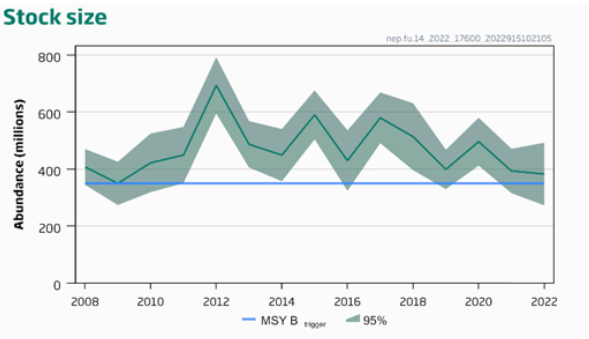
Species	Area	Stock status	Advice
cod.27.7.a	Irish Sea – Division 7a (excluding rectangles 33E2 and 33E3)	F  SSB  **Summary:** Fishing pressure on the stock is below FMSY, and spawning-stock size is below MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach and precautionary considerations are applied, there should be zero catch in 2023. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.
had.27.7a (Haddock)	Irish Sea – Division 7a (excluding rectangles 33E2 and 33E3)	F  SSB  **Summary:** Fishing pressure on the stock is below FMSY, and spawning stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 2648 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

Species	Area	Stock status	Advice
ple.27.7a (Plaice)	Irish Sea – Division 7a	  **Summary:** Fishing pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, total catches in 2023 should be no more than 2039 tonnes.
sol.27.7a (Sole)	Irish Sea – Division 7a	  **Summary:** Fishing pressure on the stock is above FMSY and between Fpa and Flim; spawning-stock size is above MSY Btrigger, Bpa, and Blim.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 605 tonnes.

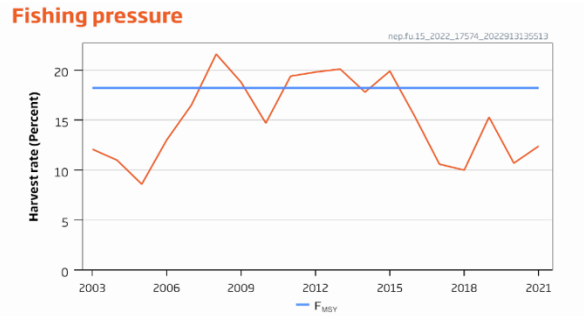
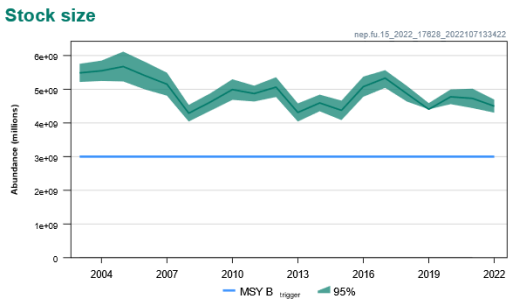
Species	Area	Stock status	Advice
Whg.27.7a	Irish Sea – Division 7a (excluding rectangles 33E2 and 33E3)	 	ICES advises that when the MSY approach and precautionary considerations are applied, there should be zero catches in 2022 and 2023. Advice for whg.27.7a is issued biennially, and was last issued in 2021 (ICES, 2021)

Summary: Fishing pressure on the stock is above F_{MSY}, F_{pa}, and F_{lim}; spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}.

Nephrops stocks

Species	Area	Stock status	Advice
nep.fu.14 (*Nephrops*)	Divisions 7.a, Functional Unit 14 (Irish Sea, West)	 	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 789 tonnes. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 7.

Summary: Fishing pressure on the stock is below F_{MSY} and stock size is above MSY $B_{trigger}$.

Species	Area	Stock status	Advice
nep.fu.15 (*Nephrops*)	Divisions 7.a, Functional Unit 15 (Irish Sea, West)	  **Summary:** Fishing pressure on the stock is below F_{MSY}, and stock size is above MSY $B_{trigger}$.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 11 069 tonnes. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 7.

5.3.4 Building the fleet

The above data sources are then combined to produce the "fleet object" which is used as an input for the FCube model. Fleet objects were created using the FLCore 2.6.17 and FLFleet 2.6.1 packages, fleets were defined by their country and predominant fishing gear and target fishery based on mesh-size. Vessel lengths have not been used in the categorisation of fleets, due to the relatively small size of the fishery operating in the Irish Sea. Fleet categories are not necessarily exclusive, and individual boats may contribute to the effort of multiple fleets if they change their fishing gear (i.e. boats may be polyvalent). Within countries fleets were split based on the following categories:

- Beam trawls (all sizes)
- Otter trawls crustaceans (mesh-size 70-99 mm)
- Otter trawls demersal fish (mesh-size ≥100 mm)
- Pelagic gears (32-69 mm)
- Seines

Any fleets which did not land >1% of any stock in the model were then grouped into an 'OTH_OTH' fleet to reduce model complexity.

Métiers were based on the Technical Regulation (TR) classes methodology outlined in the long-term plan for cod stocks, with an added category to describe gears targeting pelagic fish (OTM/PTM mesh-size 32-69 mm). Midwater otter trawls with a mesh-size >100mm were included in the TR1 category. Specifically:

Gear groupings and assigned métiers in the FCube fleets:

a) Bottom trawls and seines (OTB, OTT, PTB, SDN, SSC, SPR, OTM) of mesh:
   1. TR1 equal to or larger than 100 mm,
   2. TR2 equal to or larger than 70 mm and less than 100 mm,
   3. TR3 equal to or larger than 16 mm and less than 32 mm;

b) Beam trawls (TBB) of mesh:
   1. BT1 equal to or larger than 120 mm
   2. BT2 equal to or larger than 80 mm and less than 120 mm;

c) Gill nets, entangling nets (GN);

d) Trammel nets (GT);

e) Longlines (LL)

f) Pelagic – Otter or pelagic trawls with mesh sizes 32-69 mm

Métiers accounting for <1% of landings of any stock were grouped as 'other' within fleets. This process resulted in 14 fleets, with 1 métier per fleet (Figure 5.4). Five separate métier classes were included in the final fleet objects: TR1, TR2, BT2, pelagic and other. Métiers are described according their DCF level 5 métiers in the advice sheet for consistency with DCF, WGMIXFISH accessions and Celtic Seas Ecoregion terminology.

Table 5.4 Fleets and métiers used in the Irish Sea Mixed Fisheries model.

FCube Fleet name	Country	FCube métier name	DCF métier	Gear	Target species
Beam_all_BE	Belgium	BT2	TBB_DEF	Beam trawls	Demersal fish
Beam_all_EN	England (UK)	BT2	TBB_DEF	Beam trawls	Demersal fish
Beam_IE	Ireland	BT2	TBB_DEF	Beam trawls	Demersal fish
DSeine_IE	Ireland	TR1	SSC_DEF	Scottish seines	Demersal fish
Otter_CRU_EN	England (UK)	TR2	OTB_CRU	Otter trawls	Crustaceans
Otter_CRU_IE	Ireland	TR2	OTB_CRU	Otter trawls	Crustaceans
Otter_CRU_NI	Northern Ireland (UK)	TR2	OTB_CRU	Otter trawls	Crustaceans
Otter_DEF_BE	Belguim	TR1	OTB/OTM_DEF	Otter trawls	Demersal fish
Otter_DEF_EN	England (UK)	TR1	OTB/OTM_DEF	Otter trawls	Demersal fish
Otter_DEF_IE	Ireland	TR1	OTB/OTM_DEF	Otter trawls	Demersal fish
Otter_DEF_NI	Northern Ireland (UK)	TR1	OTB/OTM_DEF	Otter trawls	Demersal fish
Pelagic_IE	Ireland	Pelagic	OTM/PTM_SPF	Pelagic/midwater trawls	Pelagic fish
Pelagic_NI	Northern Ireland (UK)	Pelagic	OTM/PTM_SPF	Pelagic/midwater trawls	Pelagic fish
*OTH_OTH	Any	OTH	OTHER	Other gears, including dredges, pots, gillnets, trammel nets, longline trawls and gears reported as miscellaneous	Any

*** Fleets and métiers with landings < 1% of any of the stocks in the model (average 2019 to 2021)**

Alternative configurations for fleets in the Irish Sea model were discussed at the WGMIXFISH 2022 Irish Sea Mixed Fisheries Model Review meeting, and at the WGMIXFISH-Methods meeting 2022 (see ICES 2022b, pp 63-65 for details). Both of these meetings upheld the view that the separation of fleets into separate groupings relating to *Nephrops* (CRU) and demersal (DEF) fisheries produced more realistic model behaviour than previous model versions which grouped these métiers within national 'otter trawl fleets'. Specifically, disaggregating these métiers allows the model to simulate the behaviour where boats may continue fishing with a different métier (e.g. OTB_CRU instead of OTB_DEF), even after the one of these métiers has reached its limit for a particular stock. For example, under the current configuration, if a nation has reached its landings quota (stock share) of cod for its OTB_DEF fleet, that nation would be able continue fishing with its OTB_CRU fleet, if either a) there was still landings quota for cod available to the OTB_CRU fleet, or b) if the OTB_CRU fleet for that nation did not catch any cod in the model.

5.3.5 Quality control

5.3.5.1 Métier coding – WGMIXFISH vs. InterCatch

Where possible discard estimates were retrieved from InterCatch and assigned to the same métiers within the WGMIXFISH accessions files. However, this method relies on being able to match métier definitions between the two datasets. Where an exact match was not possible, expert knowledge was used to apply discard rates from similar InterCatch métiers (Table 5.5). These métier year combinations accounted for <1% of the total accessions landings for the stocks in the model.

5.3.5.2 Matching Accessions, InterCatch and ICES landings

The initial match between the accessions landings, InterCatch landings and official landings was good for plaice, sole, and *Nephrops.* However, during the Irish Sea Mixed Fisheries Model review in August 2022, discrepancies between the WGMIXFISH accession landings and the data used in the single-stock assessment were noted were noted for gadoid stocks (cod, haddock and whiting). This disparity resulted from the difference between the single stock assessment area for the gadoid stocks (cod, haddock and whiting) which exclude rectangles 33E2 and 33E3 from that requested for these stocks in the WGMIXFISH data call (subarea 7a). To improve the match between the single-species stock assessment and the accessions data, the WGMIXFISH accessions data from Ireland were resubmitted for these stocks without those rectangles (33E2 and 33E3) prior to the WGMIXFISH advice meeting. Ireland is the main country fishing for the stocks in rectangles 33E2 and 33E3, and therefore this resubmission greatly improved the match between WGMIXFISH accessions data and that used in the single stock assessment for these stocks (Figure 5.5). However, very small discrepancies remained between the WGMIXFISH accessions landings for these stocks for some fleets. Therefore, WGMIXFISH accession landings data were rescaled per country, métier and gadoid stock to exactly match those used in the single-stock assessment prior to further analyses.

Following the matching of landings data described above, discard rates from InterCatch were applied to the WGMIXFISH accessions landings to estimate discards. There was a good match between the accessions calculated discards, InterCatch discards and ICES advice discards for all stocks (Figure 5.6). In the case of two 7a stocks, ple.27.7a and sol.27.7a, discards are treated differently in the single-stock assessment stock objects. Specifically, for plaice, discards are adjusted by an estimated 40% dead discard rate in the assessment to represent survivability of discarded catch (i.e. total discards x 0.6 = dead discards) (ICES, 2022a). For sole, no discards are included in the assessment or FLR forecast of the stock, but instead discards are added to the forecast post-hoc based on an estimated 11.6% discard rate (ICES, 2022a). Therefore, the dead discard rate was applied to plaice discards on the country, year, métier level within the mixed fishery fleet objects, and the discards of sole were therefore set to zero in the mixed fisheries fleet objects. After the FCube mixed-fisheries forecast, the dead discards of plaice and the discards of sole were added onto the forecast catch estimates as per the single-stock assessment process for each stock. These procedures are intended to maximise consistency between the single-stock assessment and mixed fisheries model.

5.4 Mixed fisheries forecasts

5.4.1 Description of scenarios

Baseline runs

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

1. reproduce as closely as possible the single-species advice,
2. 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 (Table 3.2.1 above). The FCube model has been coded as a method in R 64bit (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 2.6.16 package, and two forecast methods were used, stf() from the FLAssess (version 2.6.3) and fwd() from the Flash (version 2.5.11) packages. Stock objects were processed using FLa4a (version 1.8.2), FLXSA (version 2.6.5). As such, the input parameterisation as well as the stock projections are made externally using existing methods and packages, while only 3 steps are internalised in the method, thus keeping full transparency and flexibility in the use of the model (see stock annex for details). In the mixed-fisheries baseline run, all forecasts for analytical fish stocks were calculated using the FLR forecast method.

Nephrops in the Irish Sea mixed fishery model represent the sum of FU14 and FU15 *Nephrops* stocks (see sections 5.2.2 and 5.431 for details). Therefore, in the baseline run forecasts for this stock are compared to the sum of the advice for FU14 + FU15. Only catches and landings can be compared with the single stock advice, as there is no comparable harvest rate for the combined stocks calculated in the single-stock advice. Future catches and landings of *Nephrops* are estimated following the single-stock procedures.

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 as the single stock forecasts for the baseline run. This ensured greater coherence between the single stock and mixed fishery forecasts. Some differences can occur in the forecast calculations, (because of the diversity of single-stock assessment methods used) and WGMIXFISH always investigates in depth the reasons for potential discrepancies. Adjustments to the FCube forecast methods are made if necessary to minimise discrepancies.

The baseline run acts as a quality control procedure to ensure that the stock objects and projection methods closely match those used in the single-stock assessment. The baseline run has the additional benefit of acting as a quality control check on the projections produced by the single-stock assessments.

Mixed fisheries runs

FCube intermediate and forecast year assumptions

In all FCube scenarios, the effort of fleets and métiers in the intermediate year was the average of the three preceding data years (2019-2021). This is similar to an intermediate year assumption of mean *F* of the preceding three years commonly used in single stock assessments, but individual single-stock assessments may differ in their intermediate year assumptions. These differences in assumptions may produce small differences in intermediate year forecasts between mixed fisheries and single stock assessments.

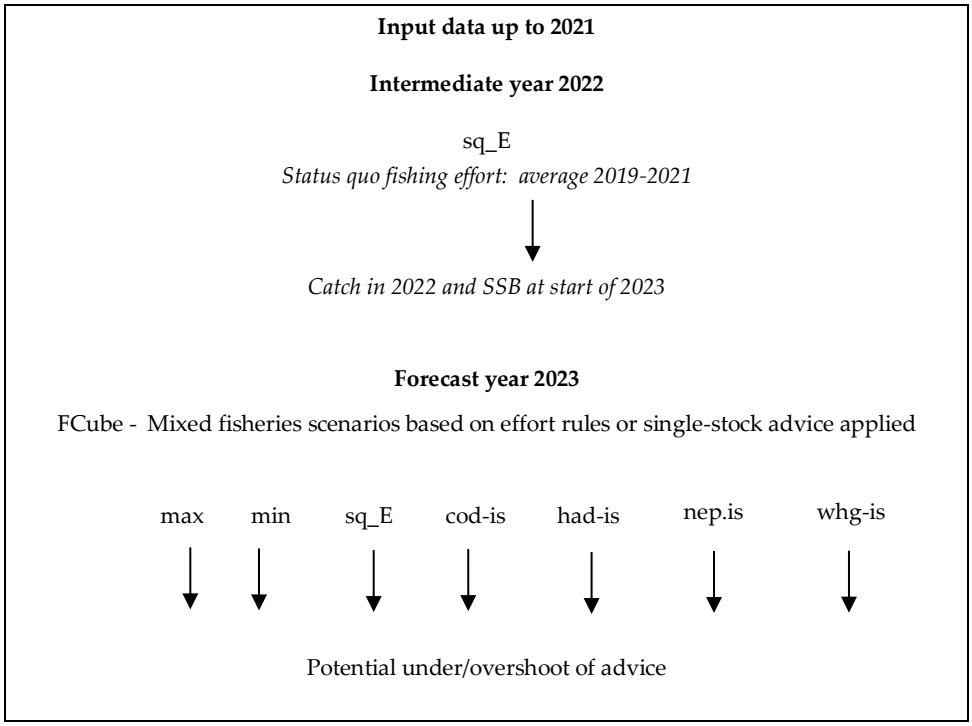
In the intermediate year and forecast years the landings and discard selectivity were assumed to be the mean of the three most recent data years. This assumption was most similar to the WGCSE

single-stock assumption of landing and discard selectivity for most stocks in the model. Stock shares of fleets and métiers are calculated as the average proportion of landings reported by each fleet and métier in the preceding three data years. Similarly, FCube catchabilities are the mean of last three data years per métier.

FCube analyses for the TAC year (2023)

Seven mixed fisheries scenarios were run as outlined in Section 5.2.2 above. For stock-specific scenarios a fishing mortality consistent with the *F* in the single stock catch advice was used. The basis of the stock-specific scenarios was the same as that in the single-stock advice.

In summary, the FCube runs followed the scheme below:



5.4.2 Results of FCube runs

5.4.2.1 Baseline run – reproducing the single stock advice

Overall consistency of results between single species stock assessments and FCube baseline runs was achieved, based on comparisons of predicted catches, landings, SSB and Fbar in 2022 and 2023 for analytical stocks (Table 5.6, Figures 5.7 and 5.8), and landings and catch in 2023 for *Nephrops* stocks (Table 5.7). For demersal fish stocks the differences between the baseline runs ('reproduce the advice') forecasts and those of WGCSE were small (≤ 1.3% in all cases). The largest deviations were seen for plaice and likely result from the difference in the forecast method used (i.e. FLR in the mixed fisheries forecast rather than SAM which is used in the single-stock assessment). However, these differences were low at ≤ 1.3% for ssb and ≤1.1% for catches, and therefore the FLR was considered to be an appropriate method for reproducing this stock forecast in the Irish Sea FCube model. *Nephrops,* comparisons between the forecast in 2023, and the sum of the advice targets for NEP14 and NEP15 from the WGCSE showed very small differences (≤ 1.9%). Hence, the process of merging the stocks in the mixed fisheries model is considered an adequate match for the advice forecasts conducted at the functional unit level by WGCSE. Hence, for all model stocks, the deviation from the in single-stock advice was well below the acceptable deviation threshold of 10%, applied in other advice regions.

Figure 5.9 shows the required change in fishing mortality for each fish stock if the intermediate year assumptions (2022) and advice targets (2023) of the single species advice are to be met. A large reduction in Fbar would be required to meet the advice target of zero catch for whiting in 2023, with smaller reductions in the Fbar of cod and sole also required. Meanwhile, an increase in Fbar would be required to catch up to the advice of haddock and plaice. *Nephrops* catches in recent years are also considerably below current single-stock advice.

5.4.2.2 Mixed fisheries analyses

The overview of the FCube catch projections for each scenario is shown in Tables 5.9-5.11 and Figures 5.10-5.11. In contrast to single-stock advice there is no single advised catch level based on the mixed fishery approach, instead a range of scenarios are presented. Scenarios that result in under or overshoot of single stock advice are useful in identifying imbalances between the fishing opportunities for 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. ICES single-stock advice for the stocks considered here are based on a combination of the MSY approach and precautionary considerations. The MSY approach is used for haddock, plaice, sole and *Nephrops*. Scenarios for cod and whiting are based on ICES zero-catch advice, based on precautionary considerations.

The "min" scenario is consistent with a full implementation of a landing obligation given the individual single-stock advice. For 2023, the "min" scenario is driven by the restriction imposed by the zero-catch advice for whiting and cod. All fleets in the Irish Sea catch whiting, which is the most limiting stock in this area. Cod is caught by 11 of the 14 fleets. The 2023 scenario with the whiting catch advice at zero ("whg-is") implies that catches of the other Irish Sea stocks would also be zero (the "min" scenario). The scenario with the cod catch advice at zero ("cod-is") is similarly low, but suggests that there would be some small catches of plaice, sole and whiting by three fleets (Table 5.9).

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 all stocks are exhausted. The assumption that all fleets continue fishing until all their stock shares are exhausted irrespective of economic viability, legality, or fleet capacity, makes it an implausible scenario. Its purpose is mainly to illustrate inconsistencies in single-stock catch advice. In 2023, the "max" scenario indicated that haddock is the least restrictive for 12 of the 14 fleets in the model. The "had-is" scenario would result in overshoot in the advice for all other stocks.

The "nep-is" advice scenario results in an overshoot for cod, sole and whiting and an undershoot for haddock and plaice. Catches in the 'nep-is' scenario are considerably above those of the 'sq_E' scenario, indicating that between 2019-2021 *Nephrops* has been harvested substantially below the level of the 2023 advice.

The *status quo* effort scenario ("sq_E"), which represents recent fishing effort across all fleets, results in forecast catches below the single-stock advice of haddock, *Nephrops* and plaice, and above the advice for cod and whiting.

In June 2022 an ICES technical service request was provided for zero-catch advice stocks including cod and whiting in the Irish Sea (ICES, 2022c). This technical service uses a different methodology to that of the mixed fisheries FCube scenarios presented here, and does not consider the full range of fleet and stock dynamics considered by WGMIXFISH. However, there are conceptual similarities between the 'unavoidable' bycatch scenarios provided in the technical service and the FCube status quo effort scenario presented here. In both cases the scenarios can be seen to represent the expected catches of cod or whiting assuming similar patterns and behaviour of the fisheries to the recent period. In the case of cod, the technical service which considers bycatch from the *Nephrops* and haddock fisheries estimates catches of cod at 159 tonnes, whilst the

FCube mixed fisheries status quo effort scenario estimates cod catches at 165 tonnes. In the case of whiting, the technical service estimates whiting catches based on a combination of *Nephrops* fishing activity and whiting recruitment, and estimates catches of whiting in 2023 at 1 125 tonnes. Catches of whiting in the status quo FCube model are higher at 1 392 tonnes. For comparison, the average catches of cod and whiting between 2019–2021 were 203 tonnes and 1 347 tonnes respectively.

Taken together 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 whiting or cod in 2023 is not considered precautionary as the stocks are estimated to be and to remain below B_{lim} under all advice options (ICES, 2022a).

5.5 References

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Kell, L.T., Mosqueira, I., Grosjean, P., Fromentin, J.-M., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M.A., Poos, J.J., Scott, F., Scott, R.D., 2007. FLR: an open-source framework for the evaluation and development of management strategies. Ices Journal of Marine Science 64, 640–646. https://doi.org/10.1093/icesjms/fsm012

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Table 5.5. Mismatch between accessions and InterCatch métiers. Table shows the accessions métiers (WGMIXFISH) for which no matching métier was available from that country and year. InterCatch métiers from corresponding countries and years were used to apply discard rates to these accessions métiers. Total landings, indicates total landings for that country, year and métier in the accessions data.

Country	Accessions métier	Year	Tonnes in accession	InterCatch métier
EN	OTB_CRU_16-31_0_0_all	2019	0.45	TBB_CRU_16-31_0_0_all
EN	OTM_SPF_32-69_0_0_all	2019	0.351	OTB_SPF_32-69_0_0_all
EN	OTB_DEF_100-119_0_0_all	2020	2.328	OTB_DEF_>=120_0_0_all
EN	OTB_CRU_16-31_0_0_all	2020	0.050	TBB_CRU_16-31_0_0_all
IE	DRB_MOL_0_0_0_all	2019	2.730	MIS_MIS_0_0_0
IE	FPO_MOL_0_0_0_all	2019	0.040	MIS_MIS_0_0_0
IE	OTB_DEF_>=120_0_0_all	2019	264.705	OTB_DEF_100-119_0_0_all
IE	OTB_DEF_>=120_0_0_all	2020	150.150	OTB_DEF_100-119_0_0_all
IE	OTB_DEF_70-99_0_0_all	2020	12.200	OTB_CRU_70-99_0_0_all

Table 5.6. Irish Sea. Summary of the 2023 ICES single-species advice. Target Fs are left justified; harvest ratios are right justified.

Species	Agreed TAC 2022	Total Catch-advice for 2023	Projected landings-advice for 2023	F_{total}/Harvest ratio for 2023	F_{wanted}/ Harvest ratio for 2023	SSB 2023	SSB 2024
cod.27.7a	206	0	0	0	0	4842	5930
had.27.7a	3038	2648	2107	0.28	0.171	11 817	9321
nep.FU.14	17038	789	735	11**	n/a	386***	n/a
nep.FU.15	17038	11069	9271	18.2**	n/a	4498***	n/a
ple.27.7a	2747	2039	967	0.196	0.061	13514	12629
sol.27.7a	787	605	435	n/a	0.189^	3299	3129
whg.27.7a	721	0	0	0	0	1223^^	2211^^

*** TAC applies to all FU's of Subarea 7, of which no more than 2804 t may be caught in FU16.**

**** Harvest ratio for projected landings + projected dead discards**

***** Stock abundance in millions of individuals**

^ F-target in the single stock forecast for Sole 7a is based on the landings (Fwanted).

^^ Single-stock advice for whg.27.7a was last issued in 2021. SSB values for 2023 and 2024 are from the 2022 WGCSE update assessment (ICES, 2022a)

Table 5.7. Comparison between the outputs from the baseline run (reproduction of advice) and ICES advice. Figures for 2022 compare results from the baseline run to the ICES single-stock 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
2022	cod.27.7a	catch	166.000	165.000	0.6
2022	cod.27.7a	Fbar	0.038	0.038	0.0
2022	cod.27.7a	landings	159.000	159.000	0.0
2022	cod.27.7a	ssb	5653.000	5653.000	0.0
2023	cod.27.7a	catch	0.000	0.000	0.0
2023	cod.27.7a	Fbar	0.000	0.000	0.0
2023	cod.27.7a	landings	0.000	0.000	0.0
2023	cod.27.7a	ssb	5400.000	5400.000	0.0
2024	cod.27.7a	catch	NA	NA	NA
2024	cod.27.7a	ssb	5930.000	5930.000	0.0
2022	had.27.7a	catch	1841.000	1846.000	−0.3
2022	had.27.7a	Fbar	0.159	0.159	0.0
2022	had.27.7a	landings	1541.000	1545.000	−0.3
2022	had.27.7a	ssb	14282.000	14274.000	0.1
2023	had.27.7a	catch	2649.000	2648.000	0.0
2023	had.27.7a	Fbar	0.280	0.280	0.0
2023	had.27.7a	landings	2108.000	2107.000	0.0
2023	had.27.7a	ssb	11811.000	11817.000	−0.1
2024	had.27.7a	catch	NA	NA	NA
2024	had.27.7a	ssb	9308.000	9321.000	−0.1
2022	ple.27.7a	catch	687.6260	680.000	1.1
2022	ple.27.7a	Fbar	0.0640	0.064	0.0
2022	ple.27.7a	landings	326.0611	322.000	1.3
2022	ple.27.7a	ssb	13125.0000	13282.000	−1.2
2023	ple.27.7a	catch	2031.2192	2039.000	−0.4
2023	ple.27.7a	Fbar	0.1960	0.196	0.0
2023	ple.27.7a	landings	963.1712	967.000	−0.4
2023	ple.27.7a	ssb	13368.0000	13514.000	−1.1
2024	ple.27.7a	catch	NA	NA	NA
2024	ple.27.7a	ssb	12467.0000	12629.000	−1.3
2022	sol.27.7a	catch	796.000	787.000	1.1
2022	sol.27.7a	Fbar	0.220	0.220	0.0
2022	sol.27.7a	landings	704.000	696.000	1.1
2022	sol.27.7a	ssb	3588.000	3588.000	0.0
2023	sol.27.7a	catch	604.000	605.000	−0.2
2023	sol.27.7a	Fbar	0.189	0.189	0.0
2023	sol.27.7a	landings	534.000	535.000	−0.2
2023	sol.27.7a	ssb	3290.000	3299.000	−0.3
2024	sol.27.7a	catch	NA	NA	NA
2024	sol.27.7a	ssb	3120.000	3129.000	−0.3
2022	whg.27.7a	catch	1548.000	1559.000	−0.7
2022	whg.27.7a	Fbar	0.779	0.779	0.0
2022	whg.27.7a	landings	292.000	292.000	0.0
2022	whg.27.7a	ssb	992.000	992.000	0.0
2023	whg.27.7a	catch	0.000	0.000	0.0
2023	whg.27.7a	Fbar	0.000	0.000	0.0
2023	whg.27.7a	landings	0.000	0.000	0.0
2023	whg.27.7a	ssb	1223.000	1223.000	0.0
2024	whg.27.7a	catch	NA	NA	NA
2024	whg.27.7a	ssb	2210.000	2211.000	0.0

Table 5.8. Comparison between WGMIXFISH baseline run (reproduction of advice) and ICES advice for *Nephrops* in the Irish Sea. FU14 and FU15 *Nephrops* stocks are merged in the mixed fisheries model, thus catches and landings are compared to the sum of those for FU14 and FU15 in the single-stock advice. NA values in 'single-stock' column in 2022 indicate values which are not calculated in the single-stock advice process for the intermediate year. Similarly, there is no equivalent merged harvest rate for both FU's given in the single-stock advice.

Year	Stock	Value	Fcube Baseline	Single-stock	% difference
2022	nep.fu.14,15	Catch	9934	NA	NA
2022	nep.fu.14,15	hr	0.15	NA	NA
2022	nep.fu.14,15	Landings	8247	NA	NA
2023	nep.fu.14,15	Catch	12046	11848	1.6
2023	nep.fu.14,15	hr	0.18	NA	NA
2023	nep.fu.14,15	Landings	10192	10006	1.9

Table 5.9. FCube scenarios for the in Irish Sea. Forecast catch (in tonnes) for mixed-fisheries scenario in 2023.

Stock	Single-stock catch advice (2023)*	Catch per mixed-fisheries scenario (2023)						
		max	min	sq_E	cod-is	had-is	nep-is	whg-is
cod.27.7a	0	293	0	165	0	290	216	0
had.27.7a	2648	2670	0	1522	1	2667	1957	0
nep.fu.14,15	11858	16488	0	9380	0	16110	11964	0
ple.27.7a	2039	2418	0	1286	1	2414	1684	0
sol.27.7a	605	1058	0	614	7	1054	795	0
whg.27.7a	0	2003	0	1392	89	2008	1639	0

* Advised catches of no more than the indicated value.

Table 5.10. Mixed fisheries for the Irish Sea. Fishing mortality (F) resulting from single-stock advice and different mixed-fisheries scenarios for demersal fish species. The colour gradients of the legend show the forecast F under each scenario in relation to reference points (detailed in legend).

Stock	Single-stock F advice (2023)	Fishing mortality per mixed-fisheries scenario (2023)						
		max	min	sq_E	cod-is	had-is	nep-is	whg-is
cod.27.7a	0	0.067	0	0.037	0	0.066	0.049	0
had.27.7a	0.28	0.28	0	0.151	0.00009	0.28	0.199	0
ple.27.7a	0.196	0.25	0	0.127	0.00007	0.25	0.168	0
sol.27.7a	0.189	0.34	0	0.186	0.00176	0.34	0.25	0
whg.27.7a	0	1.37	0	0.79	0.038	1.38	1	0

Legend:

- $F_{2023} \leq F_{MSY}$
- $F_{MSY} < F_{2023} < F_{pa}$
- $F_{pa} < F_{2023} \leq F_{lim}$
- $F_{2023} > F_{lim}$

Table 5.11. Mixed fisheries for the Irish Sea. Spawning-stock biomass SSB results from single-stock advice and different mixed-fisheries scenarios. All weights are in tonnes. The colour gradients of the legend show the forecast SSB under each scenario in relation to reference points (detailed in legend).

Stock	Single-stock advice SSB (2024)	SSB per mixed-fisheries scenario (2024)						
		max	min	sq_E	cod-is	had-is	nep-is	whg-is
cod.27.7a	5930	5593	5934	5742	5934	5597	5683	5934
had.27.7a	9321	9361	12173	10560	12172	9364	10104	12173
ple.27.7a	12629	11610	13533	12508	13532	11612	12192	13533
sol.27.7a	3129	2815	3768	3214	3762	2819	3051	3768
whg.27.7a	2211	573	2193	1010	2112	570	825	2193

Legend:

- $SSB_{2024} \geq B_{pa}$ or MSY $B_{trigger}$
- $SSB_{2024} \geq B_{lim}$, no B_{pa} defined
- $B_{lim} \leq SSB_{2024} < B_{pa}$
- $SSB_{2024} < B_{lim}$

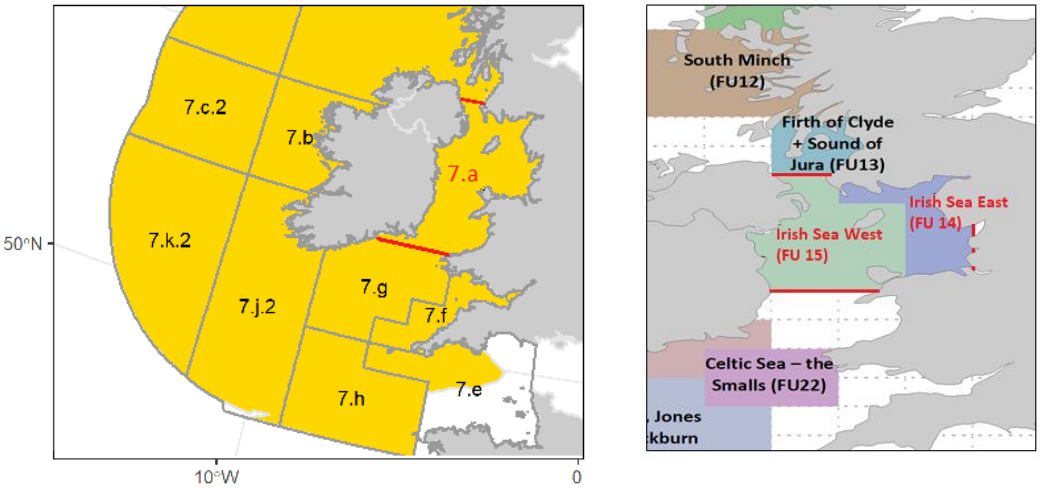


Figure 5.1 ICES Area description for fish (7a) and *Nephrops* Functional Units (FU) in the Irish Sea region.

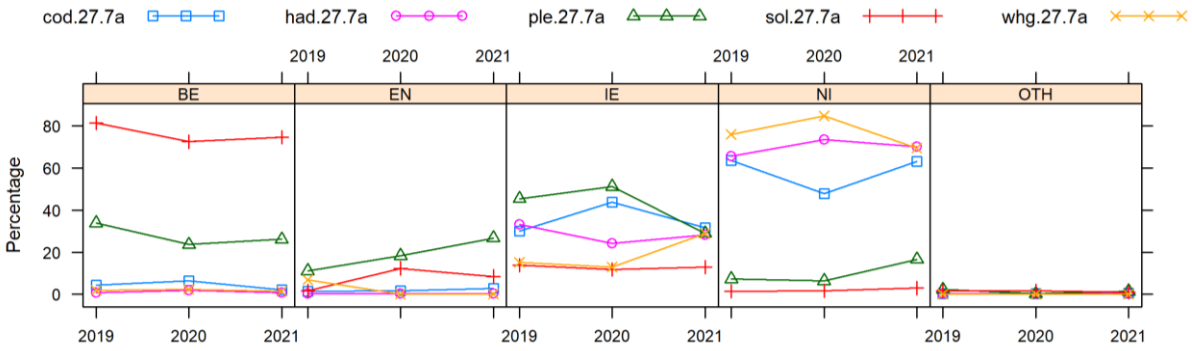


Figure 5.2. Percentage of total catches by country per fish stock 2019-2021. BE = Belgium, EN = England (UK), IE = Ireland, NI = Northern Ireland (UK). OTH = fleets of any nationality landing < 1% of any stocks.

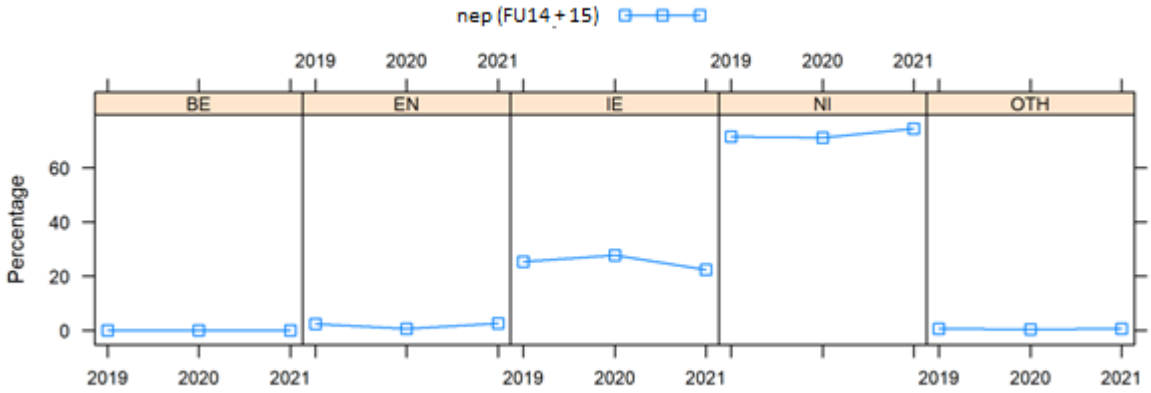


Figure 5.3. Percentage of total catches of *Nephrops* by country 2019-2021, BE = Belgium, EN = England (UK), IE = Ireland, NI = Northern Ireland (UK). OTH = fleets of any nationality landing < 1% of any stocks.

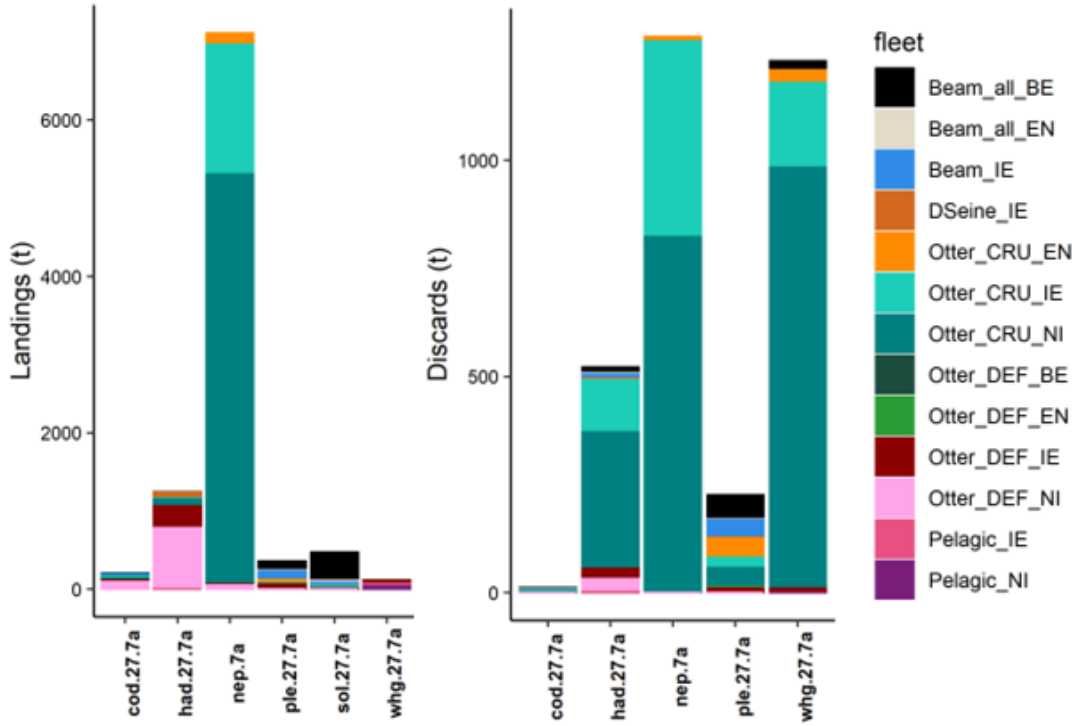


Figure 5.4. Landings and discards of stocks included in the FCube model by fleet (average 2019-2021). Y-axis scale differs between plots. Plaice discards are 'dead discards' only, calculated at the 40% survival rate as per the single species assessment. Sole discards are not included as these are not included in the FCube model as per single species stock assessment, instead they are calculated as 11.6% of catch by weight after the model forecast. Other fleets catching less than <1% of any stock are omitted from figure for visualisation reasons.

Figure 5.5. Quality control comparison of different sources of landings data. Blue dotted lines show ICES landings from WGCSE advice sheets, dashed red line shows WGMIXFISH accessions landings data and solid black lines show landings reported in InterCatch data. Note differing scales on y-axes per stock.

Figure 5.6. Quality control comparison of different sources of discards data. Blue dotted lines show ICES assessment discards from WGCSE advice sheets, dashed red line shows WGMIXFISH discards by applying the discards rate from InterCatch per métier, country and year to accessions landings. Solid black lines show discards reported in InterCatch data. Note differing scales on y-axes per stock.

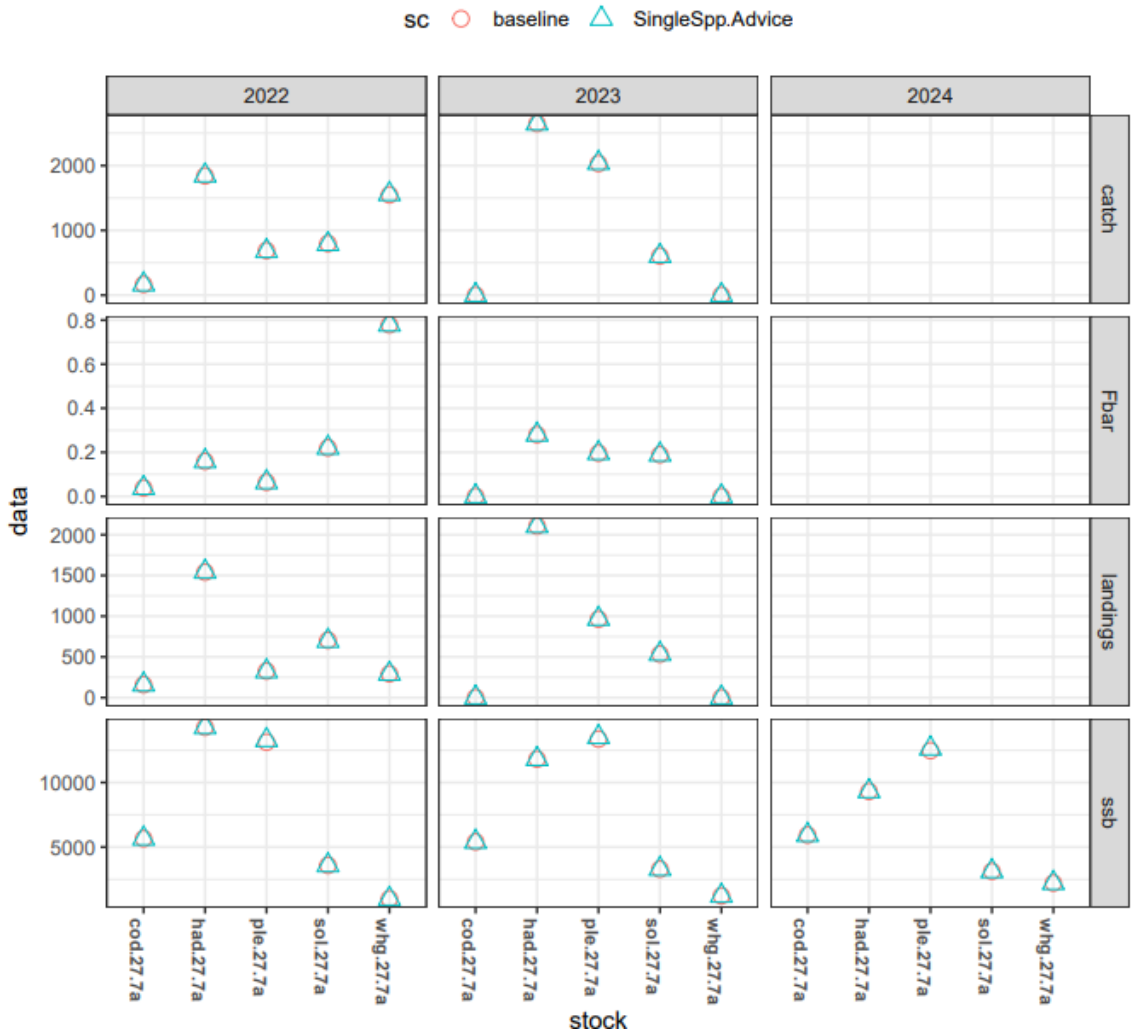


Figure 5.7. Irish Sea. Difference in absolute values between mixed fisheries baseline run (reproduction of advice) and single-stock advice for demersal fish stocks, showing catch, Fbar and landings (2022–2023) and SSB (2022–2024).

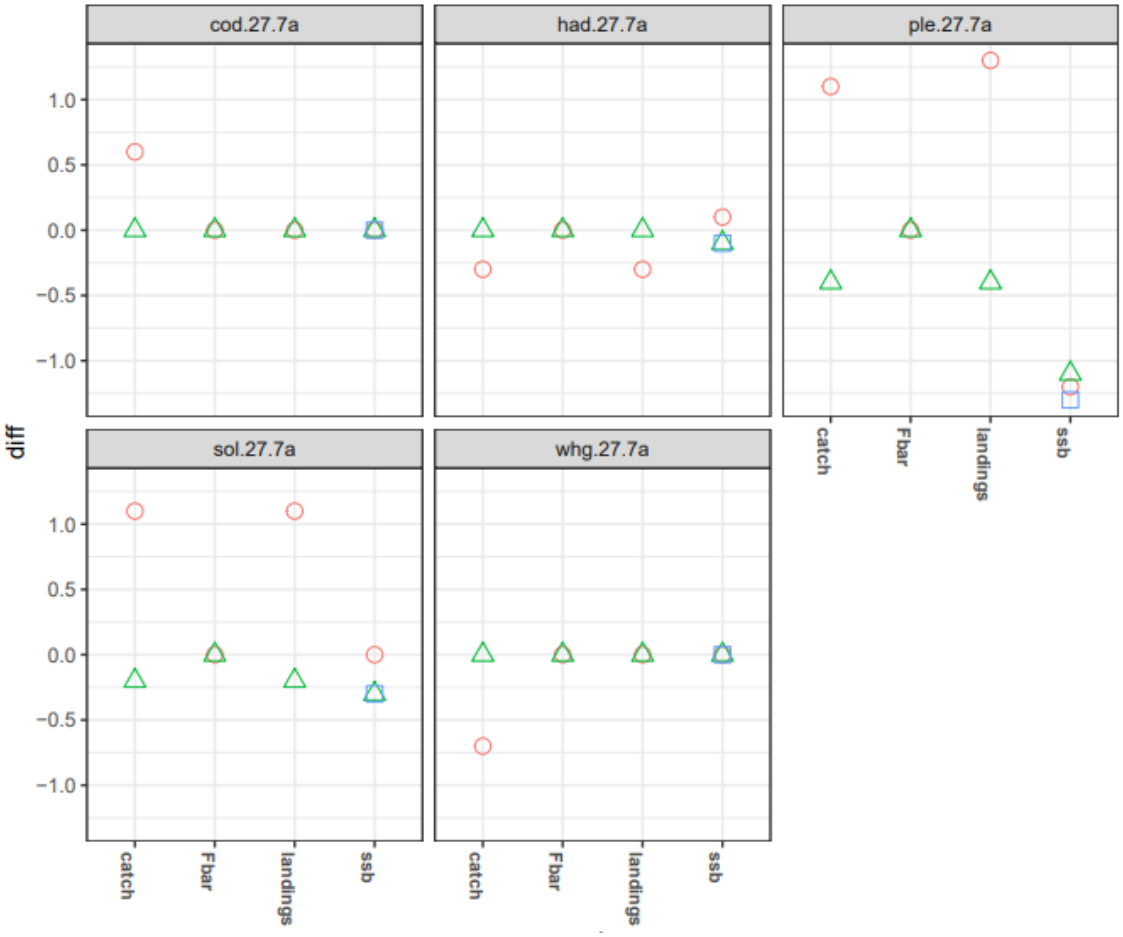


Figure 5.8. Irish Sea. Proportional difference between mixed fisheries baseline run (reproduction of advice) and single-species advice for finfish stocks, showing catch (tonnes), Fbar and landings (tonnes) (2022–2023) and SSB (tonnes)(2022–2024).

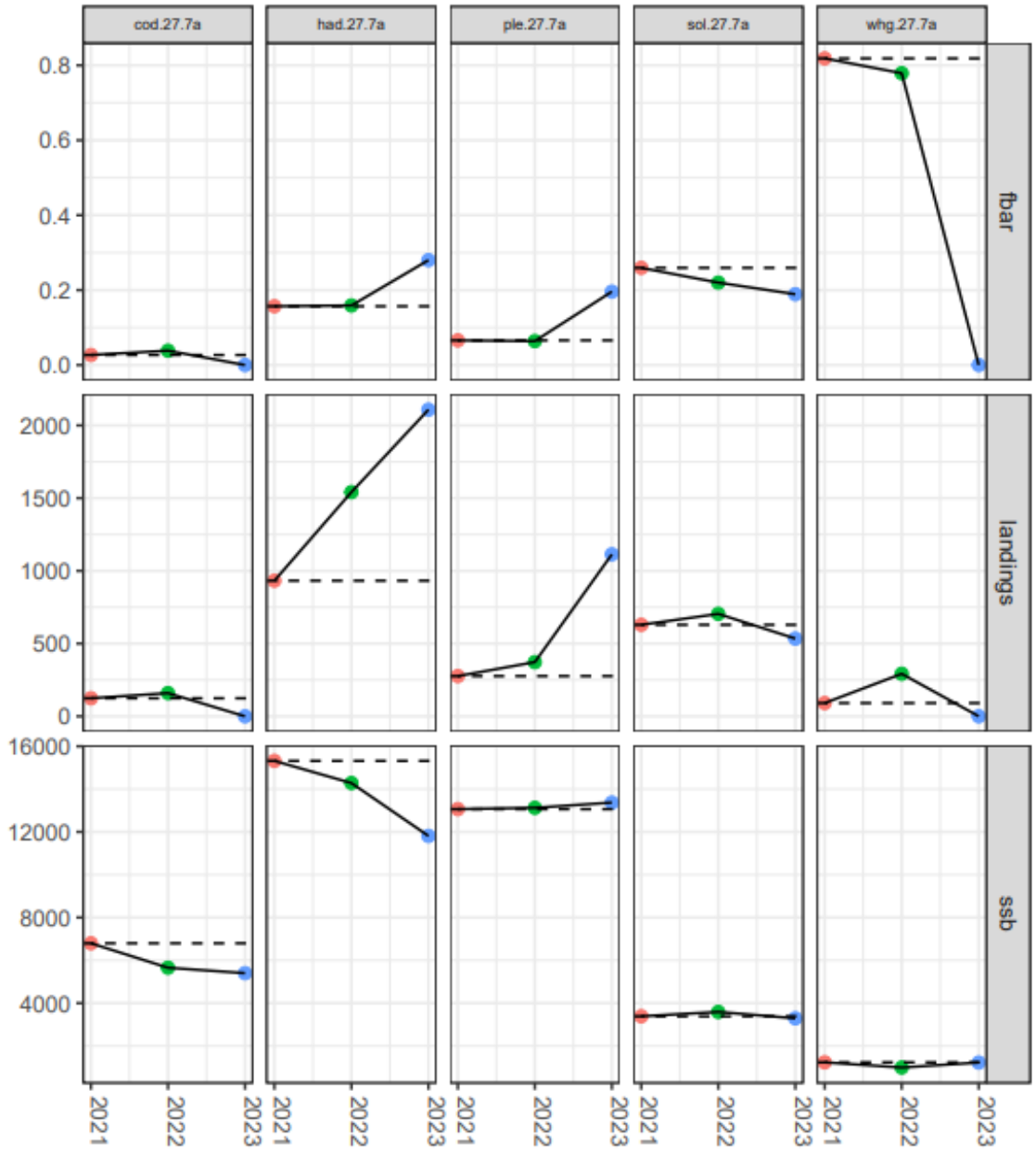


Figure 5.9. Change in fishing mortality (Fbar), landings (tonnes) and SSB (tonnes) assumed in the intermediate year (2022) and required for the TAC year (2023) under the single-stock forecast assumptions consistent with the MSY approach.

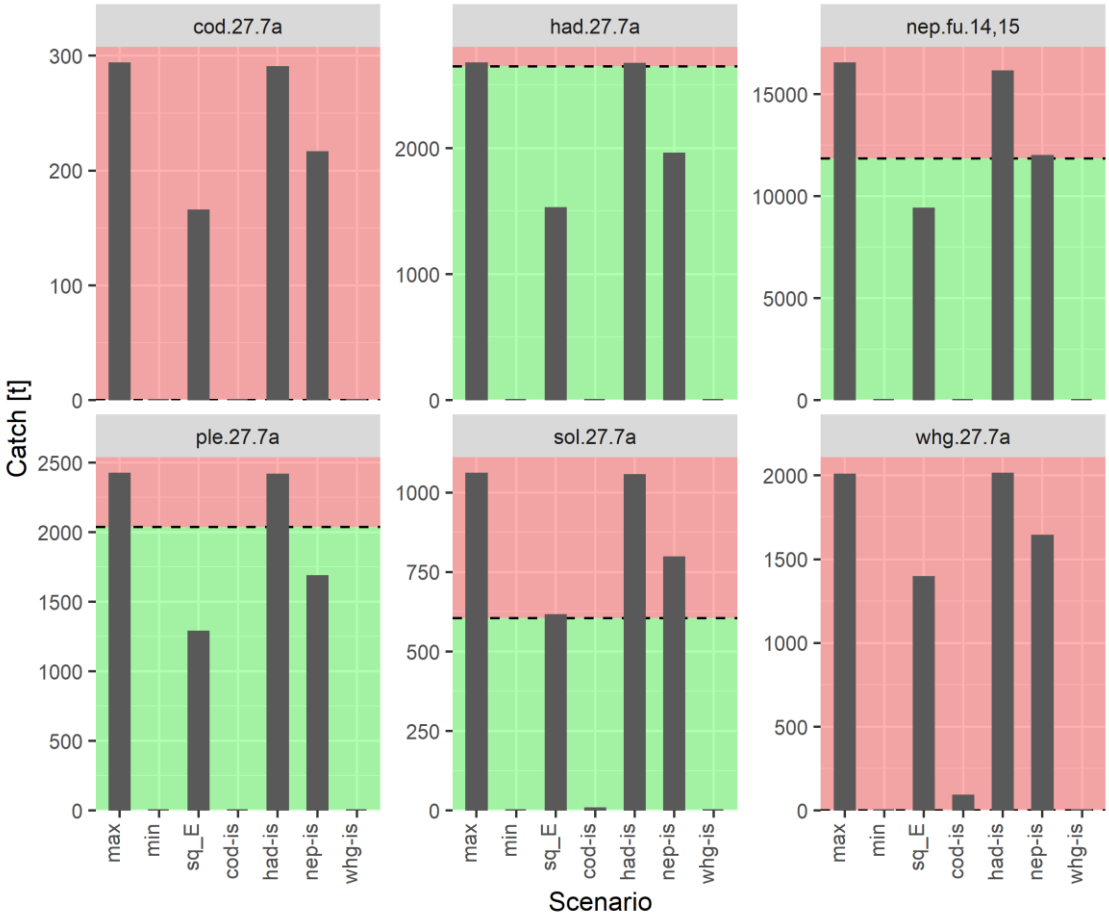


Figure 5.10 Mixed fisheries for the Irish Sea. Mixed-fisheries projections. Estimates of potential 2023 catches (in tonnes) by stock and by scenario. The horizontal dashed line corresponds to the single-stock catch advice, with areas above and below the line representing potential over and undershoot respectively.

Figure 5.11. Mixed fisheries for the Irish Sea. Estimates of effort by fleet needed to reach their stock-share of the single-stock advice. Stocks are coded by colour, with the bar for the most limiting stock ("choke species") for each fleet in 2023 highlighted with a red border and star, and the bar for the least limiting species highlighted with a green border. Fleet names reflect main gear type, target species assemblage and country. 'OTH_OTH' fleet combines all small fleets and métier with landings < 1% for any stock in the model (average 2019-2021). The status quo effort for each fleet (average 2019-2021) is shown as a dashed line for reference.

6 North Sea

6.1 Background

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

6.1.1 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.

6.1.2 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 (Regulation (EU) 2018/973), 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, UK and Norway. As there is no agreement with Norway and the UK regarding the EU MAP, ICES gives advice based on the ICES MSY approach. 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 assessments, and since they are stocks shared with UK and Norway, ICES also gives advice for the stocks on the basis of the ICES MSY framework (while according to the MAP, they should be managed according to the precautionary approach).

In the mixed fisheries simulations, it is assumed that TACs for 2023 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/UK/Norway negotiations, and may deviate from the ICES advice.

6.2 FLBEIA

6.2.1 Software

All analyses were conducted using the FLBEIA model, coded as a method in R (R Core Team, 2022), as part of the FLR framework (Kell *et al*., 2007; www.flr-project.org). Input data are in the form of FLFleetsExt and FLBiols objects inherited from the FLCore 2.6.19 package objects, and two forecast methods were used, stf() from the FLAssess (version 2.6.3) and fwd() from the Flash (version 2.5.11) packages. Both input parameterisation as well as the stock projections are made using FLBEIA functions and methods (version 1.16.0.0), that are flexible enough to allow covering different alternatives. FLBEIA source code is available at GitHub (https://github.com/flr/FLBEIA). The code, software and versions are part of the ICES

Transparent Assessment Framework (TAF) and can be fully reproduced from this repository (see https://github.com/ices-taf/2022_NrS_MixedFisheriesAdvice).

The baseline run is performed with the objective of reproducing as closely as possible the single-species advice produced by ACOM, and act as the reference scenario for subsequent mixed fisheries analyses. The single stock forecast is performed using 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. 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 forecast, they are effectively used as starting values and not replaced.

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 simpler and conducted on excel spreadsheets. This year, we also highlighted in the table what catch information is reported in the FLStocks.

Species	Assessment	Forecast	Catch in FLStock	Landings in FLStock	Discards in FLStock
COD 4, 3.a and 7.d	SAM	SAM	Observed	Observed	Observed
HADDOCK 4, 3.a and 7.d	SAM	SAM	Estimated	Estimated	Estimated
PLAICE 4	SAM	SAM	Estimated	Estimated	Estimated
SAITHE 4, 3.a and 6	SAM	SAM	Observed	Observed	Observed
SOLE 4	AAP	FLR	Estimated	Estimated	Estimated
WHITING 4 and 7.d	SAM	MFDP	Estimated	Estimated	Estimated
PLAICE 7.d	AAP	FLR	Estimated	Estimated	Estimated
SOLE 7.d	SAM	SAM	Estimated	Observed	Observed
TURBOT 4	SAM	FLR	Observed	Observed	Observed
WITCH 4, 3.a and 7.d	SAM	SAM	Observed	Observed	Observed

6.2.2 Scenarios

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. Given fishing opportunities available for each fleet (e.g. TACs by stock or effort allocation by fleet), FLBEIA estimates the potential future levels of effort for each fleet, based on fleet effort distribution and catchability by métier. Based on this effort level, landings and discards (i.e. catches) by fleet are estimated using standard forecasting procedures.

For the catch advice year FLBEIA is used to run the scenarios:

	Scenario
"**max**"	**"Maximum":** For each fleet, fishing in 2023 stops when all stock shares* of that fleet have been caught. This option causes overfishing of the single-stock advice possibilities of most stocks.
"**min**"	**"Minimum":** Fishing stops for a fleet when the fleet's catch of 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 is the most precautionary option and can highlight some potential "choke species" issues.
"**sq_E**"	**"*Status quo* effort":** The effort of each fleet in 2023 is set equal to the effort in the most recent year for which landings and discard data are available (2021).
"**cod-ns**"	**"Cod MSY approach":** All fleet effort in 2023 correspond to effort needed to take their cod stock share, regardless of other catches. (This option results in an underutilization of the single-stock advice possibilities of other stocks.)
"**range**"	"**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.

*** 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 2023 and the historical proportion of the stock landings taken by the fleet (2021).**

Incorporating *Nephrops* into the mixed fisheries advice produces a number of 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 FLBEIA 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 FLBEIA 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.

6.3 Stock input data and recent trends

6.3.1 Stock input data

The assessment data for the different stocks were supplied by ICES WGNSSK (ICES, 2022g). Similar to last year, all stock inputs formatted as FLR stock 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, witch and eastern English Channel sole). A TSA assessment was used for Northern shelf haddock and AAP as used for both plaice stocks and for North Sea sole. Therefore, for some of these stocks the advice is based on stochastic forecasts, which cannot easily be fully replicated in the deterministic FCube software. Although FLBEIA is applied for the second time this year, FCube projections are still 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 6.5); as such, WGMIXFISH does not consider the difference impacts significantly on the mixed fisheries advice.

Eastern English Channel sole was benchmarked in 2021 which altered the perception of the stock. The classification since 2019 as category 3 was upgraded to a category 1 species and the assessment model used was Sam instead of XSA. Therefore, this stock is included in the WGMIXFISH considerations.

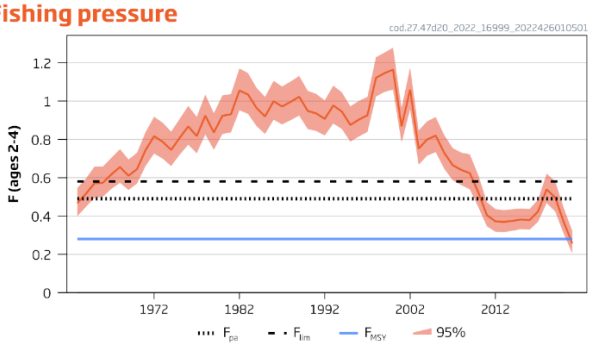
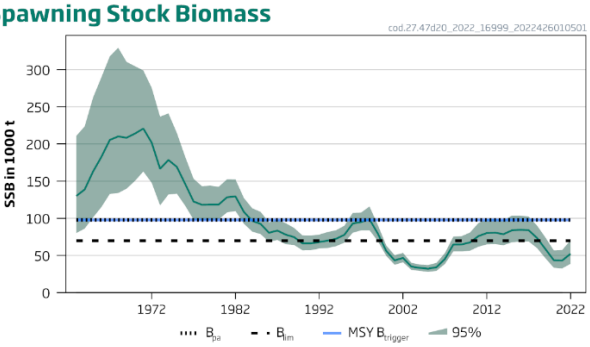
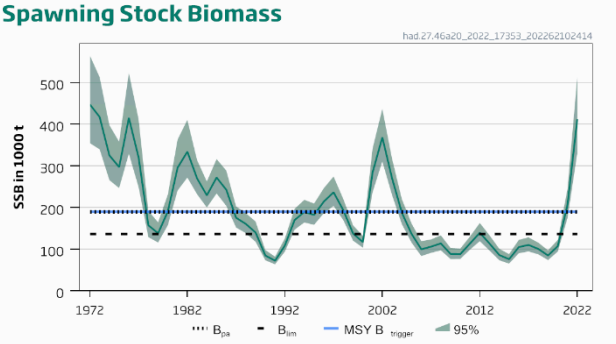
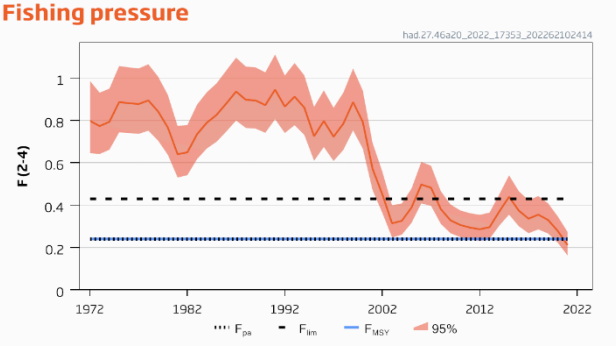
Nephrops stocks were incorporated in the evaluation by functional unit. For the *Nephrops* stocks in FU5, FU6, FU7, FU8, FU9, FU10, FU32, FU33, FU34 and *Nephrops* from areas outside the functional units, the ICES advices were taken for the F_{MSY} approach.

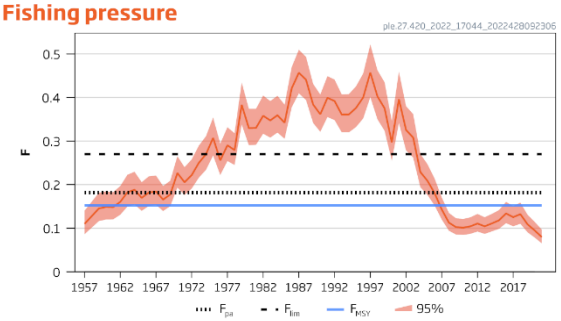
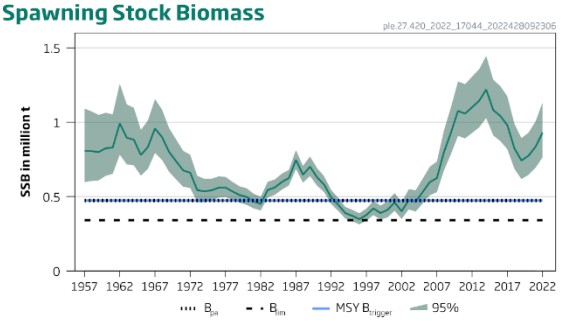
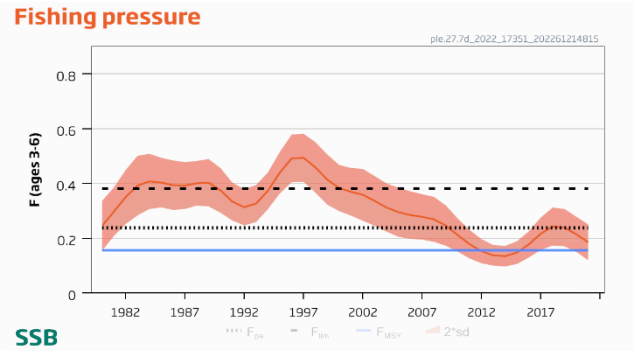
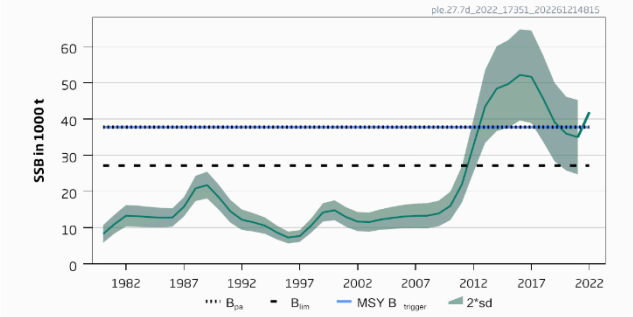
The functional units with separate stock indices and harvest rates from underwater surveys (FU6, FU7, FU8 and FU9) were treated as separate *Nephrops* identities in the projections whereas the five other functional units (FUs 5, 10, 32, 33 and 34) and catches outside the functional units in the North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

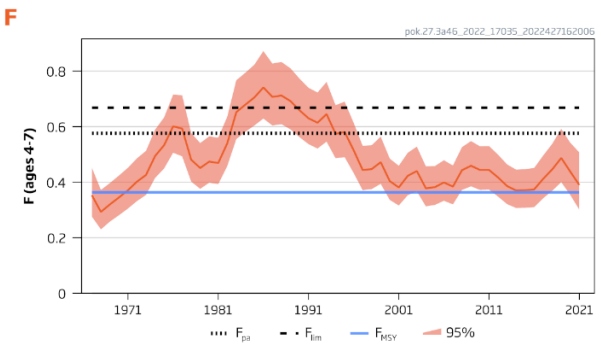
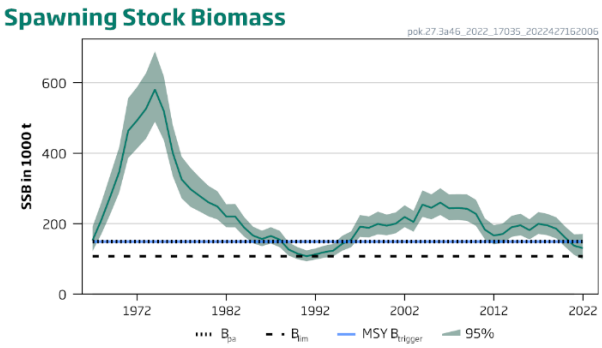
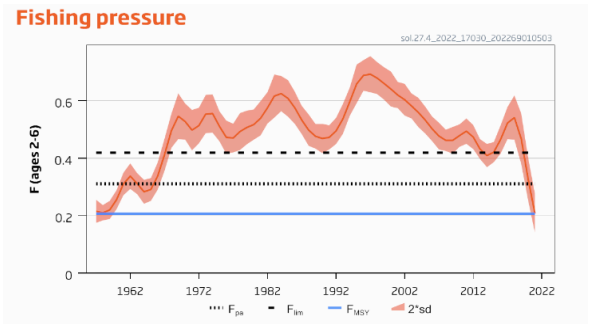
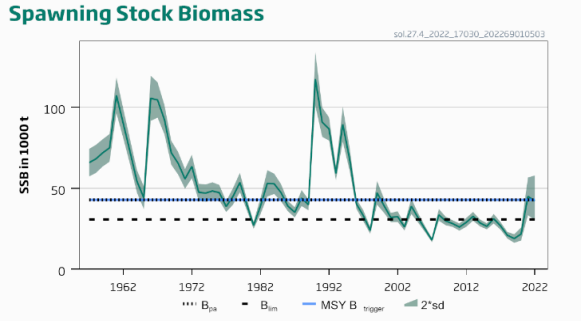
6.3.2 Recent trends and advice

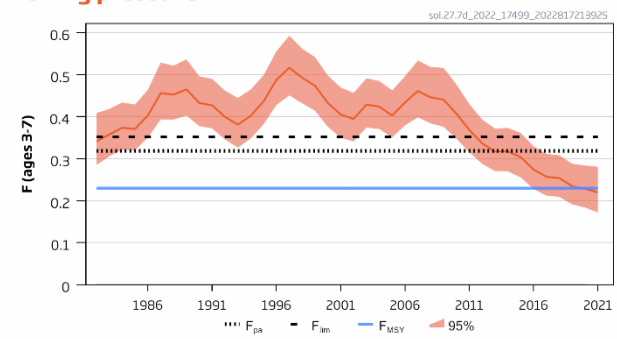
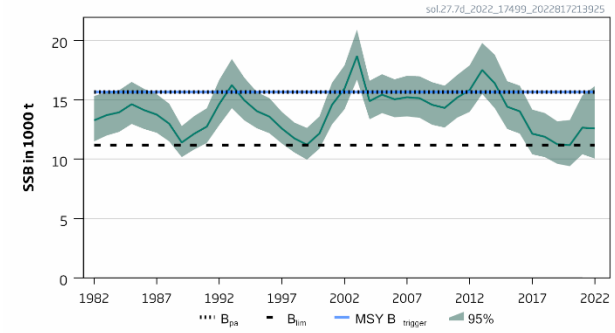
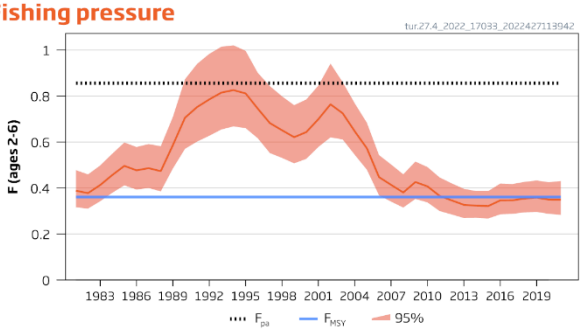
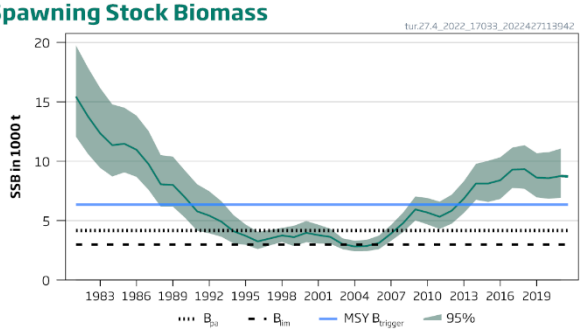
The advice for these stocks is drafted by the WGNSSK (ICES 2022) under considerations by ACOM. Recent trends are described on a stock-by-stock basis, and latest advice by stock is available on the ICES website. An overview of mixed fisheries North Sea demersal stocks advice and trends are summarized below. It should be noted that although there is only one advice, additional management considerations are also listed in each single-species advice document.

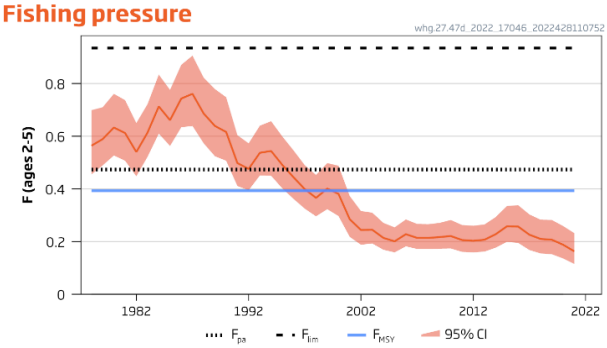
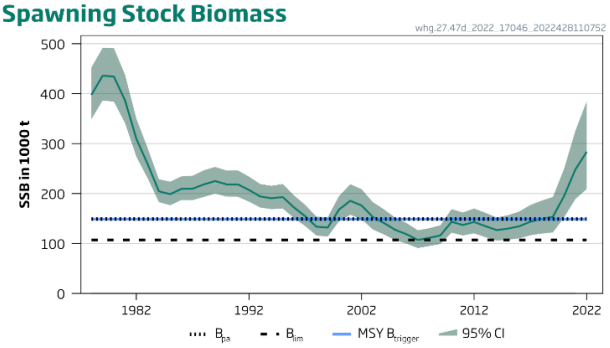
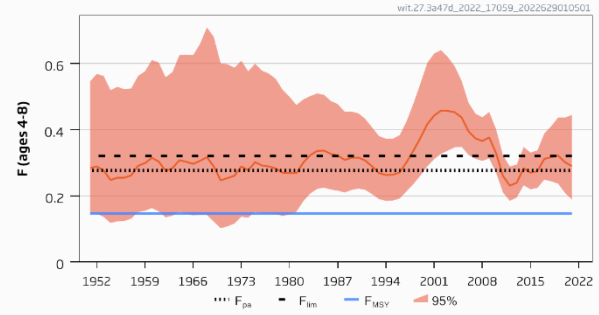
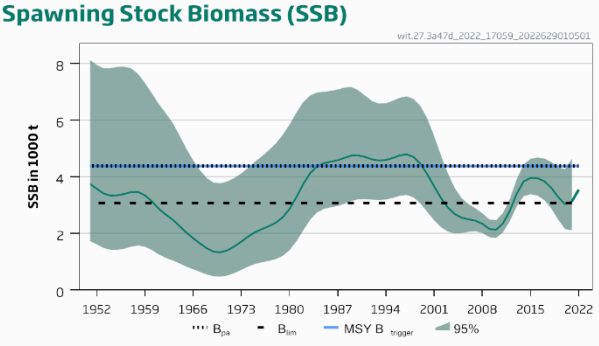
Analytical stocks

Species	Area	Stock status	Advice 2022
cod.27.47d20 (Cod)	Subarea 4, Division 7.d, and Subdivision 20 (North Sea, eastern English Channel, Skagerrak)	**Fishing pressure**  **Spawning Stock Biomass**  Summary: Fishing pressure on the stock is below F_{MSY}; spawning-stock size is below MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 22 946 tonnes.
had.27.46a20 (Haddock)	Subarea 4, Division 6.a, and Subdivision 20 (North Sea, West of Scotland, Skagerrak)	**Spawning Stock Biomass**  **Fishing pressure**  Summary: Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, total catches in 2023 should be no more than 137 058 tonnes.

Species	Area	Stock status	Advice 2022
ple.27.420 (Plaice)	Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	**Fishing pressure**  **Spawning Stock Biomass**  Summary: Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and, B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 150 705 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.
ple.27.7d (Plaice)	Division 7.d (eastern English Channel)	**Fishing pressure**  **SSB**  Summary: Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 4738 tonnes. Management of plaice in Division 7.d and 7.e under a combined TAC prevents effective control of the single-species exploitation rates and could lead to overexploitation of either species. ICES advises that management should be implemented at the stock level. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

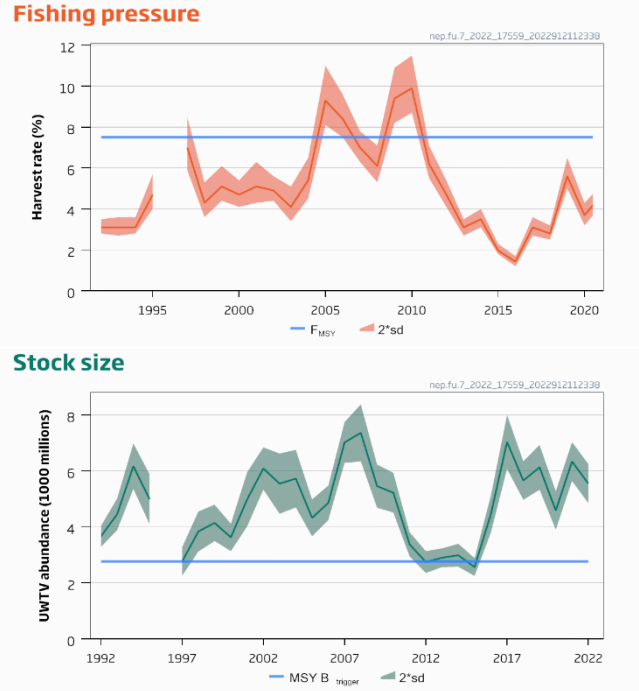
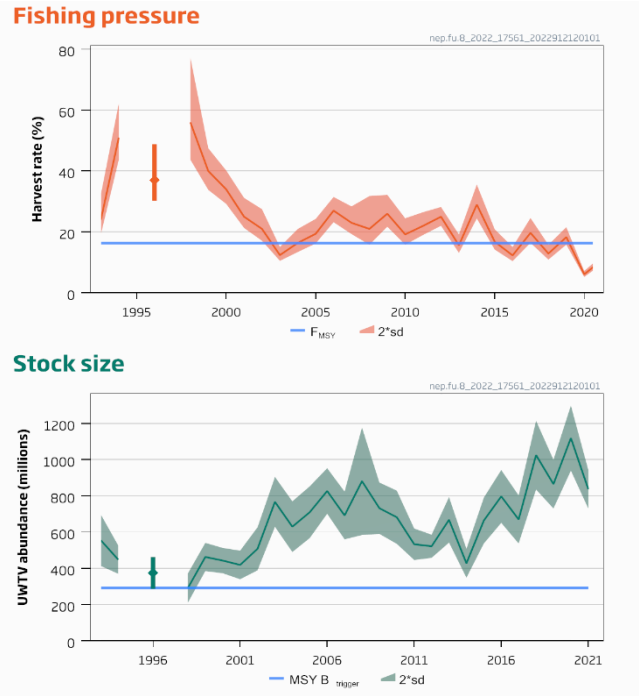
Species	Area	Stock status	Advice 2022
pok.27.3a46 (Saithe)	Subareas 4 and 6, and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	  Summary Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 58 912 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.
Sol.27.4 (Sole)	Subarea 4 (North Sea)	  Summary: Fishing pressure on the stock is above F_{MSY} but below F_{pa} and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 9152 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

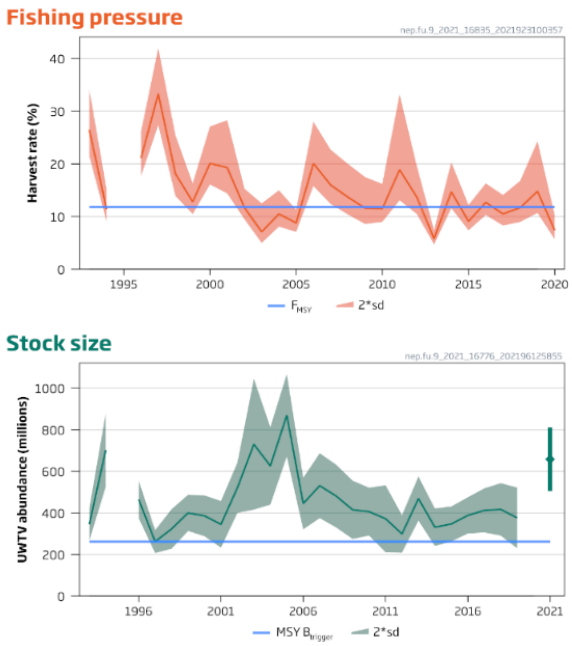
Species	Area	Stock status	Advice 2022
sol.27.7d (Sole)	Division 7.d (eastern English Channel)	**Fishing pressure**  **Spawning Stock Biomass**  Summary: Fishing pressure on the stock is below F_{MSY}; spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1747 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.
tur.27.4 (Turbot)	Subarea 4 (North Sea)	**Fishing pressure**  **Spawning Stock Biomass**  Summary: Fishing pressure on the stock is below F_{MSY}; spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 2432 tonnes. Management of turbot and brill under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. ICES advises that management should be implemented at the species level.

Species	Area	Stock status	Advice 2022
whg.27.47d (Whiting)	Subarea 4 (North Sea) and Division 7.d (Eastern Channel)	**Fishing pressure**  **Spawning Stock Biomass**  Summary: Fishing pressure on the stock is below F_{MSY} and spawning-stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 110 172 tonnes. ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock. Management should be implemented at the stock level.
wit.27.3a47d (Witch)	(North Sea, Skagerrak and Kattegat, eastern English Channel)	**Fishing pressure**  **Spawning Stock Biomass (SSB)**  Summary: Fishing pressure on the stock is above F_{MSY} and F_{pa} and below and F_{lim}; spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.	ICES advises that when the MSY approach is applied, catches in 2023 should be no more than 1313 tonnes. Management of witch and lemon sole under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. ICES advises that management should be implemented at the species level in the entire stock distribution area (Subarea 4 and divisions 3.a and 7.d).

***Nephrops* stocks**

Species	Area	Stock status	Advice 2022
Nephrops Nep.fu.5	Botney Gut-Silver Pit (FU 5)	ICES cannot assess the stock and exploitation status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points because the reference points are undefined.	ICES advises that when the precautionary approach is applied, catches in each of the years 2023 and 2024 should be no more than 1256 tonnes. To protect the stock in this functional unit (FU) from continued overexploitation, management should be implemented at the functional unit level.
Nephrops Nep.fu.6	Farn Deeps (FU 6)	 **Summary**: Fishing pressure on the stock is above F_{MSY}, and the stock size is above MSY $B_{trigger}$.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 1604 tonnes. To ensure that 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. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 4. ICES considers this plan to be precautionary when implemented at the functional unit level.

Species	Area	Stock status	Advice 2022
Nephrops Nep.fu.7	Fladen Ground (FU 7)	 **Summary**: Fishing pressure on the stock is below F_{MSY} and stock size is above MSY $B_{trigger}$.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 13 679 tonnes. To ensure that the stock in Functional Unit (FU) 7 is exploited sustainably, management should be implemented at the functional unit level. The catch in FU 7 has been lower than advised in recent years, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 4. ICES considers this plan to be precautionary when implemented at the functional unit level.
Nephrops Nep.fu.8	Firth of Forth (FU 8)	 **Summary**: Fishing pressure on the stock is below F_{MSY}, and stock size is above MSY $B_{trigger}$.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2019–2021, catches in 2023 should be no more than 3201 tonnes. To ensure that the stock in Functional Unit (FU) 8 is exploited sustainably, management should be implemented at the functional unit level. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 4. ICES considers this plan to be precautionary when implemented at the functional unit level.

Species	Area	Stock status	Advice 2022
Nephrops Nep.fu.9	Moray Firth (FU 9)	 **Summary**: Fishing pressure on the stock is below F_{MSY}, and stock size is above MSY $B_{trigger}$.	ICES advises that when the MSY approach is applied, and assuming that discard rates and fishery selection patterns do not change from the average of the years 2018–2020, catches in 2022 should be no more than 2062 tonnes. To ensure that the stock in Functional Unit (FU) 9 is exploited sustainably, management should be implemented at the functional unit level. ICES notes the existence of a management plan, developed and adopted by one of the relevant management authorities for Subarea 4. ICES considers this plan to be precautionary when implemented at the functional unit level.
Nephrops	Noup (FU 10)	ICES cannot assess the stock and exploitation status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points because the reference points are undefined.	ICES advises that when the precautionary approach is applied, catches in each of the years 2023 and 2024 should not exceed 55 tonnes, assuming discard rates. In order to ensure the stock in this FU 10 is exploited sustainably, management should be implemented at the functional unit level.
Nephrops	Norwegian Deep (FU 32)	ICES cannot assess the stock and exploitation status relative to MSY and precautionary approach (PA) reference points because the reference points are undefined	ICES advises that when the precautionary approach is applied, catches in each of the years 2023 and 2024 should not exceed 304 tonnes. This stock is under the Norwegian discard ban since 2022.
Nephrops	Horns Reef (FU 33)	ICES cannot assess the stock and exploitation status relative to MSY and PA reference points, because the reference points are undefined	ICES advises that when the precautionary approach (PA) is applied landings in each of the years 2023 and 2024 should not exceed 918 tonnes. ICES cannot quantify the corresponding total catches. To ensure that the stock in Functional Unit (FU) 33 is exploited sustainably,

Species	Area	Stock status	Advice 2022
			management should be implemented at the functional unit level.
Nephrops	Devils Hole (FU 34)	ICES cannot assess the stock and exploitation status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points because the reference points are undefined.	ICES advises that when the precautionary approach is applied, catches in each of the years 2023 and 2024 should not exceed 652 tonnes. In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level.

6.4 Fleets and métiers

6.4.1 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.

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 from 2019, 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.

This year, a data submission was received from Norway for the first time covering 2015-2021. However, due to data quality issues, Norway were only able to provide effort and landings data for vessels over 15m. The provision of data on vessels under 15m are expected within a few years. Previously, since Norwegian catches were missing from the fleet data their catches were implicitly included in the OTH-OTH fleet which includes any difference in total catches between the fleet data and the single stock assessments. This year the catches associated with the OTH_OTH fleet are much smaller since the majority of Norwegian catches (vessels >15 m) are now explicitly described within several Norwegian fleets, mostly within the TR1 métier. Further reduction in the catches associated with the OTH_OTH fleet are expected when Norway are able to provide data on the smaller vessels (<15 m).

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 country/métier/stock combination, which allows allocating discards for all WGMIXFISH métiers with matching names, such that:

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

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 by métier in InterCatch). For age-based stocks, discard rates are estimated for each age class. Similarly, proportions at age in the landing and discards from InterCatch are used to allocate age distributions to all WGMIXFISH métiers with matching names for age-based stocks. Where WGMIXFISH métiers cannot be exactly matched to métiers within the InterCatch dataset expert knowledge is used to make a match with an appropriate substitute metier.

The relative size of landings of the stocks incorporated in the mixed fisheries projections is shown in Figure 6.1.

6.4.2 Definitions of fleets and métiers

The procedure for defining fleets and métiers was not revised in 2021, 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:

1. Matching DCF métiers with definitions used in the cod long-term management plan
6. Establishing fleets by country, gear type and, when deemed necessary, vessel length group
7. Matching consistency between effort and catch data files. Métiers without catch of any of the modelled stocks in the last data year (now 2021) are not retained.
8. 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.

Despite the data now being available according to DCF categorization, WGMIXFISH is 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 6.1 and Figure 6.2.

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. This year, fleets are conditioned as age-disaggregated fleets, this means that catchability at age is considered for each metier rather than having catchability at the fleet level (see Stock Annex).

In 2022, the final data used contained 46 national fleets (including the OTH fleet). These fleets engage in 1 to 8 different métiers each, resulting in 155 combinations of country*fleet*métier*area catching fish and *Nephrops* stocks considered this year (**Error! Reference source not found.**). The b alance of landings of the stocks across gear categories is shown in Figure 6.2.

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. 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).

This year, new diagnostics were produced to check the fleet conditioning in FLBEIA. The fishing mortality at age and averaged as well as age-disaggregated and total catch, landings and discards across all fleets was compared to the values estimated from the single-species stock assessments (Figure 6.3 to Figure 6.6 andTable 6.1 to Table 6.5). Some discrepancies exist, for example for catch and landings at age for haddock. This is due to the fact that weight at age for each stock is now given at the fleet level rather than the stock. For haddock, this induces some differences in mean weight at age in landings between the InterCatch data and the ones used in the single species assessment.

6.4.3 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 6.7) and relative trends (Figure 6.8), and landings by fleet and stock (Figure 6.9) are included in this report.

6.5 Mixed fisheries forecasts

6.5.1 Description of scenarios

Baseline run

The various single-stock forecasts presented by WGNSSK are performed using different software and setups (see Section 6.2.1). For the purpose of the mixed fisheries analyses, it is necessary to gather all stock assessment output and forecasts settings into a single unified framework in FLR, which builds on the "FLBEIA" package (García *et al*., 2017). The same forecast settings as in WGNSSK are used for each stock regarding weight-at-age, selectivity and recruitment, as well as the assumptions made for the intermediate year (2022) and the basis for advice (ICES MSY advice rule). Using these settings, and not introducing any mixed-fisheries interactions, short-term forecasts are carried out at WGMIXFISH. These baseline run is then compared to the estimates provided in the ICES advice sheets.

For a number of stocks, it is not expected that the single-stock advice can be exactly reproduced within the FLR environment. There are data and model related differences between the framework used at WGMIXFISH and the different single-stock forecasts conducted at WGNSSK:

- For a number of stocks assessed using SAM (cod, haddock, saithe, sole 7d and witch), the single-stock advice is based on stochastic forecasts (in which the forecast result is the median of a number of iterations, carried out with different starting conditions and process variance realisation), which cannot be reproduced using FLR.
- For whiting, the single stock forecast uses the Multi Fleet Deterministic Projection (MFDP) forecast software, which models separately fleets fishing for human consumption and the industrial fishery, which is a different fleet specification that in FLBEIA and can also not be reproduced with the FLR function used to project the stocks.

In addition to that, the FLBEIA framework has some specificities of its own which depart from the way most stock assessment and forecast methods operate:

- Although assumption used for conditioning the forecast are the same, in FLBEIA, future assumptions regarding biology and exploitation pattern are derived from fleet-disaggregated data, while at WGNSSK they are derived from stock-level assessment input and output
- The catch process is modelled using a different equation (Baranov equation for single stock advice and for Cobb Douglas equation in FLBEIA)

In order to assess the impact of the change in modelling framework on the quantities produced in short-term projections for the various stocks considered, two different baseline runs are produced using the WGMIXFISH FLR environment:

- WGMIXFISH FLR baseline: a simple FLR deterministic forecast using the fwd() function that uses exactly the same input (starting abundances, future biology and fisheries selectivity) and the same production function (Baranov) as the forecast methods used in the WGNSSK. This run is used as a quality check that is mainly aimed at checking that all stock data and future assumptions are transferred correctly into the FLR/FLBEIA environment. Discrepancies with the WGNSSK forecast should be minimal, and only results from method used in WGNSSK not being fully reproducible in FLR (e.g. SAM stochastic forecasts).
- WGMIXFISH-FLBEIA baseline: a FLBEIA baseline run in which stocks are projected forward independently from each other (no mixed fisheries interactions). In addition to the discrepancies observed for the simple FLR run, this WGMIXFISH-FLBEIA baseline run may deviate further from the WGNSSK single stock advice as they are carried out with mean weight, discard rate and selectivity at age based on the mixed-fisheries data, and using the Cobb Douglas production function. The aim of this baseline run is to assess the impact of changing from a modelling framework not considering fleets, to a fleet-explicit one.

These two baseline runs are compared with the single-stock advice forecast from WGNSSK.

For a number of stocks (COD-NS, HAD, WHG-NS) the stock assessment produces abundances-at-age estimates until the current year (while for the other stocks, the assessment goes until one year before the current year). This means that the initial stock numbers for the short term forecast for these stocks are not a calculation of the survivors based on the last assessment year, but actual stock assessment estimates. In the default forecast configuration in both FLR/fwd() and FLBEIA, any abundance-at-age provided for the first forecast year (the current year), gets overwritten by the outcome of the survival equation using the abundances and fishing mortality from the previous year. This was identified as one of the main sources of discrepancy between the single-stock advice and the WGMIXFISH baseline run in previous years. In order to improve the

WGMIXFISH-FLR baseline run, a modification of the FLR function fwd() was made so that the abundances provided for the first forecast year are used as such and not overwritten.

This year, in order for this to be correctly implemented in FLBEIA as well, a small modification of the FLBEIA configuration was done: for those particular stocks with abundance estimates in the current year, the projection for the first year (current year) are now done using a "constant biomass" configuration. This means that the first step of the FLBEIA projection, in which abundances-at-age at the start of the projection year are calculated, is not done, and any value already provided is used instead.

In the case of the HAD stock, the methodology to conduct the short-term forecast at WGNSSK was changed this year, and this implied some modifications of the configuration of the WGMIXFISH model as well. The WGNSSK forecast for this stock starts one year earlier than for the other stocks (i.e. first forecast year is 2021 whereas it is normally 2022). Instead of reproducing this in the WGMIXFISH framework, which would have required too many modifications of the existing code, the SAM estimates of the numbers-at-age for 2022 were replaced in the FLStock object by the median of the abundances-at-age from the SAM forecast for 2022.

Mixed fisheries runs

Prior to 2013, projections were run applying the mixed fisheries 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 (

Table 6.5). 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).

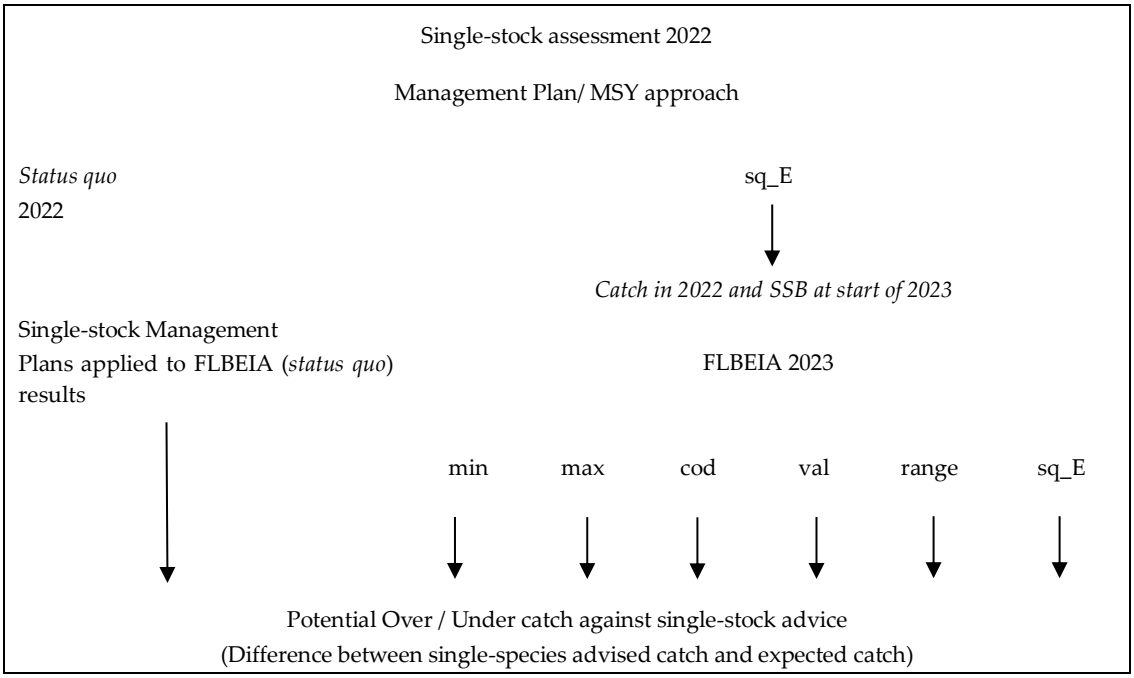
An important change to the projections was implemented in 2015, to account for the landing obligation. Historically, the mixed fisheries projections have been presented in terms of landings and overshoots or undershoots of the retained portion of the catch, assuming fishing fleets would discard as observed 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, 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 landing obligation may not be enforced for all stocks in 2022, 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.

Since 2021, projections are performed with age-disaggregated data at the métier level. This change does not affect the total catch that can be taken in the advice year of the alternative scenarios. However, for some stocks it affects the age-composition of the catch and associated Fbar values, and may provide additional insights into discard and landing quantities at the métier, fleet and stock level.

In summary, the FLBEIA runs followed the scheme below:



6.5.2 Results

Baseline run

- WGMIXFISH-FLR baseline run

The Figure 6.10 summarises the trends in single-stocks advice between the last data year (2021) and the two forecast years (2022 and 2023). The advised catch for 2023 for witch (WIT), corresponds to a 60% decrease in F_{bar} compared to the estimated value for 2022. This is due to the fact that the 2022 catches of WIT are nearly twice higher than the catch advice for 2022, which is possible as there is no specific TAC for this stock, but a combined TAC with lemon sole. Such a decrease in F_{bar} (when at the same time the stock is forecasted to increase by 30% between 2022 and 2023) implies that the effort corresponding to this advice for all fleets catching this stock would be much lower than the current effort. Other stocks also have a catch advice for 2023 that imply a decrease in F_{bar} compared to 2022 but of a smaller magnitude (around -15% for eastern English channel plaice and sole (PLE-EC and SOL-EC), -5% for North Sea cod (COD-NS)). On the other hand, the advice catch for whiting (WHG-NS) haddock (HAD) and North Sea plaice (PLE-NS) correspond to a strong increase in F_{bar} compared to 2022 (by 141%, 116% and 88% respectively).

The comparison between the WGMIXFISH-FLR baseline run and the ICES single-stock advice is summarised in Table 6.6 for the *Nephrops* stocks and in Figure 6.11 for the fish stocks. The issues encountered in replicating the single-species advice in FLR 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. Only small differences were observed (largest difference of 2.7% for SSB in 2023) between the FLR forecast and the single stock advice.

Haddock: The haddock assessment and forecast are also conducted using SAM. The SAM forecast is run with 2021 as a starting year (instead of 2022 for all other stocks). This was not reproduced in the FLR forecast, which started in 2022, using the stock abundances from the SAM forecast as starting numbers for 2022. The single-stock forecast also uses 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 FLR and were therefore entered manually.

Some small discrepancies were also observed for this stock. The -4.8% difference in SSB for 2022 is explained by the fact that the HAD advice sheet report the stock assessment estimate (SAM) for this year, which is different from the value obtained by the SAM forecast. Differences for the advice year, 2023, are smaller (maximum -2.9% for the catches). The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

Whiting: Although whiting is 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 status quo F value for this fishery, independent from the value of target F for the human consumption fishery. The FLR forecast used at WGMIXFISH does not allow for multiple fleets and therefore the industrial bycatch is included in the discards component, which means that its F is scaled to the overall F. 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.

There is a 8.5% difference in the 2022 landings (while catch are equal) which come from the fact that part of the industrial bycatch is ascribed to landings in the WGNSSK forecast, while industrial bycatch were all ascribed to the discards in the FLR forecast. Given the strong increase in F_{bar} between the current year and the advice year (+141%), the difference in the treatment of the industrial fishery bycatch (status quo and modelled separately in MFDP versus incorporated in discards and therefore scaled to the overall F) leads to -5.2% and -2.2% differences in the 2022 catch and landings, respectively. This is considered close enough for use in the mixed fisheries projection.

Saithe: As for cod and haddock, the 2022 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 -1.9% in the 2022 SSB and -5.5% in the 2023 catches and -6.6% in 2024 for SSB. The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

North Sea Plaice: the assessment and forecast are also conducted using SAM, which explain the small differences with the FLR deterministic forecast (maximum -2.2% on the 2023 catch).

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 single stock advice is based on a deterministic forecast run in FLR, which was reproduced almost identically by WGMIXFISH.

North Sea Sole: Although the single-stock forecast and the WGMIXFISH-FLR forecast are both deterministic, carried out in FLR, the libraries used were different (Flasher and Flash, respectively). The library used at WGNSSK recomputes future weight-at-age in the catches, based on assumed future landings and discards weights-at-age, and the forecasted proportions of landings and discards in the future catches (this ensure consistency in the projected catch, landings and discards amounts). The library used at WGMIXFISH uses a 3 year average for mean weight-

at-age in the catches, landings and discards. This methodological difference results in a small discrepancy in the forecast catch values (max -2.6% in 2023) while landings - and all other quantities - are equal in both forecasts.

English Channel Sole: The 2021 English Channel Sole assessment and forecast were carried out using the SAM assessment model. As for the other stocks with a SAM stochastic forecast, some small differences were observed between the single-stock and the FLR forecasts (-3.4% and -4.0% for the 2022 and 2033 SSB values).

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 discard rate in weight (5.9% in 2022). This has not been reproduced in the WGMIXFISH baseline run and explains the difference in the 2022 and 2023 catch between the single-stock advice and the WGMIXFISH baseline run.

Witch: As for other stock where SAM is used to run a stochastic forecast, small differences with the single species advice were encountered, of less than 2% for all forecasted quantities.

***Nephrops*:** The forecasts applied the recommended harvest rates to the most recent abundance estimates available for the FUs considered at category 1 stocks (FU 6, 7 8 and 9). The ICES advice for 2023 is given assuming that the landing obligation is applied in 2022 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 net grid selectivity device. The WGNSSK procedure was reproduced as closely as possible in FCube and the differences in the forecasted 2023 landings were in all cases under 1%.

- WGMIXFISH-FLBEIA baseline run

The forecast conducted using FLBEIA without mixed-fisheries interactions is compared to the WGMIXFISH-FLR baseline run and the single-stock advice on Figure 6.12. In FLBEIA, the stocks are projected forward based on catches. In order to configure the FLBEIA runs, the catches in 2022 and 2023 from the single-stock advice were used as constraints. This differs from the method applied for the single-stock advice and the WGMIXFISH-FLR baseline run, for which the constraint in the intermediate year can be either a F_{bar} or a catch constraint (depending on the stocks) and the calculation in the advice year is based on a F_{bar} value. As a result, the forecasted catches for 2022 and 2023 in the WGMIXFISH-FLBEIA baseline run are the same as the single stock advice (black line on Figure 6.12), while small differences can be observed for the WGMIXFISH-FLR baseline (as detailed above). The only exception is for TUR, for which the assessment (and the FLR objects used a WGMIXFISH) do not contain discards while in the single-stock advice, discards are added as an assumed proportion of the landings.

Differences are observed for the catches for 2021, the last data year. The 2021 catches in FLBEIA are the sum across métiers of the landings and discards-at-age multiplied by the corresponding weight-at-age which are obtained by WGMIXHFISH from the InterCatch data combined with the accession data. These sums of catches are generally close to the ICES estimates provided on the single-stock advice. The stock assessment output provided by WGNSSK, however, contain catches estimated by the stock assessment model (which differ from the observed catches) for part of the stock. This explains the differences for 2021 catch for HAD and SOL-NS on figure 6.12.

In general, the WGMIXFISH-FLBEIA forecast reproduced the single-stock forecasts well for the SSB (differences with single-stock advice generally under 5%) although larger discrepancies are often observed for the 3rd projection year (2024). The large discrepancies found for WIT are due to the fact that FLBEIA is not able to compute accurately the SSB for stocks not spawning at the start of the year, which is the case for WIT. Computing manually the SSB using the output of FLEBIA gave values close to the single-stock advice.

Large discrepancies were observed for the landings and discards for various stocks (HAD, PLE-EC, PLE-NS, SOL-EC, SOL-NS), with higher discards and lower landings in the WGMIXFISH-FLBEIA projections. The most extreme example is for SOL-NS, for which the discards in the WGMIXFISH-FLBEIA baseline are more than two times larger than the single-stock advice (while landings are around 15% lower), and PLE-EC, for which the landings are less than 60% of those from the single-stock advice (while the discards are 50% higher). The cause of these discrepancies could not be fully understood at WGMIXFISH. A potential reason could be that the proportions of discards vs. landings in the stock objects provided by WGNSSK may be different from those resulting of the use of fleet and métier disaggregated data that is used in FLBEIA. Further investigations are required to ascertain that this is indeed the cause.

Large differences are also observed for the F_{bar} values calculated by FLBEIA (projections done based on catches and fishing mortality calculated a posteriori).

In conclusion, using the mixed-fisheries model for the projections leads to some differences in forecasted quantities, which are related both to the difference in methodologies (projections based on F or catches, using the Baranov equation vs. projection based on catch only, using the Cobb-Douglas equation), and to the underlying data (stock-aggregated selectivity, weights and discard ratios, vs. fleet specific values).

The WGMIXFISH-FLBEIA baseline seems to produce similar population dynamics as the WGMIXFISH-FLR baseline since forecasted SSB values (and therefore underlying population numbers-at-age) are broadly similar, and catches are, by default, equal to single-stock (since that is the constrain used for the projection). This indicates that, when the mixed-fisheries interactions are introduced in the model, the model should represent population dynamics and catches (resulting from the choice of a most or least limiting effort) in an appropriate manner. These quantities are the main quantities relevant for the mixed fisheries advice. There could be some concern with the landings vs discards values produced, as well as with the F_{bar} values, but these quantities are not relevant for the mixed fisheries advice.

Mixed fisheries analyses

The full overview of the FLBEIA projections are presented in Table 6.7 and in Figure 6.13 to Figure 6.16. Figure 6.13 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.27.7d, sol.27.7d, tur.27.4, and wit.27.3a.47d have low landings compared to other stocks, the results for these stocks are also presented in detail in Figure 6.14. The anticipated SSBs in 2024 of the mixed fisheries scenarios compared to the baseline are shown in Figure 6.15, and Figure 6.16 shows the effort needed to reach the single-stock advice and highlights the most and least limiting stock per fleet. Figure 6.17 shows the relative quota uptake by fleet in case of the min scenario. A summary of catches by scenario, including the single-stock advice values for reference, is presented in Table 6.8. Finally, Figure 6.18 summarises all the mixed fisheries projections and compares them to the single-species advice projections.

The outcomes of the “min” and “max” scenarios are driven by the stocks that will be most and least limiting for each individual fleet. Witch 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. 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), witch would be the most limiting stock, constraining 36 of the 46 fleet segments (Figure 6.16 and Figure 6.17). Sole in the North Sea constrains four fleet segments, while three fleets are limited by cod, and Norway lobster (FU6) and saithe both limit one fleet. This would result on undershooting the catch quota for all stocks except witch in 2022 (Figure 6.13 and Figure 6.14).

Conversely, in the "max" scenario, North Sea whiting would be the least limiting stock for 35 out of 46 fleets. This is similar to the previous year. Haddock and North Sea plaice are the other stocks identified as least limiting for seven and four fleets, respectively (Figure 6.16 and Figure 6.17). Under the "max" scenario all stocks are overshot (Figure 6.13 and Figure 6.14). Besides witch, North Sea and eastern English Channel sole would experience an approximately tenfold increase in F compared to the single species advice, while fishing pressure for eastern English Channel plaice would be, approximately, nine times higher than the single species advice. This would result in catches that are about three time higher than the projected catch levels from the single species advices.

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 baseline scenario, a reduction of about 5% in fishing mortality and catch is required for North Sea cod between 2022 and 2023. 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 it was requested by managers in the past.

In the "val" scenario fishing opportunities by stock and their potential market value are taking into consideration. For 2023, this scenario estimates effort levels close to the *status quo*. Historically this scenario has been observed to predict effort levels closer to the realized effort than the other scenarios (Ulrich *et al.*, 2011). In this scenario, overshoot for all demersal stocks is predicted, except for North Sea plaice, whiting and haddock, and Norway lobster (FUs 7-10; 33).

Mixed fisheries results for Norway lobster 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 6 fleets. In order to ensure Norway lobster 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 6.19 and Figure 6.20), where the potential quota mismatch in 2023 are minimized 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 2023, 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 reduced with a 2023 catch advice in the lower part of the F_{MSY} range for haddock, North Sea plaice and whiting, and near maximum of the

range for witch, in accordance with the maximum sustainable yield (MSY) approach and the EU multiannual plan (MAP). Norway lobster stocks are not included in the "range" scenario.

During this year's WGMIXFISH ADVICE meeting, it became apparent that the optimization routine could only derive stable solutions for F values of the most and least limiting stocks – and not for all stocks. In order to avoid misinterpretation, it was decided to remove this scenario from the advice until a more appropriate approach can be developed.

6.6 References

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Table 6.1. 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 2021.

Fleet	Metier	Effort	Catch	Fleet	Metier	Effort	Catch
BE_Beam<24	beam_oth.4	362	22	GE_Beam<24	BT2.4	202	248
BE_Beam<24	BT2.4	165	160	GE_Beam>=24	BT2.4	3391	2782
BE_Beam<24	BT2.7D	185	903	GE_Otter<24	OTH	380	349
BE_Beam>=24	BT1.4	883	3112	GE_Otter<24	TR2.4	491	715
BE_Beam>=24	BT2.4	555	1267	GE_Otter>=40	OTB32-69.4	1913	1473
BE_Beam>=24	BT2.7D	1367	1575	GE_Otter>=40	OTH	1530	209
BE_Otter	OTH	42	80	GE_Otter>=40	TR3.4	287	107
BE_Otter	TR1.4	292	564	GE_Otter24-40	OTH	121	216

Fleet	Metier	Effort	Catch	Fleet	Metier	Effort	Catch
BE_Otter	TR2.4	401	1566	GE_Otter24-40	TR1.4	4832	5507
DK_<10towed	OTH	23	50	GE_Otter24-40	TR2.4	781	608
DK_<10towed	TR2.3AN	108	311	GE_Static	GN1.3AN	4	3
DK_Otter<24	OTH	401	396	GE_Static	GN1.4	190	75
DK_Otter<24	TR1.4	559	1093	NL_Beam<24	beam_oth.4	3310	99
DK_Otter<24	TR2.3AN	2741	4066	NL_Beam<24	BT1.3AN	23	575
DK_Otter<24	TR2.4	88	294	NL_Beam<24	BT1.4	15	691
DK_Otter>=24	OTH	1426	357	NL_Beam<24	BT2.4	216	3679
DK_Otter>=24	TR1.3AN	180	410	NL_Beam>=40	BT1.3AN	645	2529
DK_Otter>=24	TR1.4	2857	5177	NL_Beam>=40	BT1.4	3348	7819
DK_Otter>=24	TR2.3AN	666	907	NL_Beam>=40	BT2.4	15014	42066
DK_Otter>=24	TR2.4	446	909	NL_Beam24-40	BT1.3AN	117	563
DK_Seine	TR1.3AN	617	3771	NL_Beam24-40	BT1.4	224	532
DK_Seine	TR1.4	647	1188	NL_Beam24-40	BT2.4	2241	7310
DK_Static	GN1.3AN	493	1290	NL_Beam24-40	OTH	612	15
DK_Static	GN1.4	1051	3343	NL_Otter	OTH	26	42
DK_Static	OTH	14	60	NL_Otter	otter_oth.4	456	1132
EN_<10	GN1.4	159	56	NL_Otter	TR1.4	801	2251
EN_<10	GN1.7D	58	256	NL_Otter	TR2.4	1543	7187
EN_<10	GT1.7D	119	97	NL_Otter	TR2.7D	1093	540
EN_<10	OTH	468	64	NL_Pelagic	pelagic.4	2444	287
EN_<10	pots.4	1396	24	NL_Pelagic	pelagic.6A	1655	3
EN_<10	pots.7D	719	5	NL_Pelagic	pelagic.7D	605	0
EN_<10	TR2.4	383	1074	NO_DSeine24-40	OTH	46	200
EN_<10	TR2.7D	100	175	NO_DSeine24-40	TR1.4	353	1087
EN_Beam	BT1.4	343	785	NO_Otter>=40	OTB32-69.4	4380	1747
EN_Beam	BT2.4	1149	2577	NO_Otter>=40	OTH	44	1
EN_Beam	BT2.7D	76	178	NO_Otter>=40	otter_oth.4	2083	538

Fleet	Metier	Effort	Catch	Fleet	Metier	Effort	Catch
EN_Beam	OTH	132	0	NO_Otter>=40	TR1.4	4530	7781
EN_Otter<24	OTH	127	91	NO_Otter>=40	TR3.4	10895	2223
EN_Otter<24	TR1.4	185	498	NO_Otter24-40	OTB32-69.4	3998	142
EN_Otter<24	TR1.7D	2	7	NO_Otter24-40	OTH	1350	60
EN_Otter<24	TR2.4	710	1904	NO_Otter24-40	otter_oth.4	806	130
EN_Otter<24	TR2.7D	107	69	NO_Otter24-40	TR1.4	3187	1671
EN_Otter>=40	OTH	255	291	NO_Otter24-40	TR3.4	988	325
EN_Otter>=40	TR1.4	434	2362	NO_Pelagic	OTH	7	0
EN_Otter24-40	OTH	10	0	NO_Pelagic	pelagic.4	657	294
EN_Otter24-40	otter_oth.4	939	550	NO_Static	GN1.4	1055	898
EN_Otter24-40	ot-ter_oth.7D	614	372	NO_Static	LL1.4	154	139
EN_Otter24-40	TR1.4	400	895	NO_Static	OTH	5	29
EN_Pelagic	pelagic.4	847	51	OTH_OTH	OTH	32892	9359
EN_Pelagic	pelagic.7D	253	0	SC_Beam	BT2.6A	14	0
EN_Static	GN1.7D	11	11	SC_Beam	OTH	275	620
EN_Static	OTH	14	3	SC_Otter<10	OTH	10	23
EN_Static	pots.4	1941	8	SC_Otter<10	TR2.4	223	745
EN_Static	pots.7D	474	0	SC_Otter<10	TR2.6A	200	59
FR_<10	GN1.7D	52	1	SC_Otter<24	TR1.4	6709	19399
FR_<10	GT1.7D	234	66	SC_Otter<24	TR1.6A	915	535
FR_<10	OTH	1040	66	SC_Otter<24	TR2.4	1054	7377
FR_<10	TR2.7D	52	103	SC_Otter<24	TR2.6A	2550	3556
FR_Beam	BT2.7D	191	135	SC_Otter>=24	OTH	180	840
FR_Beam	OTH	35	5	SC_Otter>=24	TR1.4	8027	44023
FR_Nets	GT1.4	154	183	SC_Otter>=24	TR1.6A	1737	4788
FR_Nets	GT1.7D	612	409	SC_Otter>=24	TR2.7D	268	341
FR_Nets	OTH	40	8	SC_Static	GN1.4	254	5
FR_OTH	OTH	6527	964	SC_Static	LL1.4	632	30

Fleet	Metier	Effort	Catch	Fleet	Metier	Effort	Catch
FR_OTH	pelagic.4	1029	47	SC_Static	LL1.6A	556	2
FR_OTH	pelagic.6A	270	1	SC_Static	OTH	19	1
FR_OTH	pelagic.7D	793	89	SC_Static	pots.4	1623	1
FR_OTH	TR2.7D	517	684	SC_Static<10	LL1.4	264	190
FR_Otter>=40	TR1.4	2719	9328	SC_Static<10	OTH	2232	22
FR_Otter>=40	TR1.6A	1540	1300	SC_Static<10	pots.6A	2119	0
FR_Otter10-40	OTH	82	29	SW_Otter	OTH	1504	198
FR_Otter10-40	TR1.6A	493	40	SW_Otter	TR1.4	236	1306
FR_Otter10-40	TR1.7D	47	3	SW_Otter	TR2.3AN	860	714
FR_Otter10-40	TR2.4	259	571	SW_Otter	TR2_grid.3AN	915	2
FR_Otter10-40	TR2.7D	3912	4452	SW_Static	OTH	86	24
GE_Beam<24	beam_oth.4	4404	52	SW_Static	pots.3AN	855	19

Table 6.1. Average fishing mortality (Fbar) in 2021 between the single stock assessment (SSA) and FLBEIA.

	SSA	FLBEIA	Diff_FLBEIA/SSA
COD-NS	0.257	0.228	-0.112
HAD	0.211	0.218	0.031
PLE-EC	0.185	0.232	0.254
PLE-NS	0.080	0.078	-0.022
POK	0.390	0.352	-0.098
SOL-EC	0.220	0.229	0.045
SOL-NS	0.208	0.212	0.022
TUR	0.349	0.320	-0.083
WHG-NS	0.163	0.175	0.075
WIT	0.290	0.341	0.178

Table 6.2. Total catch in 2021 between the single stock assessment (SSA) and FLBEIA.

	SSA	FLBEIA	Diff_FLBEIA/SSA
COD-NS	18403.569	19250.683	0.046
HAD	51714.995	57020.361	0.103
PLE-EC	4593.868	5494.556	0.196
PLE-NS	73349.594	78981.978	0.077
POK	50951.095	52669.667	0.034
SOL-EC	1993.394	2135.259	0.071
SOL-NS	10522.042	8841.789	-0.160
TUR	2659.000	2868.044	0.079
WHG-NS	33193.348	33712.463	0.016
WIT	2079.950	2150.104	0.034

Table 6.3. Total landings in 2021 between the single stock assessment (SSA) and FLBEIA.

	SSA	FLBEIA	Diff_FLBEIA/SSA
COD-NS	14660.029	15327.889	0.046
HAD	28093.317	33572.943	0.195
PLE-EC	1640.258	1828.382	0.115
PLE-NS	35930.737	37234.999	0.036
POK	50123.709	51558.459	0.029
SOL-EC	1561.000	1734.709	0.111
SOL-NS	8855.783	7232.019	-0.183
TUR	2659.000	2868.044	0.079
WHG-NS	17816.773	18656.780	0.047
WIT	1856.914	1908.253	0.028

Table 6.4. Total discards in 2020 between the single stock assessment (SSA) and FLBEIA.

	SSA	FLBEIA	Diff_FLBEIA/SSA
COD-NS	3744.788	3922.794	0.048
HAD	23644.600	23447.418	-0.008
PLE-EC	2953.611	3666.173	0.241
PLE-NS	37522.498	41746.979	0.113
POK	827.378	1111.208	0.343
SOL-EC	346.649	400.550	0.155
SOL-NS	1398.724	1609.770	0.151
TUR	0.000	0.000	
WHG-NS	15371.489	15055.683	-0.021
WIT	245.281	241.851	-0.014

Table 6.5. Intermediate year assumption in the baseline and mixed fisheries projections.

	Fbar in 2022	Landings in 2022	Discards in 2022	Catches in 2022	SSB in 2023
cod.27.47d20	0.236	16695	7167	23862	67986
had.27.46a20	0.250	31945	49020	80965	444058
ple.27.7d	0.261	1239	4219	5459	39937
ple.27.420	0.083	34855	40975	75830	950232
pok.27.3a46	0.350	48042	4236	52277	127005
sol.27.7d	0.253	1503	547	2050	11935
sol.27.4	0.268	8345	3609	11953	36075
tur.27.4	0.319	2365	34	2399	7856
whg.27.47d	0.186	23345	19975	43320	294371
wit.27.3a47d	0.340	2009	323	2332	4808
nep.fu.5	0.003	1067	242	1309	13262
nep.fu.6	0.007	1476	706	2182	18997
nep.fu.7	0.001	8281	150	8431	181670
nep.fu.8	0.005	1739	209	1948	18913
nep.fu.9	0.002	734	6	739	10499
nep.fu.10	0.003	14	0	14	140
nep.fu.32	0.001	214	3	217	2170
nep.fu.33	0.002	1371	0	1371	13710
nep.fu.34	0.003	866	22	889	8750
nep.27.4outFU	0.003	636	43	679	6780

Table 6.6. Comparison between WGMIXFISH-FLR baseline run and ICES advice for *Nephrops in the TAC year (2023). 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
2023	landings	ICES advice	984	1390.0	13583	2988.0	1236	54	303	918	615	301
2023	landings	WGMIXFISH-FLR baseline	984	1407.0	13585	3003.0	1236	54	303	918	615	301
2023	landings	difference (%)	0	1.2	0	0.5	0	0	0	0	0	0

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

Table 6.7. Results of Final FLBEIA runs.

scenario	year	indicator	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	TUR	WHG-NS	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
baseline	2022	landings	17511	40369	2385	45191	47782	1793	9605	2435	26887	2250	18	279	1768	1129	1376	2608	12329	2367	1575	820
baseline	2023	landings	19690	116028	2204	87926	53547	1533	8459	2284	69592	1212	54	303	918	615	984	1407	13585	3003	1236	301
baseline	2022	catch	20207	52691	5407	78591	49614	2014	10299	2435	44178	2471										
baseline	2023	catch	22544	133049	4753	147370	55691	1736	8916	2284	104483	1301	55	304	918	652	1256	1613	13681	3208	1249	301
baseline	2022	Fbar	0.209	0.112	0.185	0.08	0.347	0.22	0.208	0.349	0.163	0.29	0.129	0.131	0.129	0.129	0.145	0.159	0.068	0.134	0.152	0.158
baseline	2023	Fbar	0.198	0.24	0.156	0.152	0.345	0.186	0.187	0.361	0.393	0.119						0.081	0.075	0.163	0.118	
baseline	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	3500										
baseline	2023	ssb	70903	481594	41642	964970	134994	12176	38776	7693	294165	4504										
baseline	2024	ssb	84808	407357	44175	921694	148592	12741	41086	7070	249444	5866										
min	2022	Fbar	0.236	0.25	0.261	0.083	0.35	0.253	0.268	0.319	0.186	0.34	0.003	0.001	0.002	0.003	0.003	0.007	0.001	0.005	0.002	0.003
min	2023	Fbar	0.104	0.097	0.133	0.037	0.148	0.125	0.103	0.135	0.085	0.14	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.002	0.001	0.001
min	2024	Fbar	0.078	0.074	0.089	0.033	0.129	0.08	0.095	0.116	0.064	0.103	0.001	0	0.001	0.001	0.001	0.002	0	0.002	0.001	0.001
min	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	4039	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
min	2023	ssb	67986	444058	39937	950232	127005	11935	36075	7856	294371	4808	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
min	2024	ssb	90053	439941	43866	996063	164174	13105	41824	8654	309048	6252	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
min	2022	catch	23862	80965	5459	75830	52277	2050	11953	2399	43320	2332	14	217	1371	889	1309	2182	8431	1948	739	679

scenario	year	indicator	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	TUR	WHG-NS	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
min	2023	catch	12884	47316	2912	35639	26385	1073	4957	1023	23911	1313	7	107	637	417	609	1004	3966	920	350	316
min	2024	catch	12506	42806	2069	31836	28740	763	5341	1062	19433	1328	5	85	439	290	474	675	2762	641	237	217
min	2022	landings	16695	31945	1239	34855	48042	1503	8345	2365	23345	2009	14	214	1371	866	1067	1476	8281	1739	734	636
min	2023	landings	10812	38349	697	17565	25623	816	3881	1023	15254	1138	7	105	637	407	489	678	3895	820	347	282
min	2024	landings	10514	37496	582	14782	28082	588	4292	1062	12666	1220	5	83	439	283	346	450	2711	564	234	200
min	2022	discards	7167	49020	4219	40975	4236	547	3609	34	19975	323	0	3	0	22	242	706	150	209	6	43
min	2023	discards	2071	8967	2214	18074	762	257	1076	0	8657	175	0	2	0	10	120	326	71	100	3	34
min	2024	discards	1992	5310	1487	17054	658	175	1049	0	6766	108	0	2	0	7	128	225	51	78	3	17
max	2022	Fbar	0.236	0.25	0.261	0.083	0.35	0.253	0.268	0.319	0.186	0.34	0.003	0.001	0.002	0.003	0.003	0.007	0.001	0.005	0.002	0.003
max	2023	Fbar	0.703	0.645	1.305	0.29	0.923	1.835	1.848	1.572	0.479	1.407	0.006	0.004	0.012	0.011	0.01	0.027	0.004	0.015	0.009	0.006
max	2024	Fbar	1.251	1.152	1.428	0.313	2.044	1.764	1.723	1.63	1.147	1.513	0.009	0.008	0.018	0.019	0.014	0.035	0.008	0.026	0.017	0.009
max	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	4039	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
max	2023	ssb	67986	444058	39937	950232	127005	11935	36075	7856	294371	4808	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
max	2024	ssb	48123	262159	21442	769193	80784	5236	8613	3662	243371	3289	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
max	2022	catch	23862	80965	5459	75830	52277	2050	11953	2399	43320	2332	14	217	1371	889	1309	2182	8431	1948	739	679
max	2023	catch	59747	206697	14689	219811	107288	5133	25846	5848	110594	6539	29	452	3324	1809	3248	5815	16988	4357	1807	1661
max	2024	catch	64067	175749	10212	204838	121167	2668	11200	3178	127322	5570	43	687	4797	2808	4373	7390	26607	6386	2589	2390

scenario	year	indicator	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	TUR	WHG-NS	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
max	2022	landings	16695	31945	1239	34855	48042	1503	8345	2365	23345	2009	14	214	1371	866	1067	1476	8281	1739	734	636
max	2023	landings	19137	103998	1128	72894	54238	1268	5702	2119	66856	1079	29	300	918	636	1023	1085	13435	2858	1240	282
max	2024	landings	19253	68900	692	73785	45161	959	3944	2488	54610	1152	43	300	918	636	1023	1085	13435	2858	1240	282
max	2022	discards	7167	49020	4219	40975	4236	547	3609	34	19975	323	0	3	0	22	242	706	150	209	6	43
max	2023	discards	40610	102700	13561	146918	53050	3865	20144	3729	43738	5461	0	153	2406	1173	2224	4730	3552	1499	568	1379
max	2024	discards	44814	106848	9520	131053	76006	1709	7256	690	72713	4419	0	387	3879	2173	3349	6305	13172	3528	1350	2108
sq_E	2022	Fbar	0.236	0.25	0.261	0.083	0.35	0.253	0.268	0.319	0.186	0.34	0.003	0.001	0.002	0.003	0.003	0.007	0.001	0.005	0.002	0.003
sq_E	2023	Fbar	0.235	0.22	0.265	0.082	0.349	0.271	0.27	0.318	0.182	0.436	0.003	0.001	0.004	0.004	0.003	0.008	0.001	0.005	0.002	0.003
sq_E	2024	Fbar	0.234	0.232	0.275	0.082	0.352	0.306	0.335	0.318	0.182	0.428	0.003	0.001	0.004	0.004	0.003	0.008	0.001	0.005	0.002	0.003
sq_E	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	4039	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
sq_E	2023	ssb	67986	444058	39937	950232	127005	11935	36075	7856	294371	4808	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
sq_E	2024	ssb	77936	389179	39750	952433	135033	11799	35666	7523	290548	5381	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
sq_E	2022	catch	23862	80965	5459	75830	52277	2050	11953	2399	43320	2332	14	217	1371	889	1309	2182	8431	1948	739	679
sq_E	2023	catch	27190	99633	5336	77207	56586	1976	10637	2202	48865	2824	14	217	1371	889	1309	2182	8431	1948	739	679
sq_E	2024	catch	30738	104846	5281	76286	60895	1966	10836	2345	48579	3229	14	217	1371	889	1309	2182	8431	1948	739	679
sq_E	2022	landings	16695	31945	1239	34855	48042	1503	8345	2365	23345	2009	14	214	1371	866	1067	1476	8281	1739	734	636
sq_E	2023	landings	19108	80494	1143	38017	54094	1319	7184	2202	31236	1138	14	214	918	636	1023	1085	8281	1739	734	282

scenario	year	indicator	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	TUR	WHG-NS	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
sq_E	2024	landings	22516	77287	950	36967	51504	1087	5340	2345	31818	1467	14	214	918	636	1023	1085	8281	1739	734	282
sq_E	2022	discards	7167	49020	4219	40975	4236	547	3609	34	19975	323	0	3	0	22	242	706	150	209	6	43
sq_E	2023	discards	8081	19139	4193	39190	2492	657	3453	1	17630	1686	0	3	453	253	286	1097	150	209	6	397
sq_E	2024	discards	8222	27558	4331	39320	9391	879	5496	0	16761	1762	0	3	453	253	286	1097	150	209	6	397
cod-ns	2022	Fbar	0.236	0.25	0.261	0.083	0.35	0.253	0.268	0.319	0.186	0.34	0.003	0.001	0.002	0.003	0.003	0.007	0.001	0.005	0.002	0.003
cod-ns	2023	Fbar	0.194	0.183	0.246	0.078	0.279	0.261	0.264	0.294	0.154	0.351	0.003	0.001	0.002	0.003	0.002	0.007	0.001	0.005	0.002	0.002
cod-ns	2024	Fbar	0.2	0.186	0.273	0.082	0.282	0.332	0.358	0.311	0.155	0.362	0.003	0.001	0.003	0.003	0.002	0.008	0.001	0.005	0.002	0.002
cod-ns	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	4039	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
cod-ns	2023	ssb	67986	444058	39937	950232	127005	11935	36075	7856	294371	4808	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
cod-ns	2024	ssb	81723	403978	40332	956573	144937	11902	35844	7669	295655	5588	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
cod-ns	2022	catch	23862	80965	5459	75830	52277	2050	11953	2399	43320	2332	14	217	1371	889	1309	2182	8431	1948	739	679
cod-ns	2023	catch	22946	84362	5018	72476	46694	1920	10458	2066	41888	2467	13	178	1083	806	1048	2017	7623	1805	678	572
cod-ns	2024	catch	27396	91594	5303	75377	53346	2053	11251	2341	42773	2998	13	186	1122	792	1079	2086	7474	1769	664	581
cod-ns	2022	landings	16695	31945	1239	34855	48042	1503	8345	2365	23345	2009	14	214	1371	866	1067	1476	8281	1739	734	636
cod-ns	2023	landings	19137	67827	1116	34816	45303	1318	7097	2047	26538	1138	13	176	918	636	835	1085	7488	1614	673	282
cod-ns	2024	landings	22749	75395	954	35644	49585	1088	5342	2299	27687	1471	13	183	918	636	859	1085	7341	1580	659	282
cod-ns	2022	discards	7167	49020	4219	40975	4236	547	3609	34	19975	323	0	3	0	22	242	706	150	209	6	43

scenario	year	indicator	COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	TUR	WHG-NS	WIT	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS
cod-ns	2023	discards	3809	16534	3901	37660	1390	602	3361	19	15350	1330	0	3	165	170	213	932	135	191	5	290
cod-ns	2024	discards	4647	16199	4349	39733	3761	966	5908	42	15086	1527	0	3	204	156	220	1001	133	189	5	299
val	2022	Fbar	0.236	0.25	0.261	0.083	0.35	0.253	0.268	0.319	0.186	0.34	0.003	0.001	0.002	0.003	0.003	0.007	0.001	0.005	0.002	0.003
val	2023	Fbar	0.317	0.315	0.334	0.119	0.435	0.335	0.499	0.507	0.259	0.78	0.005	0.001	0.006	0.007	0.005	0.008	0.002	0.008	0.004	0.003
val	2024	Fbar	0.315	0.327	0.342	0.119	0.439	0.356	0.538	0.49	0.259	0.727	0.005	0.001	0.006	0.007	0.005	0.008	0.002	0.008	0.004	0.003
val	2022	ssb	51801	392325	41883	922781	127985	12156	42148	8676	283605	4039	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
val	2023	ssb	67986	444058	39937	950232	127005	11935	36075	7856	294371	4808	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
val	2024	ssb	71414	354959	37651	917784	123622	11272	28716	6615	277056	4797	140	2170	13710	8750	13262	18997	181670	18913	10499	6780
val	2022	catch	23862	80965	5459	75830	52277	2050	11953	2399	43320	2332	14	217	1371	889	1309	2182	8431	1948	739	679
val	2023	catch	34306	131078	6656	109265	66862	2236	14668	3055	66900	3860	21	260	1860	1275	1882	2191	12229	3045	1178	941
val	2024	catch	36177	123749	6307	104560	67747	2128	12460	2842	62940	3910	21	260	1860	1275	1882	2191	12229	3045	1178	941
val	2022	landings	16695	31945	1239	34855	48042	1503	8345	2365	23345	2009	14	214	1371	866	1067	1476	8281	1739	734	636
val	2023	landings	19132	94199	1129	52879	56674	1279	7184	2278	42216	1138	21	252	918	636	1023	1085	12011	2679	1139	282
val	2024	landings	22320	85734	935	49636	51398	1080	5203	2497	40179	1453	21	252	918	636	1023	1085	12011	2679	1139	282
val	2022	discards	7167	49020	4219	40975	4236	547	3609	34	19975	323	0	3	0	22	242	706	150	209	6	43
val	2023	discards	15175	36878	5526	56386	10188	957	7484	778	24684	2723	0	9	942	639	858	1106	218	367	39	659
val	2024	discards	13857	38015	5371	54924	16349	1048	7257	345	22761	2456	0	9	942	639	858	1106	218	367	39	659

Table 6.8. Mixed fisheries for the North Sea. Catch per mixed-fisheries scenario 2023, in absolute values.

Stock	Single.stock.advice	max	min	cod.ns	sq_E	val	range
cod.27.47d20	22946	59747	12884	22946	27190	34583	18751
had.27.46a20	137058	206697	47316	84362	99633	131403	108783
ple.27.7d	4738	14689	2912	5018	5336	6675	5402
ple.27.420	150705	219811	35639	72476	77207	110344	119306
pok.27.3a46	58912	107288	26385	46694	56586	67230	42143
sol.27.7d	1747	5133	1073	1920	1976	2236	1511
sol.27.4	9152	25846	4957	10458	10637	14688	7665
tur.27.4	2432	5848	1023	2066	2202	3088	2114
whg.27.47d	110172	110594	23911	41888	48865	67281	82087
wit.27.3a47d	1313	6539	1313	2467	2824	3897	1250
nep.fu.5	1256	3248	609	1048	1309	1882	
nep.fu.6	1604	5815	1004	2017	2182	2191	
nep.fu.7	13679	16988	3966	7623	8431	12229	
nep.fu.8	3201	4357	920	1805	1948	3045	
nep.fu.9	1249	1807	350	678	739	1178	
nep.fu.10	55	29	7	13	14	21	
nep.fu.32	304	452	107	178	217	260	
nep.fu.33	918	3324	637	1083	1371	1860	
nep.fu.34	652	1809	417	806	889	1275	
nep.27.4outFU	301	1661	316	572	679	941	

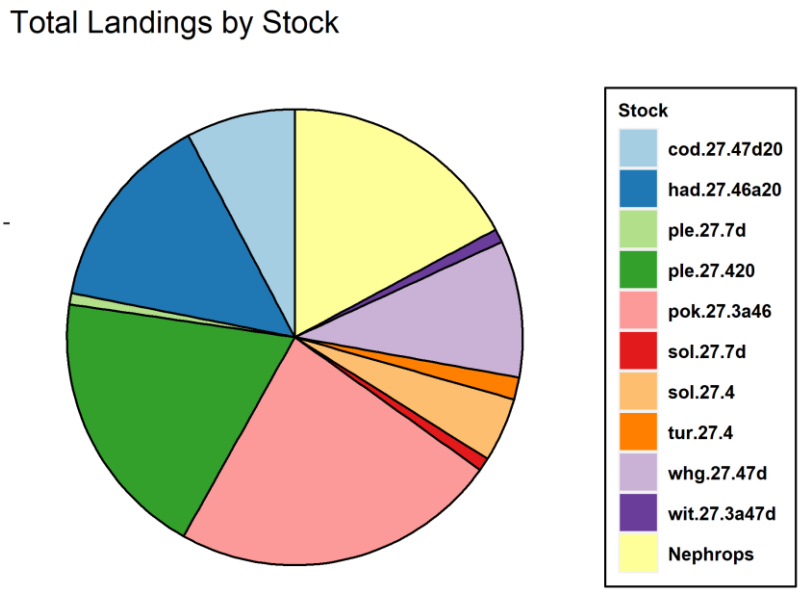

Figure 6.1. Distribution of 2021 landings of those stocks included in the mixed fisheries projections.

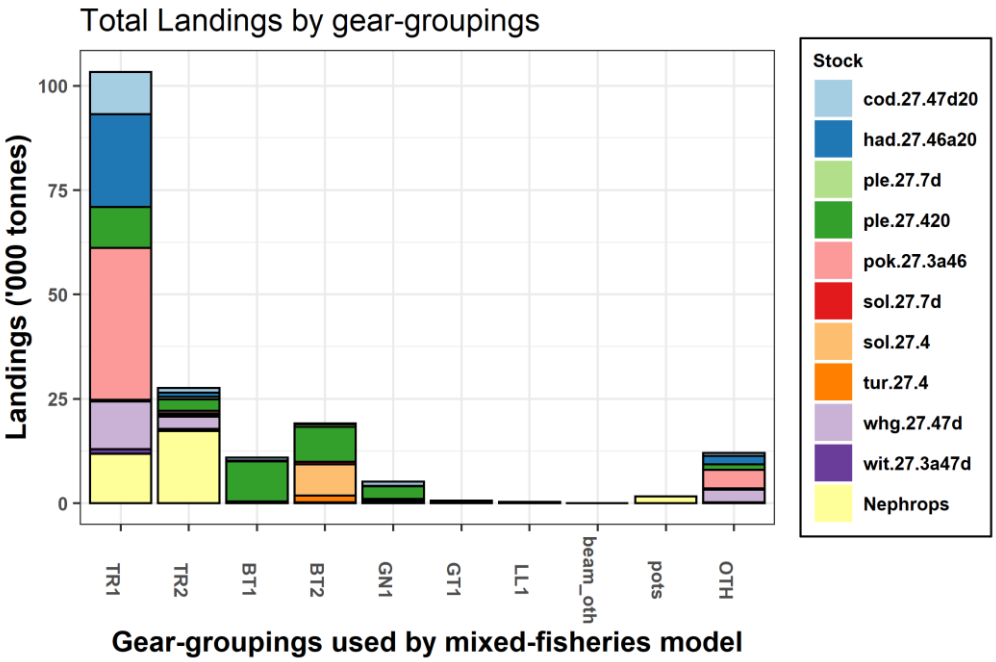

Figure 6.2. 2021 landings distribution of species by métier with landings consisting of ≥1% of any of the stocks. Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings <1% of any of the stocks.

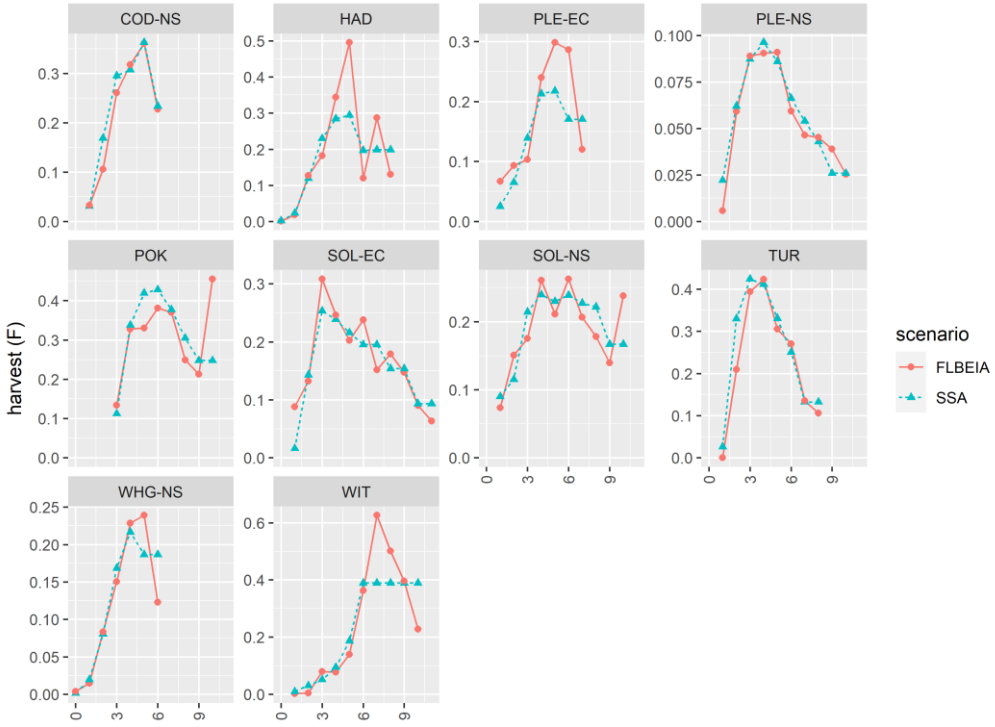

Figure 6.3. Fishing mortality at age in the last assessment year (2021).

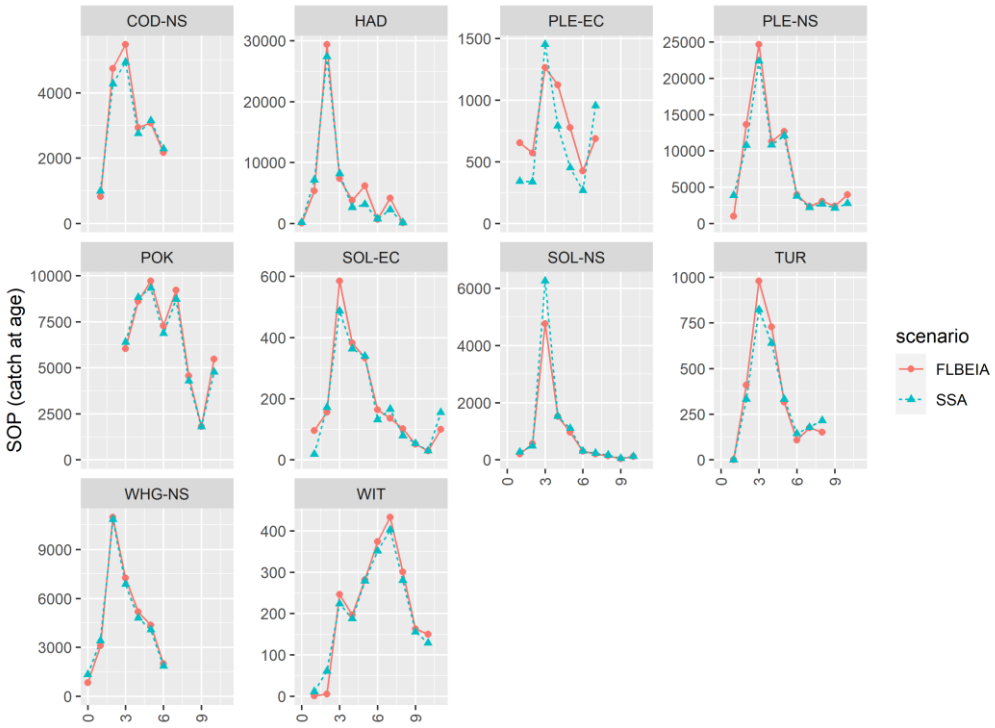

Figure 6.4. Sum of product (numbers*weight) catches in the last assessment year (2021).

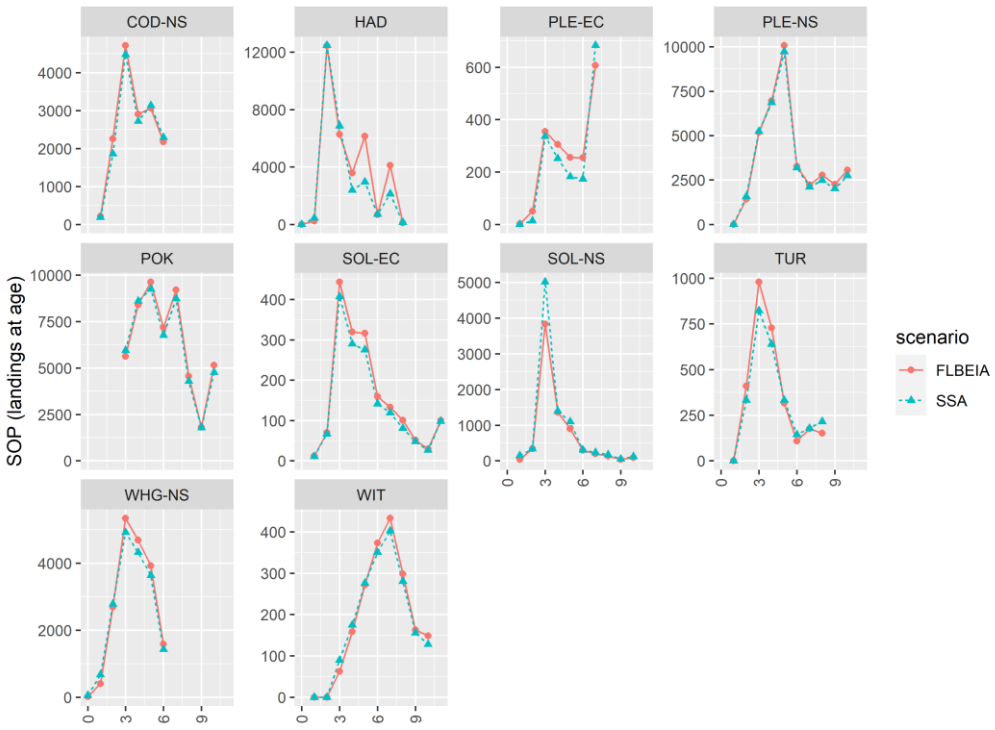

Figure 6.5. Sum of product (numbers*weight) landings in the last assessment year (2021).

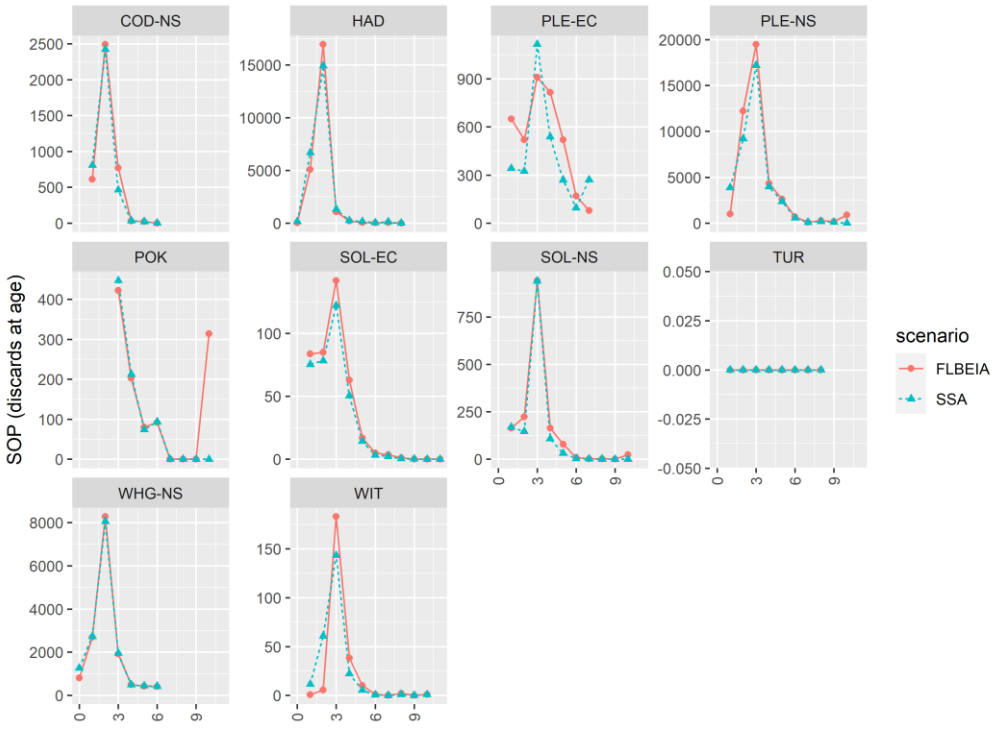

Figure 6.6. Sum of product (numbers*weight) discards in the last assessment year (2021).

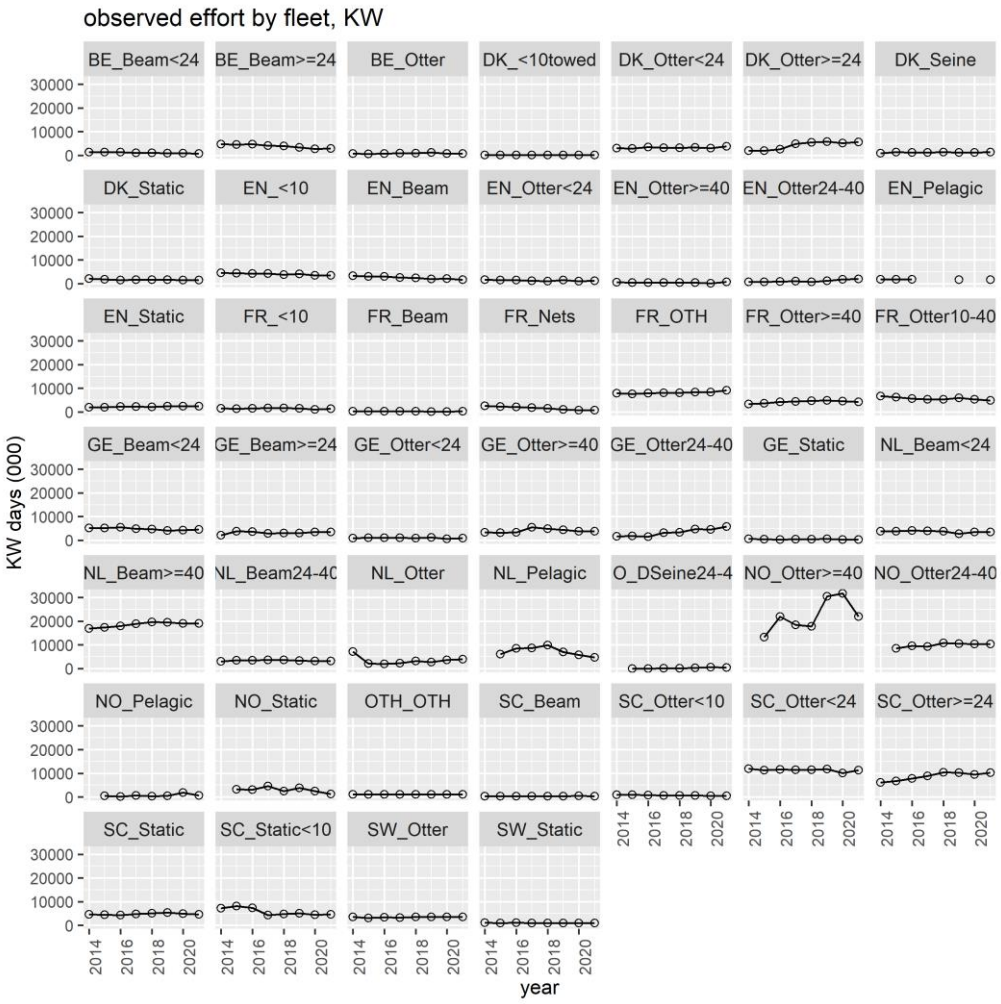

Figure 6.7. Effort by fleet and year for the North Sea demersal fleets, in '000 KWdays.

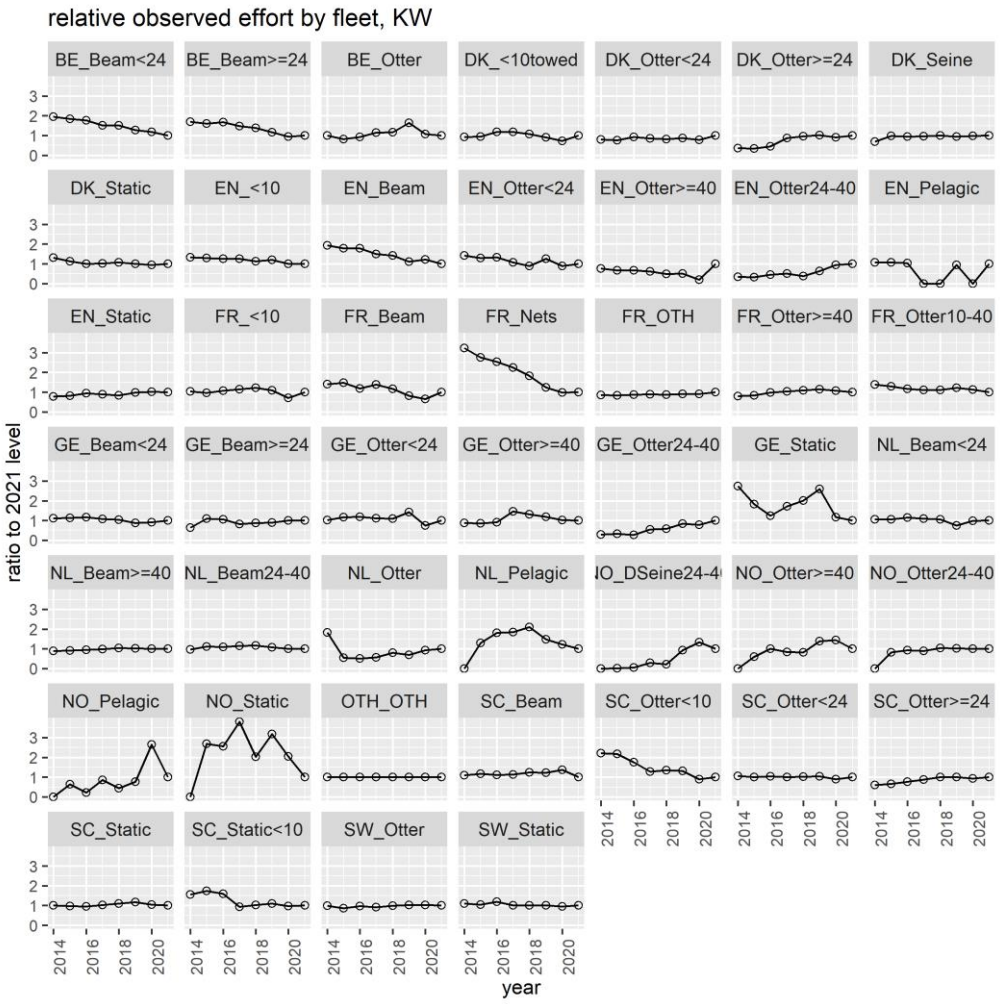

Figure 6.8. Relative trends (compared to the 2020 value) in effort (KW Days) by fleet and year for the North Sea demersal fleets.

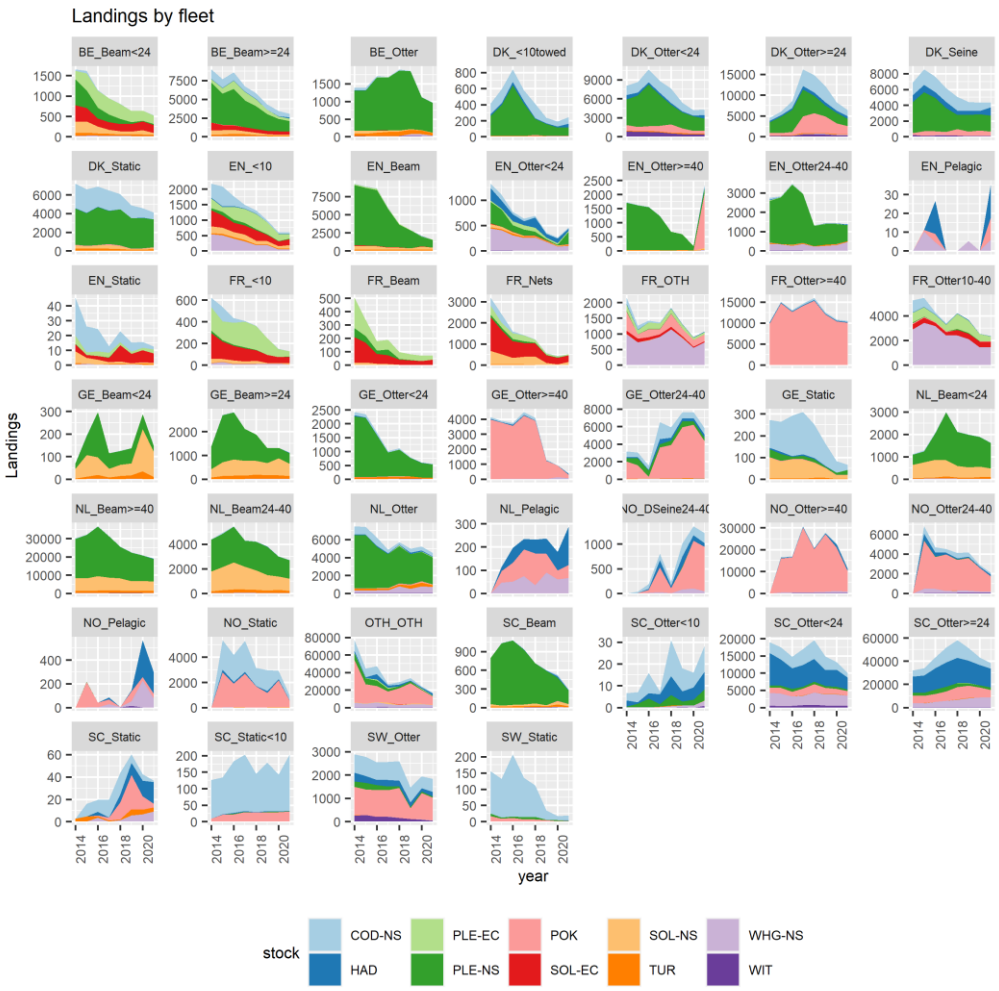

Figure 6.9. Landings by fleet, stock and year.

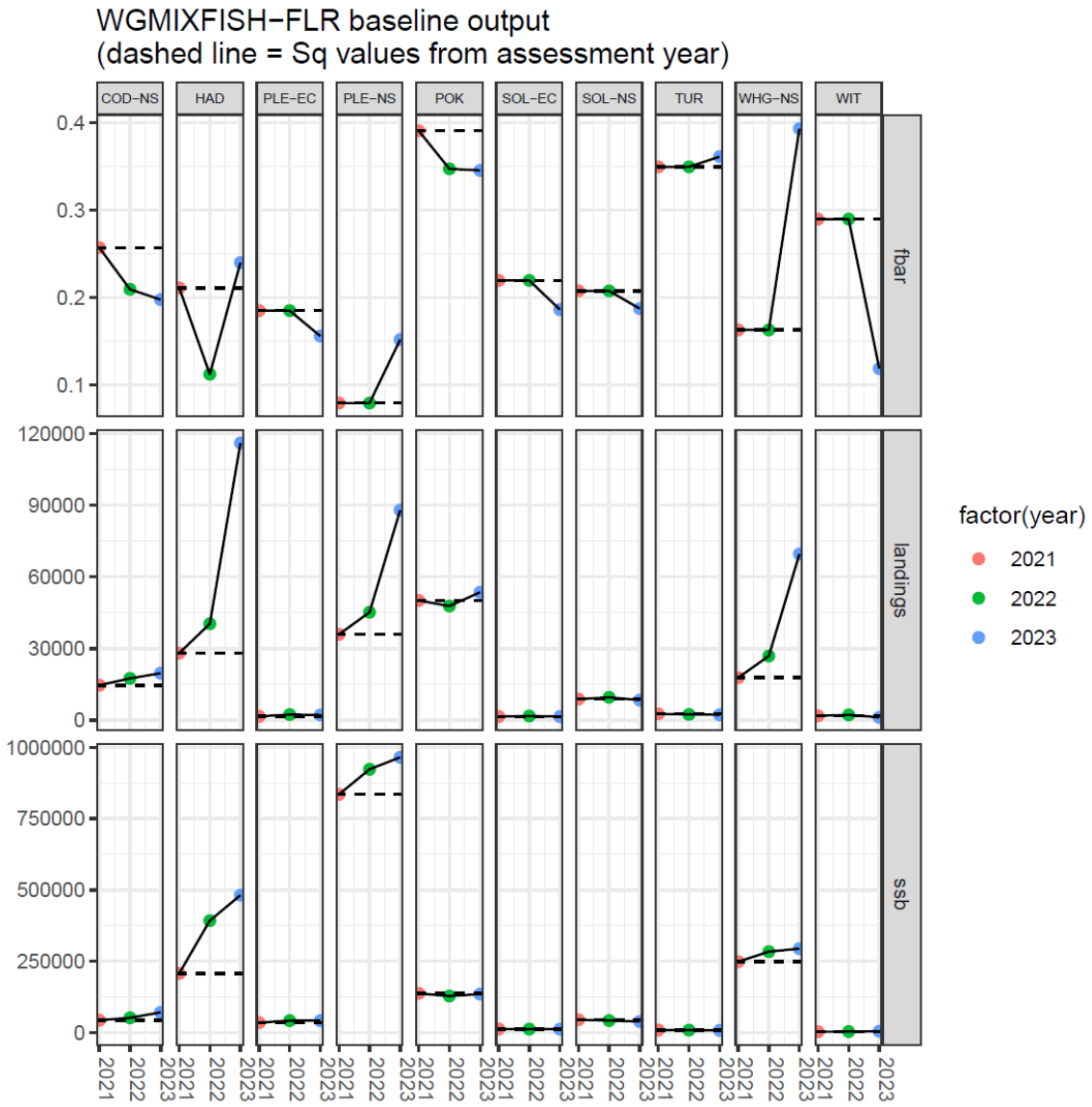

Figure 6.10. Summary of the relative changes in the single-stock advice for 2022 and 2023 compared to the situation in 2021.

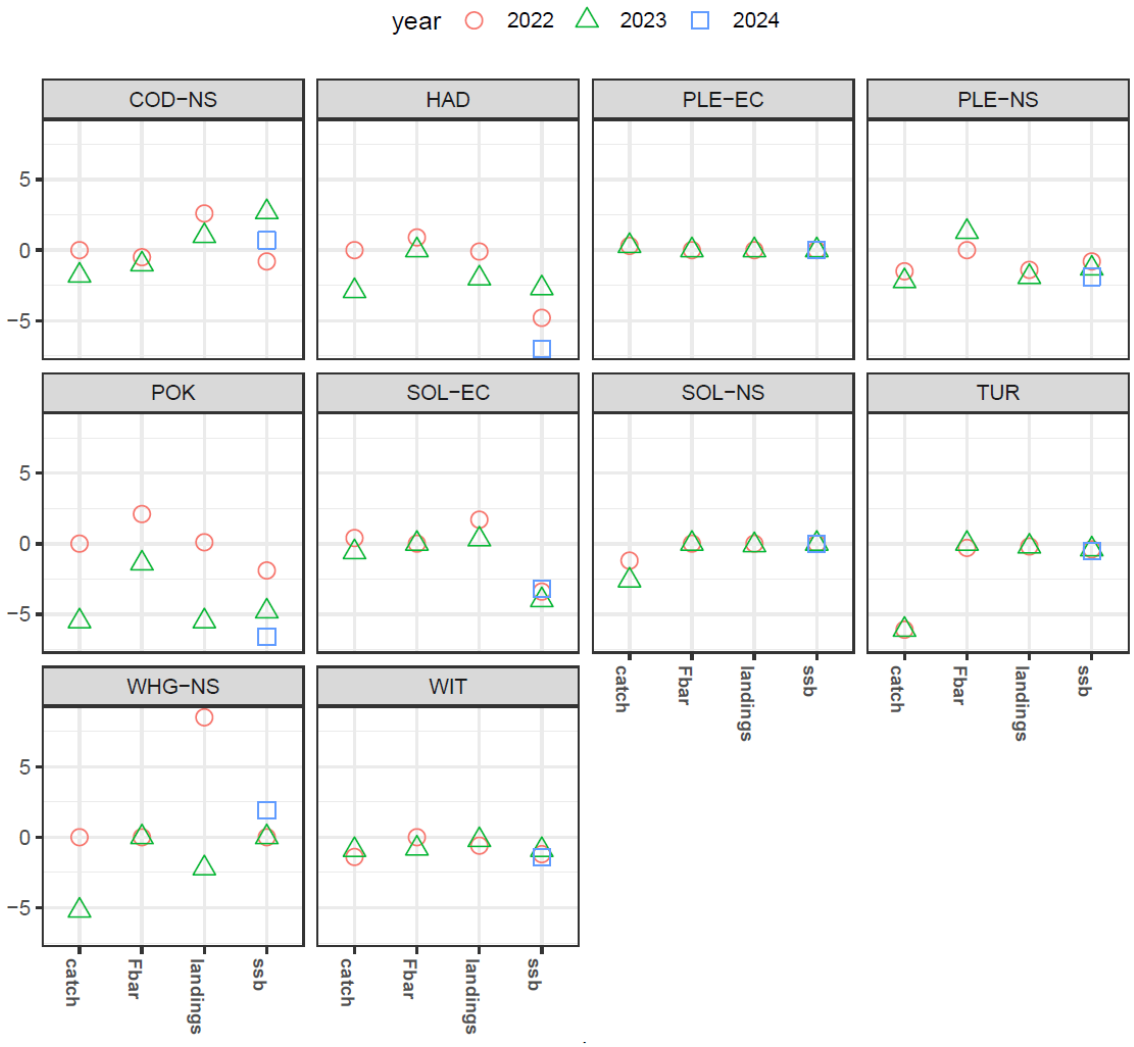

Figure 6.11. Difference (in percent) between WGMIXFISH-FLR baseline run and Single-stock advice for finfish stocks, showing Fbar, catch, landings (2022—2023), and SSB (2022—2024).

Figure 6.12. Comparison of the WGMIXFISH baseline runs and the WGNSSK single-stock advice. Displayed are the ratios of the WGMIXFISH baseline runs values (FLR in blue and FLBEIA in red) over those of the single stock advice

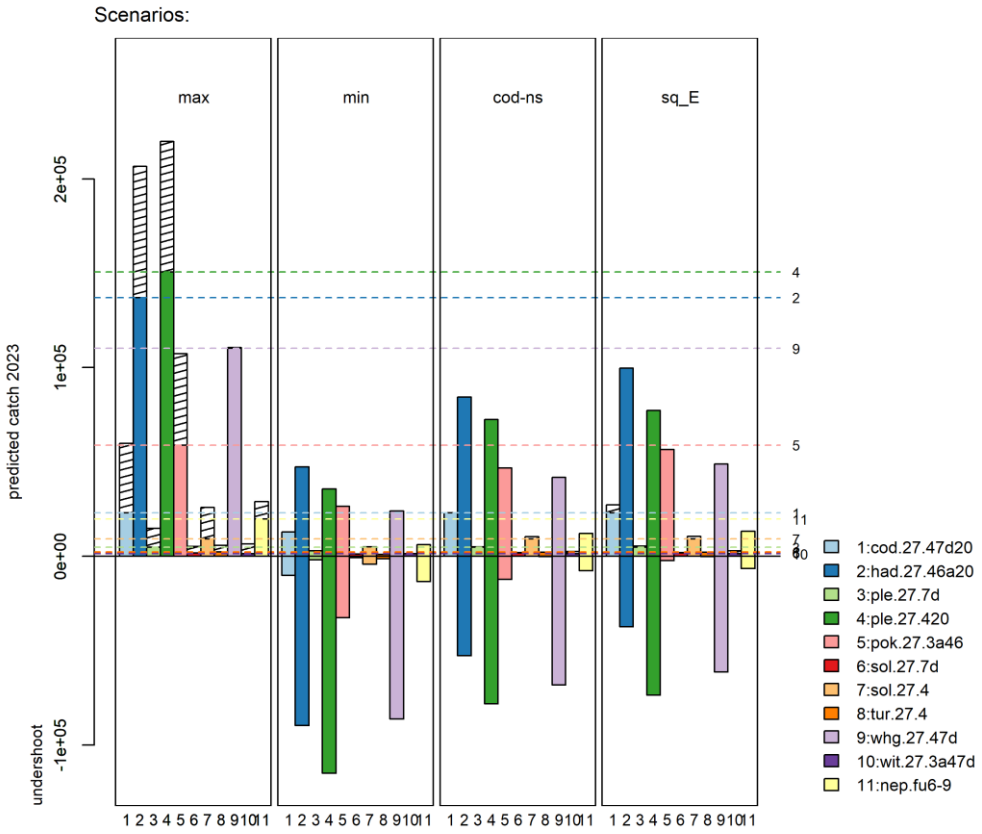

Figure 6.13. Mixed-fisheries projections. Estimates of potential catches (in tonnes) by stock and by scenario. The horizontal lines correspond to the single-stock catch advice for 2023. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched bars represent catches that overshoot the single-stock advice. Norway lobster functional units 6-9 are the main surveyed and updated stocks although all ten FUs are included in the analysis.

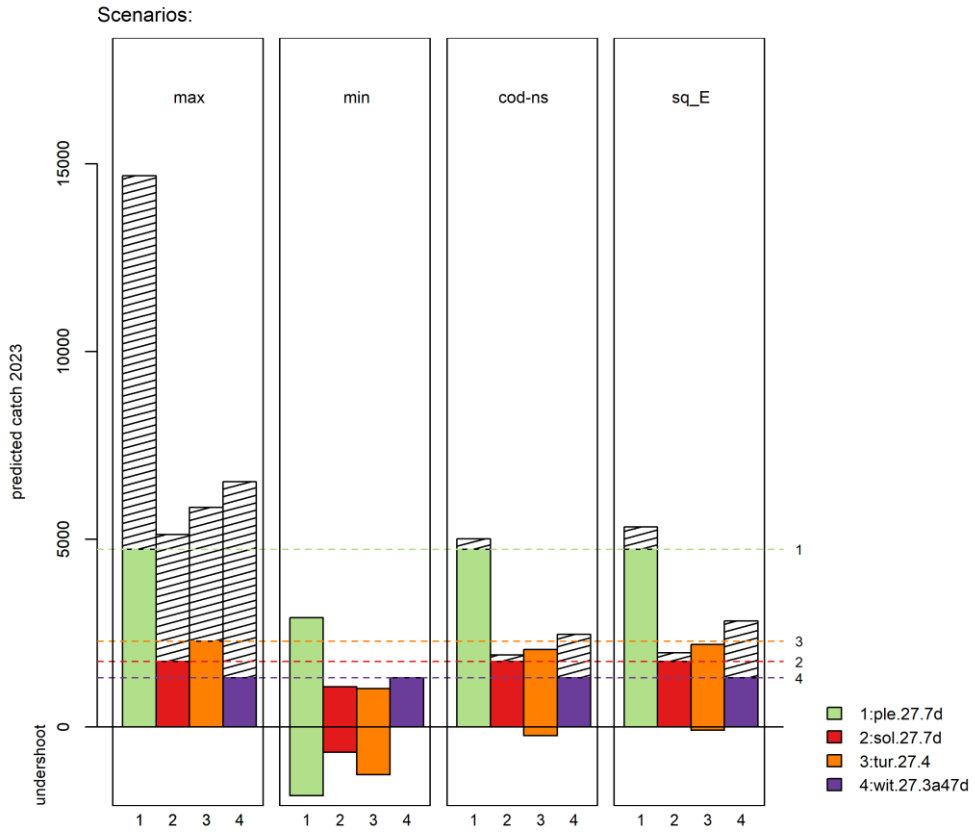

Figure 6.14. Mixed fisheries projections results for the stocks subject to lower landings (detail from Figure 6.13). Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2023. Bars below the value of zero show undershoot (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.

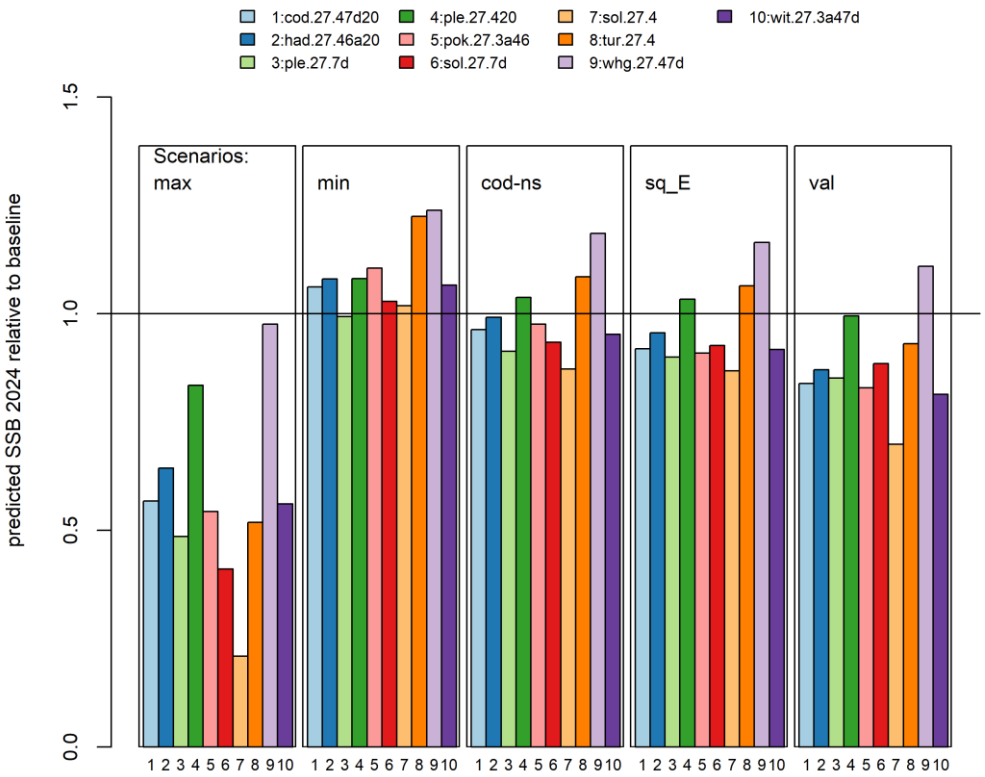

Figure 6.15. Mixed fisheries for the North Sea. Estimated SSB at the start of 2024 by stock after applying the mixed-fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line corresponds to the SSB resulting from the single-stock advice. Norway lobster are not included as the abundance was not forecasted in the mixed-fisheries model.

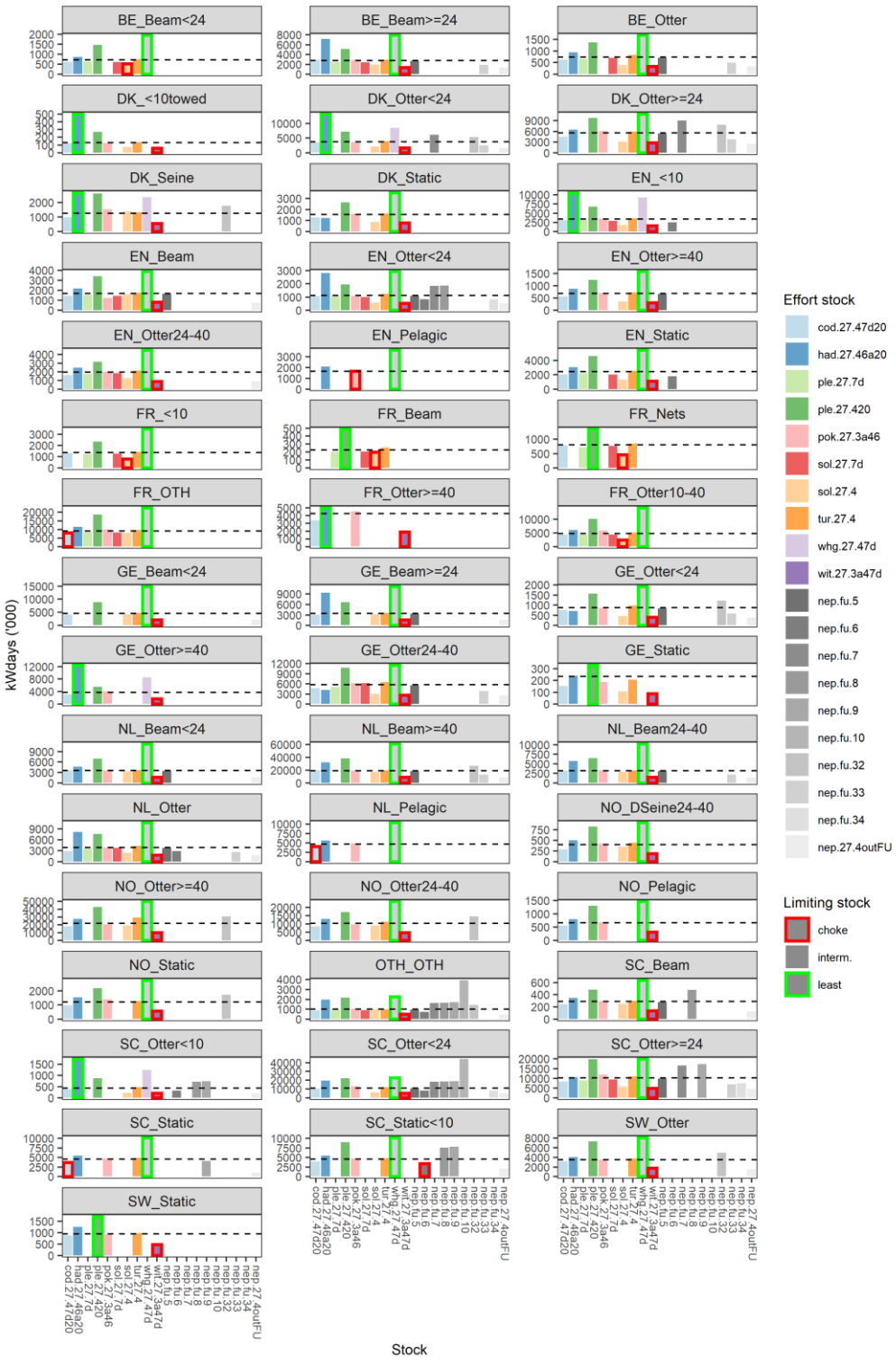

Figure 6.16. Mixed fisheries for the North Sea. Estimates of effort by fleet needed to reach each single-stock advice. Red triangles highlight the most limiting species for that fleet in 2023 ("choke species"), whereas the green triangles highlight the least limiting species. Fleet names are given by country (BE = Belgium, DK = Denmark, EN = England, FR = France, GE = Germany, IE = Ireland, NI = Northern Ireland, NL = the Netherlands, NO = Norway, 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.

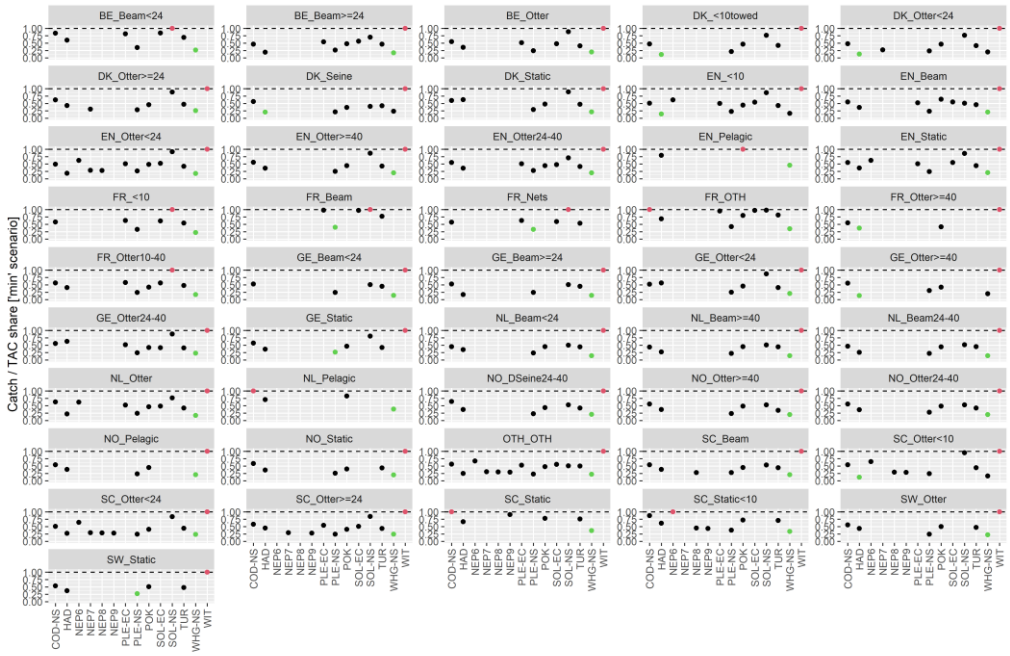

Figure 6.17. Quota uptake in 2023 in the min scenario. Red dots highlight the most limiting species for that fleet ("choke species"), whereas the green dots highlight the least limiting species.

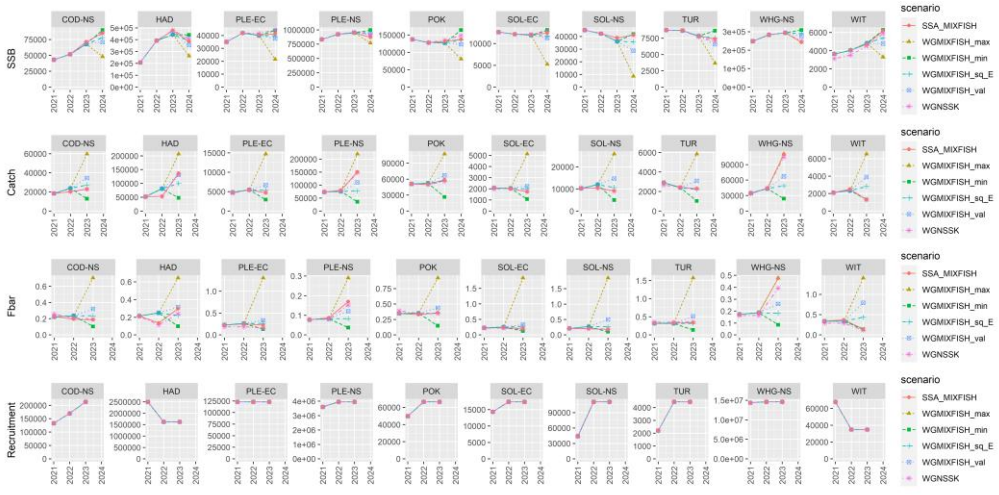

Figure 6.18. Comparison of the mixed fisheries projections in all the scenarios (WGMIXFISH) with the single-species advice projections (WGNSSK).

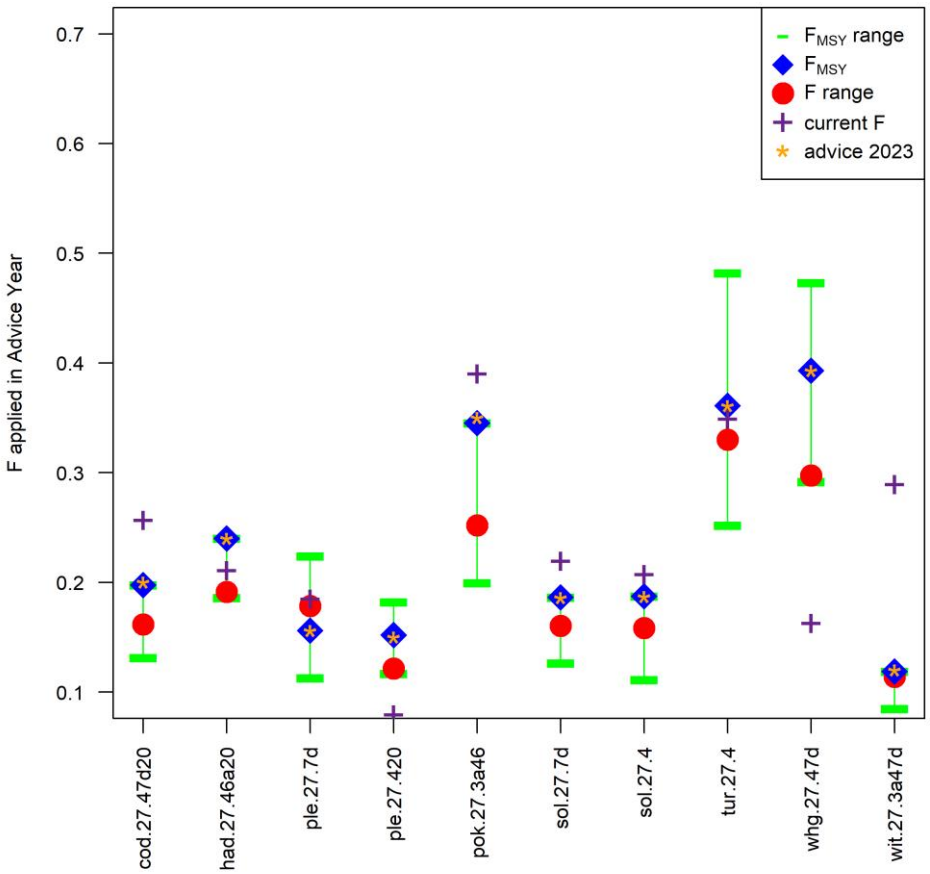

Figure 6.19. North Sea mixed-fisheries 2023 "range" fishing mortality within the F_{MSY} range, compared with F_{MSY}, the current F (F in 2021), and F in the single-stock advice for 2023. The "range" F is the one giving the lowest difference in tonnage between the "max" and the "min" scenario across 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 $MSYB_{trigger}$.

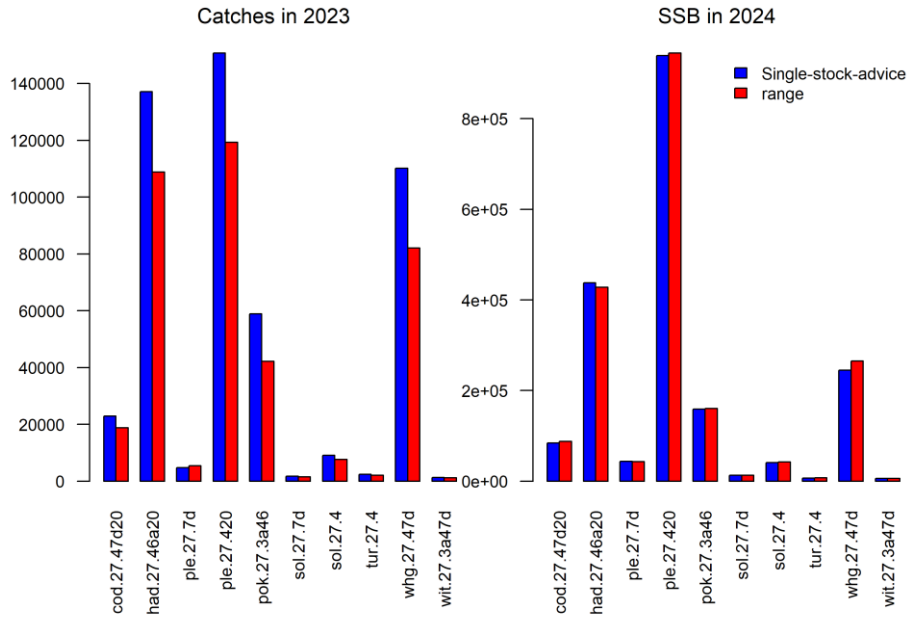

Figure 6.20. Comparison of the outcomes in terms of total catches in 2023 (left) and SSB in 2024 (right) between the F_{MSY}-based single-stock advice and the F_{range}-based forecast.

7 WGMIXFISH-METHODS planning

7.1 All regions

The following issues have been identified as being relevant to all ecoregions and therefore need to be addressed from an "all regions" perspective:

- 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.
- Develop criteria for choosing relevant scenarios to run.
- Develop criteria for stock inclusion in the mixed fisheries models.
- Define maximum fleet effort (e.g. multiple of status quo) as upper limit in scenarios.
- Assess possible use of grouped TAC constraints to better reflect management.

7.2 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, specifically for hake, white anglerfish, mackerel and blue whiting.
- Improve fleet structure based on this year's 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. Documentation and justification of the procedure.
- Analyse reported data for rays and decide on how to make assignments to the different species, given official catch data and information from surveys. Documentation and justification of the assumptions made.
- Continued implementation of the code, tables and figures in the ICES-taf repository (https://github.com/ices-taf) and automate the preparation of the different reports.
- Analyse the option of including fleet-dependent age structure in the conditioning of the model for some stocks.
- Analyse the relevance of existing scenarios and identify new relevant ones. For example, include sensitivity runs to the impact of combined TACs for anglerfishes (Lophius spp.) and rays (in case they are included next year).
- Implement the "range" scenario following further development to be conducted for the North Sea and Celtic Sea.
- Analyse the importance of the demersal species in the catches of the pelagic fleets.

7.3 Celtic Sea

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

- Continue work on the implementation of FLBEIA model.
- Streamline code, repository and results tables and figures in TAF.
- Conduct further development of the "range" scenario.

7.4 Iberian Waters

The following issues have been identified for future work in the Iberian waters case study:

- Improve mixed-fisheries fleets to best reflect the technical interactions in the region.
- Improvement of code structure in TAF. Continued implementation of report results, tables and figures in in R markdown.
- Inclusion of other stocks: The wide distributed stocks *Scomber scombrus* (mac.27.nea) and *Micromesistius poutassou* (whb.27.1-91214) are to be tested in the mixed fisheries model. These species have their southernmost distribution in the area and only have some seasonal, minor catches (when compared to the rest of the wide stock) but are relevant for some demersal métiers operating in the area.
- Consider other stocks in the area that are not included in the mixed fisheries methodology which are relevant for the effort allocation and technical interactions in mixed fisheries demersal métiers.
- Implement the "range" scenario following further development to be conducted for the North Sea and Celtic Sea.

7.5 North Sea

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

TAF:

- 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). For example, the model_03b script might be reconsidered by creating outputs from model_03c or model_04.
- 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.

Data

- The conditioning of the fleets and métiers is done manually (data_02) matching métiers in Accessions to the ones in InterCatch. Making this process automated would be of great help for consistency in the future. Developing a hierarchy of assumptions similar to the Celtic Sea is one suggested solution.

Methodology

- FIDES – Some runs have been done during the advice meeting using FIDES data to update quota shares per fleet. These results need to be investigated fully to decide if these should be used for advice in the future.
- Conduct further development of the "range" scenario.

Report & Stock Annex

- These will be further maintained, including the RMarkdown script.

7.6 Irish Sea

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

- Implement the "range" scenario following further development to be conducted for the North Sea and Celtic Sea.
- Investigate the potential for implementation of an age-based model (e.g. FLBEIA/ age-based FCube model) and compare with current FCube approach.
- Investigate of further scenarios based on alternative advice options for zero-catch stocks (e.g. cod and whiting).
- Progress work on historic model validation techniques.
- Alter WGMIXFISH datacall to specify that landings for gadoid stocks should be submitted for the same areas as used in the single-stock assessment in future years.
- Investigate differences in catch compositions of fish-stocks between Nephrops FU's if data sources allow.
- Further streamlining code, repository and results tables and figures.

7.7 Baltic Sea

- Obtain data disaggregated to level 6 metier (check RDB first before contacting national data submitters and reissuing the data call).
- Conduct initial data analysis on fleet data. Suggested outputs are checking consistency of fleet data with InterCatch and producing catch composition plots.

Annex 1: List of participants

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Annex 2: Audit reports

Audit of the Mixed-fisheries advice for the Bay of Biscay
Date: [20/10/2022]

Auditor: Klaas Sys

Summary of the advice

9. **Assessment type:** FLBEIA mixed fisheries assessment
10. **Single stock Assessments used as basis** (stock/assessment model/EG forecast method)

Species	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 8.a-b	FLR-XSA	FLR STF
MEGRIM 7.b-k and 8.a-b,d	Bayesian statistical catch at age model	ad hoc R code
NORWAY LOBSTER 8.a-b	UWTV survey	Ad-hoc (excel sheet)
HORSE MACKEREL in the Northeast Atlantic	SS3	FLR-STF
MACKEREL in the Northeast Atlantic and adjacent waters	SAM	FLR-STF
BLACK-BELLIED ANGLERFISH 7, 8.a-b,d	Survey trend (Category 3)	No
POLLACK 8 and 9.a	None (Category 5)	No
SEABASS 8a,b	SS3	SS3 (ad hoc R code)
SMOOTH-HOUND in the Northeast Atlantic and adjacent waters	Survey trend (Category 3)	Ad-hoc (excel sheet)
BLUE WHITING in the Northeast Atlantic and adjacent waters	SAM	SAM
WHITING 8 and 9.a	None (Category 5)	No

11. **Framework used for mixed fisheries forecasts:**
The FLBEIA model coded in R, using the FLR framework (www.flr-project.org).

12. **Data issues:**
Skates and rays are prone to mislabelling in the reporting of catches. Therefore, thornback ray, undulate ray, and cuckoo ray were not included in the model despite their importance in the BoB fishery. Resolving this issue would need more time to investigate in coordination with the relevant national data submitters.

Some discrepancies between the single stock advice and the Baseline run to reproduce the advice were found, all discrepancies were <10%.

13. Consistency:

Seabass has been added to the mixed fisheries advice after it was removed last year due to large discrepancies between the replicated single species advice conducted by WGMIXFISH and the single species advice. These issues were resolved, and therefore, seabass was included in the mixed fisheries advice.

The number of scenarios have been reduced compared to last year, and include the "min", "max", "sq_E" and a specific horse mackerel scenario where all fleets catch up their quota share for horse mackerel. Remark that the "min" excludes horse mackerel from the potential choke stocks. The "sq_E" was also modified as pelagic fleets did follow an other rule, and were assumed to fully uptake their quota for makerel, horse mackerel, and blue whiting.

The intermediate year assumption for the "other pelagic fleets" and "fleets that account for catches of species outside the BoB" has been modified. In contrast to other fleets, those fleets do not fish according status quo effort in the intermediate year, but are assumed to take up their full quota.

There have been some changes to the names of the defined fleets used in the mixed fisheries model, specifically the French fleets, due to a change in the metier definitions used in the accessions fleet data submission from France for 2020.

***14.* Mixed fisheries situation:**

Horse mackerel (hom.27.2a4a5b6a7a-ce-k8) is most limiting stock due to the zero catch advice When excluding horse mackerel, pollack (pol.27.89a) is te most limiting stock for 8 of the 22 fleets. The least limiting stock is whiting (whg.27.89a) (8 of 22 fleets).

15. Management Plan:

A multi-annual plan exists and covers some stocks in Western Waters and adjacent waters however, for some of these stocks, this MAP is currently not recognised by Norway or the UK. In those cases, ICES advice is given on the ICES MSY approach.

16. General comments

Advice sheet: Well written and adheres to the generic format agreed for all mixed fisheries advice sheets. Data issues affecting the advice were explained within the text.

TAF: Generally well documented and easy to follow. Results were fully reproducible. There were no issues to get the code running after manual installing of some R packages.

Report section: Wel written, includes detailed information on the stocks included in the WGMIXFISH projections, provides additional information on the scenarios and results.

Stock annex: Comprehensive document that includes background information on the stocks and fisheries in the Ecoregion.

17. Technical comments

All technical comments for documents have been added to the documents as a tracked change or comment balloon.

Advice sheet: /

TAF: The repository includes all necessary files to run the taf.bootstrap() procedure. However, it does not install all necessary packages (pals, R.utils, specific FLBEIA version) required to run all scripts.

Report section: spotted and corrected some typos

Stock annex: spotted and corrected some typos

18. Conclusions

The assessment has been carried out appropriately and is fully reproducible. There are some minor deviations from previous years related to forecast assumptions of pelagic stocks and these changes are justified. Some restructuring to the TAF repository would be beneficial.

Audit of the Mixed-fisheries advice for the Celtic Sea

Date: [23/10/2022]

Auditor: Harriet Cole

Summary of the advice

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

Species	Stock code	Assessment	Forecast
BLACK-BELLIED ANGLERFISH 7 and 8.abd	ank.27.78abd	SS3 (length-based)	FLR STF
COD 7.e-k	cod.27.7e-k	SAM	SAM
HADDOCK 7.b-k	had.27.7bce-k	SAM	SAM
HAKE 3.a, 4, 6, 7 and 8.abd	hke.3a46-8abd	SS3 (length-based)	FLR STF
MEGRIM 7.b-k and 8.abd	meg.27.7b-k8abd	a4a	FLR STF
NORWAY LOBSTER FU16	Nep.fu.16	UWTV survey	Ad-hoc (excel sheet)
NORWAY LOBSTER FU17	Nep.fu.17	UWTV survey	Ad-hoc (excel sheet)
NORWAY LOBSTER FU19	Nep.fu.19	UWTV survey	Ad-hoc (excel sheet)
NORWAY LOBSTER FU20-21	Nep.fu.2021	UWTV survey	Ad-hoc (excel sheet)
NORWAY LOBSTER FU22	Nep.fu.22	UWTV survey	Ad-hoc (excel sheet)
SOLE 7.e	sol.27.7e	XSA	FLR STF
SOLE 7.fg	sol.27.7fg	SAM	SAM
WHITE ANGLERFISH 7 and 8.abd	mon.27.78abd	SS3	FLR-STF
WHITING 7.b-ce-k	whg.27.7.b-ce-k	SAM	SAM

21. Framework used for mixed fisheries forecasts:

The FCube model coded in R, using the FLR framework (www.flr-project.org).

22. Data issues:

The production of WGMIXFISH advice additionally acts as a quality control check on the production of the single stock advice. An error was found in the single stock advice for the two monkfish stocks. Landings of these two stocks are often recorded under oe species code rather than being identified separately. The error found resulted from an error in the proportion of UK-England landings allocated to each stock. Currently, this means there is a discrepancy between

the single stock advice and the mixed fisheries results for these stocks. New landings and length distribution data were provided and the decision taken to reissue the single stock advice. A re-run of the Celtic Sea mixed fisheries model was done using the updated inputs.

Errors were also found in the single stock advice for cod and megrim. The correct application has been used in the mixed fisheries model and the single stock advice needs updating. As such, the mixed fisheries results are not compatible with the single stock advice yet (new advice sheets for the affected stock will be released at a later date).

23. Consistency:

New stocks have been added for this year: black-bellied anglerfish (ank.27.78abd) and northern hake (hke.27.3a46-8abd). This has changed the distributions of landings as hake now represents 50% of the landings and the relative importance of the main gear types (e.g. introduction of long lines, increase in importance of gillnets etc.) due to the introduction of more slope species.

New scenarios are presented in the headline advice (cod, hake, meg, mon, sole x2, nep) partly due to the addition of new stocks but also because a change in the structure of the headline advice plot has enabled more scenarios to be displayed.

The "range" scenario has been removed this year due to concerns over the validity of the optimum solution for stocks which are not the most or least limiting.

The spatial extent of 4 stocks (hake, white and black-bellied anglerfish and megrim) overlap both the Celtic Sea and Bay of Biscay ecoregions and are included in both models. Dummy "OTH" fleets are used to account for the catches taken out of the Celtic Sea region. However, these catches should only be considered representative in the contaxt of the Celtic Sea and may not correspond to the predicted catches given by the Bay of Biscay model.

Some fleet names have changed partly due to the provision of new fleet data (e.g. vessel length categories have now been provided for all gear types for Scotland) and partly due to the inclusion of additional stocks which has changed the relative importance of the fleets and metiers. Minor catches (<1% of total for all stocks) are binned together into an "OTH" fleet to reduce the complexity of the model.

***24.* Mixed fisheries situation:**

Cod (cod.27.7e-k) is most limiting stock (29 out of 32 fleets). This is due to the 0 catch advice for this stock and that nearly all fleets in the model catch cod. The most common least limiting stock is black-bellied anglerfish (ank.27.78abd, 21 out of 32 fleets).

25. Management Plan:

A multi-annual plan exists for Western Waters and adjacent waters however, this MAP is currently not agreed with Norway or the UK. For affected stocks, ICES advice is given on the ICES MSY approach.

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.

Catches of all quota species within the Celtic Sea are subject to the landings obligation (with some de minimis and survivability exemptions).

26. General comments

Advice sheet: Well written and adheres to the generic format agreed for all mixed fisheries advice sheets.

TAF: Well documented and easy to follow. Files/folder relating to updated runs were cleared labelled. Results prior to the anglerfish stock updates were fully reproducible (this was not repeated due to time constraints). There were no issues to get the code running.

Report section: Well written and easy to follow. However, the report section had not been completely revised for 2022 at the time of this audit. A number of new stocks have been added to the model so some attention is needed to ensure all stocks are mentioned/referenced properly in the text.

Stock annex: Well written with a clear structure. Some text on the new stocks added this year needs to be checked.

27. Technical comments

All technical comments for documents have been added to the documents as a tracked change or comment balloon.

The stock codes used were not consistent between the report section, advice sheet and stock annex. These have been edited (with tracked changes) to match those in the ICES Stock Inofrmation Database.

Advice sheet: Minor typos/comments.

TAF: Well structured and easy to follow.

Report section: A few minor typos/comments.

Stock annex: A few minor typos/comments.

28. Conclusions

The assessment has been carried out appropriately and is fully reproducible. three new stocks have been added this year which has slightly changed the relative importance of stocks and gear types. However, the addition of these stocks enables the model to give a fuller representation of the Celtic Sea fisheries.

One suggestion for the future is to run an additional advice option for zero TAC stocks during the "reproduce the advice" procedure. This is because reproducing a 0 catch advice may hide issues in the stock object data which may only become apparent when a non-zero catch is calculated.

Audit of the Mixed-fisheries advice for Iberian Waters

Date: [18/10/2022]

Auditor: Marc Taylor

Summary of the advice

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

Stocks	Assess-ment	Fore-cast	Fbar(range)	Fsq	Weight-at-age	Recruitment	discards propor-tion
HAKE 8c9ac	(SS3)	SS3	age1-age7	Average F (2019–2021)	Time invari-ant	Estimated BevHolt in SS3	Estimated (fixed)
FOUR-SPOT MEGRIM 8c9a	(a4a)	FLR STF	age2-age4	Average F (2019–2021)	Average (2017–2021)	GeoMean (1990–2019)	Average (2017–2021)
MEGRIM 8c9a9a	(a4a)	FLR STF	age2-age4	Average F (2019–2021)	Average (2017–2021)	GeoMean (1998–2019)	Average (2017–2021)
WHITE AN-GLERFISH 8c9a	(SS3)	SS3	30-130cm	Average F (2019–2021)	Time invari-ant	GeoMean (2003–2021	Discards negligi-ble

3. Framework used for mixed fisheries forecasts:

The FLBEIA model coded in R, using the FLR framework (www.flr-project.org).

4. Data issues:

In June, several stocks were missing from the Intercatch extraction (ank.27.8c9a, hke.27.8c9a, ldb.27.8c9a, and meg.27.8c9a) where data is missing for all years in the first 2 (ank.27.8c9a, hke.27.8c9a) and only 2021 for the last 2 (ldb.27.8c9a, meg.27.8c9a). Finalization of the data extraction by the stock assessor was probably not done initially, but was eventually remedied.

The main issues incountered this year dealt with difficulties in the translation of stocks assessed with SS3 (i.e. length-based assessments) into the age-based FLR framework used by FLBEIA. Hake proved most difficult, but differences were deemed small enough to provide mixed fishery advice (<4% in SSB, and <12% in F for forecast years).

5. Consistency:

4-spot megrim, megrim and hake were all recently benchmarked, and new assessments and ref points were used in this year's mixfish advice.

6. Mixed fisheries situation:

Southern hake (hke.27.8c9a) is limiting to all fleets (unclear if OTH_OTH as well). Black anglerfish (ank.27.8c9a) is least limiting in 10/11 fleets, and 4-spot megrim (ldb.27.8c9a) in 1/11 fleets. The limitation for hake is expected given the that the advice level is lower than the current catches

7. Management Plan:

The new multiannual management plan (MAP, EU Regulation 2019/472) includes 36 demersal and deep-sea stocks including 15 Norway lobster FUs in Western Waters, 7 of those stocks (FUs) are caught in ICES division 8c and 9a. The five stocks considered in the mixed fisheries analysis of Iberian Waters (hake, megrim and four-spot megrim, black-bellied and white anglerfishes) are

included in this new multiannual management. Combined TAC for anglerfish stocks. Combined TAC for megrim stocks.

8. General comments

Advice sheet: Well written and adheres to the generic format agreed for all mixed fisheries advice sheets. Data issues affecting the advice were explained within the text.

One detail that could be considered to add is that the SSB of HKE in Table 5 represents that of females only. Fore completeness, the OTH_OTH fleet should probably be included in Fig. 2. Table 2 should include the row (similar to North Sea): Catches outside of the North Sea (2023) – Associated with a single additional fleet ("OTH_OTH"), which follows the fleet effort control rules used by other fleets for a given scenario .

TAF: The organization of files is not TAF compliant given that all intermediate data has been uploaded within the report folder. All scripts are called within the report.R script, and any bootstrapping procedure is not considered by the scripts. Nevertheless, using these intermediate objects in the report folder, and running report.R, the results are reproducible. Scripts are organized into a logical structure and easy to follow. The organization could thus be mad TAF compliant in the future. The case study members may want to consider the use of a Rmarkdown document in the future for easing the updating of tables and summary information in the report and advice documents.

Report section: Well written and easy to follow. All data issues were documented and described.

Stock annex: Well written with a clear structure but needs to be updated. These include updates to stock assessments and reference points.

It might be good to reflect on the utility of having a specific scenario for each stock for future advice (we currently do not have a good justification as a group and thus are likely to discuss this at the mext METHODS meeting).

The dynamics of ANK are "fixed". This is appropriate for cat 2 stocks, where only trends are used in catch advice, but it was not explicitly stated anywhere. This was somewhat confusing given that the stock does go through a SPiCT assessment, which could technically be used to set up a biomass-based dynamics stock. I recommend including this detail in the stock annex and possibly the report for consistency.

9. Technical comments

All technical comments for documents have been added to the documents as a tracked change or comment balloon.

Advice sheet:

Figure 1 should show full stock names, not abbreviations, in facet names.

Headline advice (2nd paragraph) is missing a statement on the least-limiting stock (ANK). Consider explicitly stating how many fleets are choked by HKE (all?). ANK is least-limiting for 10 of 11 fleets.

Advice figure quality could be improved with higher resolution, and font size in some cases (Figs 2,3).

Full stock names should be used in Figures 1 (i.e. facet names), 3, & 4.

Table 5. SSB of hke – the advice speaks of Bpa (7556 t) and Blim (6011 t) in terms of female SSB only. Were the SSB values reported also only reflecting female SSB? Color of "mon" scenario looks wrong if this is correct. I believe this should be white given that it is > 7556 t? SSB for hake might require a note that this is for female SSB only.

TAF**:**

Lacks typical TAF structure (all script sourcing in report.r), but reproducible. A more typical structure will save on space in the TAF repositories. See general comments above. SOFTWARE.bib only contains the FLBEIA version, and should ultimately be used for all R packages. If it is at all possible to avoid, I would recommend not using the XLConnect R package as it has dependency on Java, and this was an issue for me. Perhaps use of .csv files would eliminate this.

Report section:

Unclear what the OTH_OTH fleet is. The report speaks of the "Other" metiers, but looking at the model, this is actually a fleet with a single metier. The results of the OTH-OTH fleet are not presented in the summary Figure 2. This may be recommended for completeness.

10. Conclusions

The assessment has been carried out appropriately and is fully reproducible. Some additional details have been requested for inclusion in the advice and report.

Audit of the Mixed-fisheries advice for Irish Sea

Date: [23/10/2022]

Auditor: Claire Moore

Summary of the advice

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

Stock	Assessment	Forecast
Cod 7.a	Stock Synthesis (SS3)	FLR STF
Haddock 7.a	Age-structured Assessment Programme; NOAA (ASAP)	FLR STF
Plaice 7.a	State-space Assessment Model (SAM)	SAM
Sole 7.a	Age-based Analytical Assessment (XSA)	FLR STF
Whiting 7.a	Age-structured Assessment Programme; NOAA (ASAP)	FLR STF

3. Framework used for mixed fisheries forecasts:
The Fcube model coded in R, using the FLR framework (www.flr-project.org).

4. **Data issues:**
Whg.27.7a not present in InterCatch extraction, provided separately by stock assessor.

5. Consistency:
All single species forecasts were reproducible within the FCube framework. Any deviations were within the acceptable <5% difference

6. Mixed fisheries situation:
All scenarios are limited by the COD and WHG in due to the zero TAC advice. The least limiting stock in HAD

7. Management Plan:
A multiannual management plan (MAP) for Western and adjacent waters has been adopted by the EU for stocks covered by this advice (Council Regulation (EC) 2019/472) which ICES considers to be precautionary. However, there is no agreed shared management plan with UK for this stock. Therefore, ICES does not use the MAP for basis of advice.

8. General comments
Advice sheet: Well written and adheres to the generic format agreed for all mixed fisheries advice sheets. Data issues affecting the advice were explained within the text.

A breakdown of the % of landings per gear is missing above figure 5 (see Celtic seas advice sheet)

TAF: Scripts are organized into a logical structure and easy to follow.

Report section: Well written and easy to follow. All data issues were documented and described.

Stock annex: Well written with a clear structure but needs to be updated. These include updates to stock assessments and reference points.

9. Technical comments

All technical comments for documents have been added to the documents as a tracked change or comment balloon.

Advice sheet:

A breakdown of the % of landings per gear is missing above figure 5 (see Celtic seas advice sheet)

Report section:

More information required in section "1.5.2.1 Baseline run – reproducing single species stock advice". Unclear what is driving the ~4% difference between mix fish and single species forecasts.

10. Conclusions

The assessment has been carried out appropriately, and is reproducible.

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

Date: 20/10/2022

Auditor: Johnathan Ball

Summary of the advice

1. **Assessment type:** FLBEIA 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	SAM	MFDP
PLAICE 4	SAM	FLR 2.3, FLSTF
SAITHE 4, 3.a and 6	SAM	SAM
SOLE 4	AAP	FLR 2.3, FLSTF
WHITING 4 and 7.d	MFDP	MFDP
PLAICE 7.d	AAP	FLR 2.x, FLSTF
SOLE 7.d*	SAM	SAM
TURBOT 4	SAM	FLR (fwd-routines)
WITCH 4, 3.a and 7.d	SAM	SAM
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**:

FLBEIA model using the FLR framework (www.flr-project.org). All analysis were run in R.

4. Data issues:

Norway has provided data for mixed fisheries consideration for the first time, however data on the under 15m fleet is not provided and has been included under the other fleet in the model. This creates a discrepancy of 6867t of which 5708t is haddock

5. Consistency:

The 2022 mixed fisheries assessment uses the FLBEIA simulation framework following adoption in 2021. The FLBEIA model is compared with FCube and the single stocks stochastic projections. Some difficulty is noted in replicating stochastic forecast in FLBEIA's deterministic framework; however, differences are within acceptable limits.

6. Mixed fisheries situation:

Witch is the most limiting species for 36 of the 46 fleets defined, this is a departure from last year where Cod was the most limiting. The change is due to the advice necessary to reach the Witch single species advice in 2023.

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)

8. General comments

The stock annex, report and advice are well-written, informative and are available on the ICES sharepoint. The stock annex provides a clear and concise summary of the advice areas, major fisheries and technical measures for each stock, and an overview of the data and methods used to generate the mixed fisheries advice. The report provides further details on the software and simulation scenarios evaluated. The advice sheet presents mixed fisheries considerations based on simulations for the Greater North Seas ecoregion and has been restructured based on formatting guidelines discussed during the WG advice meetings.

9. Technical comments

Code and reproducibility

The code repository is well-structured with a clear and helpful 'read me' that provides a brief outline and description of the key scripts in the analysis. Individual scripts are overall well-organized, with annotated chunks of code and the generation of useful diagnostic plots and tables. Where code has been updated in year 2022 comments have been added which is helpful, however some comments remain out of date, particularly header comments at the start of scripts. Some hard coded elements are present in the scripts, which could cause issues at a later meeting.

'model_00_settings.R', still requires a description on the git and the script comments could be extended to show where setting variable are being used in other scripts. For example the LO variable is used on line xxx of script x.

Stock Annex

The stock annex was not updated in 2022

Report

The report has not been fully updated at the time of audit due to changes in the Nephrops advice and the reopening of the Cod advice.

10. Conclusions

The assessment is fully reproducible; however, this was checked prior to the Cod and Nephrops single species advice changing.

Annex 3: 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.bob	Bay of Biscay Mixed Fisheries Annex	October 2022	mix.bob_SA
mix.cs	Celtic Sea Mixed Fisheries Annex	October 2022	mix.cs_SA
mix.iw	Iberian Waters Mixed Fisheries Annex	October 2022	mix.iw_SA
mix.is	Irish Sea Mixed Fisheries Annex	October 2022	mix.is_SA
mix.ns	North Sea Mixed Fisheries Annex	October 2022	mix.ns_SA

Annex 4: Resolutions for next meeting (draft)

Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)

2022/2/FRSGxx The **Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)**, chaired by Marc Taylor (Germany) and Harriet Cole (UK), will hold a hybrid meeting in Copenhagen, on XX–XX October 2023 to:

a) Carry out mixed fisheries projections for the Bay of Biscay taking into account the single species advice and the management measures in place for 2023 for anglerfish, megrim, sea bass, hake, sole, Norway lobster, whiting and pollack that is produced by WGBIE in May 2023; for mackerel, horse mackerel, and blue whiting produced by WGWIDE in September 2023 and rays and smooth hound produced by WGEF in October 2023.

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 2023 for cod, haddock, whiting, hake, megrim, monkfish, and *Nephrops norvegicus* that is produced by WGCSE and WGBIE in 2023.

c) Carry out mixed fisheries projections for Iberian waters taking into account the single species advice and the management measures in place for 2023 for hake, four-spot megrim, megrim and white anglerfish that is produced by WGBIE in May 2023.

d) Carry out mixed demersal fisheries projections for the Irish Sea (27.7.a) taking into account the single species advice for cod, haddock, whiting, plaice, sole, and *Nephrops norvegicus* that is produced by WGCSE in 2023.

e) Carry out mixed demersal fisheries projections for the North Sea taking into account the single species advice and the management measures in place for 2023 for cod, haddock, whiting, saithe, plaice, sole, turbot, *Nephrops norvegicus*, sole 7.d, plaice 7.d, and witch that is produced by WGNSSK in May 2023;

f) Produce draft mixed-fisheries sections for the ICES advisory report 2023 that includes a dissemination of the fleet and fisheries data and forecasts for the North Sea, Celtic Sea, Irish Sea, Bay of Biscay, and Iberian waters.

WGMIXFISH-Advice will report by XX November 2023 for the attention of ACOM.