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WORKING GROUP ON MIXED FISHERIES ADVICE (WGMIXFISH-ADVICE; OUTPUTS FROM 2019 MEETING)

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i Executive summary

The ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) chaired by Claire Moore, Ireland, met at ICES headquarters in Copenhagen, Denmark, 28 October–1 November 2019 to produce mixed fisheries forecasts for the North Sea, Celtic Sea, and Iberian waters.

Mixed fisheries advice highlights the potential implications of single-stock (total allowable catch and effort) management on the catches of multiple stocks caught together in mixed fisheries. It takes into account past fishing patterns and catchability of the different fleets, and the TAC advice produced by the single-stock advice groups for 2019 to provide quantitative forecast of over- and under-exploitation of the different stocks given mixed fishery interactions. Forecasts were based on the "FCube" (Fleet and Fishery Forecasts) methodology for the Celtic Sea and North Sea, and on the "FLBEIA" (Fisheries Library Bio-Economic Impact Assessment) methodology for the Iberian Waters—with a range of potential management scenarios relevant for the specific regional fisheries.

The North Sea demersal mixed fisheries projections consider the single-species advice for cod (cod.27.47d20), haddock (had.27.46a20), whiting (whg.27.47d), saithe (pok.27.3a46), plaice (ple.27.420 and ple.27.7d), sole (sol.27.4), turbot (tur 27.4), and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4 outFU). The most limiting TAC in 2020 will be the TAC for cod for particular fleets ("cod-ns" scenario). The "min" scenario gives a 14% higher catch of cod compared to the "cod-ns" scenario, due to the relaxing of the constraint on a stock where the country is not assumed to be limited for that stock, but the model does not take into account quota reallocation between fleets. Substantial overshoot of TACs can occur under other scenarios (e.g. "max" scenario). This "range" scenario suggests that the potential for mixed fisheries mismatch would be lowered with a 2020 TAC in the lower part of the F_{MSY} range for North Sea plaice and North Sea saithe, and at the highest possible value for cod in accordance with the MSY approach and the MAP (EU multiannual plan).

The Celtic Sea demersal mixed fisheries projections consider the single-species advice for cod (cod.27.7e–k), haddock (27.7b–k), and whiting (27.7bce–k). The resulting 2020 forecast implies that catches of haddock and whiting would also be zero, as cod single-species advised catch is zero ("min" scenario). The "max" scenario, assumes that all fleets catch their haddock and whiting quotas; this scenario leads to an overshoot for cod and to a lesser extent whiting. In order to provide a scenario with non-zero catch, a reduced cod F_{MSY} scenario was presented ('cod_F_{ARMSY}'). Applying the ICES Advice Rule (AR) gives an F (0.057) for cod and results in undershoots of both haddock and whiting, as fishing is stopped when the cod quota is reached. The range scenario was run using a reduced F range cod (F_{MSY} range [0.037–0.089]) and for whiting (F_{MSY} range [0.45–0.22]), which resulted in haddock and whiting TACs being at the lowest of their respective F_{MSY} ranges.

The Iberian waters demersal mixed fisheries projections consider the single-species advice for black anglerfish (ank.27.8c9a), hake (hke.27.8c9a), four spot megrim (lbd.27.8c9a), megrim (meg.27.8c9a), and white anglerfish (mon.27.8c9a). The limiting stock for fishing opportunities will be hake, corresponding to an undershoot of the advised catch for the other stocks considered in the mixed fisheries analysis. Conversely, black anglerfish is the least limiting stock, corresponding to an overshoot of the advised catch for the other considered stocks.

ii Expert group information

Expert group name	Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)
Expert group cycle	Annual
Year cycle started	2018
Reporting year in cycle	1/1
Chair	Claire Moore, Ireland
Meeting venue and dates	28 October–1 November 2019, Copenhagen, Denmark (14 participants)

1 Introduction

This report documents WGMIXFISH-ADVICE 2019 meeting outputs; the WGMIXFISH-ADVICE 2020 and WGMIXFISH-METHODS 2020 reports are forthcoming.

The ICES Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) chaired by Claire Moore, Ireland, met at ICES headquarters in Copenhagen, Denmark, 28 October–1 November 2019 to apply mixed fisheries forecasts to the 2019 single-species advice for the North Sea, Celtic Sea, and Iberian waters.

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

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

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

1.1 Definitions

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

- A **fleet segment** is a group of vessels with the same length class and predominant fishing gear during the year. Vessels may have different fishing activities during the reference period, but might be classified in only one fleet segment.

- A **métier** is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area, and characterised by a similar exploitation pattern.

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

1.2 Terms of reference

The **Working Group on Mixed Fisheries Advice** (WGMIXFISH-ADVICE), chaired by Claire Moore (Ireland) will meet at ICES Headquarters 28 October–1 November 2019 to:

a) Carry out mixed demersal fisheries projections for the North Sea taking into account the single-species advice and the management measures in place for 2019 for cod, haddock, whiting, saithe, plaice, sole, turbot, *Nephrops norvegicus*, sole 7.d and plaice 7.d that is produced by WGNSSK in May 2019;

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 2019 for cod, haddock, and whiting that is produced by WGCSE in 2019, and further develop mixed fisheries analyses for the region;

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

d) Produce draft mixed fisheries sections for the ICES advisory report 2019 that includes a dissemination of the fleet and fisheries data and forecasts for the North Sea, Celtic Sea, Bay of Biscay, and Iberian waters;

e) Increasing the number of species included in the current Celtic Sea mixed fisheries considerations. Priority will be given to target species identified based on knowledge of identified mixed fisheries interactions in the Celtic Sea. Primary analysis shown that stocks assessed by WGCSE and WGBIE can potentially take part to mixed fisheries interaction in the Celtic Sea. These species should be defined before WGCSE and WGBIE to allow data compilation and model parametrization before WGMIXFISH.

WGMIXFISH-Advice will report by November 2019 for the attention of ACOM.

2 North Sea

2.1 Background

2.1.1 Effort limitations

Effort restrictions, in terms of days at sea, were introduced for EU registered vessels in Annex XVII of Council Regulation 2341/2002 and has been amended by Council on an annual basis. In 2009 effort limits were changed, with effort now being measured in kilowatt days (kWdays, engine power in kW*fishing days), and being assigned a unique limitation to individual Member State fleets. The baseline effort assigned in 2009 was calculated from the track record per fleet averaged over time periods, 2004–2006 or 2005–2007, depending on national preference. The latest effort allocations available by nation and fleet are given in Appendix 1 of Annex IIa of Council Regulation (EU) 2016/72. The totals in 2018 are unchanged from those in 2012. Member states are permitted slightly larger allocations of effort in cases where that effort involves low cod catches, e.g. through the implementation of more selective gears or cod avoidance measures. Full details are given in Article 13 of Council Regulation (EC) 1342/2008.

2.1.2 Stock-based management plans

The stocks considered as part of the North Sea demersal mixed fisheries analysis follow the ICES MSY approach as the basis of advice. Multiannual management plans (MAP) were not used as basis for the advice in 2019 as stock definition and/or reference points changed the basis for MAP. The last stock under MAP is the North Sea Sole Council Reg. (EC) No. 676/2007 (EU, 2007), this plan consists of harvest rules to derive annual TACs depending on the state of the stock relative to biomass reference points and target fishing mortality. The harvest rules also impose constraints on the annual percentage change in TAC.

In the context of the new CFP, the EU has been working on designing and evaluating mixed fisheries management plans, that would eventually replace the current single-stock LTMPs with a unique framework defining objectives and constraints for both target and bycatch demersal species. A public consultation was opened from February to May 2015[1] with potential outcomes of a mixed fisheries plan evaluated by STECF in March 2015[2]. A draft version was published by the EC in August 2016[3] and is in force since 4 July 2018 as EU Regulation 2018/973[4]. Until further progress is made, and the mixed fisheries plan finalised, the current LTMPs are still in effect, although ICES does not use them for the basis of advice.

[1] http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/north-sea-multiannual/index_en.html

[2] http://stecf.jrc.ec.europa.eu/documents/43805/969556/2015-05_STECF+15-04+-+NSMAP_JRCxxx.pdf

[3] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0493&from=EN

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

2.2 FCube

2.2.1 Software

All analyses were conducted using the FLR framework[5] (Kell *et al.*, 2007; FLCore 2.6.13, FLAssess 2.6.3, Flash 2.5.11) running with R 3.5.1 (R Development Core Team, 2011). The code, software and versions are part of the ICES Transparent Assessment Framework[6] (TAF,) and can be fully reproduced from this repository. 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 is outlined in the text table below:

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

2.2.2 Scenarios

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

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

Incorporating *Nephrops* into the mixed fisheries advice produces a number complicating factors: For example, *Nephrops* are fished in distinct geographic areas or functional units (FU), only some of which receive an abundance estimate (necessary to calculate a catchability). This WG followed the approach adopted by ICES (2009) which is to perform the normal FCube prediction for those FUs with absolute abundance estimates, then to calculate a ratio of change from the current yields to the ICES advice for the same FUs. For those FUs without absolute abundance estimates,

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

[6] https://github.com/ices-taf/2019_NorthSea_MixedFisheriesAdvice

landings resulting from the FCube run were simply taken to be the most recently recorded landings multiplied by the same ratio R. To do this, landings for each métier had to be apportioned across the FUs. This was facilitated by the supply of effort and catch data by FU.

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

1. **"Max"**: For each fleet, fishing effort in 2020 stops when all stock shares* of that fleet have been caught up. This option causes overfishing of the single-stock advice possibilities of most stocks. The underlying assumption is that fishing stops for a fleet when all quota species are fully utilised for that fleet with quotas set corresponding to single-stock exploitation boundary for each species.
2. **"Min"**: The underlying assumption is that fishing stops for a fleet when the catch for the first quota species for that fleet meets the corresponding single-stock exploitation boundary. Choke species are assessed at the country-level comparing the sum of fleet catches and catches at status quo effort for each fleet, assuming that quota reallocation between fleets can occur at country level. For each fleet, fishing effort in 2020 stops when the most limiting of the predefined choke stock shares of that fleet is attained. If a fleet has no identified choke stock then the status quo effort for that fleet is used. This option causes underutilization of the single-stock advice possibilities of other stocks. This scenario can highlight some potential "choke species" issues.
3. "**Sq_E**": The effort was set as equal to the effort in the most recently recorded year for which landings and discard data were available. The effort of each fleet in 2019 and 2020 is set equal to the effort in the most recently recorded year for which landings and discard data are available (2018).
4. **"Value"**: A simple scenario accounting for the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the quota of each of the stocks, weighted by the historical catch value of that stock. This option causes overfishing of some stocks and underutilisation of others. The "value" scenario is a simple proxy balancing fishing opportunities by stock with their potential market value, in the absence of a formal economic behaviour model. For example, if a fleet would need 100 days fishing for catching its share of stock A, and 200 days fishing for catching its share of stock B, and if the value (tonnage × mean price) of that fleet's stock shares is 75% from stock A and 25% from stock B, then the resulting effort would be (100 × 0.75) + (200 × 0.25) = 125 days.
5. **"Cod MSY approach" (COD-ns):** All fleets set their effort in 2019 and 2020 corresponding to their cod stock share, regardless of other catches. (There are small differences in the cod catches between this scenario and the single-stock advice because of the slightly different forecast methods used.) This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks. This scenario can highlight some potential "choke species" issues.
6. **"Range"**: as described in Ulrich *et al.* (2017), this scenario searches for the minimum sum of differences between potential catches by stock under the "min" and the "max" scenarios within the F_{MSY} ranges.

2.3 Stock input data and recent trends

2.3.1 Stocks

2.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGNSSK (ICES, 2019a). Similar to last year, all stock inputs formatted as FLStock objects were directly provided to

WGMIXFISH by the respective stock coordinators, and this eased greatly the quality of the process of collecting stock data.

An increasing number of WGNSSK stocks are being assessed using stochastic assessments (SAM model for North Sea cod, saithe and whiting, TSA for Northern shelf haddock and AAP for the Eastern Channel plaice, North Sea sole, plaice and turbot). Therefore, for some of these stocks the advice is based on stochastic projections, which cannot easily be fully replicated in the deterministic FCube software. However, FCube projections are routinely compared to the median projections of the single-species stochastic forecasts on which single-stock advice is based and results are very similar (see Section 2.5.2.1 below); as such, WGMIXFISH does not consider the difference impacts significantly on the mixed fisheries advice.

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

2.3.1.2 Trends and advice

The advice for these stocks is drafted by the WGNSSK-2019 under considerations by ACOM. Recent trends are described on a stock-by-stock basis in ICES (2019a), and latest advice by stock is available on the ICES website. In order to give a global overview of all North Sea demersal stocks at one time, this information is summarised below. It should be noted that although there is only one advice, additional management considerations are also listed in the single-species advice.

Analytical stocks

Species	Area	Stock status	Advice 2020
cod.27.47d20 (Cod)	Subarea 4, Division 7.d, and Subdivision 20 (North Sea, eastern English Channel, Skagerrak)		ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 13 686 tonnes.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above		MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	o	o	✗	Harvested unsustainably		B_{pa},B_{lim}	o	✗	✗	Reduced reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable		B_{MGT}	–	–	–	Not applicable

Summary: Fishing mortality (F) has increased since 2016, and is above F_{lim} in 2018. Spawning-stock biomass (SSB) has decreased since 2015 and is now below B_{lim}. Recruitment since 1998 remains poor.

had.27.46a20 (Haddock)	Subarea 4, Division 6.a, and Subdivision 20 (North Sea, West of Scotland, Skagerrak)		ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 41 818 tonnes.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	o	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable		B_{MGT}	–	–	–	Not applicable

Summary: Fishing mortality (F) has declined since the beginning of the 2000s but it has been above F_{MSY} for the entire time-series. Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019 year class is estimated to be the largest since 2000.

Species	Area	Stock status	Advice 2020
ple.27.420 (Plaice)	Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)		ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 166 499 tonnes.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable		B_{MGT}	–	–	–	Not applicable

Summary: The spawning-stock biomass (SSB) is well above MSY $B_{trigger}$ and has markedly increased since 2008, following a substantial reduction in fishing mortality (F) since 1999. Recruitment has been fluctuating around the long-term average since the mid-1990s. Recruitment in 2019 is estimated to be the second highest in the time-series. Since 2009, fishing mortality (F) has been estimated below F_{MSY}.

Species	Area	Stock status	Advice 2020
ple.27.7d (Plaice)	Division 7.d (Eastern Channel)		ICES advises that when the EU multiannual plan (MAP) for the Western Waters is applied, catches from the Division 7.d plaice stock in 2020 that correspond to the F ranges are between 6545 tonnes and 12 029 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (9073 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within range		MAP MSY $B_{trigger}$	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has increased rapidly from 2010 following a period of high recruitment between 2009 and 2015, and is now still well above the MSY $B_{trigger}$, despite a decline since 2016. Fishing mortality (F) has declined since the early 2000s, with an increase in the recent years to slightly below F_{MSY}. Recruitment(R) is currently around the average of the last 10 years of the time series.

Species	Area	Stock status	Advice 2020
pok.27.3a46 (Saithe)	Subareas 4 and 6, and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)		ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 88 093 tonnes.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	At FMSY		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable		B_{MGT}	–	–	–	Not applicable

Summary: Spawning-stock biomass (SSB) has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996. Fishing mortality (F) has decreased and stabilised at or below F_{MSY} since 2014. Recruitment(R) has shown an overall decreasing trend over time with lowest levels in the past 10 years.

Species	Area	Stock status	Advice 2020
Sol.27.4 (Sole)	Subarea 4 (North Sea)		ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the MAP are between 10 192 tonnes and 29 767 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (17 545 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within range		MAP MSY $B_{trigger}$	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has increased since 2007 and has been estimated above MSY $B_{trigger}$ since 2012. Fishing mortality (F) has declined since 1999 and is close to F_{MSY} in 2018. Recruitment(R) has fluctuated without trend since the early 1990s. Recruitment in 2019 is estimated to be the highest since 1988.

Species	Area	Stock status	Advice 2020
tur.27.4 (Turbot)	Subarea 4 (North Sea)		In the context of the EU multiannual plan for demersal fisheries in the North Sea, in which this stock is considered by-catch, the EC has requested that ICES provide advice based on the precautionary approach. ICES advises that catches of up to 4538 tonnes are considered to be precautionary. ICES advises that turbot should be managed using a single-species TAC covering an area appropriate to the relevant stock distribution (ICES Subarea 4).
whg.27.47d (Whiting)	Subarea 4 (North Sea) and Division 7.d (Eastern Channel)		ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 22 082 tonnes. Management should be implemented at the stock level

tur.27.4 (Turbot) — Stock status

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	–	–	–		B_{MGT}	–	–	–	

Summary: Recruitment(R) is variable without a trend. Fishing mortality (F) has decreased since the mid-1990s, and has been just below F_{MSY} since 2012. The spawning-stock biomass (SSB) has increased since 2005 and has been above MSY $B_{trigger}$ since 2013.

whg.27.47d (Whiting) — Stock status

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	o	Increased risk
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

Summary: Spawning-stock biomass (SSB) has fluctuated around MSY $B_{trigger}$ since the mid-1980s and is just below it in 2019. Fishing mortality (F) has been above F_{MSY} throughout the time-series, apart from 2005. Recruitment(R) has been fluctuating without trend, but the last two-year classes are below average.

Nephrops stocks

Species	Area	Stock status	Advice 2020
Nephrops	Botney Gut-Silver Pit (FU 5)	The state of this stock is unknown. Preliminary stock surveys (2010 and 2012) indicate relatively high density compared to neighbouring FUs.	ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should be no more than 1637 tonnes. This would imply wanted catch of no more than 1074 tonnes.
Nephrops	Farn Deeps (FU 6)		ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the MAP are between 2055 tonnes and 2384 tonnes. The entire range is considered precautionary when applying the ICES advice rule. In order to ensure the stock in Functional Unit (FU) 6 is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to FU 6 could rapidly lead to overexploitation.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	?	?	?	Undefined	B_{pa},B_{lim}	✓	✓	✓	Above possible reference point
Management plan	F_{MGT}	✗	✗	✗	Above	B_{MGT}	✓	✓	✓	Above

Summary: The stock abundance index has increased since 2015, and currently it is above MSY $B_{trigger}$. Harvest rates have been above the MSY level since 2001, except for 2008 and 2017.

Species	Area	Stock status	Advice 2020
Nephrops	Fladen Ground (FU 7)		ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the plan are between 12 552 tonnes and 14 263 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 7 is exploited sustainably, management should be implemented at the functional unit level. In recent years, the catch in FU 7 has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs.
Nephrops	Firth of Forth (FU 8)		ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the plan are between 2045 tonnes and 3143 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit 8 is exploited sustainably, management should be implemented at the functional unit level.

Fladen Ground (FU 7)

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points	B_{pa},B_{lim}	✓	✓	✓ Above possible reference points
Management plan	F_{MGT}	✓	✓	✓	Below	B_{MGT}	✓	✓	✓ Above

Summary: The stock size declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015. From 2016 the stock size increased and is currently above MSY $B_{trigger}$. The harvest rate has declined since 2010 and remains well below F_{MSY}.

Firth of Forth (FU 8)

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019
Maximum sustainable yield	F_{MSY}	✓	✗	✓	Below	MSY $B_{trigger}$	✓	✓	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	?	✓	Below possible reference points	B_{pa},B_{lim}	✓	✓	✓ Above possible reference points
Management plan	F_{MGT}	✓	✗	✓	Within range	B_{MGT}	✓	✓	✓ Above

Summary: The stock size has been above MSY $B_{trigger}$r for most of the time-series. The harvest rate is varying and is now below F_{MSY}.

Species	Area	Stock status	Advice 2020
Nephrops	Moray Firth (FU 9)		ICES advises that when the EU multiannual plan (MAP) for the North Sea is applied, catches in 2020 that correspond to the F ranges in the plan are between 1008 tonnes and 1307 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit 9 is exploited sustainably, management should be implemented at the functional unit level.
Nephrops	Noup (FU 10)	Underwater TV (UWTV) surveys in Functional Unit (FU) 10 have been conducted sporadically and indicated that the density is relatively low (0.13 *Nephrops* m−2). Landings are at a historical minimum.	ICES advises that when the precautionary approach is applied, and under the assumptions that fishery selection patterns do not change from the average (2015–2017), catches in each of the years 2019 and 2020 should not exceed 48 tonnes. This would imply wanted catch of no more than 46 tonnes. In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	?	✓	✓	Below possible reference points	B_{pa},B_{lim}	✓	✓	✓	Above possible reference points
Management plan	F_{MGT}	✗	✓	✓	Within range	MAP MSY$B_{trigger}$	✓	✓	✓	Above

Summary: The stock has been above MSY $B_{trigger}$ for the entire time-series. The harvest rate has fluctuated around F_{MSY} and is now just below.

<table>
<tr><th>Species</th><th>Area</th><th>Stock status</th><th>Advice 2020</th></tr>
<tr><td>Nephrops</td><td>Norwegian Deep (FU 32)</td><td>The state of this stock is unknown. Harvest rates are thought to be low for this stock even if a low density is assumed (e.g. the lowest observed density in the North Sea is in Functional Unit (FU) 7, Fladen Ground). Catches have been decreasing since 2006. Discarding has been low in the last 4 years.</td><td>ICES advises that when the precautionary approach is applied, catches in each of the years 2019 and 2020 should be no more than 323 tonnes. If this stock is not under the Norwegian discard ban in 2019 and 2020 and discard rates do not change from the average of the period 2014–2016, this implies landings of no more than 318 tonnes.</td></tr>
<tr><td>Nephrops</td><td>Horns Reef (FU 33)</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>2016</th><th>2017</th><th colspan="2">2018</th><th></th><th>2016</th><th>2017</th><th colspan="2">2018</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>Undefined</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>Undefined</td></tr>
<tr><td>Management plan</td><td>F_{MGT}</td><td>–</td><td>–</td><td>–</td><td>Unknown</td><td>B_{MGT}</td><td>–</td><td>–</td><td>–</td><td>Unknown</td></tr>
<tr><td>Qualitative evaluation</td><td>-</td><td>–</td><td>–</td><td>–</td><td></td><td>-</td><td>?</td><td>?</td><td>↘</td><td>Decreasing</td></tr>
</table>
Summary: The state of this stock is unknown. Landings have been relatively stable since 2004, fluctuating without trend at around 1000 tonnes. The mean density of Norway lobster decreased by 43% from 2017 to 2018.
</td><td>ICES advises that when the precautionary approach (PA) is applied, wanted catches in each of the years 2019 and 2020 should not exceed 898 tonnes. ICES cannot quantify the corresponding total catches.

To ensure that the stock in Functional Unit (FU) 33 is exploited sustainably, management should be implemented at the functional unit level.</td></tr>
</table>

Species	Area	Stock status	Advice 2020
Nephrops	Devils Hole (FU 34)	The state of the stock is unknown. The mean survey density indicates the stock has declined from 2009 to 2017.	ICES advises that when the precautionary approach is applied, and under the assumptions that fishery selection patterns do not change from the average (2008–2011), catches in each of the years 2019 and 2020 should not exceed 394 tonnes. This would imply wanted catch of no more than 368 tonnes. In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level.

2.4 Fleets and métiers

2.4.1 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. From 2015, ICES generalised the data call to most stocks and regions. The process and the quality of data have thus continuously improved over time.

In 2019, InterCatch data were extracted for the longest time series possible , on the basis that most North Sea demersal stocks have been benchmarked in the recent years, and thus have updated catch-at-age information starting in 2004. Nevertheless, it was realised that this information prior to 2009 is still incomplete for some stocks; the reasons for these were not investigated. Consequently, the data presented here cover only the period 2009–2018.

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 using e.g. some R shiny apps. Thus, in 2019 a substantial amount of time was still dedicated during the WG to understand and correct a number of data mismatches which had not been detected in previous years.

The relative size of catches of the stocks incorporated in the mixed fisheries projections is shown in Figure 2.1.

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

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

The final dataset extracted from InterCatch for use by WGNSSK includes discards estimates (either imported or raised) for all stocks and métiers. These InterCatch estimates have been used to estimate a discard ratio for each métier, 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 FCube, l is the weight of landings for the métier used by FCube and L and D are the weight of landings and discards entered for the (vessel length aggregated by métier in InterCatch).

2.4.2 Definitions of fleets and métiers

The procedure for establishing fleets and métiers was not revised in 2019, and has therefore been the same since 2012. Nevertheless, as the procedure is applied to the last data year, the number of fleets and métiers can vary slightly from one WGMIXFISH report to the next.

In summary, the procedure follows a number of steps:

- Matching DCF métiers with definitions used in the cod long-term management plan
- Establishing fleets by country, gear type and, when deemed necessary, vessel length group
- Matching consistency between effort and catch data files. Métiers without catch of any of the modelled stocks in the last data year (now 2018) are not retained.
- Aggregating "small" métiers to reduce the number of units in the modelling. A métier failing to catch at least 1.0% of at least one of the stocks considered in the most recent data year is classified as small. Within each fleet, all these small métiers are then aggregated by fleet in one "Other" métier (OTH). Further, all small fleets (i.e. containing only the "OTH" métier), are aggregated into one single "OTH" fleet.

In 2019, the final data used contained 42 national fleets (plus the OTH fleet). These fleets engage in one to five different métiers each, resulting in 105 combinations of country*fleet*métier*area catching cod, haddock, whiting, saithe, plaice, sole and *Nephrops* (Table 2.1). The balance of landings of the stocks across gear categories is shown in Figure 2.2.

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

2.4.3 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 2.3) and relative trends (Figure 2.4), and landings by fleet and stock (Figure 2.5–Figure 2.9) are included in this report.

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

The various single-stock forecasts presented by WGNSSK are performed using different software and setups (see Section 2.2 above). However, for the purpose of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the 'fwd()' method in FLR (Flash R add-on package). The same forecast settings as in WGNSSK are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (EU Multiannual Plan or MSY approach).

Some differences can occur in the forecast calculations, sometimes because of the diversity of single-stock assessment methods used, and the WG always investigates in depth the reasons for potential discrepancies. Adjustments to the FCube forecasts are made if necessary to minimise discrepancies to the largest extent possible. In 2019, such differences occurred when WGMIXFISH replicated the forecast for cod.27.47d20. The single-species advice for this stock is produced using the SAM R package. This stochastic forecast uses 2019 as the base year and the intermediate year. This means that the 2019 catch is assumed equal to the 2019 TAC, the fishing mortality in 2019 is obtained by optimization, and finally the recruitment and SSB in 2019 are simulated from the 2019 assessment estimates.

Alternately, in FCube 2019 estimates are ignored, as FLash forecasts do not incorporate information on recruitment and SSB from the assessment model. Therefore, this resulted in a discrepancy between the stock numbers for cod assumed in the SAM forecast for 2019 and the ones forecasted in 2019 by MIXFISH, resulting in an overestimation of 2019 SSB in FCube. The 2019 stock size used in the SAM forecast is estimated based on cohort projection within the assessment during optimization assuming process errors on the biological processes such as fishing mortality, fish survival and recruitment. The 2019 stock size for cod in FCube is estimated by deterministic forward projection using 2018 as starting year and average fishing selectivity in the past 3 years. This results in different 2019 assumptions for both forecasts.

To confirm that the difference observed between the two forecasts for cod was caused by the above assumption differences, a deterministic SAM forecast starting from 2018 instead of 2019 was implemented during the advice meeting. The values for 2019 and 2020 obtained in the deterministic SAM forecast were similar to the ones obtained with FCube.

As FLash does not allow starting the forecast with 2019 as base year, in the F-value for 2019 and 2020 in the MIXFISH forecast were set to the F-values of the single-species forecast. This allowed reducing the overestimation of SSB and landings in 2020 in FCube for cod; however, it does not resolve the inconsistency in the forecast assumptions between FCube and SAM.

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

2.5.1.2 Mixed fisheries runs

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

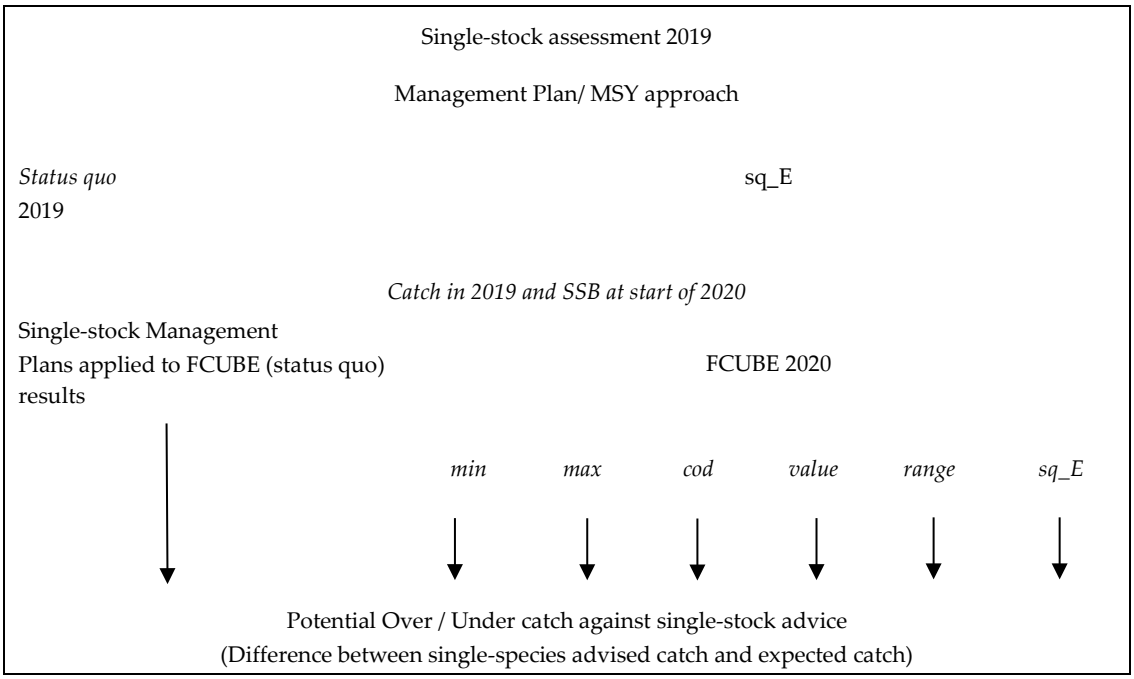
However, since 2013, the working group adopted a forecast approach for the intermediate year on the basis of s*tatus quo* effort. As a roll-over of effort limitations from the cod management plan has been adopted by the EC since 2013, a *status quo* effort assumption is considered a plausible assumption and is more in line with the standard single-stock short-term forecasting approach (which apply a *status quo* F, unless a TAC constraint is used).

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

This year, the projections were run assuming a full and perfect implementation of a discard ban in 2018 (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 landings obligation may not be implemented for all stocks in 2020, and that discards will not disappear overnight, it was considered that this option would bring new insights to where the choke effects will lie. The main implication of this change in the results would be that stocks for which some fleets had high discards in the past may become more limiting for those fleets, due to the mismatch between their catches (which now all count against the fleets' stock shares) and their stock shares based on historical landings.

In summary, the FCube runs followed the scheme below:



2.5.2 Results of FCube runs

2.5.2.1 Baseline run

The Figure 2.10 summarises the trends in single-stocks advice for 2020, highlighting are likely to be the most limiting due to a reduction in F (i.e. cod_NS, this stock is likely to be the most limiting finfish stocks. The issues encountered in replicating the single-species advice in FCube are detailed below and summarised below in Table 2.2 and Figure 2.11.

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. Whereas, WGMIXFISH forecast is a deterministic projection. Therefore small discrepancies between the two forecasts occur:

i. As the median of the forecasted assessment may be slightly different from the forecast of the median assessment, small discrepancies may appear.
ii. The SAM model incorporates process error (deviations of N-at-age from the survival equation) which is carried on into the SAM forecast.
iii. The projections carried out in SAM do not follow equation used in the deterministic forecast carried out at WGMIXFISH, which generate differences between the two forecasts.

As the intermediate year assumption used in single-species is TAC constraint and implies a huge increase/decrease of effort, the 'value' scenario is considered more appropriate as it kind of weights the effort based on the available catches depending on the fleets. This results in a starting point in the advice year that is very close to that of the single-species. Whereas if status quo effort is used then the starting point in the advice year (2020) might be very different from the single-species one.

Some small differences were observed (-1.3% for the Fbar value for 2018, 3.4% and 1.8% in the estimated catches in 2018 and 2019 respectively and -0.4% difference in SSB in 2020). Nevertheless, the FCube forecast was considered sufficiently close that it could be used as a satisfactory basis for the mixed fisheries projection.

Haddock: In 2019, the haddock was assessed using a TSA (time series analysis, Fryer 2002) assessment model and MDFP programme as the forecasting software. The method developed in WGNSSK to parameterise future selectivity and weight-at-age for haddock are sometimes quite specific and do not always follow common standards (e.g. weights–at-age in the forecasted period produced by a growth model instead of the commonly used assumption of constant weights equal to the average over the recent years). Those specific values could not be reproduced in the forecasting procedure of FCube and were therefore entered manually.

In addition, the survivors at the start of 2019 produced by the TSA assessment model used as the initial abundance-at-age in the MFDP short-term forecast were slightly different from the initial numbers at age computed by the forecasting procedure in FLR.

The forecast results were slightly different with a-0.2% and -0.1% discrepancy between SSB projections in 2020 and 2021 respectively. Forecasted catches in 2018 and 2019 showed a -0.2% and 0.8% difference respectively. The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

Whiting: Although the whiting is now assessed using SAM, the WGNSSK forecast is deterministic, and therefore no discrepancies are expected to result from the difference in framework used (MFDP vs. FLR).

The WGNSSK forecast treats the industrial bycatch separately from the landings for human consumption, with specific future weights-at-age and selectivity and assumes a F value of 0.02,

independent from the value of target F for the human consumption fishery. The FCube forecast used at WGMIXFISH did not allow for multiple fleets and therefore the industrial bycatch is included in the landings component. The future landings selectivity and weights-at-age were recalculated as the weighted means of the values in the landings for human consumption and industrial by catch.

This difference in forecast procedure resulted in small discrepancies in the output with differences in catches of 0% and 2.7% for 2019 and 2020 respectively, and of -3.6% and -0.4% in 2020 and 2021 respectively for the SSB.

Saithe: As for cod, the 2019 saithe assessment and forecast were carried out using the SAM assessment model. The difference in forecast procedure compare to WGMIXFISH resulted in differences in the output of -2.9% in the 2020 catches and -4.2% in the 2021 SSB. The FLR forecast was considered sufficiently close for use in the mixed fisheries projection.

North Sea Plaice: Straightforward, no problems encountered.

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

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

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

English Channel Sole: not included as now a category 3 stock.

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

It should be noted, that in the mixed fisheries forecasts *Nephrops* are treated slightly differently to the approach taken by WGNSSK. The following two changes are made:

First, there is a difference in the assumed harvest ratio in the intermediate year. Whereas WGNSSK assumes that the harvest ratio is equivalent to the average ratio of the most recent three years, the WGMIXFISH value is based on a share of the 2019 TAC applied to the abundance estimates in 2019 for that particular FU (equal to proportion of the North Sea TAC that was taken from the FU in the most recent year). This can cause pronounced differences if the harvest ratio has a steep decrease or increase in the most recent year. The assumption taken in WGMIXFISH may be more appropriate, as it is quicker to react to changes in biomass or exploitation patterns where activity moves between FUs; however, it has no consequence either for WGNSSK or WGMIXFISH TAC year harvest ratio or TAC advice as the harvest ratio in 2018 is not used in the forecasts for 2019.

Second, the TAC result for FUs may be different between WGNSSK and WGMIXFISH. This results because the TAC advice from the single-species assessments is an advised landing per FU. However, because management is currently by a combined TAC, not FU, WGMIXFISH assumes that the total TAC is taken in proportion to the ratio of last year's landings by FU, distributing the landings differently to the advice. Such an approach assumes the same catchability as last year, as for other stocks in the FCube simulations.

2.5.2.2 Mixed fisheries analyses

The full overview of the FCube projections are presented in Table 2.3 and Figure 2.12–Figure 2.14. A summary of landings relative to the single-stock advice is presented in Table 2.4.

The outcomes of the "minimum" and "maximum" scenarios are driven by the stocks that will be most and least limiting for each individual fleet. Cod was estimated to be the most limiting stock in the "minimum" scenario. For 2020, assuming a strictly implemented landings obligation (i.e. a discard ban where all catches of quota species must be counted against quota, with no flexibilities such as exemptions, *de minimis* allowed discards or inter-species flexibility, as the "minimum" scenario represents), cod would be the most limiting stock, constraining 24 of the 42 fleet segments, respectively.

Conversely, in the "maximum" scenario, if *Nephrops* was managed by separate TACs for the individual functional units (FU), many *Nephrops* FU would be considered as being the least limiting stocks. *Nephrops* FU 7, FU 5, FU 33and FU Others would be least limiting for fleets representing to 9, 2, 1 and 1 of the fleets segments. The "minimum" 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.

In contrast to the "minimum" scenario, the "maximum" scenario demonstrates the upper bound of potential fleet effort and stock catches. This scenario assumes all fleets continue fishing until all their quotas are exhausted irrespective of the economic viability of such actions, therefore this is also considered the least plausible.

Three intermediate scenarios are included reflecting current management measures, and a *status quo* scenario. The "value" scenario is a simple proxy, which in the absence of a formal economic behaviour model, balances fishing opportunities by stock with their potential market value. For example, if a fleet requires 100 fishing days to catch its share of stock A, and 200 fishing days for catching its share of stock B, and if the value (tonnage × mean price) of that fleet's stock shares is 75% from stock A and 25% from stock B, then the resulting effort would be (100 × 0.75) + (200 × 0.25) = 125 days. For 2020, this scenario estimates effort levels close to the *status quo*, and historically this scenario has been observed to predict effort levels closer to the realised effort than the other scenarios (Ulrich *et al.*, 2011). In this scenario, some overshoot of cod, whiting, and sole, and undershoot of plaice and haddock fishing opportunities are predicted.

The "cod_ns" scenario reflects the fishing mortality corresponding to the single-species advice for cod.27.47d20 (based on the ICES MSY approach), and the results present fishing opportunities for other stocks in a mixed fisheries context. According to the single-stock advice, a reduction of about 51% in cod F is required (from 0.5 in 2019 to 0.31 in 2020). It is assumed that effort reductions in fleets (to achieve new partial Fs) apply equally to all fleets with any cod catch, including those where it represents a small bycatch component. Similar scenarios based on the single-stock advice for the other finfish stocks could be provided by ICES, but the "cod_ns" scenario is considered here because cod is assumed to be the limiting species.

As ple.27d and tur.27.4 have low landings compared to other stocks and the results for these stocks are presented in detail in Figure 2.13.

Mixed fisheries results for *Nephrops* are displayed after combining all functional units (FUs) in one plot, but stock status and fishing opportunities differ widely across FUs. In particular, FU6 (Farn Deep) is currently exploited over the MSY target, and this FU acts therefore as a limiting stock for some fleets in the mixed fisheries advice 2020. Conversely, FU7 (Fladen Ground) is exploited well below the MSY target, and acts as a least limiting stock. In order to ensure *Nephrops* stocks are exploited sustainably in the different FUs, management should therefore be

implemented at the FU level. Potential undershoot of catch opportunities for FU7 should not be transferred to other FUs.

To get an overview of the amount of total catches for the various scenarios, Figure 2.12 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 2020 with the mixed fisheries catch estimates.

The anticipated SSBs in 2021 of the FCube scenarios are shown in Figure 2.14.

Optimised range option

A "range" scenario is presented (Figure 2.15 and Figure 2.16), where the potential TAC mismatch in 2020 are minimised by setting target fishing levels within the F_{MSY} ranges. This scenario returns a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2020, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. This "range" scenario suggests that the potential for mixed fisheries mismatch would be lowered with a 2020 TAC in the lower part of the F_{MSY} range for eastern Channel plaice and saithe, and in the upper part of the range for cod and North Sea plaice.

Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input is calculated as the average landing share by fleet and stock in 2020. In previous years, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results showed only minor deviations across all scenarios. Since 2016, as total catches are used rather than landings, some distortions occur, as the proportion of catches does not reflect the proportion of landings since discards rates differ across fleets.

Table 2.1. Final fleet and métier categories used in the mixed fishery analysis. 4, 3AN and 7D refer to ICES area.

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
BE_Beam<24	BT2.4	441.41	1357.23	FR_Otter>=40	OTH	1147.08	17.59
	BT2.7D	281.27	841.57		TR1.4	5099.72	8459.59
	OTH	664.69	26.34	FR_Otter10-40	OTH	1315.32	108.81
BE_Beam>=24	BT1.4	1457.18	5827.74		TR2.4	1436.60	4128.15
	BT2.4	1321.52	3356.25		TR2.7D	8418.56	7512.97
	BT2.7D	1965.28	2036.54	FR_U10m	OTH	104.88	26.00
BE_Otter	OTH	167.55	1052.60		TR2.7D	144.05	231.08
	TR2.4	584.99	3196.76	GE_Beam>=24	BT2.4	959.86	2442.17
BE_Static	GT1.7D	44.85	57.72		OTH	61.57	284.68
	OTH	63.46	32.60	GE_FDF	OTH	21.78	169.03
DK_Beam	BT1.4	355.93	1434.41		TR1.4	433.85	4352.92
	OTH	70.66	283.31	GE_Otter<24	OTH	15.81	96.34

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
DK_FDF	OTH	15.47	74.81		TR1.4	128.21	1736.16
	TR1.3AN	297.83	2605.87		TR2.4	124.17	3047.13
	TR1.4	1691.25	7371.62	GE_Otter>=40	OTH	5.85	45.83
	TR2.4	63.77	313.16		TR1.4	458.51	4146.21
DK_Otter<24	OTH	438.26	181.47	GE_Otter24-40	OTH	38.09	141.48
	TR1.3AN	304.66	1947.88		TR1.4	394.27	2861.54
	TR1.4	309.97	2383.52		TR2.4	109.82	1319.03
	TR2.3AN	1931.14	3476.85	NL_Beam<24	BT2.4	230.25	1621.27
	TR2.4	102.52	769.51		OTH	4.17	46.97
DK_Otter24-40	OTH	1173.60	1134.08	NL_Beam>=40	BT1.3AN	162.81	1141.35
	TR1.4	672.23	3217.83		BT1.4	800.68	3732.71
	TR2.4	212.59	1560.88		BT2.4	15771.64	44623.00
DK_Seine	TR1.3AN	319.28	4234.85		OTH	2288.70	65.53
	TR1.4	551.83	3631.57	NL_Beam24-40	BT2.4	9.71	6977.26
DK_Static	GN1.3AN	290.73	912.57	NL_Otter	OTH	89.97	5.64
	GN1.4	1416.05	5768.72		TR1.3AN	1004.01	960.97
	OTH	58.77	195.07		TR1.4	1286.98	6544.98
EN_Beam	BT1.4	1576.60	6707.23		TR2.4	927.29	9902.53
	BT2.4	1548.14	4959.73		TR2.7D	2032.64	1138.87
	BT2.7D	185.71	372.96	NO_Otter<40	OTH	1959.41	958.94
	OTH	2.21	3.68		TR1.4	5155.91	11425.94
EN_FDF	OTH	0.54	26.59	NO_Otter>=40	TR1.4	681.67	28718.40
	TR1.4	1342.56	11370.27	NO_Static	GN1.4	671.28	4384.89
EN_Otter<24	OTH	156.54	79.78		LL1.4	4.82	2124.28
	TR1.4	112.84	500.77		OTH	50379.59	199.00
	TR2.4	936.59	2155.58	OTH_OTH	OTH	3.17	12143.20
EN_Otter>=40	OTH	72.08	225.62	SC_FDF	OTH	1956.76	14.98
	TR1.4	586.46	1797.80		TR1.4	0.93	17230.89
EN_Otter24-40	OTH	173.52	481.66	SC_Otter<24	OTH	3901.88	2.89

Fleet	Métier	Effort	Catch	Fleet	Métier	Effort	Catch
	TR1.4	301.30	2282.54		TR1.4	3183.89	18445.99
EN_U10	GN1.7D	732.40	729.22		TR2.4	4281.56	11689.65
	GT1.7D	353.34	410.84	SC_Otter>=24	TR1.4	148.94	28090.73
	OTH	3357.10	841.16		TR2.4	678.24	570.31
	TR2.4	553.11	1667.86	SC_Static	OTH	4244.73	148.98
	TR2.7D	121.51	158.28		pots.4	2.24	35.18
FR_Beam	BT2.7D	247.89	305.40	SC_U10_OTB	OTH	447.40	6.53
	OTH	28.91	108.70		TR2.4	3609.65	727.86
FR_Nets	GT1.4	801.56	956.82	SW_Otter	OTH	236.05	2365.17
	GT1.7D	2691.92	2812.15		TR1.4	9777.00	1502.24
	OTH	103.83	105.27				

Table 2.2. Comparison between baseline run and ICES advice for *Nephrops. 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.**

		Stock	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
2018	landings	ICES	895	1029	13264	2441	1105	40	464	1119	459	525
		base line	1105	1016	12962	2649	1048	40	484	1219	477	525
		% difference	23.5	-1.3	-2.3	8.5	-5.2	0	4.3	8.9	3.9	0

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

Table 2.3. Results of Final FCube runs.

			COD-NS	HAD	PLE-NS	POK	SOL-NS	WHG-NS	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS	NEP Tot	PLE-EC	SOL-EC
landings	2017	baseline	40759	39409	96767	106331	14995	24407	15	184	1074	425	3301	1971	2224	1948	1150	1407	13699	4232	3117
Fbar	2016	baseline	0,35	0,28	0,20	0,28	0,22	0,24						0,13	0,01	0,12	0,13			0,13	0,23
	2017	baseline	0,35	0,18	0,20	0,39	0,21	0,24						0,13	0,01	0,12	0,13			0,13	0,23
	2018	baseline	0,31	0,19	0,21	0,36	0,20	0,15						0,07	0,08	0,16	0,12			0,25	0,24
		had	0,32	0,19	0,21	0,20	0,18	0,13						0,08	0,01	0,08	0,07			0,11	0,18
		max	1,44	1,27	0,65	0,61	0,34	0,87						0,65	0,08	0,60	0,57			0,32	0,41
		min	0,25	0,16	0,17	0,18	0,15	0,08						0,06	0,01	0,06	0,06			0,08	0,13
		pok	0,53	0,34	0,36	0,36	0,28	0,26						0,20	0,02	0,18	0,17			0,18	0,26
		sq_E	0,41	0,27	0,28	0,28	0,23	0,20						0,15	0,01	0,14	0,13			0,14	0,22
		val	0,35	0,22	0,24	0,28	0,20	0,18						0,13	0,01	0,10	0,10			0,14	0,23
FmultVsF16	2017	baseline	1	0,645	1	1,387	0,953	1						0,95	0,91	0,96	1,01			1,00	1,00
		sq_E	1,16	0,95	1,39	0,98	1,06	0,83						0,93	1,06	0,98	0,98			1,08	0,97
		val	1,06	0,83	1,17	1,05	0,91	0,8						0,85	0,92	0,86	0,85			1,03	0,93
	2018	baseline	0,882	0,67	1,041	1,272	0,929	0,616						0,50	5,36	1,33	0,93			1,88	1,05
		had	0,9	0,67	1,04	0,71	0,85	0,54						0,63	0,63	0,62	0,57			0,82	0,77
		max	4,09	4,47	3,21	2,17	1,57	3,59						4,92	5,36	4,91	4,52			2,40	1,77
		min	0,72	0,56	0,83	0,63	0,71	0,32						0,47	0,52	0,51	0,47			0,59	0,57
		pok	1,5	1,21	1,78	1,27	1,3	1,08						1,49	1,32	1,46	1,35			1,35	1,11
		sq_E	1,16	0,93	1,39	0,98	1,06	0,83						1,15	1,02	1,13	1,04			1,08	0,94
		val	1,01	0,76	1,17	1,01	0,91	0,74						1,00	0,75	0,84	0,78			1,08	0,97
landings	2017	baseline	40759	39409	96767	106331	14995	24407	15	184	1074	425	3301	1971	2224	1948	1150	1407	13699	4232	3117
		sq_E	46167	55664	130203	78997	16425	20669	16	193	1125	446	3458	1912	2615	1989	1123	1474	14351	4554	3046
		val	42815	49317	112042	84121	14364	19926	14	170	993	393	3051	1752	2272	1740	976	1300	12662	4346	2925
	2018	baseline	39638	50284	95812	100134	14244	16968	39	484	1219	477	1105	1016	12962	2649	1048	525	21524	7137	3866
		had	42483	50284	96051	70680	13473	15936	10	130	329	129	298	1293	1551	1265	654	141	5800	3352	3012
		max	120939	220293	244040	165263	22669	80061	85	1053	2653	1038	2404	10153	13157	9971	5176	1142	46831	8841	6132
		min	32653	41436	75208	58443	11182	9373	8	105	265	104	240	978	1284	1042	543	114	4685	2400	2254
		pok	52343	75234	130982	100134	17429	27977	24	297	748	293	678	3084	3252	2969	1544	322	13211	4985	3909
		sq_E	48045	64286	115925	87792	15618	23089	18	229	577	226	523	2376	2506	2288	1190	248	10181	4234	3517
		val	43691	54641	103345	88259	14168	20821	14	179	450	176	408	2074	1853	1705	888	194	7940	4274	3664
discards	2017	had	9874	5648	39994	8682	980	9727												1901	393
		pok	18128	11137	72466	16474	1585	18888												3237	565
		sq_E	13386	8104	54651	12096	1239	13604												2452	464
	2018	had	18380	0	39911	9089	890	9740												1655	0
		max	59302	0	97517	23164	1541	54245												4348	0
		min	14725	0	31525	7828	742	5780												1195	0
		pok	27037	0	54753	14224	1230	18162												2505	0
		sq_E	22376	0	48274	11779	1061	14505												2104	0
		val	19857	0	43020	11953	946	13012												2120	0
Ld_MgtPlan	2018	sq_E	37931	47451	89212	109776	13939	17356	39	484	1219	477	1105	1016	12962	2649	1048	525	21524	7066	3885
ssb	2017	baseline	167925	237220	936773	251769	67961	305135												59712	17784
	2018	baseline	199525	229741	959446	260232	63477	353984												55845	18260
	2019	baseline	208502	267716	975653	267781	63769	353841												46665	18697
ssb	2017	sq_E	167925	237220	936773	251769	67961	305135												59712	17784
	2018	sq_E	192008	212729	912241	289314	62051	358992												55287	18345
	2019	had	214510	267716	978944	362988	66631	363256												53909	20251
		max	91380	106861	745833	226078	56174	274853												43802	16634
		min	215196	266155	978476	341644	67469	367550												54012	20594
		pok	156291	208920	794999	267781	54211	335921												46978	17902
		sq_E	187234	238305	890225	316163	60859	349038												50709	19146
		val	199183	253692	938847	309074	64530	352637												51004	19151

Table 2.4. Catch per mixed fisheries scenario 2020, in absolute values relative to the single-stock advice.

Stock	Single-stock catch advice (2020) *	Catch per mixed fisheries scenario (2020)					
		Max.	Min.	Cod-ns	*Status quo* effort	Value	Range
Cod in 4, 7.d, 3.a.20	13686	70825	15645	13373	40168	39583	13996
Haddock in 4, 6.a, 3.a.20	41818	109295	14643	13781	48165	45445	41249
Plaice in 7.d	9073	13061	5756	3109	9573	9317	7370
Plaice in 4	166499	208687	50219	44974	145469	147000	117808
Saithe in 4, 6, 3.a.20	88093	153336	46471	26720	83843	84333	75388
Sole in 4	17545**	23315	5648	5964	18823	18564	19344
Turbot in 4	4538	4576	1406	1173	3487	3512	3072
Whiting in 4, 7.d	22082	53846	12838	8349	28284	27114	23017
Norway lobster FU 5	1637	1523	153	152	622	670	NA
Norway lobster FU 6	2384**	5981	711	697	2607	2587	NA
Norway lobster FU 7	14263**	13688	1281	1281	5408	5917	NA
Norway lobster FU 8	3143**	5903	570	570	2395	2655	NA
Norway lobster FU 9	1307**	3168	317	317	1330	1485	NA
Norway lobster FU 10	48	65	7	7	27	29	NA
Norway lobster FU 32	323	552	55	55	225	243	NA
Norway lobster FU 33	898	1273	128	127	520	560	NA
Norway lobster FU 34	394	783	78	78	320	344	NA
Norway lobster in 4, but outside FUs	376	744	75	74	304	328	NA

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

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

**** Single-stock advice is based on ranges in accordance with the EU MAP for demersal stocks in the North Sea (EU, 2018). The value presented here is for catches corresponding to F_{MSY}.**

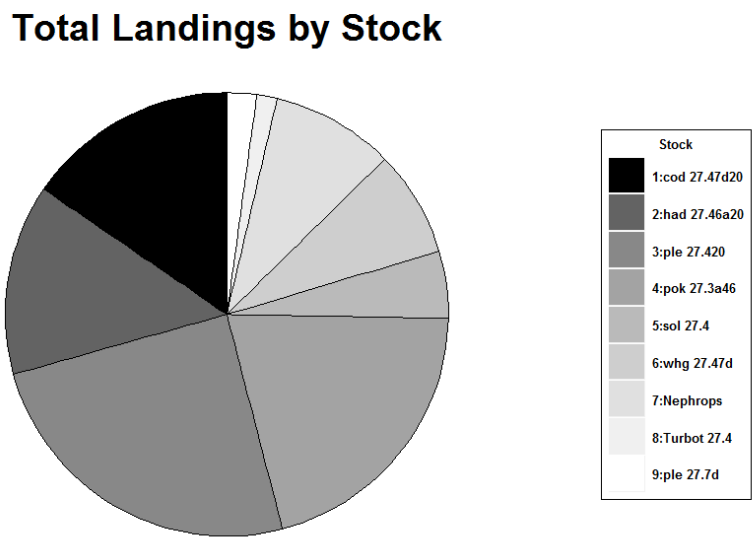


Figure 2.1. Distribution of 2018 landings of those stocks included in the mixed fisheries projections.

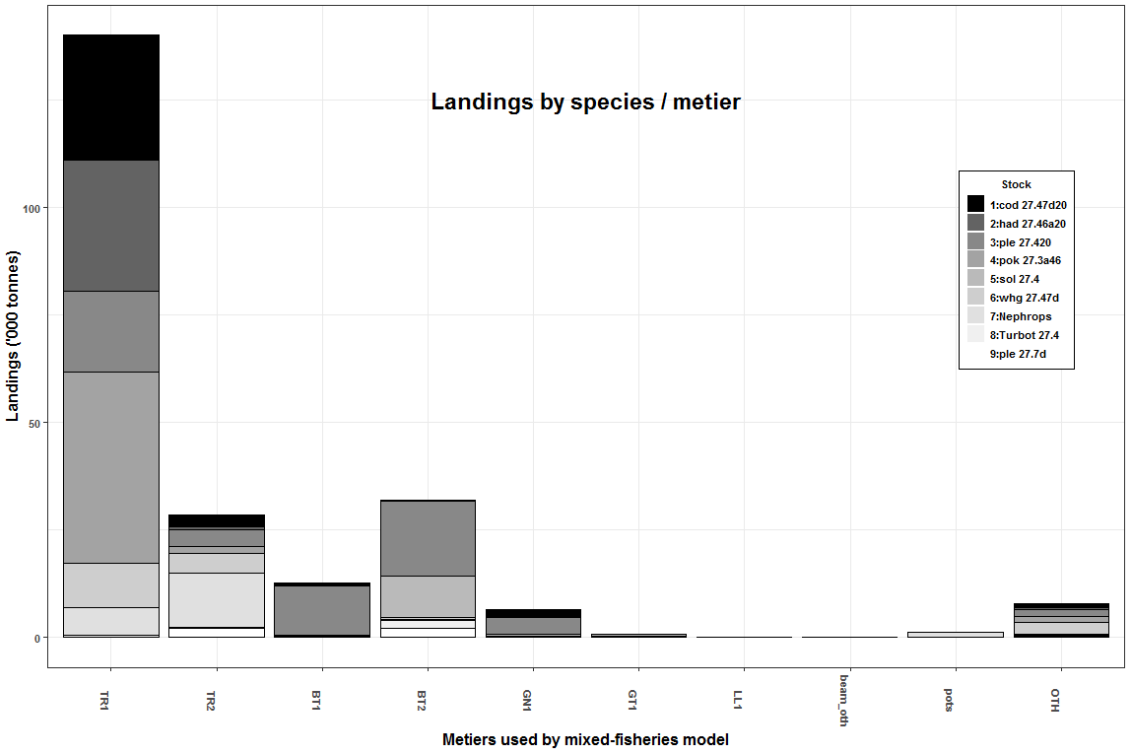


Figure 2.2. 2018 landings distribution of species by métier with landings consisting of ≥1% of any of the stocks 1–9. Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings <1% of any of the stocks 1–9.

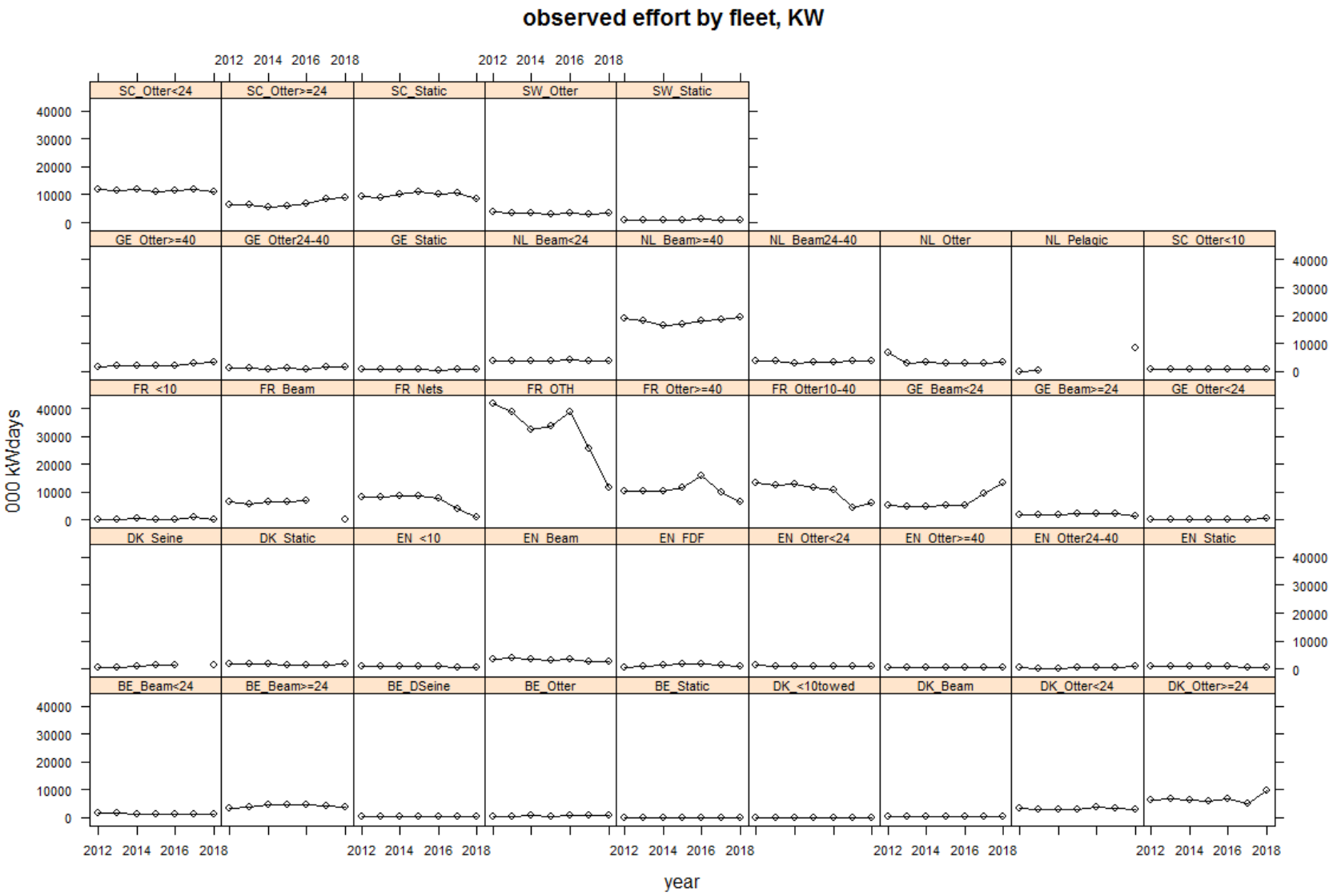


Figure 2.3. Effort by fleet and year for the North Sea demersal fleets, in '000 KWdays.

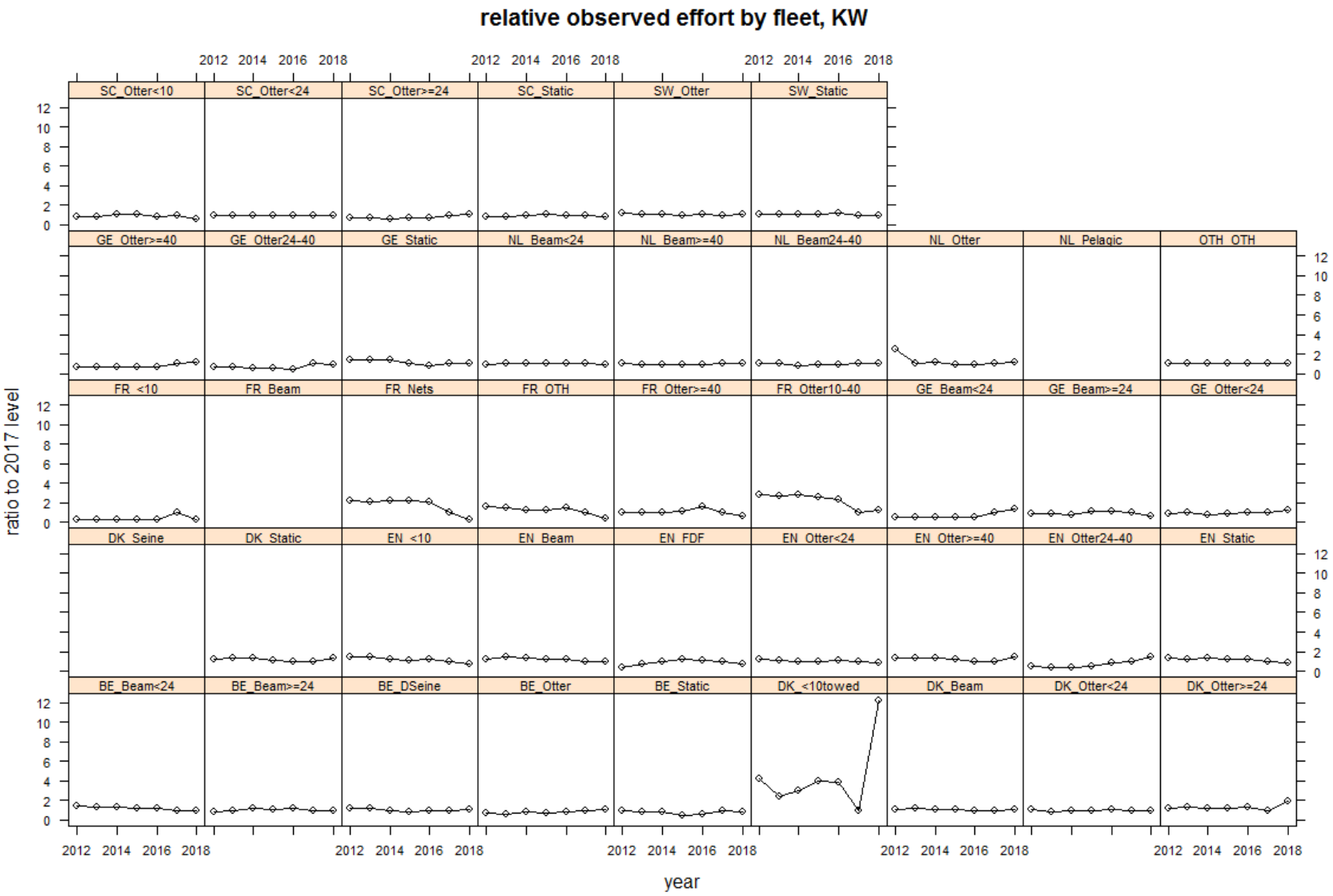


Figure 2.4. Relative trends (compared to the 2017 value) in effort (KW Days) by fleet and year for the North Sea demersal fleets.

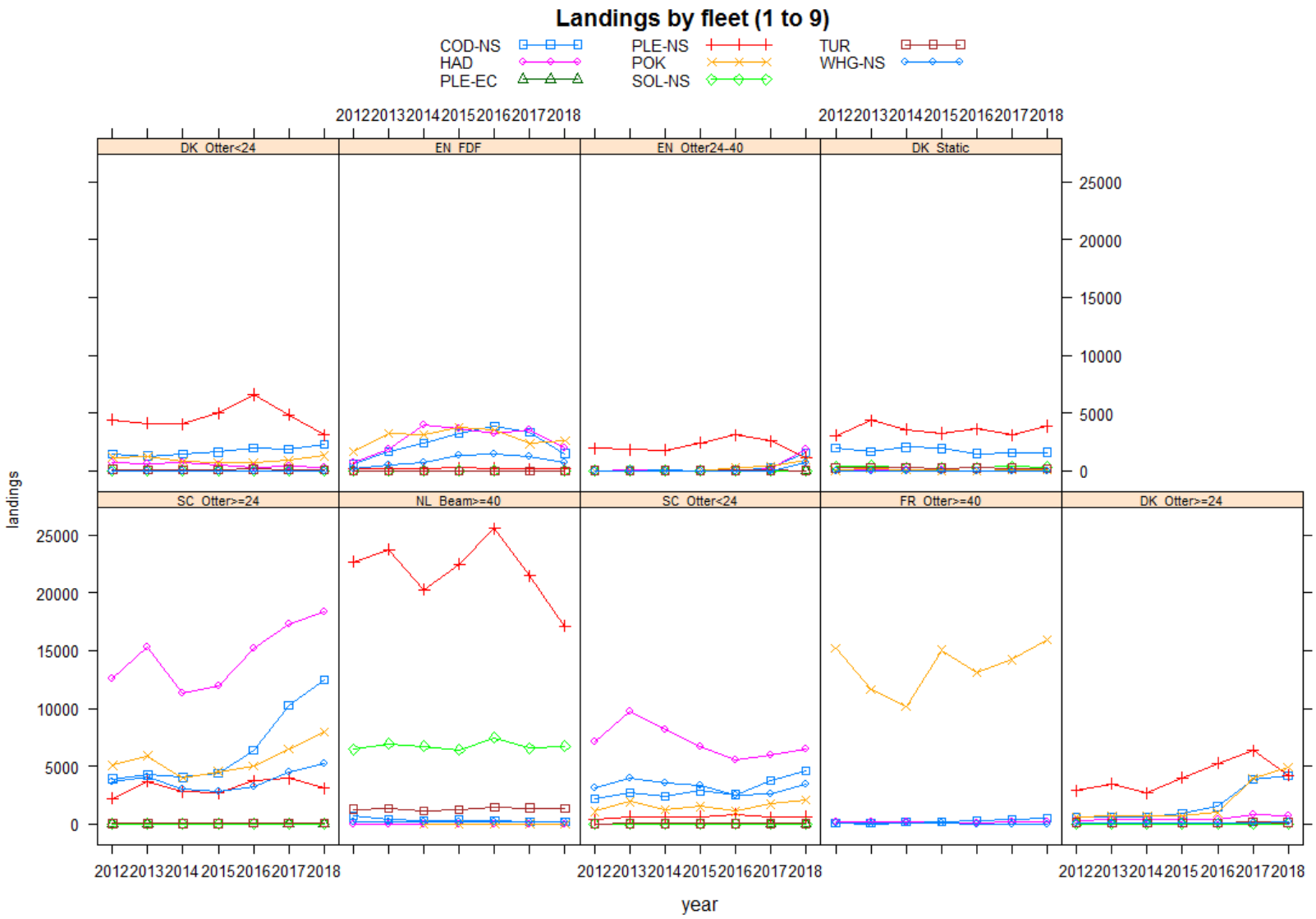


Figure 2.5. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings.

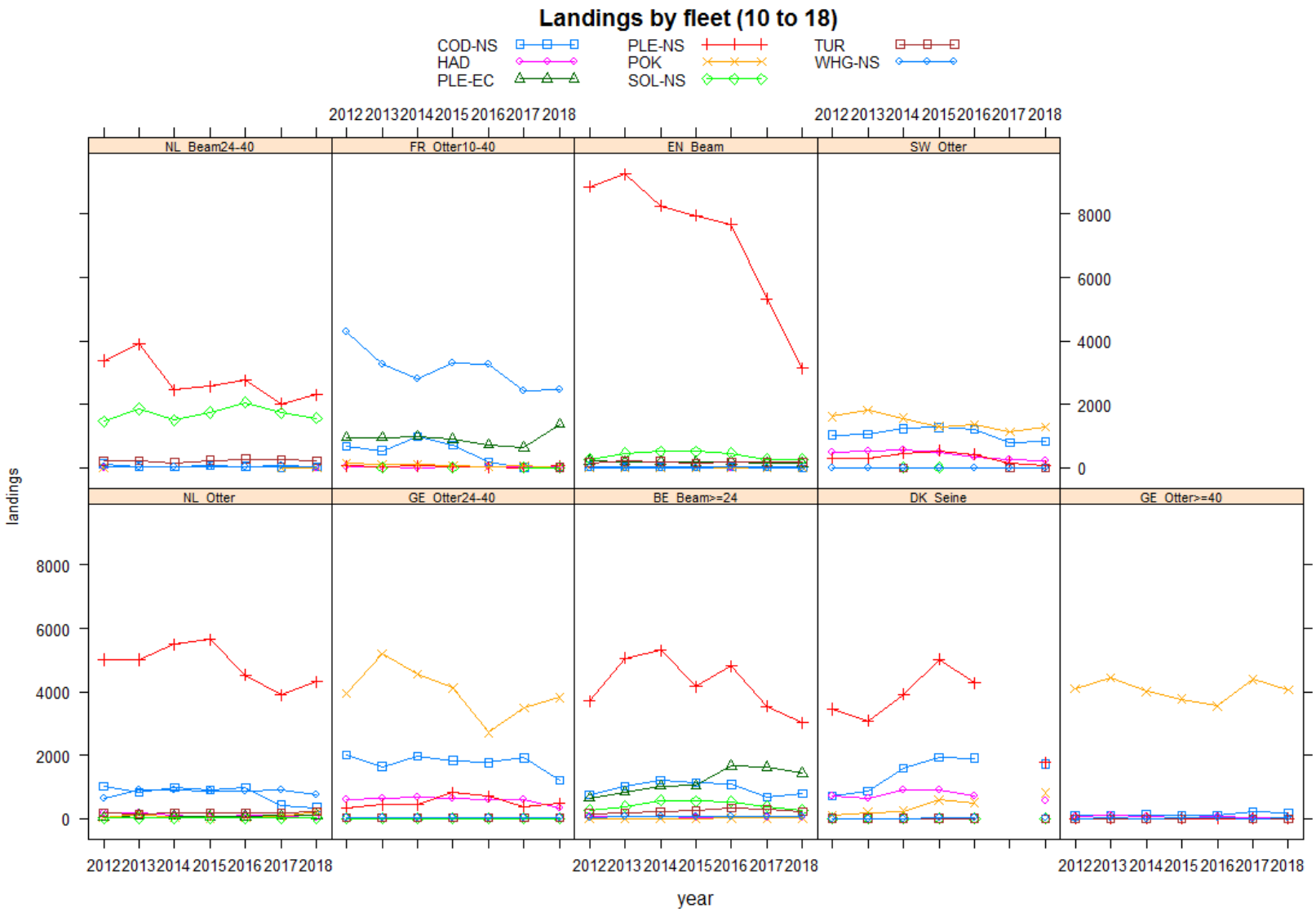


Figure 2.6. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings.

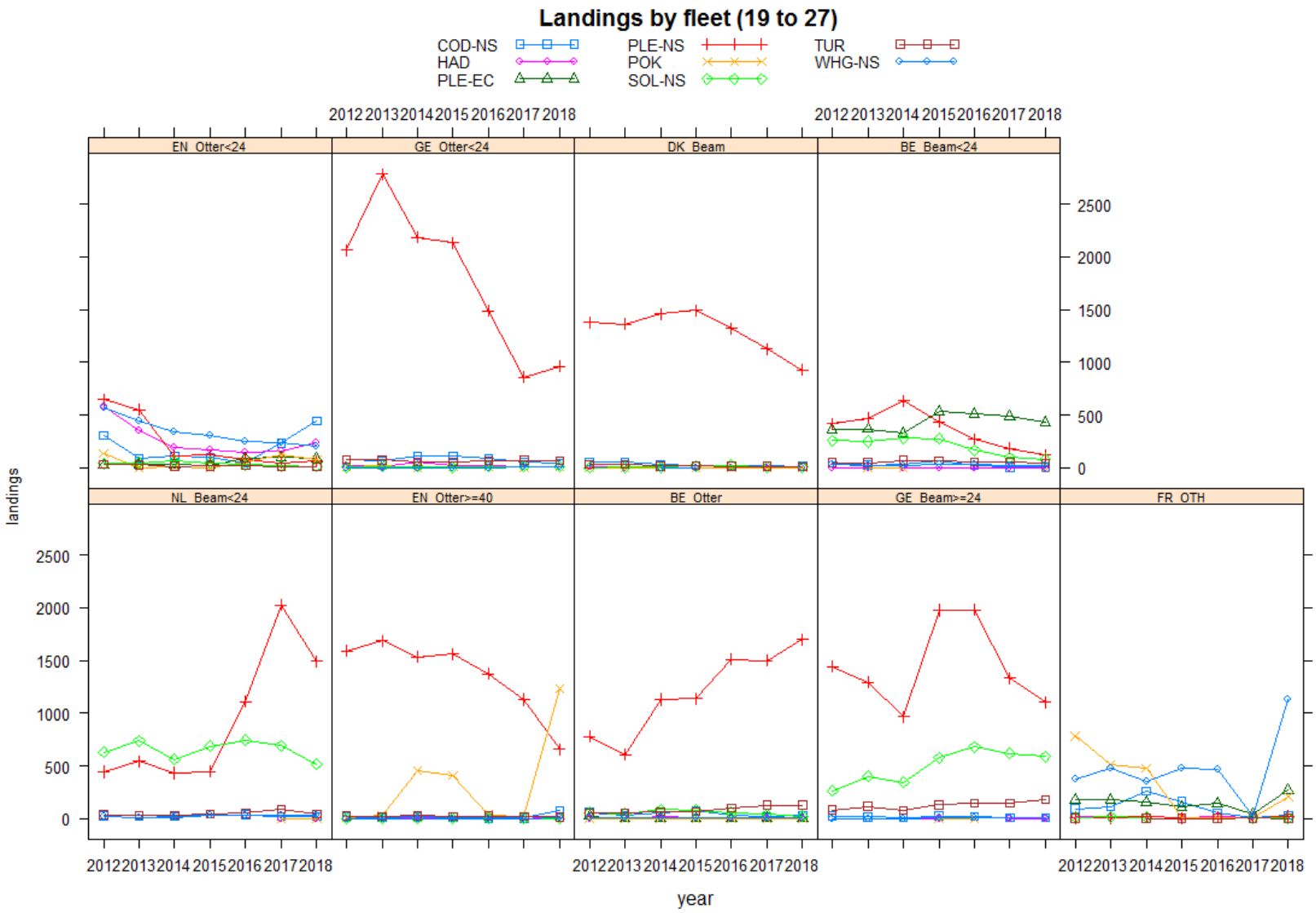


Figure 2.7. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings.

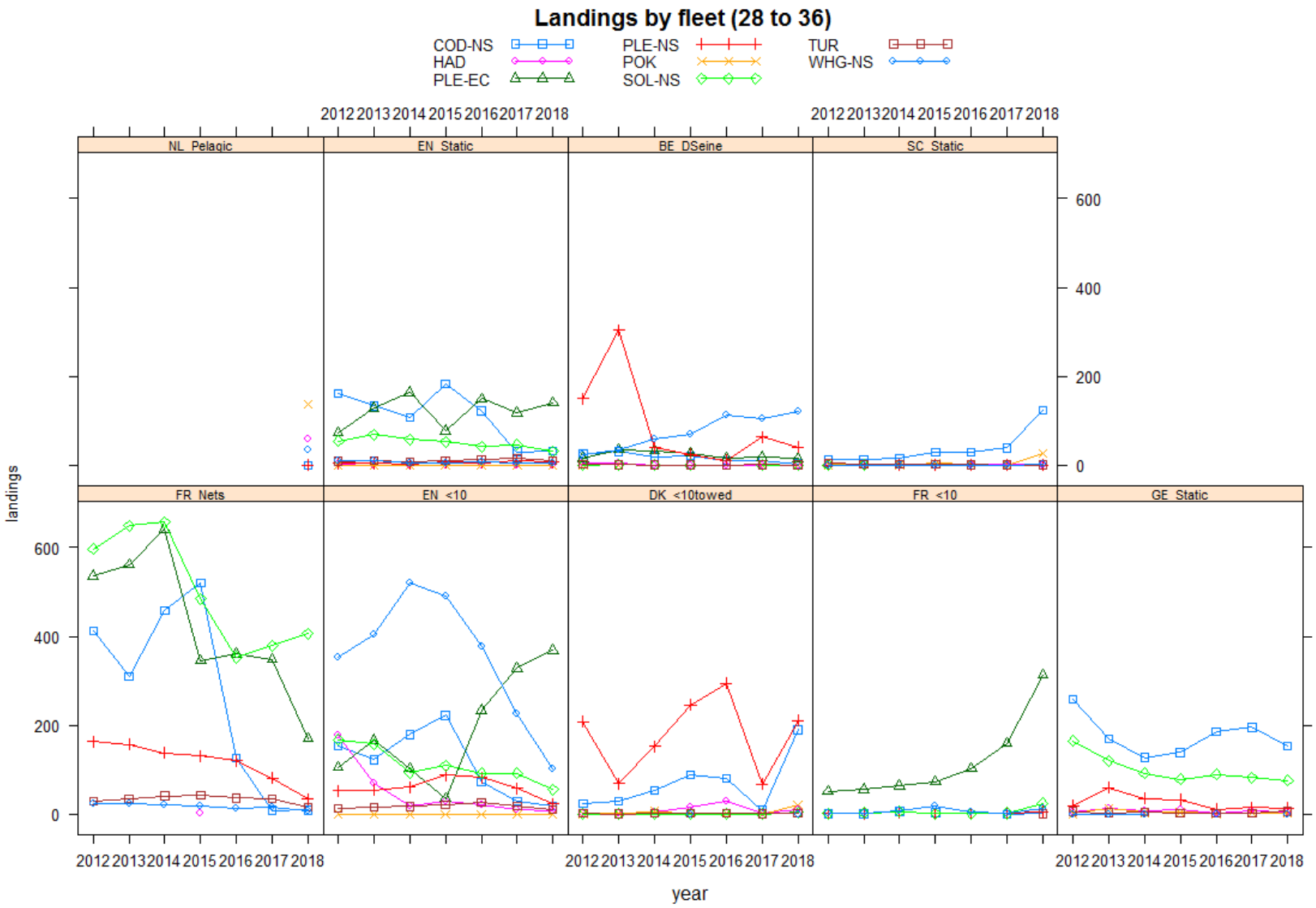


Figure 2.8. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings.

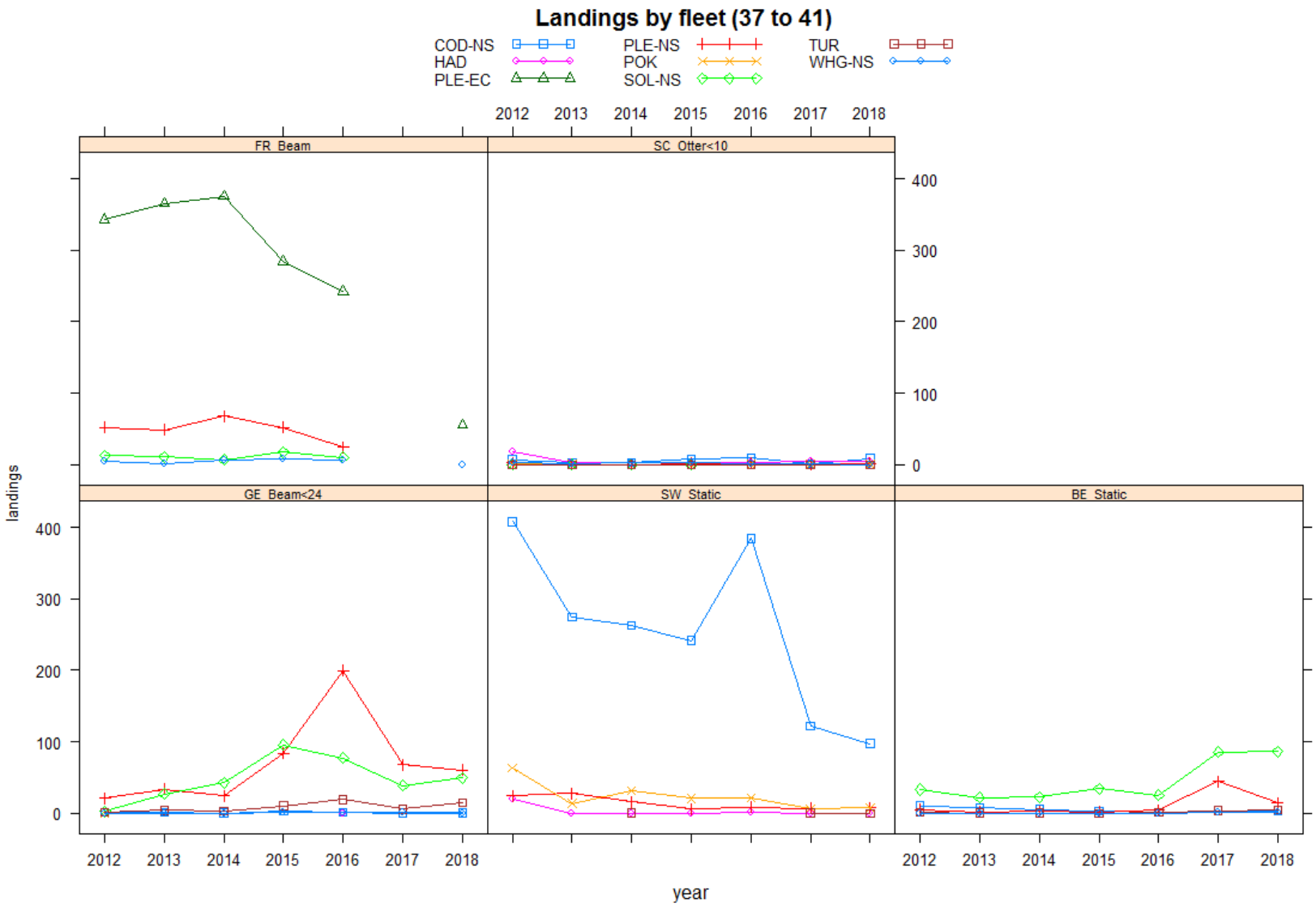


Figure 2.9. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings.

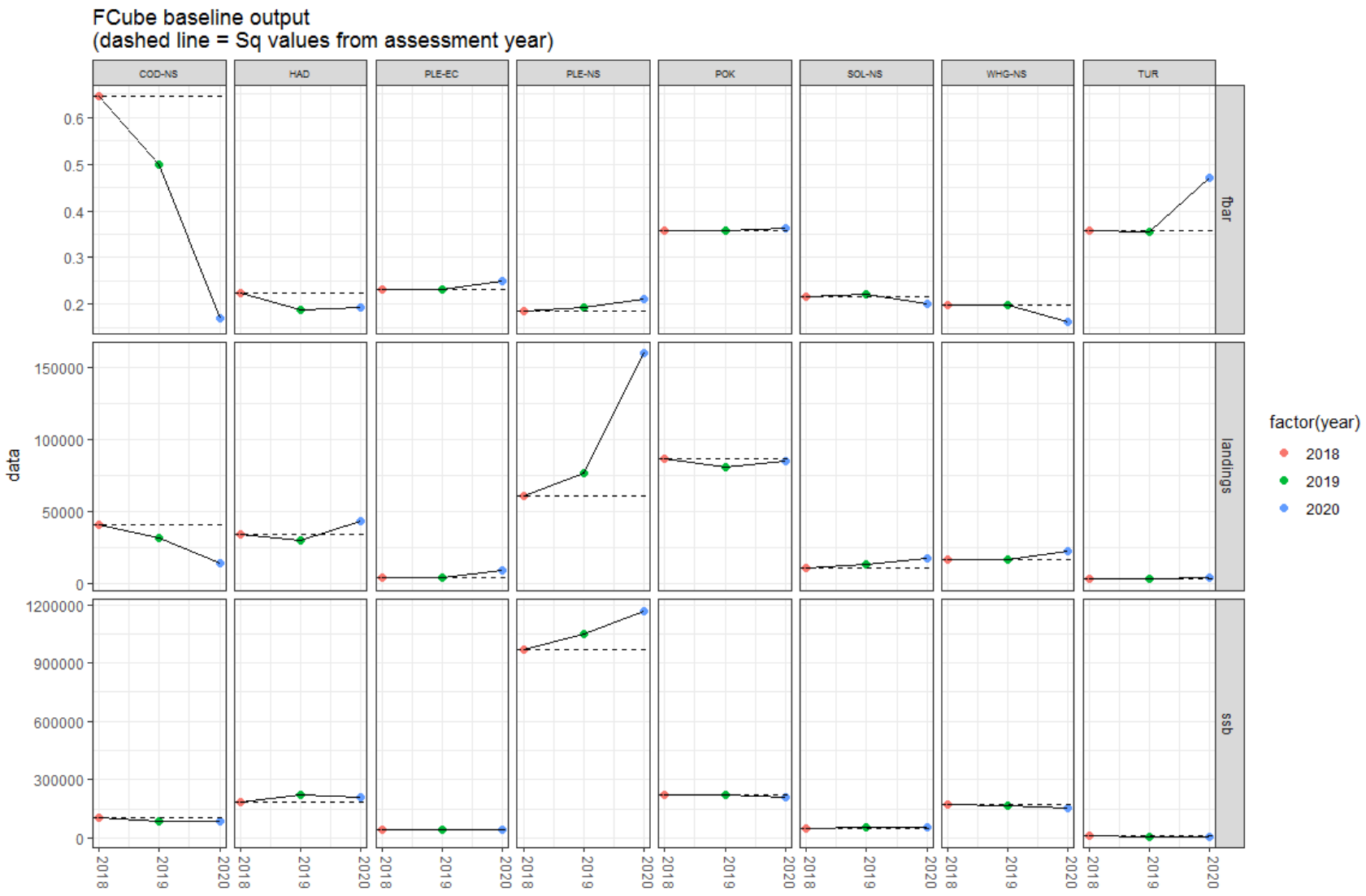


Figure 2.10. Summary of the relative changes in the single-stock advice for 2020 compared to the situation in 2018.

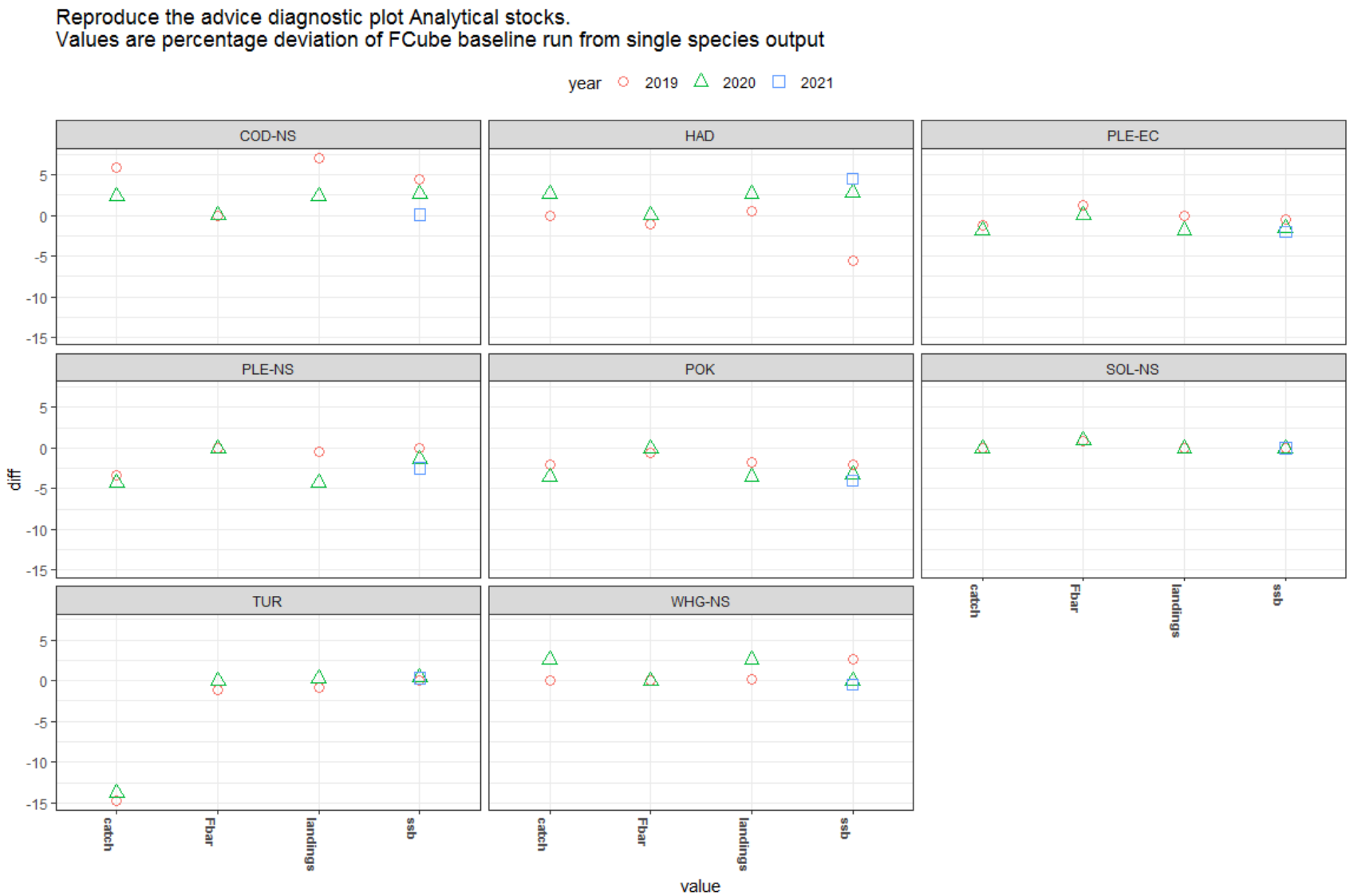


Figure 2.11. Difference between FCube baseline run and Single-species advice for finfish stocks, showing Fbar (2019—2020), landings (2019—2020) and SSB (2019—202).

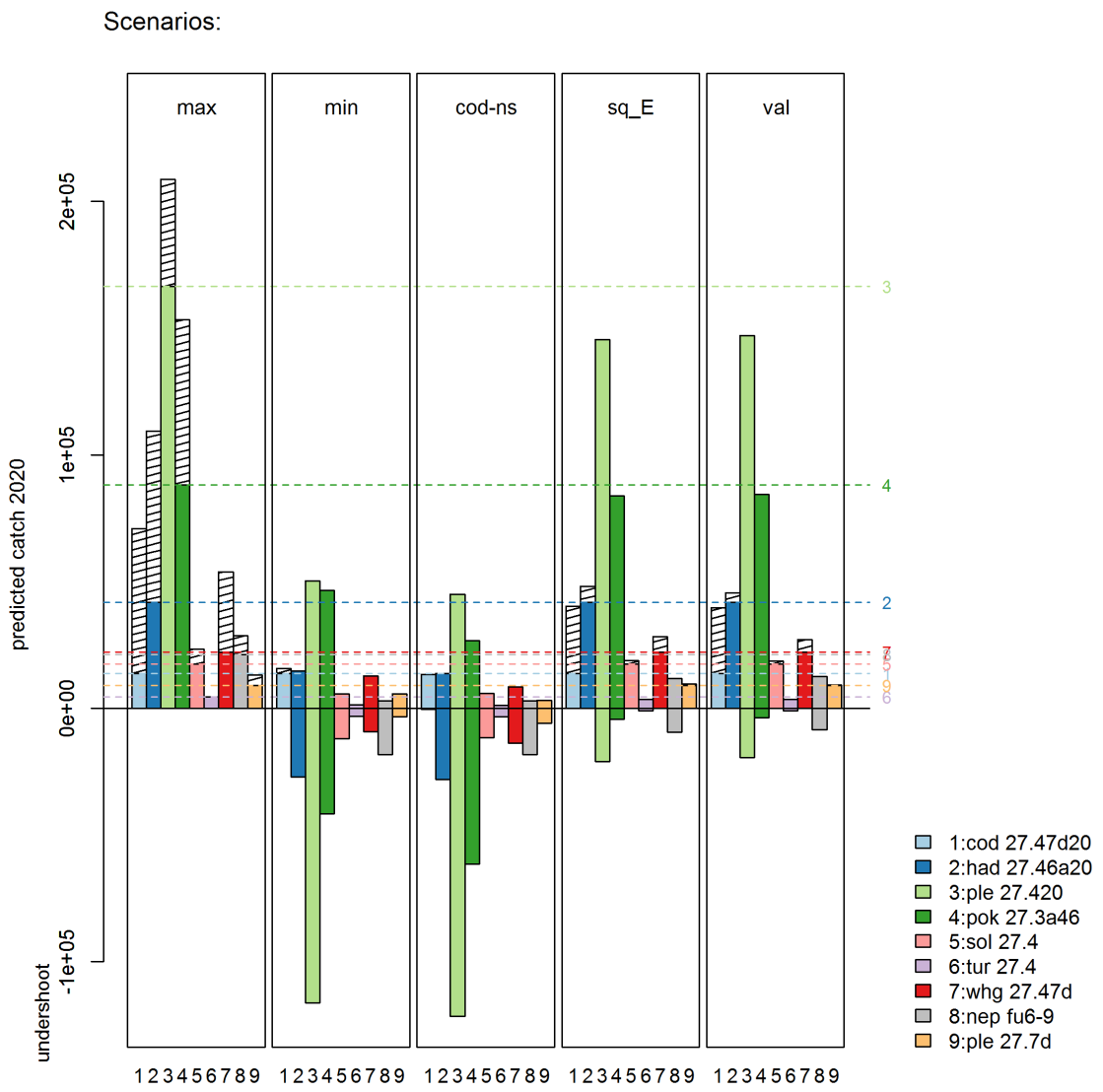


Figure 2.12. Mixed fisheries projections. Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2020. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

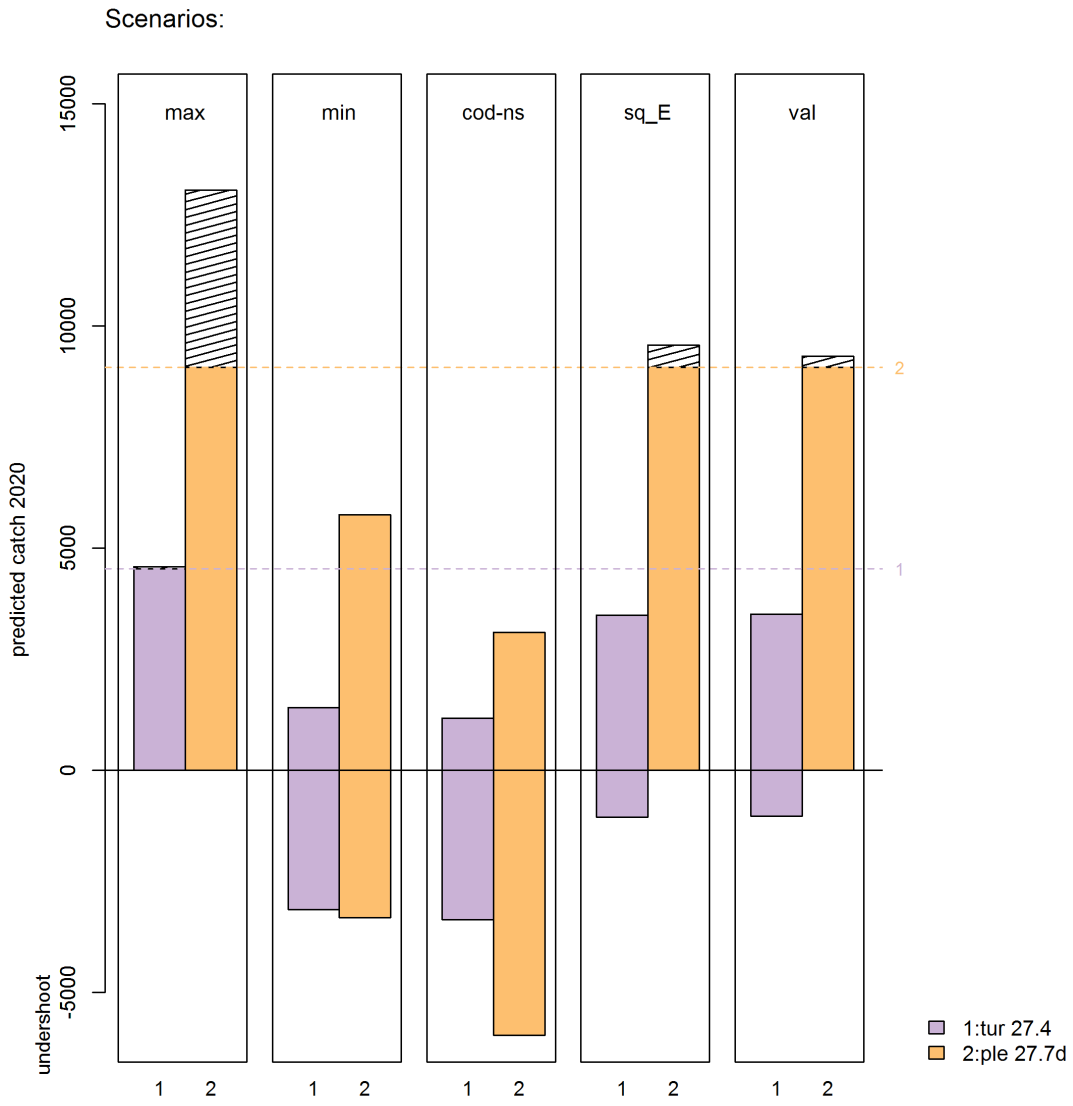


Figure 2.13. Mixed fisheries projections results for the stocks subject to lower landings (detail from Figure 2.12). Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2020. Bars below the value of zero show undershoot (com-pared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

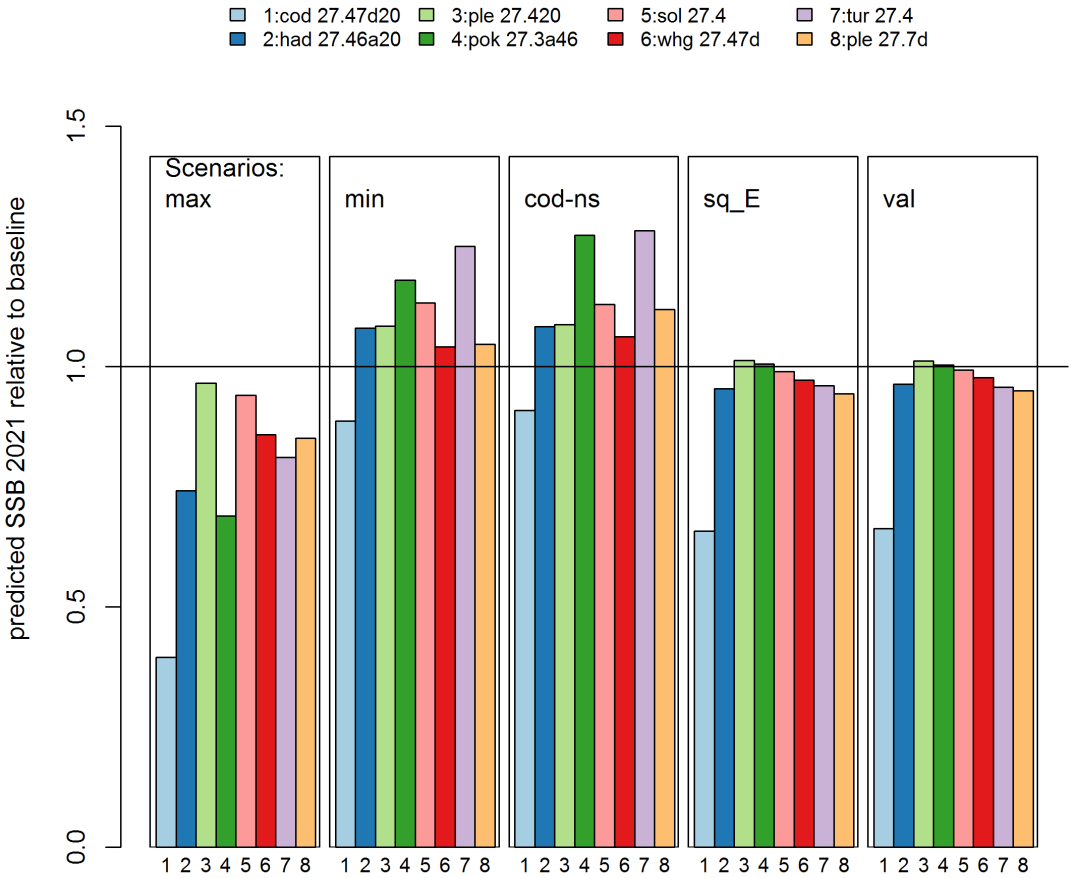


Figure 2.14. Estimated SSB at the start of 2021 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line corresponds to the SSB resulting from the single-stock advice. *Nephrops* are not included, as the abundance was not forecasted in the mixed fisheries model.

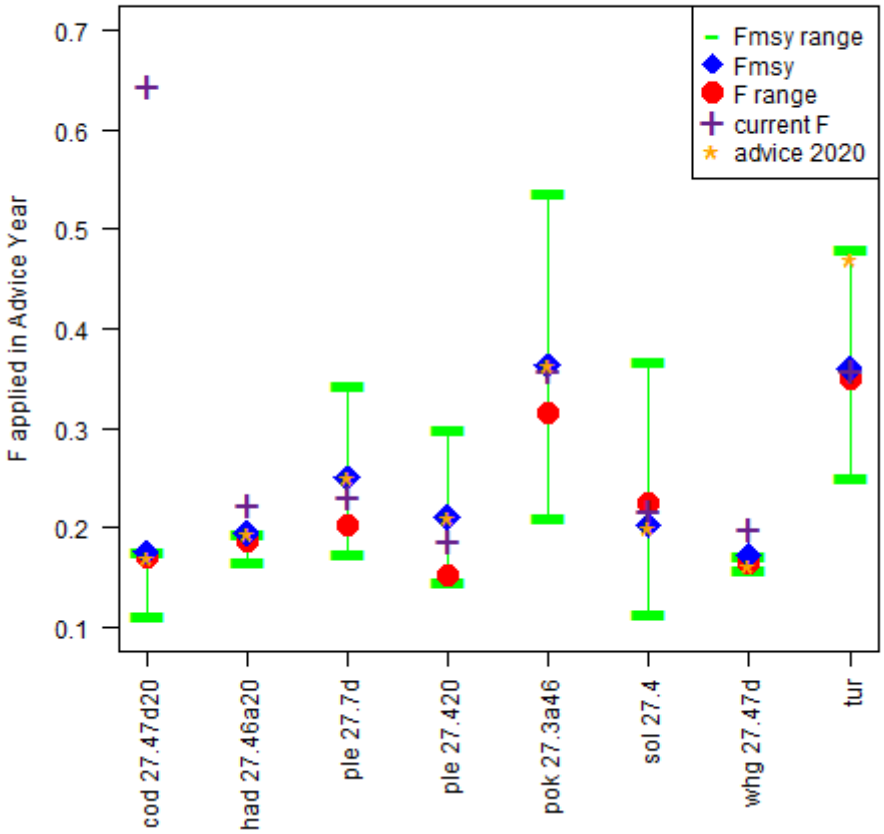


Figure 2.15. North Sea mixed fisheries 2020 "range" fishing mortality within the F_{MSY} range, compared with F_{MSY}, the current F (F in 2018), and F in the single-stock advice for 2020. The "range" F is the one giving the lowest difference in tonnage between the "max" and the "min" scenario across all stocks and fleets. For cod in the North Sea, F_{MSY} ranges are limited in accordance with the MSY approach and the MAP when below MSY $B_{trigger}$.

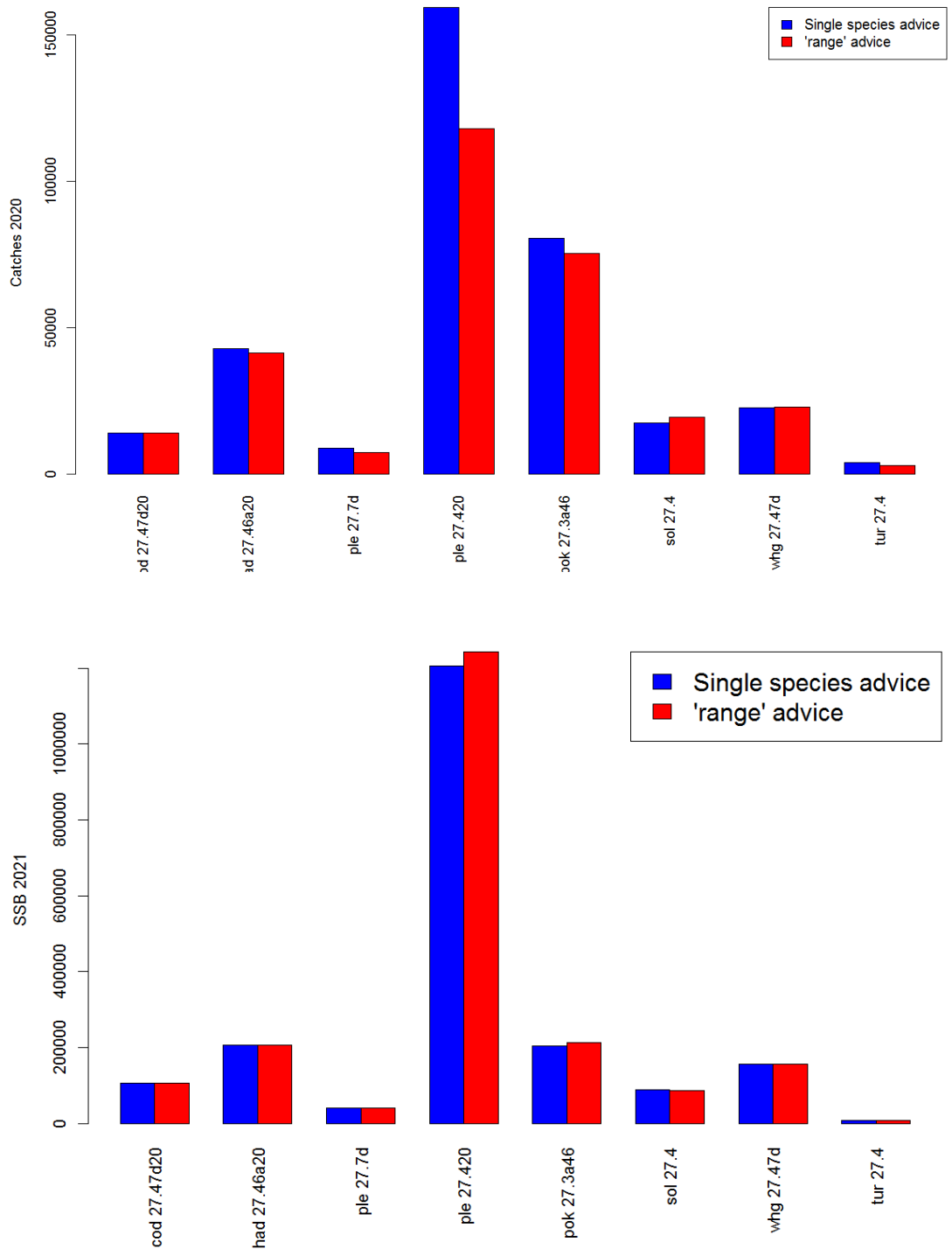


Figure 2.16. Comparison of the outcomes in terms of total catches in 2020 (left) and SSB in 2021 (right) between the F_{MSY}-based single-stock advice and the Frange-based forecast.

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 2019 the ICES advice for the Celtic Seas cod was given in terms of MSY, and haddock and whitting was given in terms of the EU multiannual plan for Western waters and adjacent waters. There are two species specific management plans in this region; a recovery plan for hake (Council Regulation (EC) No 811/2004) which implements a Total Allowable Catch (TAC) annually based on a defined Harvest Control Rule (HCR) and a management plan with both a HCR and effort management element for sole in the Western channel (7.e; Council Regulation (EC) No 509/2007). There are also a number of effort, technical and area closure measures in place, which are summarised below.

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

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

Since 2005, three ICES rectangles (30E4, 31E4, and 32E3) have been closed during the first quarter (Council Regulations 27/2005, 51/2006, and 41/2007, 40/2008 and 43/2009) known as the Trevose closure, with the objective of reducing fishing mortality on cod. A second area closure is in place to reduce fishing mortality on *Nephrops* within FU16, the Porcupine bank fishery. This currently

[7] http://www.bim.ie/media/bim/content/downloads/BIM-fisheries-management-chart-2019.pdf

month long closure in May (Council Regulation (EU) No 43/2014) has been in operation since 2009.

As of the 1 January 2016 a European demersal species landings obligation was introduced (Commission Delegated Regulation (EU) 2015/2438). This regulation prevents the discarding of certain species on a fishery by fishery approach. From 1 January 2019, catches of all quota species in the Celtic Seas are subject to the EU landings obligation rule, except an exemption is in place. An overview of the exemptions of the landings obligation can be found below:

Exemptions to the landing obligation in 2019

Species	Exemption type	ICES Sub-area/division	Gear	Maximum de minimis Exemption
Albacore tuna	De minimis	7	Midwater pair trawls	5
Whiting	De minimis	7d	Bottom trawls and seines ≥ 80 mm, Pelagic and beam trawls 80 - 119 mm	6
Whiting	De minimis	7b-c & 7e-k	Bottom trawls and seines ≥ 80 mm, Pelagic and beam trawls 80 - 119 mm	6
Sole	De minimis	7d,e,f & g	Trammel nets and gillnets	3
Sole	De minimis	7d,e,f,g & h	Beam trawl 80 -119 mm equipped with Flemish panel	3
Haddock	De minimis	7b-c & 7e-k	Bottom trawls, seines & beam trawls ≥ 80 mm	7
Cod	De minimis	7b-c & 7e-k	Bottom trawls, seines & beam trawls ≥ 80 mm	7
Horse mackerel	De minimis	6 & 7b-k	Bottom trawls, seines & beam trawls	7
Mackerel	De minimis	6 & 7b-k	Bottom trawls, seines & beam trawls	7
Species	**Exemption type**	**ICES Sub-area/division**	**Gear**	**Discard Release Notes**
Nephrops	Survivability	6 & 7	Pots, creels or traps	Released whole, immediately & where caught
Nephrops	Survivability	6a <12nm	Bottom trawls 80-110 mm with a highly selective gear (HSG*)	Released whole, immediately & where caught
Nephrops	Survivability	7	Bottom trawls 70-99 mm with HSG* or ≥ 100 mm	Released whole, immediately & where caught
Skates & rays	Survivability	6 & 7	All gears	Released immediately and below sea surface
Plaice	Survivability	7d, e ,f & g	Trammel nets and otter trawls	Released immediately and below sea surface
Plaice	Survivability	7a-7k	BT2 (vessels ≤221 kW or ≤24 m) inside 12 nm, tows ≤ 1:30 hour	Released immediately and below sea surface
All Species	Survivability	EU 5b; 6 & 7	Pots, creels and traps	Released immediately

*** Highly selective gears (HSG) include: 300 mm SMP, Seltra, Grid, Cefas net grid and flip-flap**

COMMISSION DELEGATED REGULATIONS (EU) 2018/190 & 2018/2034

3.2 FCube

3.2.1 Software

All analyses were conducted using the FLR framework[8] (Kell *et al.*, 2007; FLCore 2.6.13, FLFleet 2.6.1, FLAssess 2.5.2, Flash 2.5.2) running with R3.6.1 (R Development Core Team, 2015). All forecasts were projected using the same fwd() function in the Flash Package. The FCube method is developed as a stand-alone script using FLR objects as inputs and outputs.

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

Stock	Assessment	Forecast
cod.27.7.e–k	Age-bases analytical assessment (FLR 2.x FLXSA)	FLR STF
had.27.7.bc,e–k	ASAP (Age Structured Assessment Programme; NOAA toolbox)	FLR STF
whg.27.7.bc,e–k	Age-based analytical assessment (XSA)	FLR STF

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

3.2.2 Scenarios

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

Prior to 2009, precursors to WGMIXFISH compiled age-disaggregated data over a large number of categories. Analyses in 2008 highlighted that the age composition of landings showed distinct differences to that supplied to the single-species stock assessment working group (WGNSSK) and therefore WGMIXFISH runs projections on the basis of total landings and discards alone.

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

1. **range:** estimates a fishing mortality by stock (using the F_{MSY} ranges) which, if used for setting single-stock fishing opportunities, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. F_{MSY} ranges are bound by the ranges in the single-species advice sheet where the F_{msy} ranges is adjusted using the ICES advice rule when the stock is below MSY $B_{trigger.}$ Unlike the other scenarios the range scenario does not assume fixed fishing patterns in the future i.e. technical interactions can be adjusted in each fleet independently.
2. **max**: For each fleet, fishing stops when all stocks but cod have been caught up to the fleet's stock shares[9]. This option causes overfishing of the single-stock advice possibilities of most stocks.
3. **min**: 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.
4. **had:** Haddock MSY approach, all fleets set their effort corresponding to that required to catch their haddock stock share, regardless of other catches.
5. **whg:** Whiting MSY approach, all fleets set their effort corresponding to that required to catch their whiting stock share, regardless of other catches.
6. **sq_E**: *Status quo* effort, The effort of each fleet is set equal to the effort in the most recently recorded year (2018) for which catch and effort data are available.
7. **cod_F_{ARMSY}:** Reduced Cod F_{MSY}, all fleets set their effort corresponding to that required to catch their cod stock share, where the cod TAC is set according to reduced F_{MSY} (F = 0.057, F_{MSY} × (SSB(2020) / MSY $B_{trigger}$)), regardless of other catches.
8. **val:** Value, a simple scenario accounting for the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the fleet's stock shares of each of the stocks, weighted by the historical catch value of that stock (see example below). This option causes overfishing of some stocks and underutilization of others.

[9] 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 2020 and the historical proportion of the stock landings taken by the fleet.

3.3 Stock input data and recent trends

3.3.1 Stocks

3.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGCSE (ICES, 2019b). All stock inputs were formatted as FLStock objects were directly provided to WGMIXFISH by the respective stock coordinators, and this eased greatly the quality of the process of collecting stock data.

3.3.1.2 Trends and advice

The advice for these stocks is drafted by the WGCSE-2019 under considerations by ACOM. Recent trends are described on a stock-by-stock basis in ICES (2019b), and latest advice by stock is available on the ICES website. In order to give an overview of the Celtic Sea demersal stocks considered for mixed fisheries analysis, this information is summarised below. Table 3.1 lists the final advised TACs for 2019 and forecast SSBs in 2019.

Analytical stocks

Species	Area	Stock status	Advice 2020
cod.27.7e–k (Cod)	Divisions 7. e–k (western English Channel and southern Celtic Seas)		ICES advises that when the MSY approach is applied, there should be zero catch in 2020.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	o	✗	✗	Harvested unsustainably	B_{pa},B_{lim}	✗	✗	✗	Reduced reproductive capacity
Management plan	F_{MGT}	✗	✗	✗	Above range	B_{MGT}	✗	✗	✗	Below trigger

Summary: Spawning–stock biomass (SSB) has been below Blim since 2004, except from 2011 to 2013. Fishing mortality (F) has been above F_{MSY} for the entire time-series and has fluctuated around Flim in recent years. Recruitment has been highly variable over time. Recent recruitment has been low, with the exception of 2014, which was above average.

Species	Area	Stock status	Advice 2020
had.27b–k (Haddock)	Divisions 7.b–k (southern Celtic Seas and English Channel)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 11 418 and 23 262 tonnes. According to the MAP, catches higher than those corresponding to FMSY (16 671 tonnes) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✗	✗	✗	Above range	B_{MGT}	✓	✓	✓	Above trigger

Summary: Spawning–stock biomass (SSB) has declined since 2011 and remains above MSY $B_{trigger}$ in 2019. Fishing mortality (F) has been above F_{MSY} for the entire time series. Recruitment in 2018 was estimated to be the second highest in the time-series.

Species	Area	Stock status	Advice 2020
whg.27.b–c, e–k (Whiting)	Divisions 7.b–c and 7.e–k (southern Celtic Seas and western English Channel)		ICES advises that when the EU multiannual plan (MAP) for the Western Waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 4157 tonnes and 6481 tonnes. Management should be implemented at the stock level.
Sol.27.7.e (Sole)	Division 7.e (western English Channel)		ICES advises that when the EU multiannual plan (MAP) for the Western Waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 878 and 1685 tonnes. According to the MAP, catches higher than those corresponding to FMSY (1478 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

Whiting — Stock status

		Fishing pressure				Stock size			
		2016	2017	2018		2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✗	✗	Above	MSY $B_{trigger}$	✗	✗	✗ Below trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	o	✗	✗ Reduced reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within the range	B_{MGT}	✗	✗	✗ Below trigger

Summary: The spawning-stock biomass (SSB) has decreased since 2012 and is estimated at below MSY $B_{trigger}$ since 2017 and below B_{lim} since 2018. Fishing mortality (F) was below F_{MSY} between 2008 and 2016, but has increased above F_{MSY} since. Recruitment(R) has been below average since 2014.

Sole — Stock status

		Fishing pressure				Stock size			
		2016	2017	2018		2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓ Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within the range	B_{MGT}	✓	✓	✓ Above trigger

Summary: Spawning–stock biomass (SSB) has increased since 2008 and is well above MSY $B_{trigger}$. Fishing mortality (F) has been below F_{MSY} since 2009. Recruitment (R) has been variable without a trend and is currently around the long-term geometric mean.

Species	Area	Stock status	Advice 2020
Sol.27.7.f–g (Sole)	Divisions 7.f and 7.g (Bristol Channel, Celtic Sea)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 1020 and 2665 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1731 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Within the range	B_{MGT}	✓	✓	✓	Above trigger

Summary: Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ since 2001 and shows an increasing trend over the last few years. Fishing mortality (F) has decreased in recent years to below F_{MSY} since 2017. Recruitment has been variable without an overall trend. The 2015 and 2017 recruitments are estimated to be among the highest in the time series.

Nephrops stocks

Species	Area	Stock status	Advice 2020
Nephrops	Divisions 7.b–c and 7.j–k, Functional Unit 16 (west and southwest of Ireland, Porcupine Bank)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, and assuming zero discards, catches in 2020 that correspond to the F ranges in the MAP are between 2127 tonnes and 2637 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 16 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✗	✓	Below	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	✓	?	✓	Below possible reference points	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	✓	✗	✓	Within the range	B_{MGT}	?	?	?	Undefined

Summary: Stock abundance is estimated to have decreased in 2019 from its historical high in 2018. The harvest rate has decreased, and is now below F_{MSY}.

Species	Area	Stock status	Advice 2020
Nephrops	Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 696 and 800 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 17 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below	MSY $B_{trigger}$	✗	✓	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	?	✓	✓	Below possible reference points	B_{pa},B_{lim}	?	✓	?	Undefined
Management plan	F_{MGT}	✗	✓	✓	Below	B_{MGT}	✗	✓	✗	Below trigger

Summary: The abundance showed an overall decreasing trend up to 2014, and is currently just below MSY $B_{trigger}$. The harvest rate has fluctuated across the time-series and is currently estimated to be below F_{MSY}.

Species	Area	Stock status	Advice 2020
Nephrops	Divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of southwest of Ireland)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 749 and 839 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 19 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points	B_{pa},B_{lim}	✓	?	?	Undefined
Management plan	F_{MGT}	✓	✓	✓	Below range	B_{MGT}	✓	✗	✗	Below trigger

Summary: The harvest rates have been below F_{MSY} since 2014. Stock abundance has shown a declining trend, and has been below MSY $B_{trigger}$ since 2018.

Species	Area	Stock status	Advice 2020
Nephrops	Divisions 7.g and 7.h, functional units 20 and 21 (Celtic Sea)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 1131 and 1150 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in functional units 20 and 21 is exploited sustainably, management should be implemented at the level of the combined functional units 20 and 21.
Nephrops	Divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)	ICES assesses that fishing pressure on the stock is above F_{MSY}, and that stock size is above MSY $B_{trigger}$. **Summary**: The harvest rate has fluctuated over the time-series and it is now just above F_{MSY}. The stock abundance has been above MSY $B_{trigger}$, except in 2016 and 2018.	ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 2247 and 2820 tonnes. The entire range is considered precautionary when applying the ICES advice rule. To ensure that the stock in Functional Unit (FU) 22 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below		MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points		B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	✓	✓	✓	Below range		B_{MGT}	?	?	?	Undefined

Summary: The harvest rate is below F_{MSY} for the time-series. Stock abundance has decreased since 2017, and is at its lowest observed level in 2019.

3.4 Fleets and métiers

3.4.1 Catch and effort data

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

The WGMIXFISH information was requested with the same DCF métier-based definitions as those to InterCatch, but separated into vessel length categories specified to match fleet segments from the STECF AER (Annual Economic Report) and provided directly as comma separated files.

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. In the case of discard raising of Irish landings, the same proportion discards were applied to the gear irrespective of target species, consistent with the data submitted to InterCatch (and the single-stock advice raising procedures).

Age distribution by métier and area, which is now available in InterCatch, was not integrated in the MIXFISH data, but ultimately it is the aim to include them in future. The relative size of catches of the stocks incorporated in the mixed fisheries projections is shown in Figure 3.1.

The final dataset extracted from InterCatch for use by WGCSE 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 FCube, l is the weight of landings for the métier used by FCube and L and D are the weight of landings and discards entered for the (vessel length aggregated) métier in InterCatch.

All discard estimates were retrieved from Intercatch and assigned to the same métiers within the WGMIXFISH csv files. However, this method relies on being able to match métier definitions between the two datasets. The conformity of métiers in MIXFISH and InterCatch was generally high and improving year after year, but it was still not possible to match a few métiers. It would be desirable for Member States to keep improving the consistency between data uploaded to InterCatch and data submitted to WGMIXFISH and this is expected to improve as the Celtic Sea mixed fisheries advice develops.

3.4.2 Definitions of fleets and métiers

The procedure for defining the fleets and métiers in the model was similar to that applied in the North Sea. In summary:

- Fleets were defined by aggregating catch and effort across country, gear group, and vessel length (where applicable).
    - → *Any fleet catching < 1% of any of the stocks included the analysis was binned into an "others" ("OTH") fleet to reduce the dimensions of the model.*
    - → *Effort and catch files were matched to ensure consistency, métiers with effort and no catch were aggregated to the OTH fleet.*

- Within a fleet, a métier was defined as a combination of gear, target species (e.g. demersal fish, DEF, or crustaceans, CRU) and ICES subarea (e.g. 7.b).

  → *Similar aggregating procedure as for the fleets was performed, where any métier catching < 1% of a métiers catch of each stock was aggregated into an "OTH" métier.*

The final data used contained 13 national fleets (plus an OTH fleet) from three countries, covering catch and effort for the years 2014 to 2018. These fleets engage in one to eight different métiers each, resulting in combinations of country*fleet*métier*area catching cod, haddock, and whiting (Table 3.2). The balance of catches of the stocks across gear categories is shown in Figure 3.2.

Fleet definitions in the final selection are summarised as follows:

- England: Beam trawling vessels 24–40 m for demersal species; two otter trawl fleets separated by length (10–24 m and 24–40 m); a static gear fleet;
- France: Otter trawling vessels by vessel length (10–24 m, 24–40 m);
- Ireland: Beam trawling vessels distinguished by vessel length (10–24 m and 24–40 m); two otter trawl fleets, again by vessel length (10–24 m, 24–40 m); and an Irish static (10–24 m) containing for example gillnetting.

All the WGMIXFISH métiers for the Celtic Sea are defined as combinations of gear, target species (level 5; see Table 3.2) and area (7.b–k). The list of fleets, métiers with their catch (tonnes, all species) and effort are provided in Table 3.3.

As a crosscheck of the data, the total landings and discards across all fleets were compared to the values estimated from the single-species stock assessments (Table 3.4 and Figure 3.3). Some landings may not be allocated to fleets, due to issues such as missing countries or areas or national landings with missing logbook information that cannot be allocated to a fleet. The landings coverage for all fish stocks is very high (above 95% of landings of each fish stock for each of the years 2017–2019 could be allocated to one of the fleets). To address the remaining small inconsistencies between fleet data used by WGMIXFISH and stock data, the differences between them were pooled into the "OTH" fleet (both landings and discards).

3.4.3 Trends

A series of tables and figures were produced to check the quality of the data once compiled into the final fleets object. Some are useful to show the relative importance of the fleets chosen in their effort and catches. Effort by fleet in absolute levels (Table 3.3; not presented in a figure due to short time-series), effort share by métier and fleet (Figure 3.4) and landings by fleet and stock (Figure 3.5) are also included in this report.

3.5 Mixed fisheries forecasts

3.5.1 Description of scenarios

3.5.1.1 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 presented by WGCSE are performed using different software and setups (see Section 3.2.1 above). However, for the purpose of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the 'fwd()'

method in FLR (Flash R add-on package). The same forecast settings as in WGCSE 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 intention of the baseline runs was thus mainly to act as a check to ensure that the projections were set up correctly within the FCube script, but these runs also have the incidental benefit of acting as a quality control check on the WGCSE projections themselves. As the forecast methods for Celtic Sea cod, haddock and whiting single-stock advice are based on FLR fwd(), matching the forecasts for these stocks is relatively straight forward. Addition of stocks with more diverse assessment and forecasting methods in future will require consideration of how to integrate these stocks into the forecasts.

3.5.1.2 Mixed fisheries runs

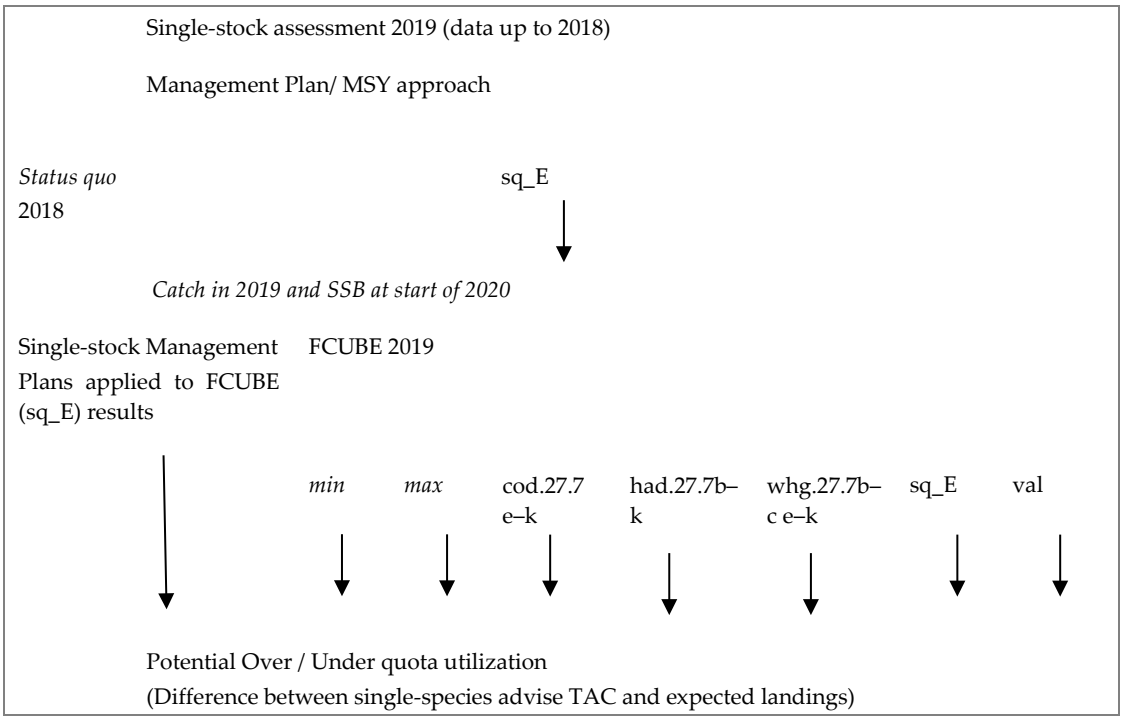
FCube analyses of the intermediate year (2019)

This results in the same catches, F and SSBs in the intermediate year FCube forecast as the single-stock forecasts and thus the same starting point for the TAC year results. It was considered that *status quo* effort was a more appropriate scenario than two successive FCube scenario years as it is consistent with recent observed trends in fishing effort and assumptions in the single-stock advice (see next Section 3.5.2 below).

FCube analyses for the TAC year (2018)

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

In summary, the FCube runs followed the scheme below:



3.5.2 Results of FCube runs

3.5.2.1 Baseline run

Table 3.5 summaries the results of the baseline runs for each cod, haddock and whitting in Fcube. Figure 3.6 shows the required change in fishing mortality for each stock. This trend shows that cod requires the biggest reduction in F, indicating the potential for it to be the 'choke' species for the fisheries that catch cod. No issues were encountered in replicating the single-species advice. The results from these baseline runs are compared with the results from the corresponding ICES runs in Table 3.6 and summarised in Figure 3.7. The replicated forecast for all stocks were almost identical to the single-stock advice.

3.5.2.2 Mixed fisheries analyses

Intermediate year baseline

The full overview of the FCube projections to 2020 is presented in Table 3.7, Figure 3.8, and Figure 3.9. The results for 2020 can be compared to each other as in a single-species option table. For ease of comparison, a table with the landings relative to the single-stock advice is also presented on Table 3.8. For all baseline scenarios, WGMIXFISH assumed *status quo F* in 2019.

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 3.8). The 2020 forecast with the cod catch advice at zero, implies that catches of haddock and whiting would also be zero ('min' scenario). Because the zero catch for cod results in the same outcome as the 'min' scenario, the cod scenario is not presented here. The 'max' scenario, assumes that all fleets catch their haddock and whiting quotas; this scenario leads to an overshoot for cod and to a lesser extent whiting.

In order to provide a scenario with non-zero catch, a reduced cod FMSY scenario is presented ('cod_F_{ARMSY}'). Applying the ICES Advice Rule (AR) gives an F (0.057) for cod and results in undershoots of both haddock and whiting, as fishing is stopped when the cod quota is reached.

The 'min' scenario is based on the assumption of a strictly implemented Landings Obligation with the individual single-stock advice TACs. In 2020, the 'min' scenario shows that cod limits all fleets due to the zero catch advice for cod and that all fleets catch cod to a greater or lesser extent. 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. In 2020, the 'max' scenario indicated that haddock is the least limiting quota for most fleets (9 of 12 fleets, representing 68% of the effort in 2018), while whiting is the least limiting quota for the remaining three fleets (representing 31% of the effort in 2018).

It is important to note that the 'Sq_E' scenario shows catches higher than the 'max' scenario. This indicates that the current fishing effort is higher than available fishing opportunities for all three gadoid stocks, indicating other stocks may also play a role in driving effort dynamics in the fisheries.

Mixed fisheries catch scenarios can take specific management priorities into account, and these results indicate that it is not possible to achieve all single-species management objectives simultaneously. ICES single-stock advice for demersal stocks is based on ICES maximum sustainable yield (MSY) approach. Any catch of cod in 2020 is not considered (Table 3.8), precautionary as the stock is estimated to be and remain below B_{lim}. The 'max' and 'Sq_E' scenarios result in whiting and haddock being fished above F_{MSY} in 2020. 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 cod and whiting would be considerably higher than advised in the single-stock advice, with haddock being slightly above. This indicates that not all fleets are limited by the same stock. However, as all fleets catch cod to a greater or lesser extent, any fishing effort directed at catching haddock or whiting is likely to result in catches of cod above the single-stock advice (zero catch), with any catch of cod above the single-stock advice considered not precautionary. The 'cod_F_{ARMSY}' scenario, where the cod TAC is set at reduced F_{MSY}, results in catches of cod, and in underutilizations of both the haddock and whiting single-stock TACs.

Of the presented scenarios, the 'min' and 'range' scenarios meet the objective of all stocks being fished at or below F_{MSY}. In contrast to single-stock advice there is no single recommendation from this advice, instead a range of scenarios are presented. The ICES single-stock advice provides catch opportunities consistent with the ICES MSY approach. To be consistent with these objectives a scenario is necessary that delivers the SSB and/or F objectives of the single-stock advice for all stocks considered simultaneously. This is not possible in 2020 due to the cod stock being < B_{lim} in 2021, even with a zero cod catch in 2020 and any fisheries for haddock and whiting likely to result in some catches of cod.

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

In the absence of a full economic behaviour model, a "Value" scenario was run that balances fishing opportunities by stock with their potential market value. For 2020, the "Value" scenario estimates results close to the "whg_cs" scenario.

Optimised range option

A "range" scenario is presented (Figure 3.12), this scenario as described in Ulrich *et al*. (2017) searches for the minimum sum of differences between potential catches by stock under the 'min' and the 'max' scenarios within the F_{MSY} ranges. The outcomes of this scenario are driven by the restrictive nature of the cod advice this year, with the minimum of the F_{MSY} range advice for haddock and whiting resulting from the need to reduce cod catches to a minimum. Other 'range' scenarios could be computed in the future, for example scenarios minimizing the potential for discarding (e.g. catching unwanted catch) or maximizing fleets' revenue or profit.

Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input is calculated as the average landing share by fleet and stock in 2019. As a cross-check, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input (Figure 3.13). The results show some deviations across all scenarios which arise because (under the assumption of a full discard ban), fleets with a small share of a stock but high discard rate have their fishing activity limited by that stock, resulting in underutilization of their target stock(s) This can translate to underutilization at the national level, as seen by the change in landings share of the stocks by EU Member States in the mixed fisheries forecasts.

Table 3.1. Celtic Sea. Summary of the 2019 ICES single-species advice. Target Fs are left justified; harvest ratios are right justified. Where a stock/Functional Unit does not have a management plan the landings follow ICES advice.

Species	Agreed TAC (summed TACs) 2019	Total Catch-advice for 2019	Wanted Catch-advice for 2019	F_{total}/Harvest ratio for 2019	F_{wanted}/ Harvest ratio for 2019	SSB 2020	SSB 2021	Rational
Cod 7. e–k	1610**	0	0	0	0	1664	4447	MSY
Haddock 7.bc, 7. e–k	8329^	16671	8068	0.4	0.35	49821	47629	MAP
Whiting 7.bc, 7. e–k	9882*	6481	3885	0.35	0.25	23615	33720	MAP
Nephrops FU16	2645			6.2				MAP
Nephrops FU17	19784 ***			7.8				MAP
Nephrops FU19	19784***			8.4				MAP
Nephrops FU20-21	19784***			6.0				MAP
Nephrops FU22	19784***			12.8				MAP
Nephrops FU18+7.OTH	19784***							n/a

**** Applies to divisions 7.b,c,e–k, subareas 7.I, IX, and X, and EU waters of CECAF 34.1.1.**

^ Applies to divisions 7.b–k and subareas 7.I, IX, and X.

*** TAC covers Subarea 7. (except Division 7.a).**

****TAC for whole of Subarea 7.**

Table 3.2. Celtic Sea. Métiers consistent with DCF métier level 5. Mixed fisheries métiers are further disaggregated into areas: 7.b, 7.c, 7.e, 7.f, 7.g, 7.h, 7.j, and 7.k.

Gear	Target species	Mixed fisheries métiers (plus area)
Gillnets	Demersal fish	GNS_DEF
Otter trawls	Crustaceans	OTB_CRU
Otter trawls	Demersal fish	OTB_DEF
Seines	Demersal fish	SSC_DEF
Beam trawls	Demersal fish	TBB_DEF
Twin otter trawls	Crustaceans	OTT_CRU
Twin otter trawls	Demersal fish	OTT_DEF
Other gears	Any	MIS_MIS / OTH

Table 3.3. Celtic Sea. Final fleet and métier categories used in the mixed fishery analysis.

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
BEL_Beam_24<40 m	OTH	3.17	6094.91	0.01	6108.33	1.01	5496.89
BEL_Beam_24<40 m	TBB_DEF_27.7.e	15.18	888.09	0.45	1296.22	39.2	1734.58
BEL_Beam_24<40 m	TBB_DEF_27.7.f	214.15	2158.7	54.29	1638.27	98.15	1889.08
BEL_Beam_24<40 m	TBB_DEF_27.7.g	62.29	2432.23	3.99	3399.89	65.36	2816.45
BEL_Beam_24<40 m	TBB_DEF_27.7.h	9.52	205.29	0.17	248.21	6.87	342.32
FRA_Ot-ter_10<24m	OTB_CRU_27.7.e	0	0	0	0.48	0	0
FRA_Ot-ter_10<24m	OTB_CRU_27.7.f	0	0	0	1.7	0	0
FRA_Ot-ter_10<24m	OTB_CRU_27.7.g	0	0	0.61	95.58	0	0
FRA_Ot-ter_10<24m	OTB_CRU_27.7.h	0	0	0.18	15.41	0	0
FRA_Ot-ter_10<24m	OTB_DEF_27.7.b	0	0	0	17.64	0.66	12.68
FRA_Ot-ter_10<24m	OTB_DEF_27.7.c	0	0	0	113.88	0.89	30.02
FRA_Ot-ter_10<24m	OTB_DEF_27.7.d	0	0	0	3333.53	5.73	6930.12

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
FRA_Otter_10<24m	OTB_DEF_27.7.e	3215	6539.16	2.95	3336.93	2501.5	7624.98
FRA_Otter_10<24m	OTB_DEF_27.7.f	465	913.47	2.95	393.7	314.8	815.43
FRA_Otter_10<24m	OTB_DEF_27.7.g	490	3183.81	8.36	419.83	193.79	300.76
FRA_Otter_10<24m	OTB_DEF_27.7.h	736	4216.12	5.8	1201.46	422.04	1173.31
FRA_Otter_10<24m	OTB_DEF_27.7.j	10	415.99	1	217.23	35.23	276.02
FRA_Otter_10<24m	OTB_MOL_27.7.e	0	0	0	0	4.89	135.45
FRA_Otter_10<24m	OTH	0	0	0.47	114.7	1.94	63.52
FRA_Otter_10<24m	OTM_DEF_27.7.e	0	0	0.16	72.8	10.89	526.52
FRA_Otter_10<24m	OTM_DEF_27.7.f	0	0	0.54	48.4	36.28	123.97
FRA_Otter_10<24m	OTM_DEF_27.7.g	0	0	0.34	18.4	7.95	16.29
FRA_Otter_10<24m	OTM_DEF_27.7.h	0	0	0.09	25.99	17.3	38.28
FRA_Otter_10<24m	OTT_CRU_27.7.g	0	0	5.68	314.68	63.18	251.11
FRA_Otter_10<24m	OTT_CRU_27.7.h	0	0	1.26	108.35	11.2	40.91
FRA_Otter_10<24m	OTT_DEF_27.7.c	0	0	0	16.4	0.01	6.96
FRA_Otter_10<24m	OTT_DEF_27.7.e	0	0	0.12	109.53	61.59	644.35
FRA_Otter_10<24m	OTT_DEF_27.7.f	0	0	0.3	53.32	4.14	44.62
FRA_Otter_10<24m	OTT_DEF_27.7.g	0	0	25.43	1378.73	401.91	1169.28
FRA_Otter_10<24m	OTT_DEF_27.7.h	0	0	6.47	3293.41	732.47	4185.52
FRA_Otter_10<24m	OTT_DEF_27.7.j	0	0	2.09	629.68	40.95	967.29
FRA_Otter_10<24m	SSC_DEF_27.7.e	0	0	0	0	0	69.14

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
FRA_Otter_24<40m	OTB_DEF_27.7.b	172	1055.79	0	717.75	84.95	771.83
FRA_Otter_24<40m	OTB_DEF_27.7.c	45	3717.25	0	2743.56	35.45	1041.24
FRA_Otter_24<40m	OTB_DEF_27.7.d	0	0	0	226.25	0.65	1082.95
FRA_Otter_24<40m	OTB_DEF_27.7.e	1565	4206.69	2.6	2707.2	1269.84	6968.01
FRA_Otter_24<40m	OTB_DEF_27.7.f	428	569.49	1.62	241.6	168.75	403.12
FRA_Otter_24<40m	OTB_DEF_27.7.g	704	2649.8	21.27	769.9	375.85	476.1
FRA_Otter_24<40m	OTB_DEF_27.7.h	2006	3610.7	9.25	2726.68	1452.74	2881.07
FRA_Otter_24<40m	OTB_DEF_27.7.j	346	3321.03	5.23	3174.84	166.12	3158.31
FRA_Otter_24<40m	OTH	0	0	3.09	958.66	2.46	433.3
FRA_Otter_24<40m	OTM_DEF_27.7.e	0	0	0	0	1.23	13.57
FRA_Otter_24<40m	OTM_DEF_27.7.f	0	0	0	1.22	0	0
FRA_Otter_24<40m	OTM_DEF_27.7.h	0	0	0	0	8.12	53.54
FRA_Otter_24<40m	OTT_DEF_27.7.c	0	0	0	49.31	3.2	90.71
FRA_Otter_24<40m	OTT_DEF_27.7.e	0	0	0	1.2	0	0
FRA_Otter_24<40m	OTT_DEF_27.7.g	0	0	0.04	7.2	0	0
FRA_Otter_24<40m	OTT_DEF_27.7.h	0	0	0.57	318.66	61.9	463.01
FRA_Otter_24<40m	OTT_DEF_27.7.j	0	0	0.18	594.06	11.54	979.98
FRA_Otter_24<40m	SSC_DEF_27.7.e	0	0	0	0	0.02	26.19
IRL_Beam_10<24m	OTH	0	0	0	0.44	0	0
IRL_Beam_10<24m	TBB_DEF_27.7.f	0.13	0.44	0	0	0	0
IRL_Beam_10<24m	TBB_DEF_27.7.g	121.91	753.05	21.64	565.61	110.46	419.52

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
IRL_Beam_10<24m	TBB_DEF_27.7.h	0.03	1.33	0	0	0	0
IRL_Beam_24<40m	OTH	1.24	6.63	0	2.22	0.51	9.07
IRL_Beam_24<40m	TBB_DEF_27.7.f	0.38	2.21	0	0	0.07	0
IRL_Beam_24<40m	TBB_DEF_27.7.g	232.12	2703.77	50.88	2552.43	212.64	1815.25
IRL_Beam_24<40m	TBB_DEF_27.7.h	0.16	0.66	0	0	0	0
IRL_Otter_10<24m	OTB_CRU_27.7.b	25.68	695.28	0	541.11	10.24	376.48
IRL_Otter_10<24m	OTB_CRU_27.7.f	0.28	0.81	0	0	0.44	0
IRL_Otter_10<24m	OTB_CRU_27.7.g	227.83	3406.11	12.54	3194.65	190.86	1313.64
IRL_Otter_10<24m	OTB_CRU_27.7.h	40.02	536.85	1.45	366.31	27.98	237.76
IRL_Otter_10<24m	OTB_DEF_27.7.b	94.07	1217.91	8.97	1078.1	77.28	646.18
IRL_Otter_10<24m	OTB_DEF_27.7.c	3.71	231.9	0	0	4.12	0
IRL_Otter_10<24m	OTB_DEF_27.7.e	0	0	0	249.98	5.36	246.44
IRL_Otter_10<24m	OTB_DEF_27.7.f	0.15	0.79	0.04	0	0.29	0
IRL_Otter_10<24m	OTB_DEF_27.7.g	3400.78	6241.56	412.09	5761.44	2015.52	3476.38
IRL_Otter_10<24m	OTB_DEF_27.7.h	20.94	314.14	1.9	396.44	36.64	233.7
IRL_Otter_10<24m	OTB_DEF_27.7.j	369.54	2938.93	19.48	3055.59	218.11	1864.36
IRL_Otter_10<24m	OTH	16.31	364.42	0.01	273.09	1.79	111.14
IRL_Otter_10<24m	OTM_SPF_27.7.b	0	0	0	0	0.6	39.13
IRL_Otter_10<24m	OTM_SPF_27.7.j	0	0	0	24.33	0.88	26.32
IRL_Otter_10<24m	SSC_DEF_27.7.b	39.67	46.21	55.25	34.11	24.16	21.3
IRL_Otter_10<24m	SSC_DEF_27.7.g	1081.74	930.34	845.04	834.52	422.24	511.14
IRL_Otter_10<24m	SSC_DEF_27.7.j	256.97	416.09	228.86	377.37	228.99	265.68
IRL_Otter_24<40m	OTB_CRU_27.7.b	10.13	464.44	0	262.57	2.79	145.35
IRL_Otter_24<40m	OTB_CRU_27.7.f	0.16	4.41	0	0	0	0
IRL_Otter_24<40m	OTB_CRU_27.7.g	87.31	1875.05	4.11	1494.56	105.32	847.56
IRL_Otter_24<40m	OTB_CRU_27.7.h	30.63	481.87	0.91	282.06	33.3	386.24
IRL_Otter_24<40m	OTB_DEF_27.7.b	239.33	693.2	73.28	756.41	508.53	612.14

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
IRL_Otter_24<40m	OTB_DEF_27.7.c	4.42	186.53	0	0	3.8	0
IRL_Otter_24<40m	OTB_DEF_27.7.e	0.04	75.64	0	946.03	3.03	885.74
IRL_Otter_24<40m	OTB_DEF_27.7.f	42.92	12.87	0.3	0	75.7	0
IRL_Otter_24<40m	OTB_DEF_27.7.g	2523.29	2465.11	301.42	2453.04	1035.88	1428.64
IRL_Otter_24<40m	OTB_DEF_27.7.h	35.64	541.54	0.76	816.91	52.35	456.52
IRL_Otter_24<40m	OTB_DEF_27.7.j	102.54	887.51	7.41	1056.05	66.62	762.97
IRL_Otter_24<40m	OTH	1.52	2491.03	0.14	431.91	1.24	211.88
IRL_Otter_24<40m	OTM_SPF_27.7.b	0	0	0	170.82	9.59	119.35
IRL_Otter_24<40m	OTM_SPF_27.7.j	0	0	0	136.79	0	0
IRL_Otter_24<40m	SSC_DEF_27.7.b	141.33	115.3	39.42	31.63	35.52	33.78
IRL_Otter_24<40m	SSC_DEF_27.7.g	723.12	402.52	536.16	342.51	515.45	242
IRL_Otter_24<40m	SSC_DEF_27.7.j	312.17	398.99	254.2	370.05	270.59	335.65
IRL_Static_10<24m	GNS_DEF_27.7.f	0.18	0.05	0	0	0.34	0
IRL_Static_10<24m	GNS_DEF_27.7.g	196.96	727.03	215.6	729.89	94.07	440.8
IRL_Static_10<24m	GNS_DEF_27.7.j	65.84	673.76	223.42	752.62	52.22	484.07
IRL_Static_10<24m	OTH	10.49	161.75	0.01	57.63	2.07	56.29
OTH_OTH	OTH	0	1000	0	1000	0	1000
UKE_Beam_24<40m	TBB_DEF_27.7.e	64.95	1987.92	35.65	2349.31	39.78	2298.63
UKE_Beam_24<40m	TBB_DEF_27.7.f	24.62	185.13	0.41	191.06	19.71	216.15
UKE_Beam_24<40m	TBB_DEF_27.7.g	17.05	167.44	0.64	216.02	15.62	224.02
UKE_Beam_24<40m	TBB_DEF_27.7.h	55.43	747.24	0.62	531.15	24.8	356.05
UKE_Otter_10<24m	OTB_DEF_27.7.e	710.7	1711.81	167.76	1755.18	570.74	1426.74
UKE_Otter_10<24m	OTB_DEF_27.7.f	11.04	117.29	0.25	83.99	9.4	109.01
UKE_Otter_10<24m	OTB_DEF_27.7.g	0.71	9.23	0.02	15.54	0.36	9.49
UKE_Otter_10<24m	OTB_DEF_27.7.h	1.79	2.37	0	0	0	0

fleet	métier	Catch 2016	Effort 2016	Catch 2017	Effort 2017	Catch 2018	Effort 2018
UKE_Otter_10<24m	OTH	0.01	142.75	0	130.74	0	0
UKE_Otter_24<40m	OTB_DEF_27.7.b	0.5	203.73	0.03	193.66	0.67	188.67
UKE_Otter_24<40m	OTB_DEF_27.7.c	0.21	264.75	0	230.51	0.18	249.91
UKE_Otter_24<40m	OTB_DEF_27.7.e	0	0	0.04	3.26	0	0
UKE_Otter_24<40m	OTB_DEF_27.7.g	7.23	103.46	0.24	61.81	6.75	101.52
UKE_Otter_24<40m	OTB_DEF_27.7.h	3.31	142.54	0.1	149.27	3.87	126.93
UKE_Otter_24<40m	OTB_DEF_27.7.j	30.05	855.77	1.26	803.14	18.67	781.76
UKE_Otter_24<40m	OTH	0.08	23.52	0	42.88	0.04	25.04
UKE_Static_all	GNS_DEF_27.7.e	82.54	503.23	45.78	537.17	64.46	574.73
UKE_Static_all	GNS_DEF_27.7.f	59.93	282.23	0.52	227.64	27.61	250.09
UKE_Static_all	GNS_DEF_27.7.g	101.75	280.3	2.87	275.47	67.91	223.67
UKE_Static_all	GNS_DEF_27.7.h	16.59	143.49	0.59	103.6	27.13	104.4
UKE_Static_all	GNS_DEF_27.7.j	24.67	136.07	0.95	109.19	16.28	144.28
UKE_Static_all	GNS_SPF_27.7.f	0.98	44.41	0	45.92	11.02	43.2
UKE_Static_all	GTR_DEF_27.7.e	2.14	33.18	0.28	29.12	1.59	44.24
UKE_Static_all	GTR_DEF_27.7.h	2.12	20.68	0.09	36.59	1.1	27.3
UKE_Static_all	OTH	27.38	4003.48	0.74	3842.38	1.19	19.04

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	WG. land	MIX. land	Land. diff	WG. disc	MIX. disc	Disc. diff	ratio. land	ratio. disc
2016	cod.27.7 e–k	3299	3273	26	0	269	-613	0.99	Inf
2017	cod.27.7 e–k	2237	2813	-576	0	231	-664	1.26	Inf
2018	cod.27.7 e–k	1385	1343	42	0	110	-456	0.97	Inf
2016	had.27.7b–k	7594	7477	117	10337	3627	-6720	0.98	0.35
2017	had.27.7b–k	8097	10238	-2141	7975	0	-4988	1.26	0
2018	had.27.7b–k	7109	6290	819	5436	1835	1779	0.88	0.34
2016	whg.27.7bce–k	15179	15195	-16	7278	5708	960	1.00	2.19
2017	whg.27.7bce–k	11693	18724	-7031	4505	3637	3293	1.60	0.78
2018	whg.27.7bce–k	8773	90523	-81750	1495	1039	790	1.03	0.81

Table 3.5. Celtic Sea. Baseline run outputs from the FCube FLR package.

year	value	cod.27.7e-k	had.27.7b-k	whg.27.7b-ce-k
2019	catch	1330	20456	9184
2019	discards	NA	13494	3122
2019	Fbar	0.87	0.77	0.62
2019	FmultVsF18	1.04	1	1
2019	landings	1330	6963	6061
2019	ssb	1290	14205	17423
2020	catch	0	16666	6481
2020	discards	0	0	0
2020	Fbar	0	0.4	0.35
2020	FmultVsF18	0	0.52	0.56
2020	landings	0	16666	6481
2020	ssb	1664	49821	23615
2021	ssb	4447	47598	33720

Table 3.6. Comparison between baseline run and ICES advice. Figures for 2019 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.

		cod.27.7 e–k	had.27.7b–k	whg.27.7b–c, e–k
2019	Total Catches*			
	Baseline	1330	20456	9184
	ICES	1321	20457	9183
	% difference	0.7%	0.0%	0.0%

		cod.27.7 e–k	had.27.7b–k	whg.27.7b–c, e–k
2020	Total Catches**			
	Baseline	0	16666	6481
	ICES	0	16671	6481
	% difference	0.0%	0.0%	0.0%

***cod.27.7 e–k landings only**

****cod.27.7 e–k baseline includes a 10.6% inflation for discards included in the single-species forecast**

Table 3.7. Celtic Sea. Results of Final FCube runs.

year	scenario	value	cod.27.7 e–k	had.27.7b–k	whg.27.7bce–k
2019	baseline	landings	1330	6963	6061
2019	baseline	Fbar	0.87	0.77	0.62
2020	baseline	Fbar	0	0.4	0.35
2019	baseline	FmultVsF18	1.04	1	1
2019	sq_E	FmultVsF18	1.04	1	1
2020	baseline	FmultVsF18	0	0.52	0.56
2020	cod_fmsy	FmultVsF18	0.07	0.04	0.06
2020	had.27.7b–k	FmultVsF18	0.87	0.52	0.79
2020	max	FmultVsF18	0.88	0.54	0.81
2020	min	FmultVsF18	0	0	0
2020	sq_E	FmultVsF18	1.01	0.61	0.94
2020	val	FmultVsF18	0.61	0.39	0.57
2020	whg.27.7bce–k	FmultVsF18	0.6	0.36	0.56
2019	sq_E	Fbar	0.865418	0.772785	0.623576
2019	sq_E	Fbar	0.87	0.77	0.62
2020	cod_fmsy	Fbar	0.056544	0.031715	0.039607
2020	cod_fmsy	Fbar	0.06	0.03	0.04
2020	had.27.7b–k	Fbar	0.724926	0.4	0.495597
2020	had.27.7b–k	Fbar	0.72	0.4	0.49
2020	max	Fbar	0.729414	0.417113	0.504212
2020	max	Fbar	0.73	0.42	0.51
2020	min	Fbar	6.67E-34	2.98E-34	2.34E-34

year	scenario	value	cod.27.7 e–k	had.27.7b–k	whg.27.7bce–k
2020	min	Fbar	0	0	0
2020	sq_E	Fbar	0.838282	0.470547	0.586882
2020	sq_E	Fbar	0.84	0.47	0.59
2020	val	Fbar	0.505193	0.301839	0.357283
2020	val	Fbar	0.51	0.3	0.36
2020	whg.27.7bce–k	Fbar	0.497184	0.278859	0.350851
2020	whg.27.7bce–k	Fbar	0.5	0.28	0.35
2019	sq_E	landings	1229	6963	6061
2020	baseline	landings	0	16666	6481
2020	cod_fmsy	landings	190	1521	807
2020	had.27.7b–k	landings	1854	16666	8772
2020	max	landings	1862	17270	8902
2020	min	landings	0	0	0
2020	sq_E	landings	2055	19106	10119
2020	val	landings	1408	13044	6587
2020	whg.27.7bce–k	landings	1390	12156	6481
2020	sq_E	Ld_MgtPlan	0	16666	6481
2019	sq_E	catches	1229	20457	9183
2020	baseline	catches	0	16666	6481
2020	cod_fmsy	catches	190	1521	807
2020	had.27.7b–k	catches	1854	16666	8772
2020	max	catches	1862	17270	8902
2020	min	catches	0	0	0
2020	sq_E	catches	2055	19106	10119
2020	val	catches	1408	13044	6587
2020	whg.27.7bce–k	catches	1390	12156	6481
2019	baseline	ssb	1290	14205	17423
2020	baseline	ssb	1664	49821	23615
2020	sq_E	ssb	1664	49821	23615

year	scenario	value	cod.27.7 e–k	had.27.7b–k	whg.27.7bce–k
2021	cod_fmsy	ssb	4246	63520	38541
2021	had.27.7b–k	ssb	2535	47598	31811
2021	max	ssb	2527	46975	31703
2021	min	ssb	4447	65147	39236
2021	sq_E	ssb	2337	45088	30699
2021	val	ssb	2983	51355	33631
2021	whg.27.7bce–k	ssb	3001	52282	33720
2020	sq_E	ssb_MgtPlan	1664	49821	23615

Table 3.8. Celtic Sea. Catches under the mixed fisheries scenarios relative to the single-stock advice.

	Single-stock catches	**Catches per mixed fisheries scenario 2017 Relative to the single-stock advice**						
Stock	Single-stock advice	max	min	sqE	cod_fmsy	val	had_cs	whg_cs
cod.27.7 e–k	0	1862	0	2055	190	1408	1854	1390
had.27.7b–k	16671	17270	0	19106	1521	13044	16666	12156
whg.27.7bce–k	6481	8902	0	10119	807	6587	8772	6481

***Weights in thousand tonnes.**

Advised catches no more than the indicated value.

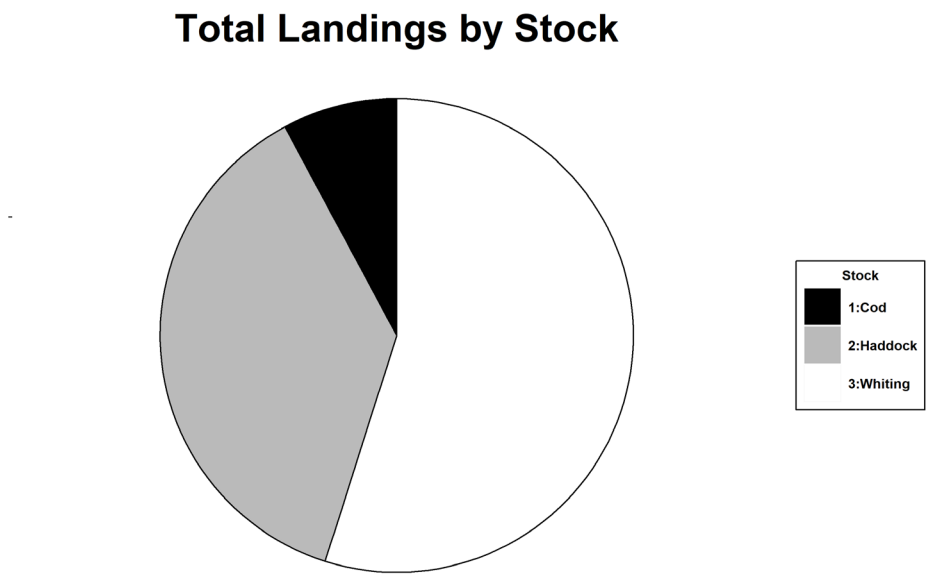


Figure 3.1. Celtic Sea. Distribution of landings of those stocks included in the mixed fisheries projections.

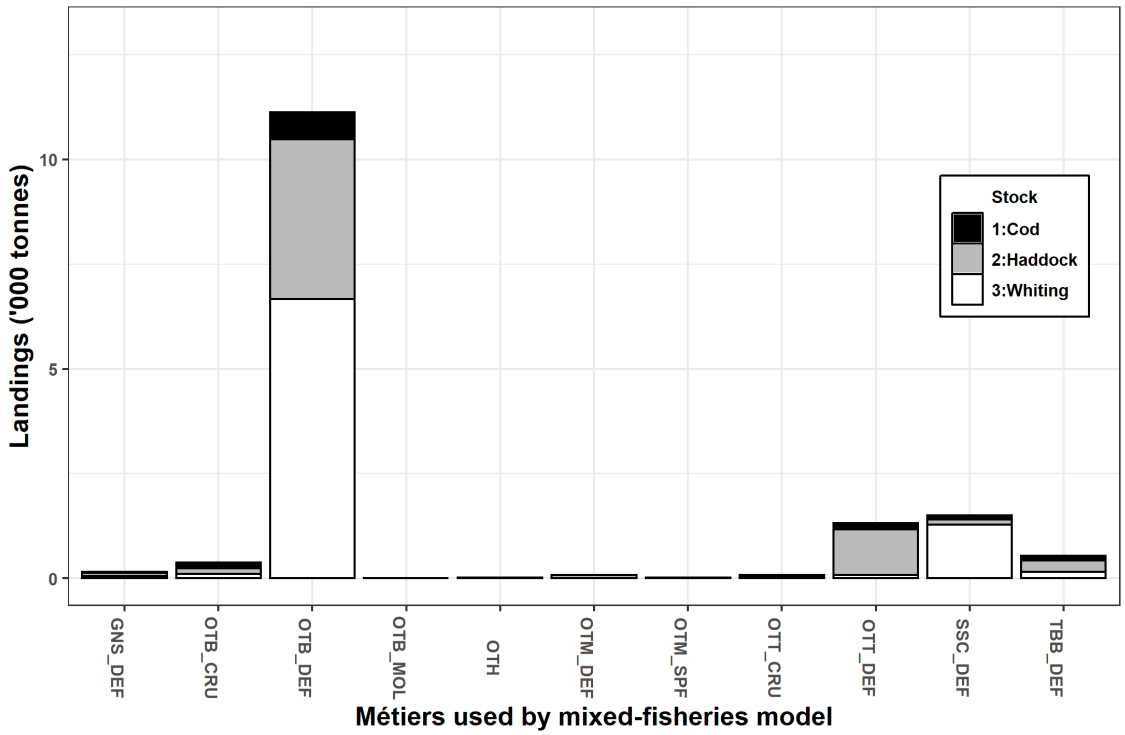


Figure 3.2. Celtic Sea. Landings distribution of species by métier with landings consisting of ≥ 1% of any of the stocks 1–10 in 2016 Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks 1–10 in 2015. The "non-allocated" is the differences between total landings used in single-stock advice and mixed fisheries advice, such as saithe and haddock landings in Subarea VI and VIa respectively.

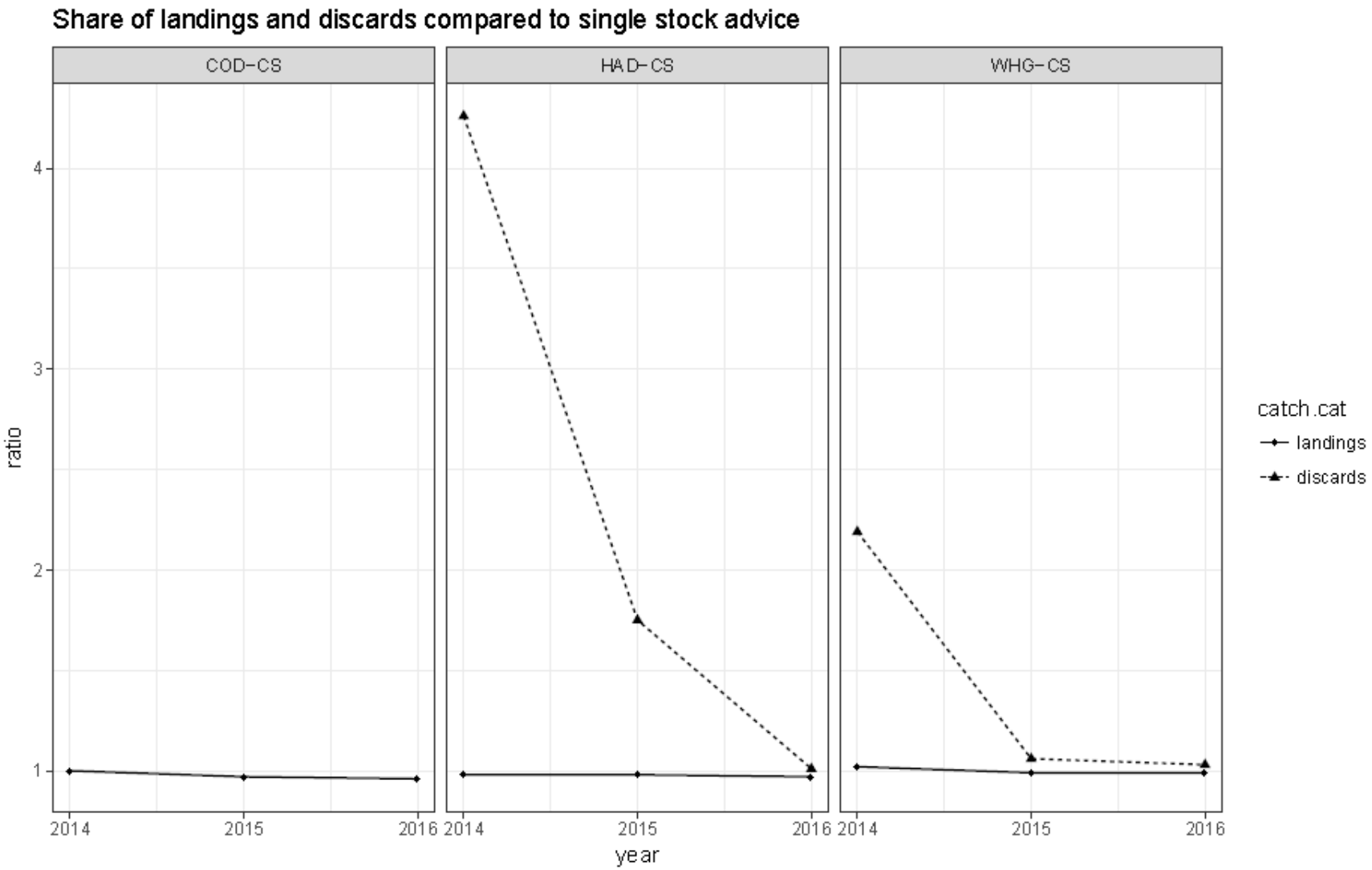


Figure 3.3. Celtic Sea. Ratio between the sum of landings (blue, l) and discards (red,d) across fleets used in the MIXFISH analysis and the landings and discards estimated by the WGCSE stock assessments.

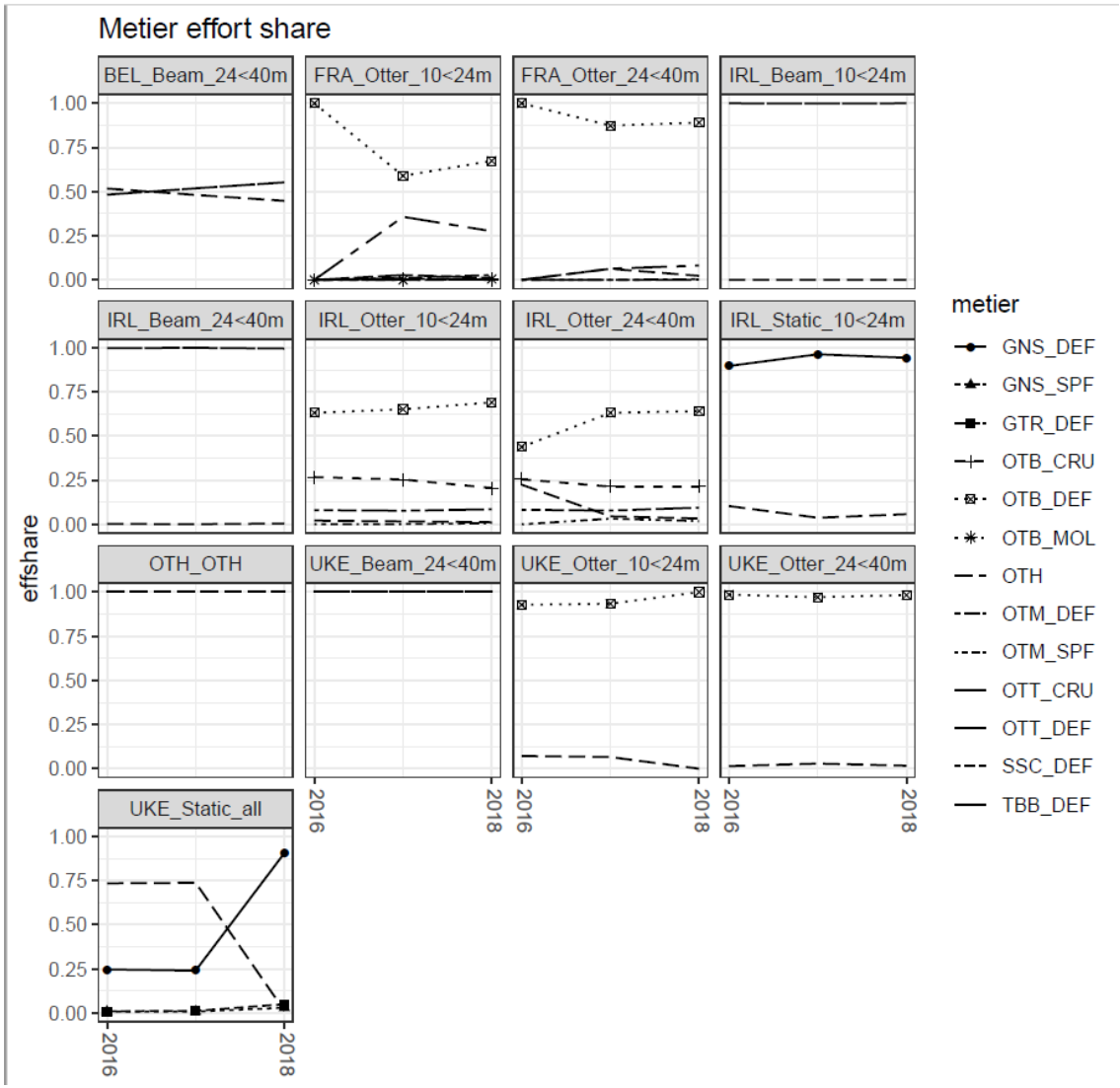


Figure 3.4. Effort share (in proportion) by métier for each fleet.

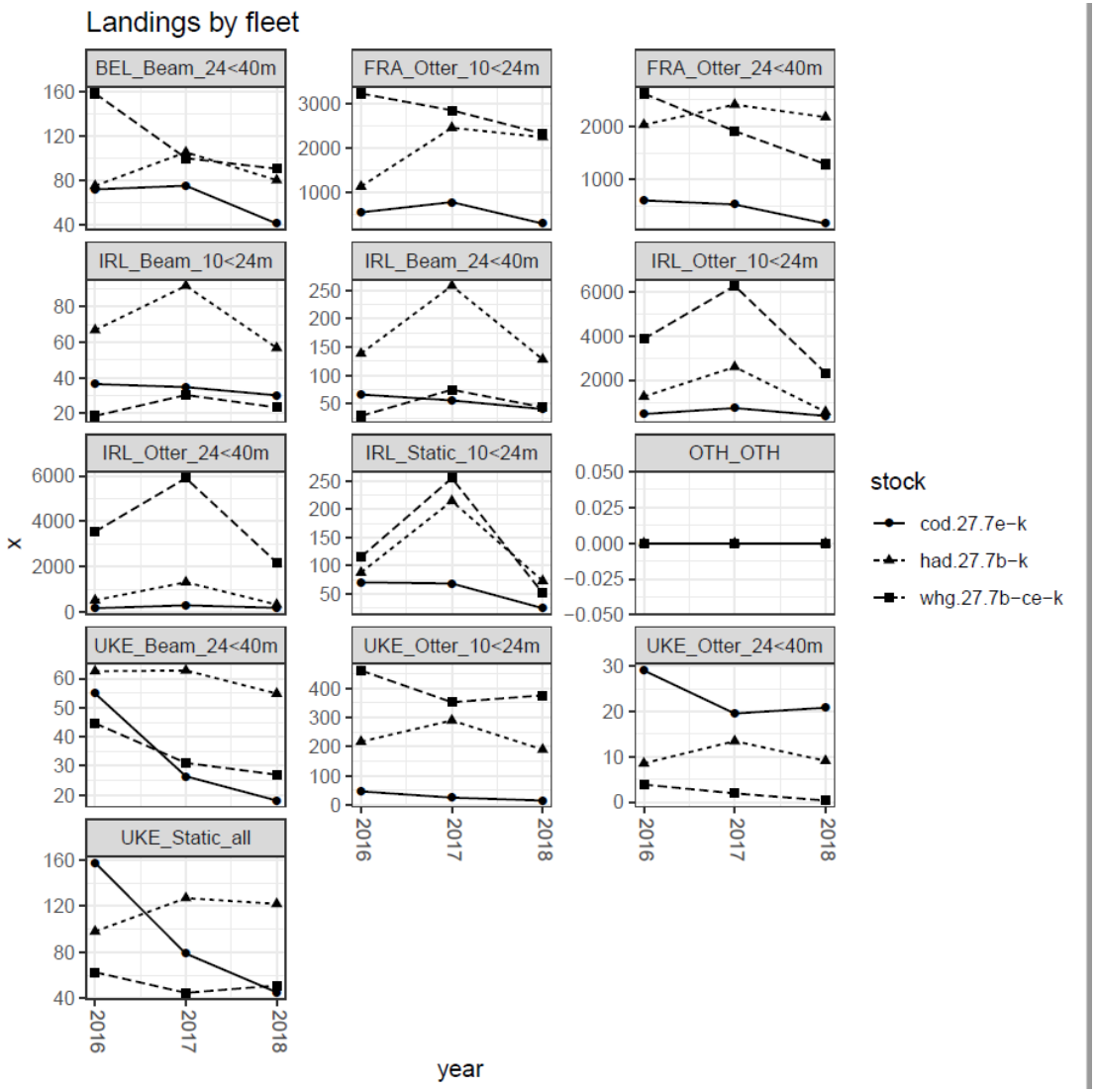


Figure 3.5. Landings by fleet, stock and year. Note: different scales on the y-axis.

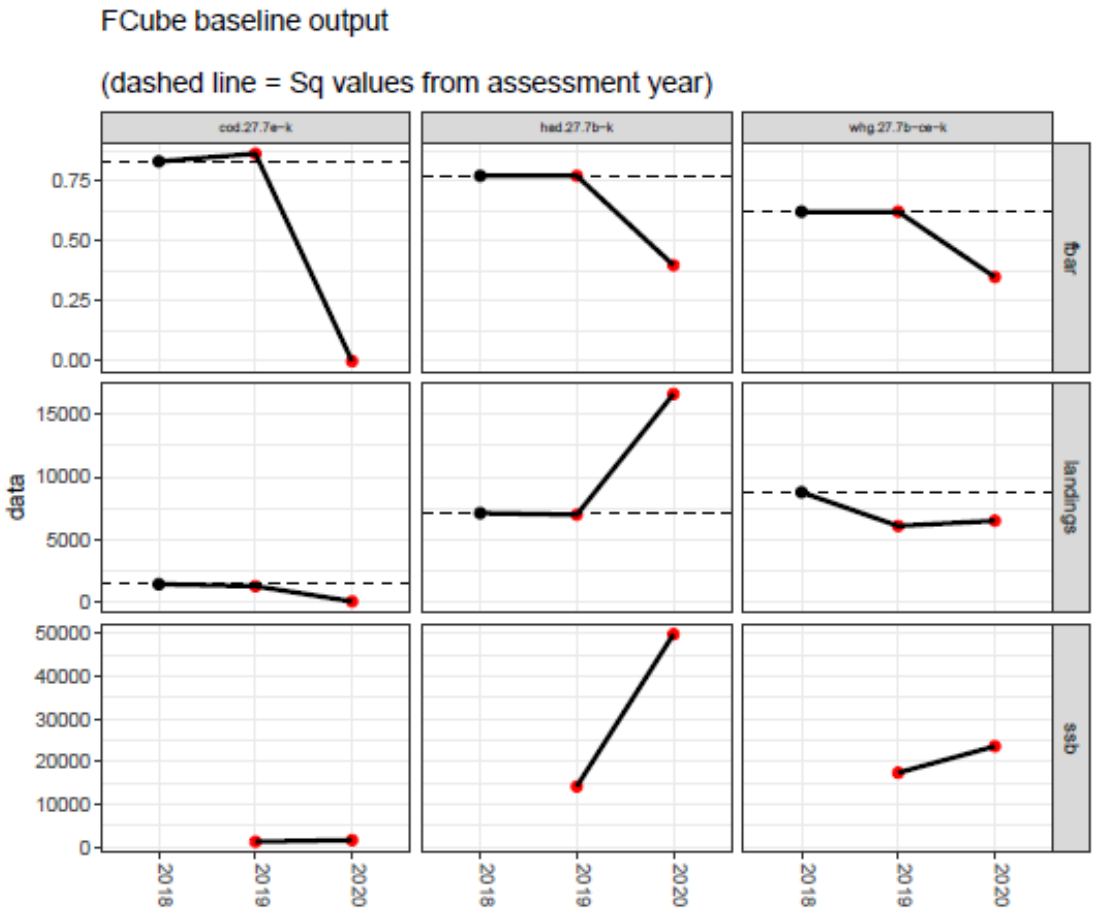


Figure 2: FCube baseline forecast Fs

Figure 3.6. Change in fishing mortality (Fbar), landings (tonnes) and SSB (tonnes) assumed in the intermediate year (2019) and required for the TAC year (2020) under the single-stock forecast assumptions consistent with the MSY approach.

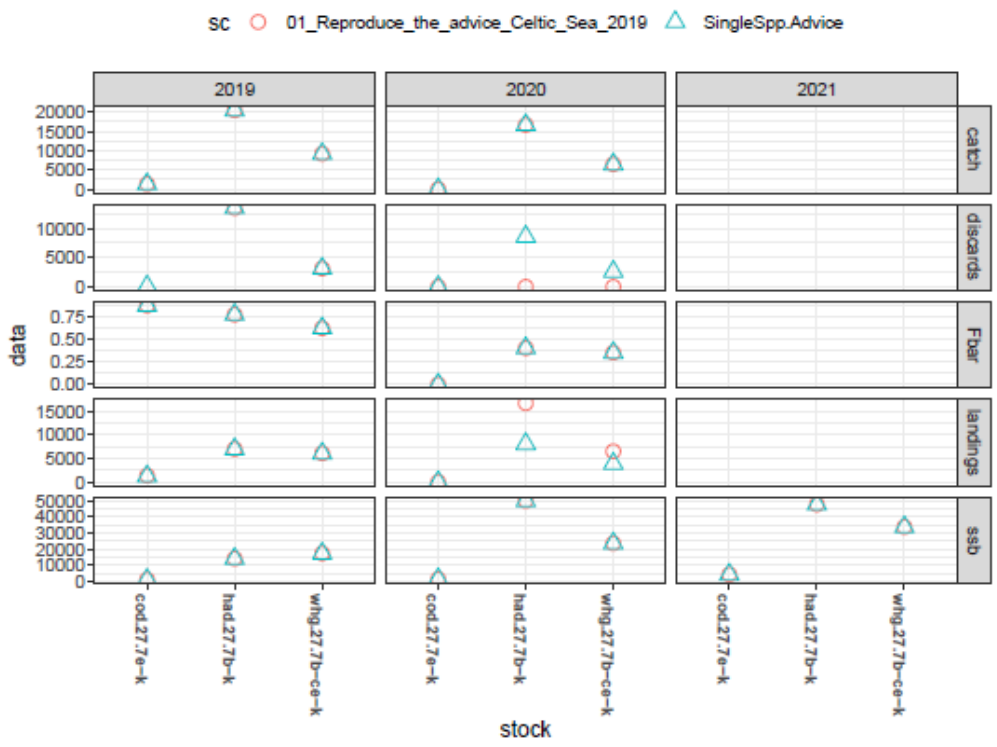


Figure 3.7. Celtic Sea. Difference between FCube baseline run and single-species advice for finfish stocks, showing Fbar (2019–2021), catch, discards and landings (2019–2020) and SSB (2019–2021).

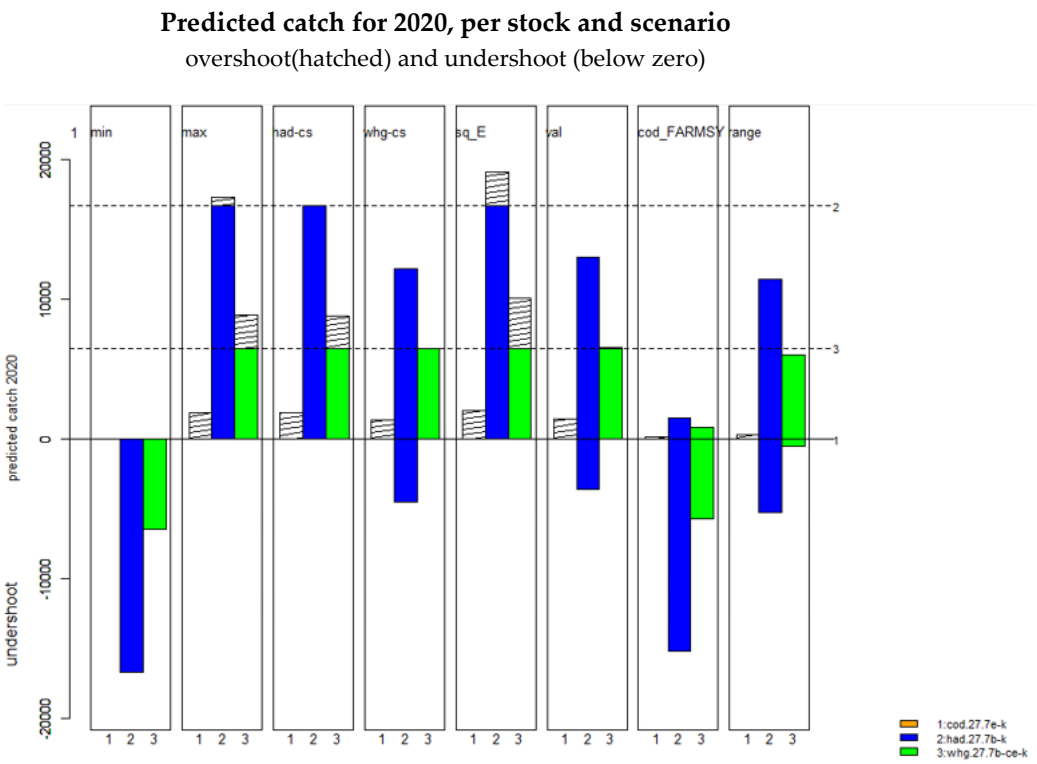


Figure 3.8. Celtic Sea. TAC year results (2020). FCube estimates of potential landings by stock after applying the status quo effort scenario to all stocks in the intermediate year followed by the FCube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species TAC) in cases where landings are predicted to be lower when applying the scenario.

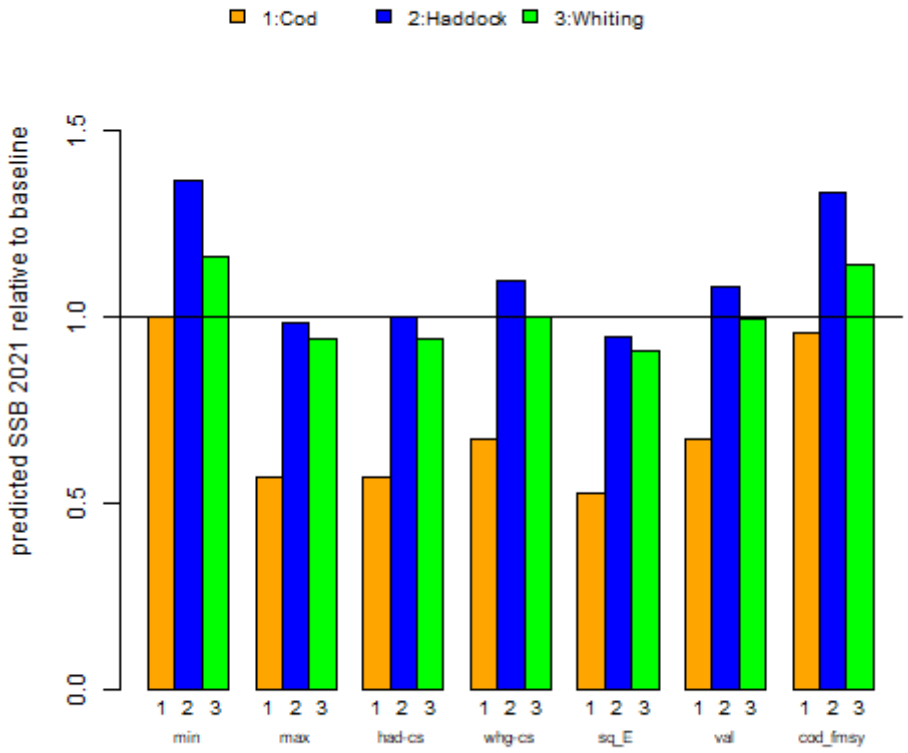


Figure 3.9. Mixed fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential SSB at the start of 2021 by stock after applying the mixed fisheries scenarios, relative to SSB resulting from the single-stock advice forecast (the horizontal line).

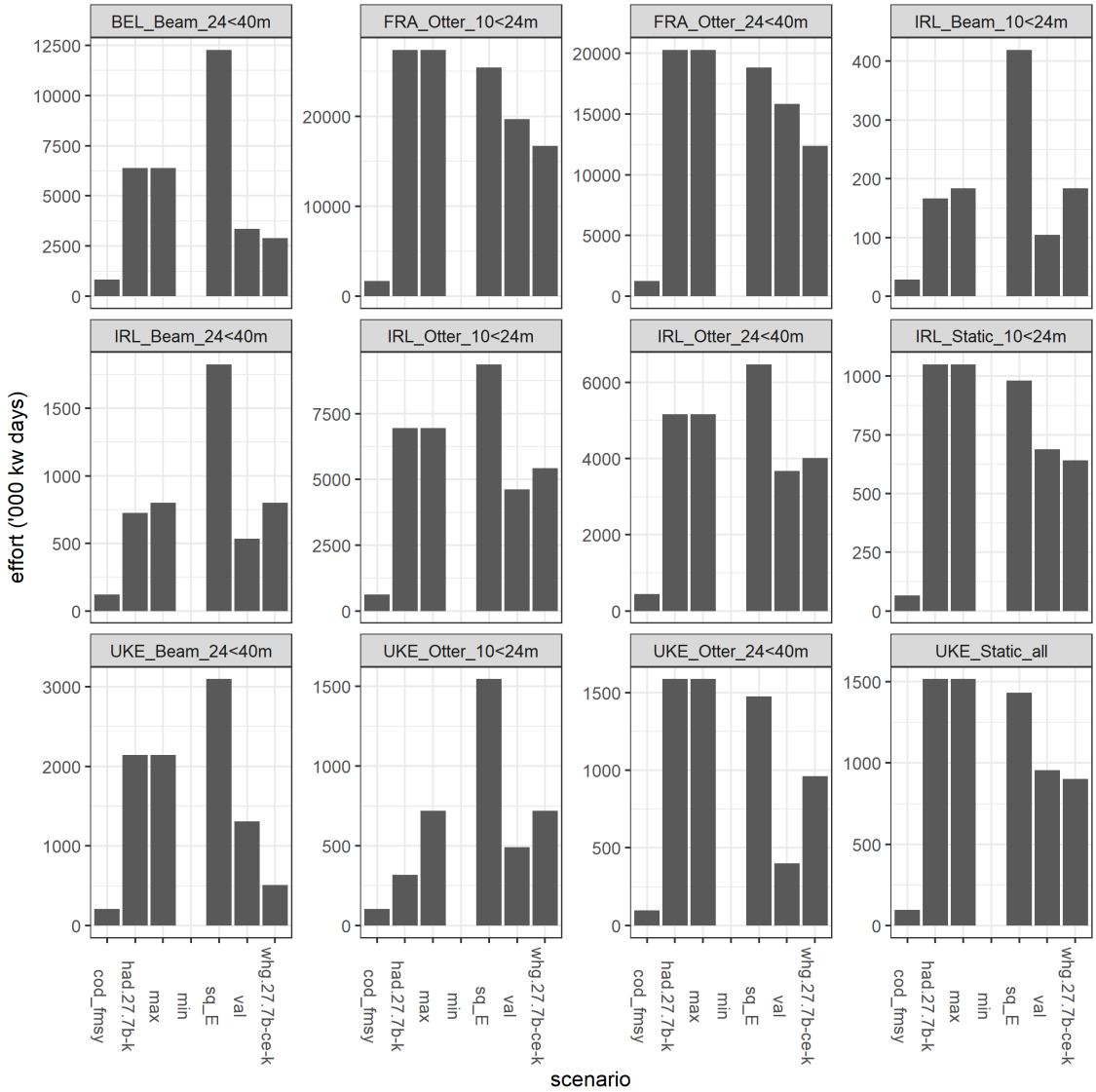


Figure 3.10. Celtic Sea. FCube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2020 (baseline run).

Figure 3.11. Mixed fisheries advice in the Celtic Sea. Relative fishing effort required to catch each quota by fleet. Each wedge represents the fishing effort required to catch one quota, with the fishing effort to reach the least limiting quota equal to one (outer edge of ring) coloured in green. The most limiting stock is coloured in red. The width of the wedge is proportional to the landings of the stock by the fleet in 2020.

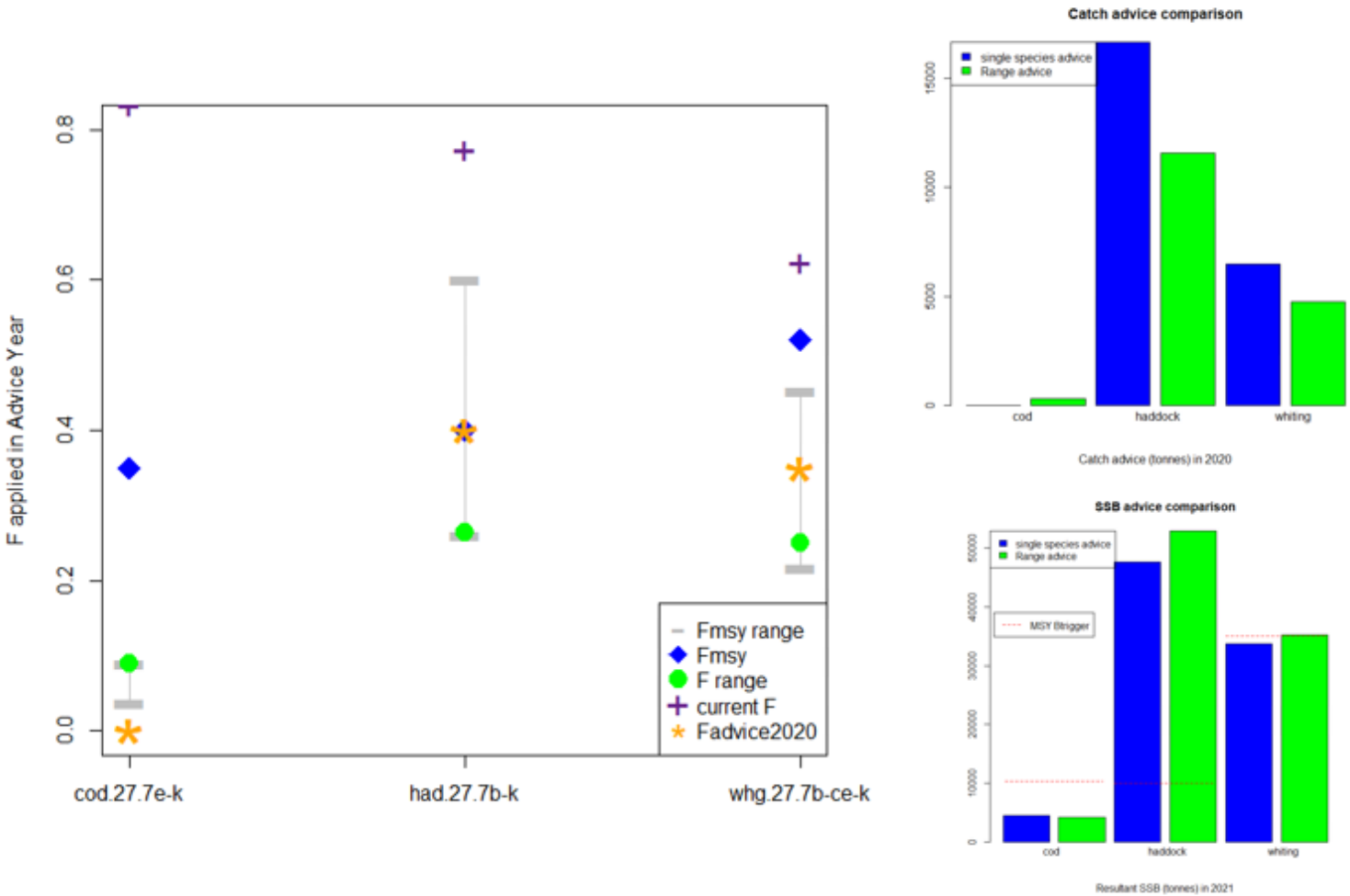
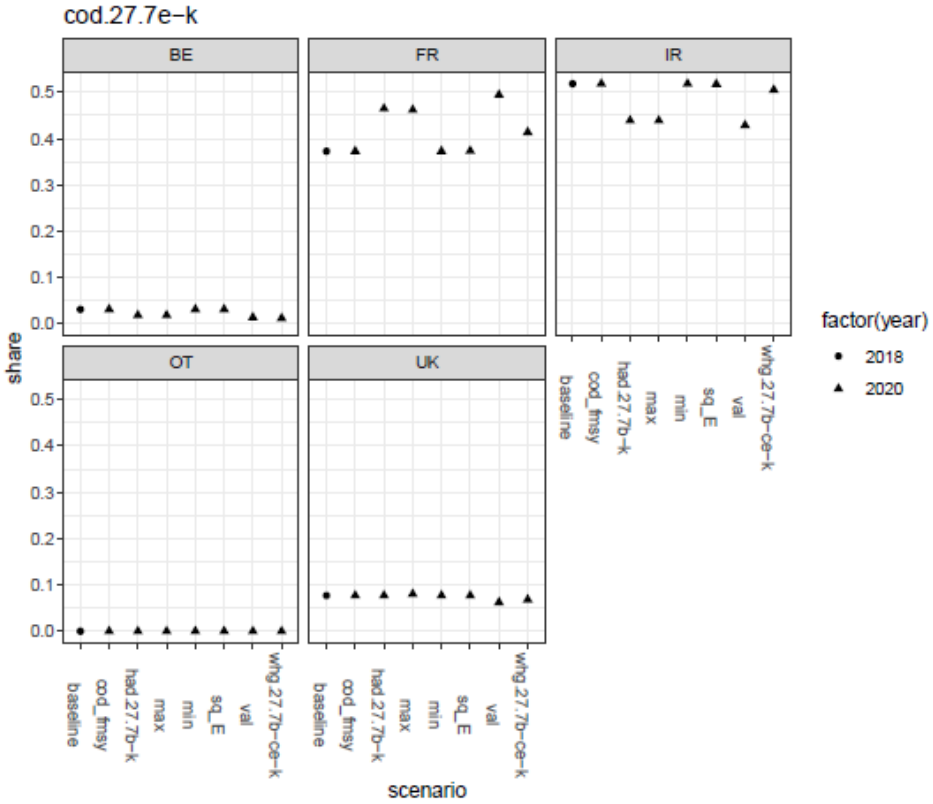
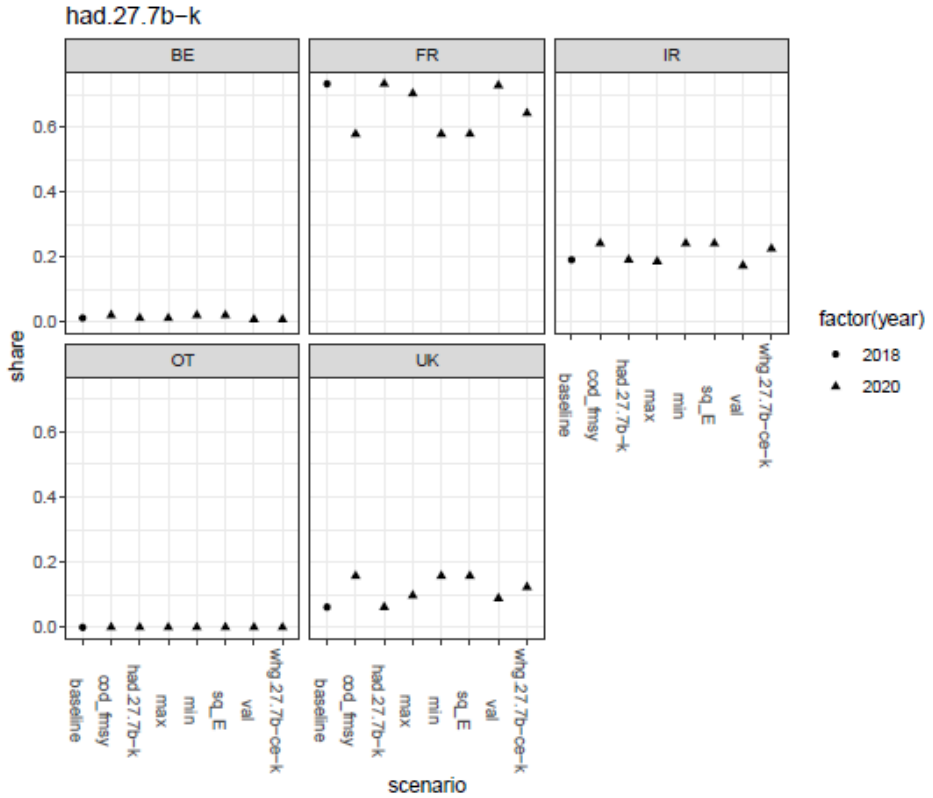


Figure 3.12. Range scenario advice for divisions 7.b–c and 7.e–k. Left: the fishing mortality rates for each stock which reduce the mismatch between opportunities for the three stocks (green point), along with the current fishing mortality (purple cross), the fishing mortality corresponding to the single-stock advice (yellow star) and the FMSY (blue rotated square) and the F_{MSY} ranges (grey lines). Right: Comparison of the outcomes in terms of total catches in 2020 (top) and SSB in 2021 (Bottom) between the FMSY-based single-stock advice and the F-range based forecast


cod.27.7e−k
BE
FR
IR
OT
UK
share
0.0
0.1
0.2
0.3
0.4
0.5
baseline
cod_fmsy
had.27.7b−k
max
min
sq_E
val
whg.27.7b−ce−k
scenario
factor(year)
2018
2020


had.27.7b−k
BE
FR
IR
OT
UK
share
0.0
0.2
0.4
0.6
baseline
cod_fmsy
had.27.7b−k
max
min
sq_E
val
whg.27.7b−ce−k
scenario
factor(year)
2018
2020

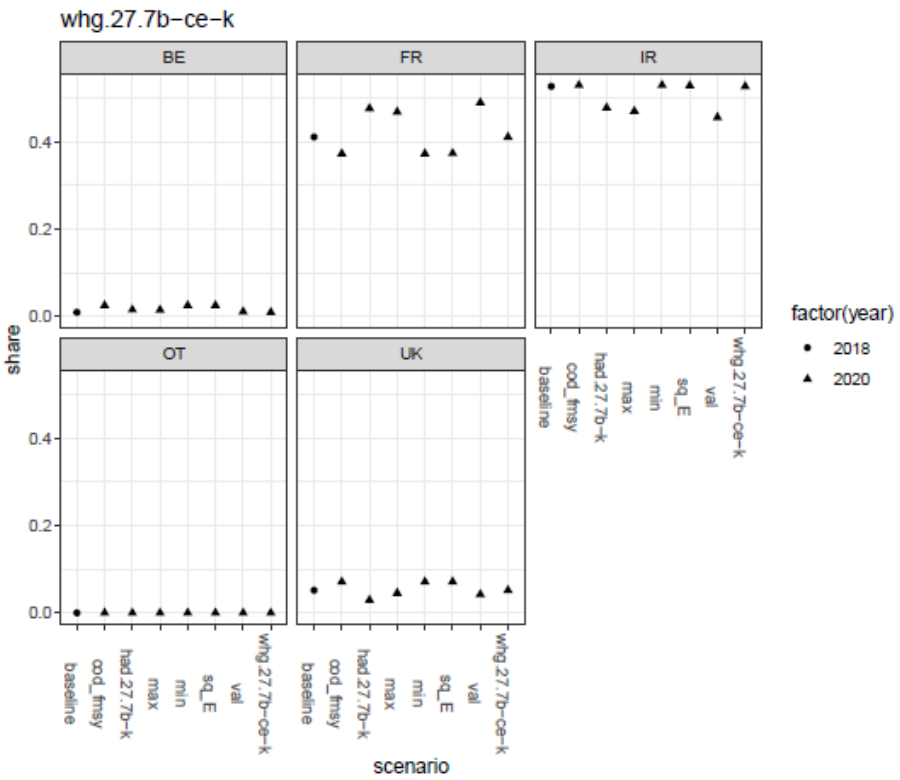


Figure 3.13. Test for relative stability. Changes of relative share of species' landings by country in 2019 and 2020 compared to the 2018 share, for the 'baseline' and 6 FCube scenarios.

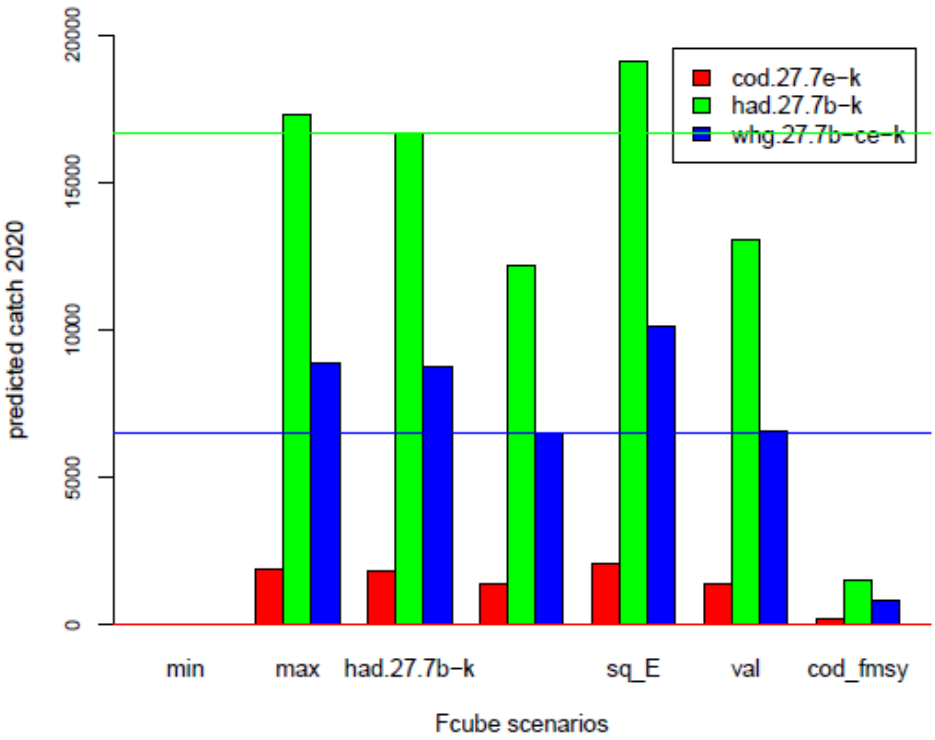


Figure 3.14. Celtic Sea predicted catch per mixed fisheries scenarios (2020).

4 Iberian waters

4.1 Background

4.1.1 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in Annex IVb of Council Regulation 27/2005 and amended by Council on an annual basis (Annex IIB since then). The objective of this management plan is the recovery of hake and *Nephrops* of ICES Divisions VIIIc and IXa, and it is applied in both Divisions with the exception of Gulf of Cadiz. The baselines assigned in 2018 (EU Regulation 2018/120) were based on track record per vessel on years 2015 and 2016.

The Regulation (EU) 2019/472 of the European Parliament and of the Council, published in 19 March 2019, has established a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending the (EC) Nº 2166/2005.

4.1.1.1 Stock-based management plans

Hake was the only stock considered here as part of the demersal mixed fisheries of the Iberian waters, which was subject to multiannual management plans (Council Regulation (EC) Nº 2166/2005). This plan seeks to rebuild the stock to safe biological limits, set as a spawning-stock biomass above 35 000 tonnes by 2016, and to reduce fishing mortality to 0.27. The main elements of the plan are a 10% annual reduction in F and a 15% constraint on TAC change between years. Since the enforcement of the plan, the stock historical perception has changed. The SSB of the recovery plan is therefore no longer valid and the stock has returned to a healthy state (ICES 2017).

The new multiannual management plan (EU Regulation 2019/472) includes the five stocks considered in the mixed fisheries analysis of Iberian Waters: hake, megrims and black and white anglerfishes.

4.2 FLBEIA

4.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.*, 2007); www.flr-pro-ject.org; FLCore 2.6.13; FLAssess 2.6.3; Flash 2.5.11) running with R 3.5.2 (R Development Core Team, 2018). All forecasts were projected using the FLBEIA Package (v1.15.4) (García *et al.*, 2017). FLBEIA is an FLR package that facilitates the bioeconomic evaluation of management strategies in a multi-stock and multi-fleet framework. It can be used to produce both short and long-term simulations.

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

Stocks	Assessment	Forecast
BLACK ANGLERFISH 8c9	Spict	NA
HAKE 8c9ac	GADGET	GADGET (script: predict.st.sh)
FOUR-SPOT MEGRIM 8c9a	XSA	MFDP

Stocks	Assessment	Forecast
MEGRIM 8c9a9a	XSA	MFDP
WHITE ANGLERFISH 8c9a	SS3	SS3 (ad hoc R code)

4.2.2 Scenarios

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

In 2019, single-stock ICES advice was given according to MSY approach for all stocks, except black anglerfish for which the precautionry approach was applied (Table 4.1). Therefore, the same basis was retained in the current mixed fisheries framework, in which the following seven scenarios are considered in the advice:

1. **"max"**: The underlying assumption was that fishing stops when all quota species are fully utilised with respect to the upper limit corresponding to single-stock exploitation boundary. Each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares. This option causes overfishing of the single-stock advice possibilities for most stocks.
2. **"min"**: The underlying assumption was that fishing stops when the catch for the first quota species meets the upper limit corresponding to single-stock exploitation boundary. Each fleet, fishing stops when the catch for any one of the stocks meets the fleet's stock share *. This option is the most precautionary option, causing underutilization of the single-stock advice possibilities of other stocks.
3. **"ank" / "Black anglerfish PA approach"**: The underlying assumption was that all fleets set their effort at the level corresponding to their black anglerfish quota share, regardless of other catches.
4. **"hke" / "Hake MSY approach"**: The underlying assumption was that all fleets set their effort at the level corresponding to their hake quota share, regardless of other catches.
5. **"ldb" / "Four-spotted megrim MSY approach"**: The underlying assumption was that all fleets set their effort at the level corresponding to their four-spot megrim quota share, regardless of other catches.
6. **"meg" / "Megrim MSY approach"**: The underlying assumption was that all fleets set their effort at the level corresponding to their megrim quota share, regardless of other catches.
7. **"mon" / "White anglerfish MSY approach"**: The underlying assumption was that all fleets set their effort at the level corresponding to their white anglerfish quota share, regardless of other stocks.
8. **"sq_E"/ "*Status quo* effort"**: The effort is set equal to the effort in the most recently recorded year for which landings and discard data are available (2018).

Additionally, the above eight scenarios were reproduced using a multi-stock harvest control rule (HCR) to estimate single-stock catch advice in 2020. A multi-stock HCR for the four stocks with an analytical assessment in Iberian Waters mixed fisheries, was developed following the methodology described in García *et al*. (2019). The objectives pursued by using a multi-stock HCR are: to provide a compatible catch advice among stocks, maximise the fishing opportunities and to generate fishing mortality levels compatible with the F_{MSY} ranges.

4.3 Stock input data and recent trends

4.3.1 Stocks

4.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGBIE (2019c). Two of the WGBIE stocks considered here are being assessed using statistical assessments: GADGET model for southern hake and SS3 for southern white anglerfish. Both assessments are length based and seasonal. However, the implementation of FLBEIA used in this analysis is annual and age based. These differences could produce significant differences in the projections carried out with both approaches. The projections carried out with FLBEIA are routinely compared to those carried out in the single-species assessment working group to assess the potential impact of using different approaches. The black anglerfish stock is assessed with a stock production model (SPiCT) and the results are only indicative of trends. The single-stock advice for black anglerfish is provided following ICES guidelines for category 3 stocks.

The results show variation mainly for hake and megrim, as such WGMIXFISH consider the difference may impact significantly on the mixed fisheries advice. The final dataset extracted from InterCatch for use by WGBIE includes discards estimates for all stocks and some métiers, and they are included in the assessment of hake and both megrims. InterCatch files also provided non-reported landings besides the official landings. The fleet files specifically required by the WGMIXFISH, needed to split landings by fleet segment and métier, were provided by Spain and Portugal with official landings and economic value. France only provided landings. Discards and non-reported landings were added during the meeting from the respective InterCatch files.

4.3.1.2 Trends and advice

The advice for these stocks is drafted by the WGBIE-2019 under considerations by ACOM. Recent trends in SSB, F and recruitment are described on a stock-by-stock basis in ICES (2019), and latest advice by stock is available on the ICES website. In order to give a global overview of all Iberian demersal stocks of interest to this analysis, this information is summarised below. It should be noted that although there is only one advice, additional management considerations are also listed in the single-species advice. The following table lists the final advised TACs for 2020 and expected SSBs in 2021.

Analytical stocks included in the advice

Species	Area	Stock status	Advice 2020
ank.27.8c-9a (black anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 2050 tonnes.

	Fishing pressure					Stock size				
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY} proxy	✓	✓	✓	Below proxy	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Below F_{MSY} proxy	B_{MGT}	✓	✓	✓	Above trigger
Qualitative evaluation	-	→	↘	↘	Decreasing	-	↘	↘	↘	Decreasing

Summary: The assessment is indicative of trends only. The stock biomass (B) increased from 2005 to 2016 and has since decreased. Fishing mortality (F) has decreased since 1994.

Species	Area	Stock status	Advice 2020
hke.27.8c-9a (Hake)	Divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)		ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 4694 tonnes and 8991 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (6615 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

	Fishing pressure					Stock size				
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	○	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✗	✗	✗	Above the range	B_{MGT}	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has increased since 1998 and has been above MSY $B_{trigger}$, B_{pa}, and B_{lim} since 2007. The fishing mortality (F) is decreasing although it remains above F_{MSY}, but below F_{pa} and F_{lim}. Since 2010, recruitment (R) has been close to the historical average.

Species	Area	Stock status	Advice 2020
ldb.27.8c-9a. (Four-spot Megrim)	Divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 1275 tonnes and 2651 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1885 tonnes) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two megrim species, *L. whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation rates, and could lead to overexploitation of either species.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Below the range		B_{MGT}	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has been increasing since 2002 and has been above MSY $B_{trigger}$ since 2008. Fishing mortality (F) has decreased in the last three years and is now below F_{MSY}. Recruitment has been variable without trend over the time series, and 2017 is the lowest estimated value.

Species	Area	Stock status	Advice 2020
meg.27.8c-9a (Megrim)	Divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 357 tonnes and 648 tonnes. According to the MAP, catches higher than those corresponding to FMSY (534 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two megrim species, *L. whiffiagonis* and *L. boscii*, under a combined species TAC prevents effective control of the single-species exploitation rates, and could lead to overexploitation of either species.

		Fishing pressure					Stock size				
		2016	2017	2018				2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✗	✓	✓	Below		MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably		B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✗	✓	✓	Within the range		B_{MGT}	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has generally increased from a minimum in 2008 and is well above MSY $B_{trigger}$ in 2019. Large variation is evident in fishing mortality (F) for much of the time series. F has declined from F_{lim} in 2014 to below F_{MSY} in the last two years. Estimated recruitment (R) from 2015 to 2017 is the highest since the mid-1990s.

Species	Area	Stock status	Advice 2020
mon.27.8c-9a (white anglerfish)	Divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)		ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 1519 tonnes and 2813 tonnes. According to the MAP, catches higher than those corresponding to FMSY (2146 tonnes) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule. Management of catches of the two anglerfish species, *Lophius budegassa* and *L. piscatorius*, under a combined species TAC prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

	Fishing pressure					Stock size				
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✓	Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✓	✓	✓	Below the range	B_{MGT}	✓	✓	✓	Above trigger

Summary: The spawning-stock biomass (SSB) has been increasing since 1994 and has been above MSY $B_{trigger}$ since 2005. Fishing mortality (F) has been decreasing and below F_{MSY} since 2010. Recruitment (R) has been low in recent years, with no evidence of strong year classes since 2001.

Nephrops stocks

Species	Area	Stock status	Advice 2020
Nephrops	Division 8.c, Functional Unit 25 (southern Bay of Biscay and northern Galicia)		ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021, and 2022. To ensure that the stock in Functional Unit 25 is managed sustainably, ICES advises that management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable
Qualitative evaluation	-	?	?	?	Unknown	-	✗	✗	✗	Below possible reference points

Summary: Catches and CPUE have fluctuated along a marked downward trend and are currently very close to zero. The *Nephrops* fishery in Division 8.c was closed in 2017 and 2018. The available information indicates that the stock is at a very low abundance.

Species	Area	Stock status	Advice 2020
Nephrops	Division 8.c, Functional Unit 31 (southern Bay of Biscay and Cantabrian Sea)		ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021, and 2022. To ensure that the stock in Functional Unit 31 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY} proxy	✓	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	?	?	?	Undefined	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	✓	?	?	Unknown	B_{MGT}	?	?	?	Undefined
Qualitative evaluation	-	✓	?	?	Unknown	-	✗	✗	✗	Below possible reference points

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. Qualitatively, the spawning stock size is below any possible biomass reference point.

Species	Area	Stock status	Advice 2020
Nephrops	Division 9.a, functional units 26–27 (Atlantic Iberian waters East, western Galicia, and northern Portugal)		ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021, and 2022. To ensure that the stocks in functional units 26–27 are exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY} proxy	✓	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	?	?	?	Undefined	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	✓	?	?	Unknown	B_{MGT}	?	?	?	Undefined
Qualitative evaluation	-	✓	?	?	Unknown	-	✗	✗	✗	Below possible reference points

Summary: ICES cannot assess the stock and exploitation status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points because the stock size reference point is undefined and current exploitation is unknown. Qualitatively, the spawning stock size is below any possible biomass reference point.

Species	Area	Stock status	Advice 2020
Nephrops	Division 9.a, functional units 28–29 (Atlantic Iberian waters East and south-western and southern Portugal)		ICES advises that when the precautionary approach is applied, catches in each of the years 2020 and 2021 should be no more than 309 tonnes. To ensure that the stock in Functional Units 28–29 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY} proxy	✓	✓	✓	Below proxy	MSY $B_{trigger}$	?	?	?	Undefined
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points	B_{pa},B_{lim}	?	?	?	Undefined
Management plan	F_{MGT}	✓	✓	✓	*Below proxy	B_{MGT}	?	?	?	Undefined
Qualitative evaluation	-	↗	↗	↘	Decreasing	-	↗	↘	↗	Increasing

Summary: Standardized commercial CPUE (used as the stock size indicator) has increased since 2011 and the mean size of individuals has been relatively stable over the past decade.

Species	Area	Stock status	Advice 2020
Nephrops	Division 9.a, Functional Unit 30 (Atlantic Iberian waters East and Gulf of Cadiz)		ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 77 tonnes. To ensure that the stock in Functional Unit (FU) 30 is exploited sustainably, management should be implemented at the functional unit level.

		Fishing pressure				Stock size				
		2016	2017	2018			2017	2018	2019	
Maximum sustainable yield	FMSY	?	?	?	Undefined	MSY Btrigger	?	?	?	Undefined
Precautionary approach	Fpa,Flim	?	?	?	Undefined	Bpa,Blim	?	?	?	Undefined
Management plan	FMGT	—	—	—	Not applicable	BMGT	—	—	—	Not applicable
Qualitative evaluation	-	↗	↘	↘	Decreasing	-	↗	↘	↘	Decreasing

Summary: Stock abundance has decreased from 2017 onwards. The harvest rate has decreased from 2016.

Ancillary stocks

Species	Area	Stock status	Advice 2020
bss.27.8c-9a (Seabass)	Divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, commercial catches in each of the years 2020 and 2021 should be no more than 478 tonnes. All commercial catches are assumed to be landed. Recreational catches cannot be quantified and therefore total catches cannot be calculated.

		Fishing pressure				Stock size				
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	—	—	—		B_{MGT}	—	—	—	
Qualitative evaluation	-	?	?	?	Unknown	-	?	?	?	Unknown

Summary: The commercial landings in the last two decades have been variable. Recreational catch is unknown but may be substantial.

Species	Area	Stock status	Advice 2020
ple.27.8-9a (Plaice)	Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, wanted catches in each of the years 2020 and 2021 should be no more than 155 tonnes. ICES cannot quantify the corresponding total catches.
pol.27.8-9a (Pollack)	Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, commercial catches in each of the years 2020 and 2021 should be no more than 1131 tonnes. All commercial catches are assumed to be landed. ICES cannot quantify the corresponding total catches because the recreational catches cannot be quantified.

ple.27.8-9a (Plaice)

		Fishing pressure					Stock size				
		2016	2017	2018				2016	2017	2018	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown		MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown		B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	–	–	–			B_{MGT}	–	–	–	
Qualitative evaluation	-	?	?	?	Unknown		-	?	?	?	Unknown

Summary: Landings have steadily decreased since 2010, with lowest values observed in 2017 and 2018. The available information is insufficient to evaluate stock trends and exploitation status.

pol.27.8-9a (Pollack)

		Fishing pressure					Stock size				
		2016	2017	2018				2016	2017	2018	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown		MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown		B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	–	–	–	Not applicable		B_{MGT}	–	–	–	Not applicable
Qualitative evaluation	-	?	?	?	Unknown		-	?	?	?	Unknown

Summary: The commercial landings have been stable for the last 19 years. The information available is insufficient to evaluate stock trends and exploitation status.

Species	Area	Stock status	Advice 2020
sol.27.8c-9a (Sole)	Divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, catches in each of the years 2020 and 2021 should be no more than 502 tonnes. Management of catches of all sole species under a combined TAC prevents effective control of each single-species exploitation rate and could potentially lead to overexploitation of all of the species.
whg.27.8-9a (Whiting)	Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)		ICES advises that when the precautionary approach is applied, catches in each of the years 2019, 2020, and 2021 should be no more than 2276 tonnes.

sol.27.8c-9a (Sole)

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY}	?	?	?	Unknown	MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	?	Unknown	B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	?	?	?	Unknown	B_{MGT}	?	?	?	Unknown
Qualitative evaluation	-	?	?	?	Unknown	-	?	?	?	Unknown

Summary: Catches of sole have generally increased across the time-series, with a relatively stable period from 2010. The available information is insufficient to evaluate stock trends.

whg.27.8-9a (Whiting)

		Fishing pressure				Stock size			
		2016	2017	2018			2016	2017	2018	
Maximum sustainable yield	F_{MSY} proxy	✓	✓	✓	Below proxy	MSY $B_{trigger}$	?	?	?	Unknown
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Below possible reference points	B_{pa},B_{lim}	?	?	?	Unknown
Management plan	F_{MGT}	✓	✓	✓	*Below proxy	B_{MGT}	?	?	?	Unknown
Qualitative evaluation	-	–	–	–	-	-	?	?	?	Unknown

Summary: Landings have been fluctuating without trend over the time period and have decreased in the last three years. Discard rates have been stable.

4.4 Fleets and métiers

4.4.1 Catch and effort data

Métier-based landings and effort files requested by the WGMIXFISH data call were provided by the three countries with fleets operating in Atlantic Iberian waters, i.e. Spain, Portugal and France. InterCatch data files are used to compile discards and non-reported landings which are not provided in the MIXFISH datacall. Due to problems with the quality and disaggregation of the historical data only the last three years (2016–2018) were used to carry out a comparison of effort and catches by country, fleet and métier. Proportion of landings by stock considered in the mixed fisheries projections are presented in Figure 4.1. Hake was the dominant species, comprising of 77% of total landings, followed by white anglerfish (9%).

4.4.2 Definitions of fleets and métiers

The WGMIXFISH data call provided landings and effort which was combined to provided fleet and métier information for Spain, Portugal and France. As France only submit estimated landings of hake, they are not considered in the single-species hake assessment, and therefore, to ensure consistency they not included in the mixed fisheries analysis. The final data provided to the WG contained 14 métiers (Table 4.2).Regarding fleet segments, vessel size categories were not included because in the case of Spanish trawlers the disaggregation by length match the disaggregation by métier. In the case of Portugal, the contribution of the smallest categories was small, and their catch profile was similar to the biggest category, hence a single fleet was used for the three categories.

Total catches (in weight) were obtained by multiplying the catch-at-age in numbers by the average weight at age used as input in the WGMIXFISH analysis are compared with the total catches (in weight) used by WGBIE in the single-species assessments (Table 4.3). The largest discrepancies were observed for hake (2%). The structure of the stock assessment model used in WGBIE (seasonal, length structure and with observation error in catches) and that of the short-term forecast used here (annual and age structured) are different and this difference is probably causing the differences.

The original 14 métiers were regrouped for the mixed fisheries analysis according to the their target assemblage of species and the technical characteristics of the fishing gear, resulting in 10 métiers Figure 4.2). Hake provides the highest catches of all métiers except for DEF_>=100_0_0, which corresponds with the Spanish gillnet targeting white anglerfish ("*rasco*"). Megrim are mainly caught by the bottom otter trawl métiers, identified here as DEF_>=55_0_0 and DEF_>65_0_0.

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

4.4.3 Trends

Analyses of trends by fleet were carried out on 2016–2018 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. In order not to extend the report with repetitive graphics, only the catchability plots by stock, fleet and métier for Spain (Figure 4.3) and Portugal (Figure 4.4) are included in this report. With only three years of data it is not possible to ensure that there is

any trend in the data. There is evidence of more long trends in the data. However, no assessment has been made on the impact of this variability on the results, therefore it is not possible to anticipate the possible impact of this variability. In some specific cases, like hake and black anglerfish in Spanish otter trawlers or megrim in Portuguese otter trawlers, the catchability has decreased since 2016 which points out a possible decreasing trend that should be confirmed when more data is available.

4.5 Mixed fisheries forecasts

Discrepancies were found between the FLBEIA baseline runs and the single-stock forecasts. Discrepancies in catches were important for hake, four-spot megrim and white anglerfish (Table 4.5). These discrepancies in the case of hake an white anglerfish are attributed to methodological differences between the length-based, seasonal and statistical assessment models used by WGBIE and the age-based annual forecast used by WGMIXFISH. The differences in the SSB of the megrims are lower than 2% (Table 4.6) but the for SSB of hake are around 11%. There are differences in the weights at age used in both approaches that should be investigated for four-spot megrim and hake.

4.5.1 Description of scenarios

4.5.1.1 Baseline runs

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

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

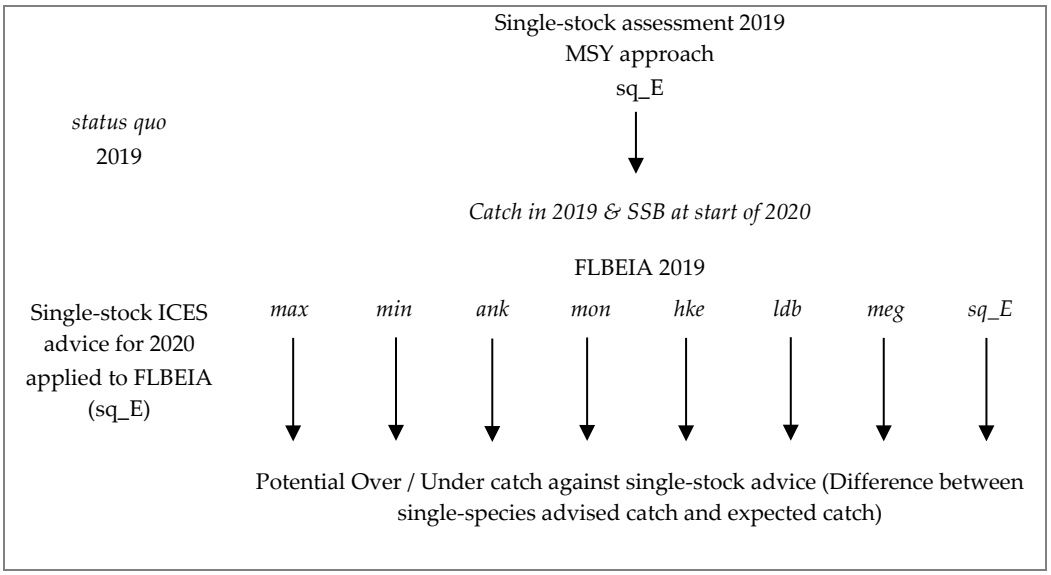
The various single-stock forecasts presented by WGBIE are performed using different software and setups (see 4.2.1 above). However, for the purposes of the mixed fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the "FLBEIA" library (García *et al*., 2017). The same forecast settings as in WGBIE are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY approach).

4.5.1.2 Mixed fisheries runs

The mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2019), with the FLBEIA scenarios used for the TAC year (2020). The *status quo* effort assumption for the intermediate year is considered a plausible assumption because is in line with the standard single-stock short-term forecasting approach.

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

In summary, the FLBEIA runs followed the scheme below:



4.5.2 Results of FLBEIA runs

4.5.2.1 Baseline runs

The rationale behind the single-species baseline runs is given in Section 4.3.1.2. The ICES single-stock advice for four stocks in 2019 (ICES, 2019) is based on the maximum sustainable yield (MSY) approach and on precautionary approach for black anglerfish. The issues and problems encountered in replicating the single-species advice for each species are given below. The results from these baseline runs are compared with the results from the corresponding ICES runs in Table 4.4 to Table 4.6.

There are some differences between the single-stock catch and SSB values, and the values obtained from the baseline run scenario. For catch the difference is around 11% for four-spot megrim and hake, and around 12% for white anglerfish (Table 4.4). In SSB the difference for hake was around 13% and for the rest of the stocks it was lower than 7% (Table 4.6). The higher differences in F was presented for four-megrim with 11% of discrepancies (Table 4.6). For hake and white anglerfish, differences are expected because the length-based seasonal models used in the stock assessments are approximated with annual age-based models in the mixed fisheries analysis. The reasons for the discrepancy is unknown in the case of the megrims, although the different catch equation used by FLBEIA might have an impact. This issue could not be investigated in depth at this time.

Hake: Discrepancies around 13% were obtained for hake in SSB and 11% in catches. This stock is assessed by the GADGET model (Frøysa *et al.*, 2002; Begley and Howell, 2004), a stochastic assessment model which is difficult to simulate in a mixed fisheries deterministic forecast. GADGET is a forward simulation model that can be structured in both age and length; therefore requiring direct modelling of growth within the model. In the case of southern stock of hake, the model is length based and F multipliers do not apply linearly.

Four-spot megrim: Discrepancies in biomass were negligible but here were bigger differences in landings (~11%). This stock is assessed by applying the XSA model. Differences in landings between single-stock assessment and FLBEIA may be caused by the different catch equation used in FLBEIA. In 2014, a benchmark (WKSOUTH) was undertaken in order to include discards on the assessment (ICES, 2014).

Megrim: Discrepancies in biomass were low (< 2%) but here were bigger differences in landings (~5%). This stock is assessed by applying the XSA model. In 2014, a benchmark (WKSOUTH) was undertaken in order to include discards on the assessment (ICES, 2014).

White anglerfish: Discrepancies of 6% in SSB and of 12% for landings were obtained for white anglerfish. The assessment of this stock is performed by applying the SS3 model (Methot, 2000) disaggregated by length. This methodology is applied to this stock since it was accepted in the WKFLAT benchmark in 2012 (ICES, 2012) to replace the previous assessment method (ASPIC; Prager, 1994). In 2018, the stock was benchmarked (ICES, 2018b) and some of the model setting were changed.

The initial WG purpose of investigating in depth the reasons for potential discrepancies was not possible to fulfil with the time available during the WG meeting. However, the results were considered still illustrative regarding the modelling of the technical interactions between stocks and fleets.

4.5.2.2 Mixed fisheries analyses

The full overview of the FLBEIA projections to 2020 is presented in Table 4.7, Figure 4.5 and Figure 4.6. The results for 2020 can be compared to each other as in a single-species option table. For ease of comparison, the landings relative to the single-stock advice are also presented (Figure 4.5).

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

ICES single-stock advice provides TACs expected to meet single-stock F_{MSY}. To be consistent with these objectives a scenario is necessary that delivers the SSB and/or F objectives of the single-stock advice for all stocks considered simultaneously. The "min" scenario meets this outcome. Additionally, this scenario assumes that fleets would stop fishing when their first stock share is exhausted, regardless of the actual importance of this stock share for the fleet. This scenario reflects the constraints that result from a strictly implemented discard ban. Fishing effort should be reduced more than 58% of its 2018 level to comply with this scenario, consistent with the reductions in fishing mortality advised for hake, and causing reductions of catches in the remaining species higher than those determined by their respective single-stock advice.

The results of **"ank"** scenario are the same of those of the "max" scenario indicating that black anglerfish would be the least limiting stock. Within the scenarios based on each of the stocks, the "**hke**" scenario gives the same result as the "min" scenario, showing hake as the choke species. This scenario reflects the target fishing mortality as set for the hake MSY approach; however the results present loss of fishing opportunities for black and white anglerfish and, in a lesser extent, for megrims. The SSB_{2021} estimated for hake in "**hke**" scenario was 25% lower than the value estimated by the single-stock forecast (Figure 4.6). This discrepancy is not related with the differences between models (GADGET and FLBEIA) and no explanation was found during the working group. The potential reasons should be investigated deeper with the stock assessor of hake stock.

The "**ldb**" and "**meg**" scenarios provide a very similar perspective, almost doubling the fishing opportunities of the stocks in comparison with the "hke" scenario. Megrims and anglerfishes are mainly caught by bottom otter trawl gears, while hake occurs in the catches of almost all the Iberian métiers. The "**mon**" scenario estimates effort levels close to "ank" and "max" scenarios.

This scenario maintains the single-stock advice for white anglerfish, but doubles the single-stock advice for hake and almost doubles the advice for four-spot megrim.

The "**sq_E**" scenario is almost in the middle of "hke" and "ank" scenarios. Under this scenario the quota of megrim for 2020 would be caught and almost the entire quota of four-spot megrim. However, with this level of effort, the hake catches would double the hake quota and anglerfishes catches would be less than half of their quotas.

Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input was derived from the landing share by fleet and stock in 2018. The landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results did not show big deviations across all scenarios (Figure 4.8).

Multi-stock HCR scenarios

The multi-stock HCR was applied to the last assessment results to estimate the TAC advice for 2020 using this HCR instead of the MSY approach. The F-advice for 2020 obtained with the multi-stock HCR, together with the Fsq and the Fmultiplier, are shown in Table 4.8. The multi-stock HCR resulted in the upper limit advice for hake ($F_{MSY\_upper} = 0.36$) and advice below lower limits for white anglerfish and megrims.

The results for the eight scenarios where a multi-stock HCR is used for setting single-stock fishing opportunities for 2020 are presented in Table 4.9, Figure 4.9 and Figure 4.10. The **"max"** scenario provide same results as **"hke"** scenario, indicating that hake would the least restrictive stock among the scenarios using multi-stock HCR. The remaining four single-stock scenarios and the **"min"** scenario show very close results, limiting in all cases the catches of hake. Considering the scenario with effort *status-quo* in 2020, catches for all stocks would be above the single-stock advice and for white anglerfish and the four-spot megrim would be almost doubled.

Table 4.1. Iberian waters: Summary of the 2020 landings and target Fs, resulting from the Advice Approaches considered by ICES. TACs make reference to total catches, as they are used in the as-assessment model, except for black and white anglerfish, which represent only landings.

Stock	TAC 2020	F 2020	SSB 2021	Rational
Black anglerfish 8c9a	2050 t	n/a	n/a	Precautionary approach
Hake 8c9a	6615 t	0.25	29972 t	MSY approach
Four-spot megrim 8c9a	1885 t	0.19	8673 t	MSY approach
Megrim 8c9a	534 t	0.19	2330 t	MSY approach
White anglerfish 8c9a	2146 t	0.24	11251 t	MSY approach

Table 4.2. Métier categories used in the Iberian waters mixed fisheries analysis.

Acronym	DCF definition	Description
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Spanish set gillnet ("*rasco*") targeting white anglerfish in ICES Division 8c with mesh size of 280 mm

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

Table 4.3. Iberian waters: Proportion of the stocks total catches (from WGBIE) covered by the WGMIXFISH fleets. A ratio >1 means that the catch information in WGMIXFISH is larger than the information used by WGBIE.

YEAR	STOCK	WGBIE	WGMIXFISH	DIFFERENCE	RATIO
2018	ANK	764	764	0	1.00
2018	HKE	12125	11843	282	0.98

YEAR	STOCK	WGBIE	WGMIXFISH	DIFFERENCE	RATIO
2018	LDB	906	909	3	1.00
2018	MEG	352	352	0	1.00
2018	MON	1153	1149	4	1.00

Table 4.4. Iberian waters: Baseline run outputs from the FLBEIA package.

Management Plan		ANK	HKE	LDB	MEG	MON
2019	Fbar	-	0.68	0.17	0.191	0.093
	Fmult	-	1.13	1.87	1.12	1
	Landings	726	10320	1388	485	1050
	SSB	-	17357	8843	2650	13690
2020	Fbar	-	0.25	0.19	0.19	0.24
	Fmult	-	0.37	1.14	1	2.6
	Landings	2050	4737	1672	509	2146
	SSB	-	17479	8840	2488	13660
2021	SSB	-	25989	8673	2285	11981

Table 4.5. Iberian waters: Comparison between baseline run and ICES advice. Figures for 2019 compare results from the baseline run - that use the same assumptions for F in the intermediate year as the forecasts leading to ICES advice–to the ICES intermediate year results.

		ANK	HKE	LDB	MEG	MON
2019	Catches Baseline	726	12755	1778	508	1181
	Catches ICES	-	14368	1596	522	1050
	% diff	-	0.89	1.11	0.97	1.12
2020	Catches Baseline	.	6615	1885	505	2146
	Catches ICES	2050	6615	1885	534	2146
	% diff	-	1	1	0.95	1

Table 4.6. Iberian waters: FLBEIA baseline run outputs for SSB and F relative to ICES advice.

	SSB_2018	SSB_2019	SSB_2020	SSB_2021	F_2018	F_2019	F_2020
HKE	0.99	1	1	0.87	1.03	0.91	0.96
LDB	1	1	1	1	1	0.89	0.91
MEG	1	1	0.99	0.98	1	1	0.98
MON	1	1.02	1.03	1.06	1	1.02	1.05

Table 4.7. Results of running FLBEIA scenarios on the TAC year (2020). Comparison of the single-stock ICES advice and potential landings in the various FLBEIA scenarios.

	Single Stock Catches advice in 2020		Catches per mixed-fisheries scenario 2020 relative to the single-stock catch advice							
	WGBIE	WGMIXFISH	"max"	"min"	"ank"	"hke"	"ldb"	"meg"	"mon"	"sq_E"
ank.27.8c9a	2050	2050	1	0.22	1	0.22	0.42	0.37	0.86	0.35
hke.27.8c9a	6615	6615	2.4	1	2.4	1	1.92	1.79	2.4	1.82
lbd.27.8c9a	1885	1885	2	0.48	2	0.48	1	0.9	1.83	0.93
meg.27.8c9a	534	505	1.36	0.56	1.36	0.53	1.11	1	1.28	1.03
mon.27.8c9a	2146	2146	1.15	0.25	1.14	0.25	0.47	0.42	1	0.46

Table 4.8. Fishing mortalities obtained from multi-stock HCR. Fadv is shown in the third row.

	HKE	LDB	MEG	MON
Fsq	0.68	0.17	0.191	0.093
Fmult	0.53	0.53	0.53	0.53
Fadv	0.36	0.09	0.10	0.05

Table 4.9. Results of running FLBEIA scenarios on the TAC year (2020) using multi-stock HCR.

	TAC multi-stock HCR	“max"	“min"	"ank"	"hke"	"ldb"	"meg"	"mon"	"sq_E"
ank.27.8c9a	458	1.3	0.8	1.0	1.3	0.9	0.9	0.9	1.6
hke.27.8c9a	8991	1.0	0.6	0.7	1.0	0.7	0.7	0.7	1.3
lbd.27.8c9a	943	1.3	0.8	1.0	1.3	1.0	1.0	0.9	1.8
meg.27.8c9a	297	1.2	0.8	0.9	1.2	0.9	0.9	0.8	1.5
mon.27.8c9a	479	1.5	1.0	1.1	1.5	1.1	1.0	1.0	2.0

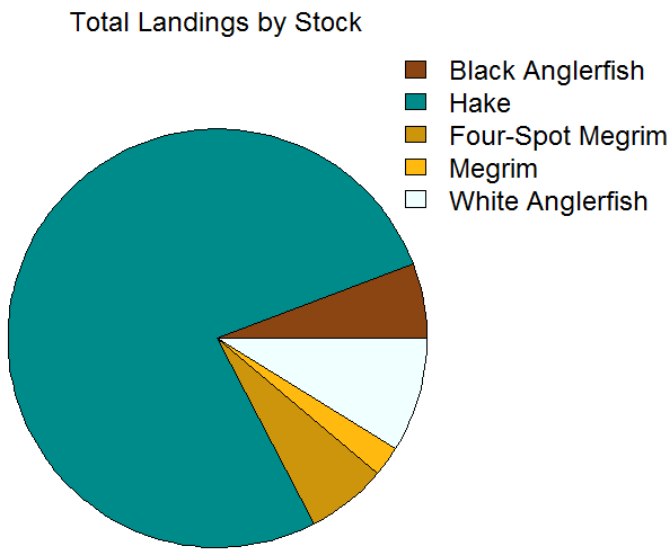


Figure 4.1. Iberian waters: Distribution of landings of the stocks included in the mixed fisheries projections.

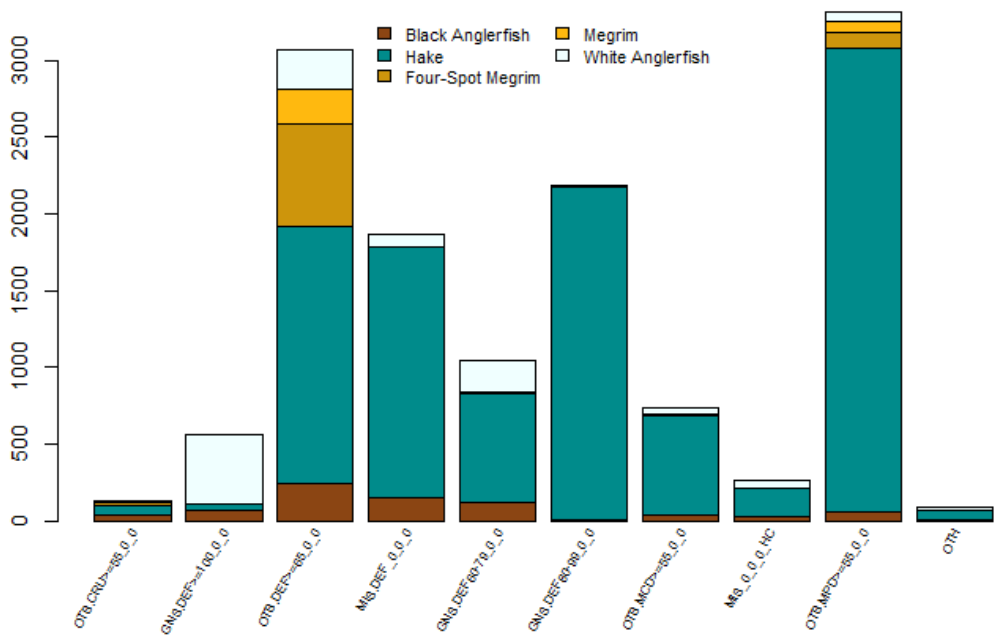


Figure 4.2. Iberian waters: Landings distribution of species by métier

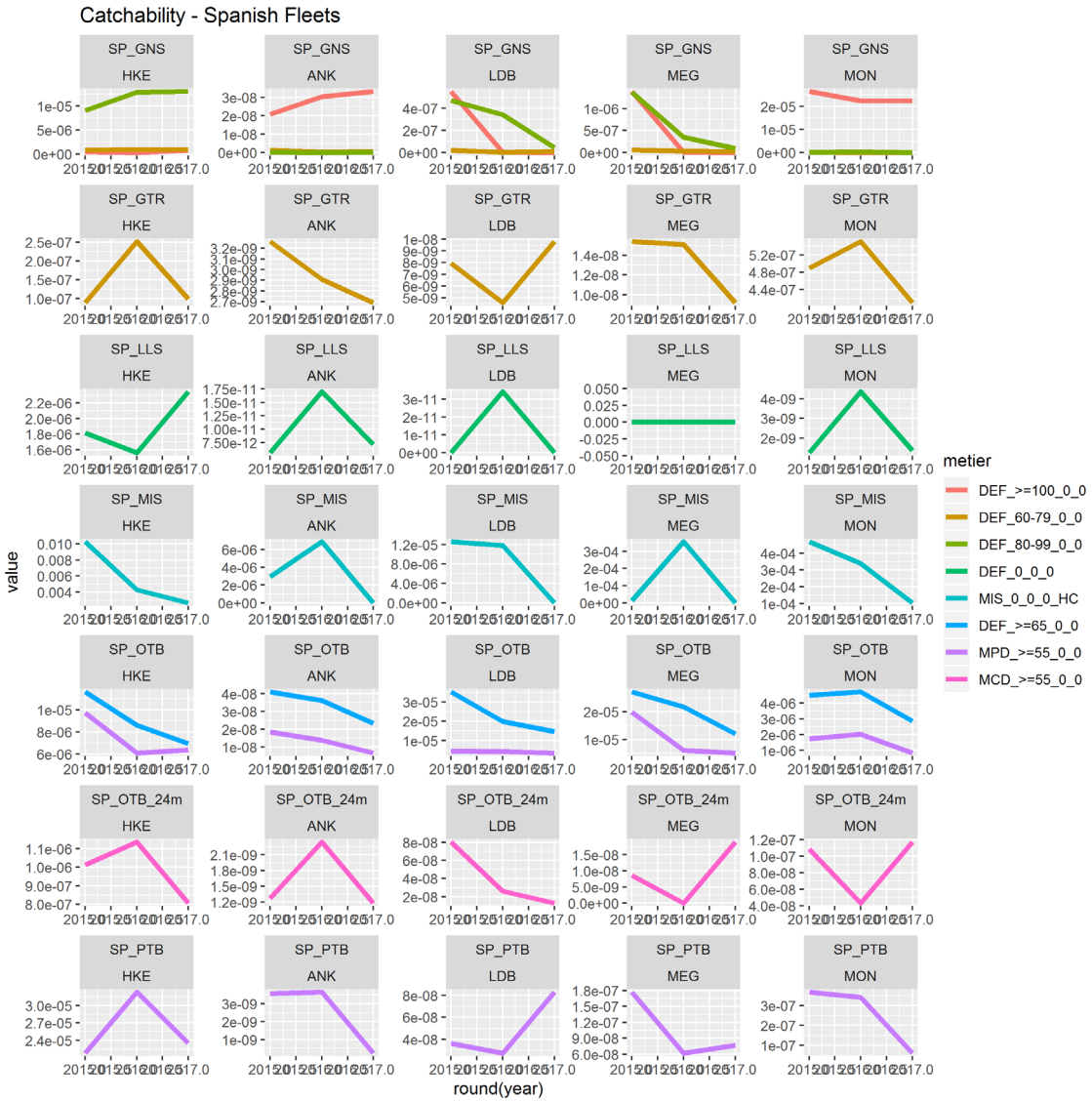


Figure 4.3. Iberian waters: trends of Spanish catchability by stock, fleet and métier.

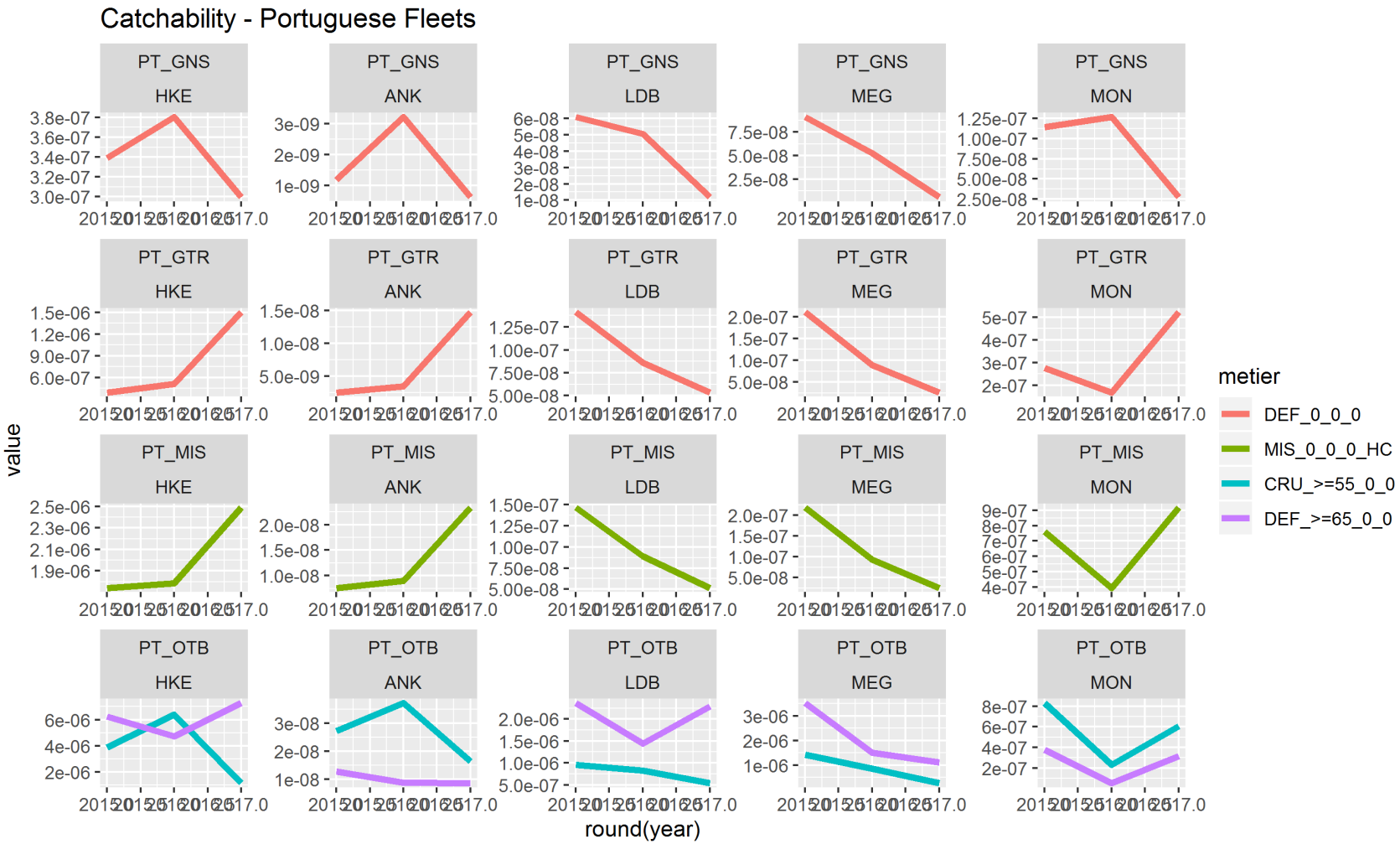


Figure 4.4. Iberian waters: trends of Portuguese catchability by stock, fleet and métier.

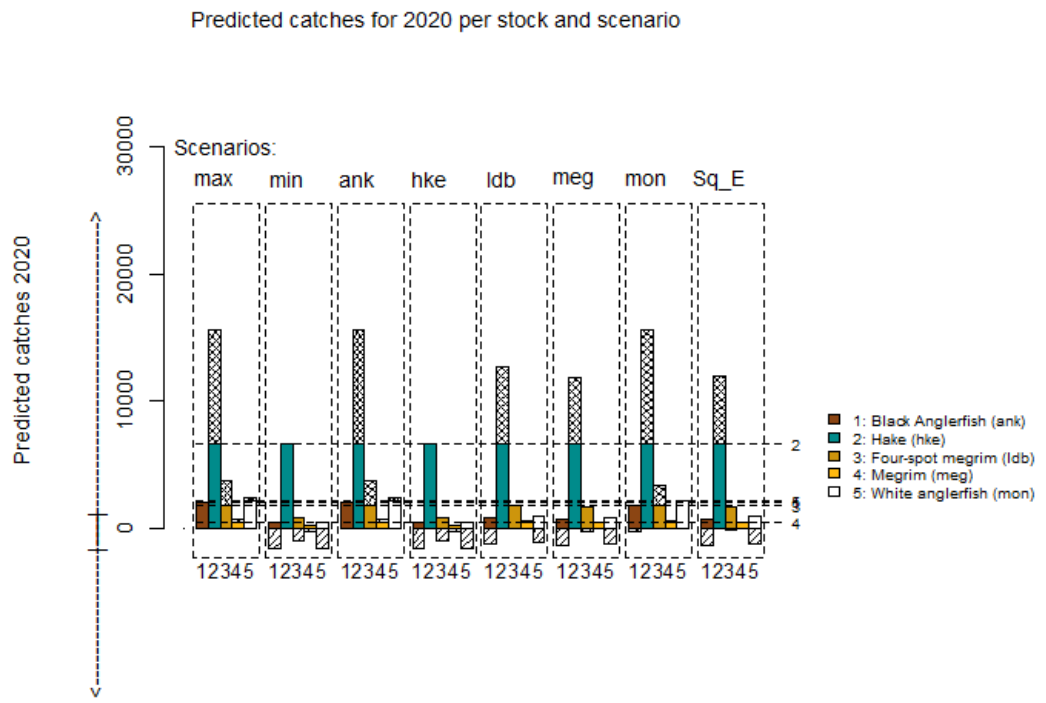


Figure 4.5. Iberian waters mixed fisheries forecasts: TAC year results (2020). FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year followed by the FLBEIA scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single-species catch advice) in cases where catches are predicted to be lower when applying the scenario.

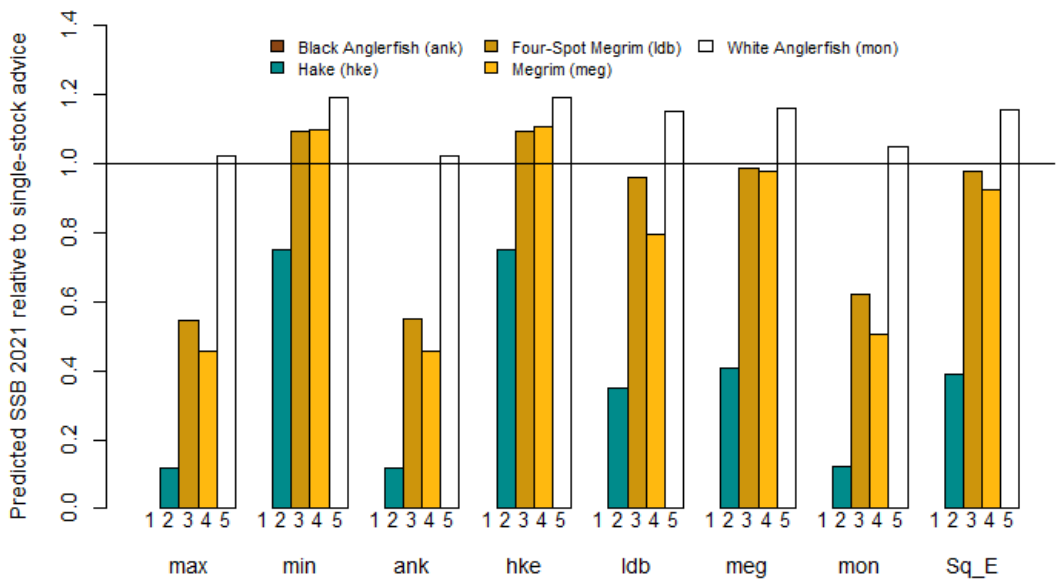


Figure 4.6. Iberian waters mixed fisheries forecasts: Estimates of potential SSB at the start of 2021 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2021).

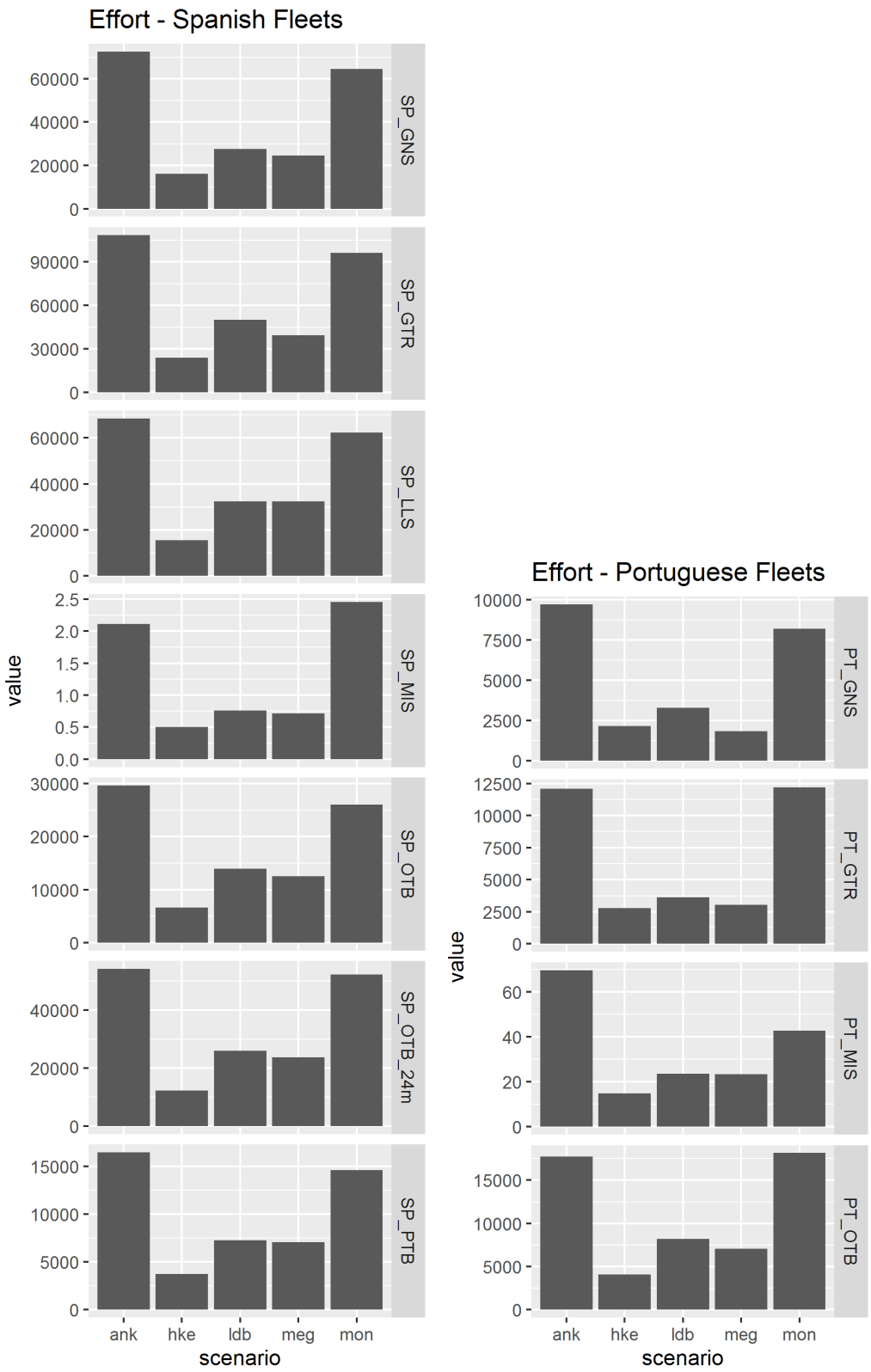


Figure 4.7. Iberian waters mixed-fisheries forecasts: TAC year results (2020). FLBEIA estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2020 (baseline run).

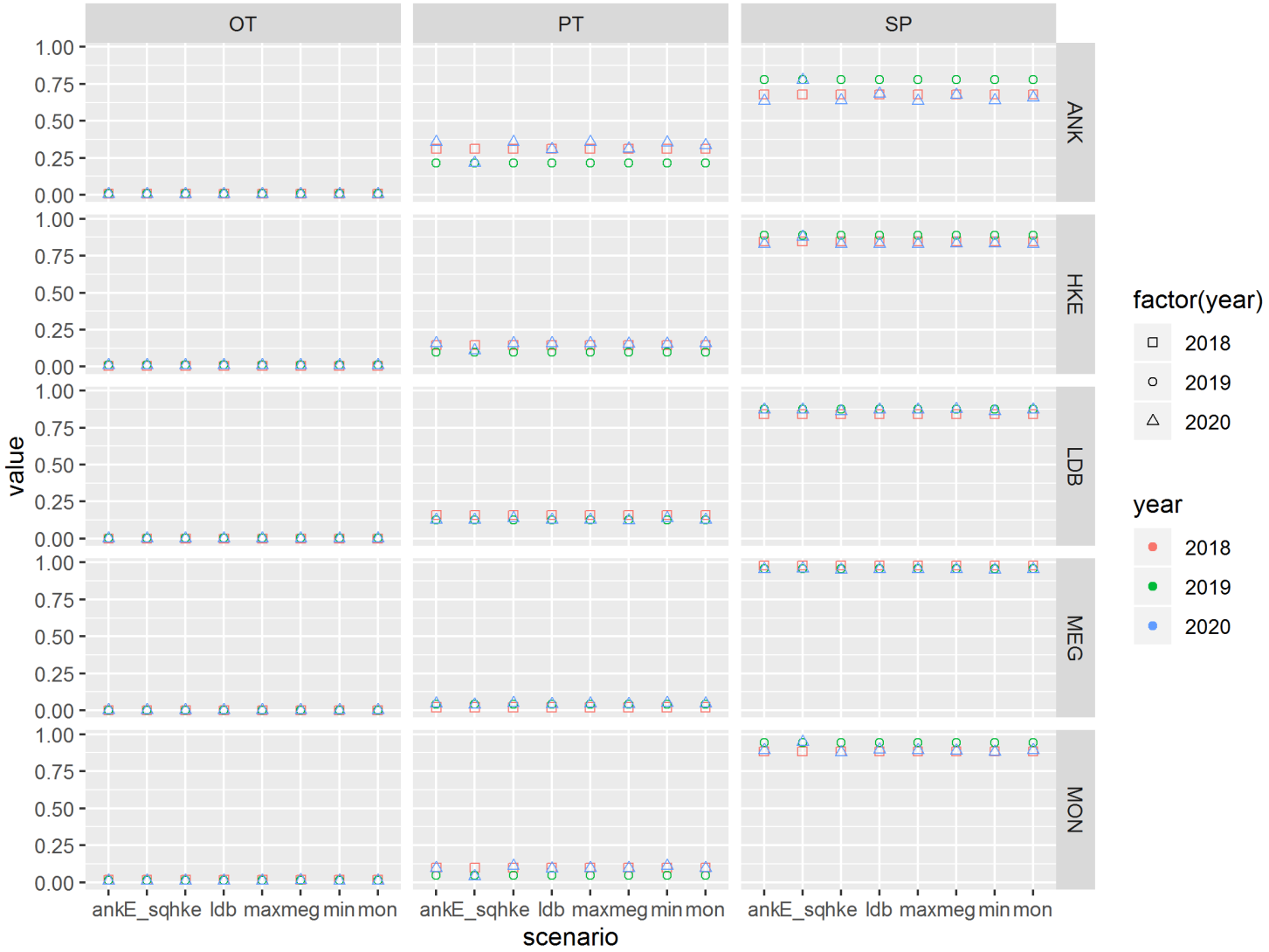


Figure 4.8. Iberian waters mixed fisheries forecasts: Test for relative stability. Changes of relative share of landings by country in 2019 and 2020 compared to the 2018 share for the eight FLBEIA scenario

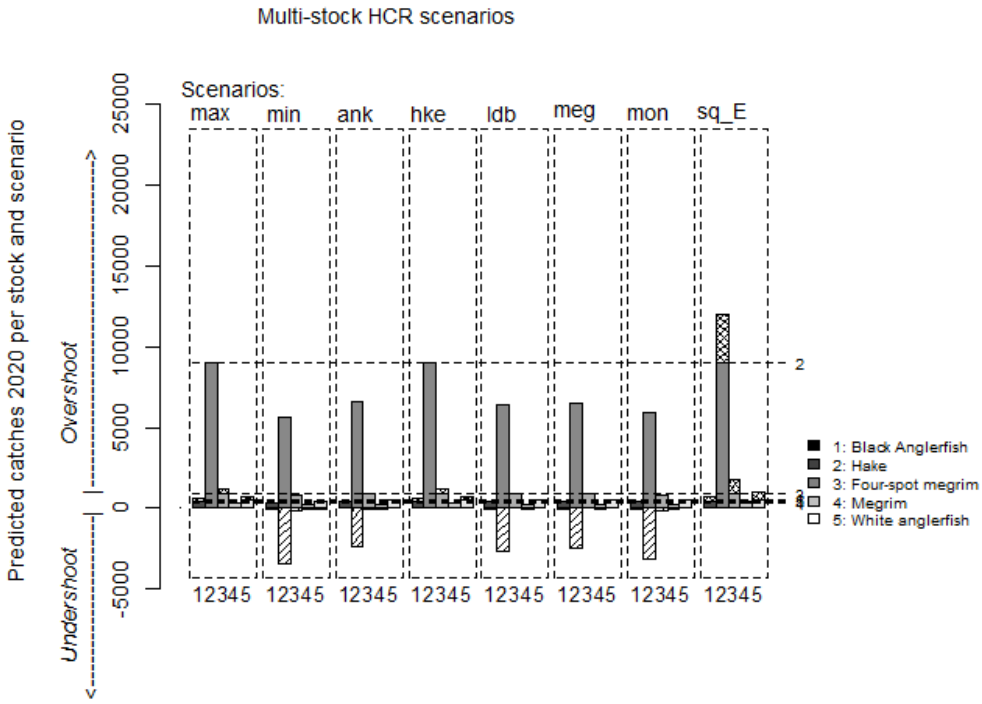


Figure 4.9. Iberian waters mixed fisheries forecasts for multi-stock HCR: TAC year results (2020). FLBEIA estimates of potential catches by stock after applying the status-quo effort scenario to all stocks in the intermediate year followed by FLBEIA scenarios using the multi-stock HCR. Horizontal lines correspond to the TAC set by the multi-stock HCR 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.

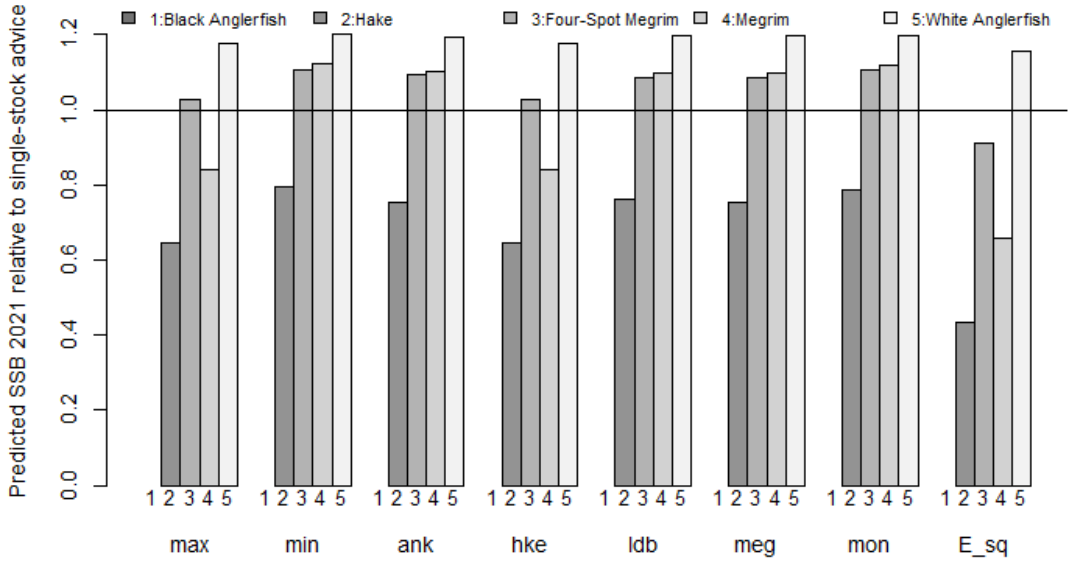


Figure 4.10. Iberian waters mixed fisheries forecasts using multi-stock HCR: Estimates of potential SSB at the start of 2021 by stock after applying the mixed fisheries multi-stock HCR scenarios, expressed as a ratio to the single-species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2021).

5 WGMIXFISH-METHODS planning

5.1 Introduction to the EU landings obligation

The EU landings obligation for demersal species is since the beginning of 2016 for the demersal fishes in a phased approach with all quota stocks subject to the landings obligation from 2019 onwards, while Norwegian fisheries have been subject to a landing obligation for cod since 1987 and for most finfish species since 2009.

To anticipate this move, since the 2016 working group the mixed fisheries advice was presented in terms of catch (not landings) against the advised single-stock catch advice with all the fleets catch counting against the fleets' stock share. This departs from previous advice where the mixed fisheries projections were presented in terms of landings and overshoots or undershoots of the retained portion of the catch, with the assumption that fishing fleets would discard as observed in past years with only the landed portion of the catch counting against the fleets' stock shares.

To account for this difference, the TACs of the different stocks in the TAC year (i.e. FCube implementation year, 2018) were raised to the total forecast catch from the single-stock advice but the fleet stock shares continued to be distributed based on historic landings by the fleets. This change is equivalent to 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) and assumes any uplift in quota is distributed according to past landings shares (consistent with relative stability). The different plan allow for *de minimis* for some fleets given their acceptation by STECF but it is hard to reproduce in the mixed fisheries consideration as it might happen that not whole fleet segment described in the simulation can benefit from the *de minimis*. After several trials of describing as precisely as possible the fleets under *de minimis*, the conclusion was to base the advice on catch and as a consequence, all quota species caught must be landed with no exemptions, *de minimis* or inter-species flexibilities. While the actual proposed implementation of is yet to be decided, and it is unlikely a full discard ban will be in place from 2018, it was considered basing advice on total catch under a full discard ban would highlight the pinch points in the upcoming implementation of the landings obligation. For example, one of the main consequences of a full implementation would be that some fleets with high discards and low landings of a species in the past would now become 'choked' early on in the fishery limiting their catches of other target stock, as the discard species (of which they have a low quota share) would have a greater mismatch between their catches (which now all count again the fleets stock shares) and their stock shares based on historic landings.

It is likely that further developments to the methodology will be required to take account of changes in management and the implementation of the landings obligation in the coming years, and the October WGMIXFISH-METH's meeting will look specifically at this issue (for example, by progressing age-based mixed fishery forecasting methods).

In addition, methods to include data-limited stocks in the mixed fisheries forecasts based on catch per unit of effort are being developed. This is in order to take account of the potential 'choke' species for fleets operating under a landings obligation.

WGMIXFISH notes that the landing obligation will mean a significant change in the management and therefore exploitation patterns of fleets will most likely change. Predictions of such changes (gear used, areas and times fished) are challenging due to the multitude of economic, social and regulatory drivers and such a fleet behavioural model is not currently incorporated within the mixed fisheries advice forecast. Changes in fishers behaviour will likely lead to an increased

uncertainty in MIXFISH forecasts until information becomes available after some years with the landing obligation implemented.

5.2 WGMIXFISH-METHODS meeting

Since 2012 a further WGMIXFISH meeting (the ICES Working Group on mixed- fishery methods; WGMIXFISH-METH) will take place in June, during which methodology will be developed

The proposed terms of reference for the WGMIXFISH-METH meeting in October are as follows:

2019/2/FRSG16 The **Working Group on Mixed Fisheries Advice Methodology** (WGMIXFISH-METHODS), chaired by Claire Moore, Ireland, will meet in Galway, Ireland[10], on 22–26 June 2020 to:

a) Continue improvement of WGMIXFISH-ADVICE workflow, updating associated documentation and increasing transparency;
b) Respond to the outcomes of the Mixed Fisheries Scoping Meeting;
c) Respond to the outcomes and issues encountered during WGMIXFISH-Advice;
d) Review of updated data call, identifying possible areas of improvements;
e) Assess the fleet/métier definition in Bay of Biscay;
f) Development of Irish Sea FCube;
g) Continued development of the combined implementation of FCube and FLBEIA in conjugation with STECF/WGECON economists.

WGMIXFISH-METHODS will report by 3 August 2020 for the attention of ACOM.

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

[10] Due to the COVID-19 disruption, WGMIXFISH-METHODS 2020 was held via an online meeting.

6 Recommendations

None.

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Annex 1: List of participants

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Annex 2: Resolutions

The **Working Group on Mixed Fisheries Advice** (WGMIXFISH-ADVICE), chaired by Claire Moore (Ireland) will meet at ICES Headquarters[11] 26 October–30 October 2020 to:

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

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

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

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

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

[11] Due to the COVID-19 disruption, WGMIXFISH-ADVICE 2020 will be held via an online meeting.

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
mix.ns	North Sea Mixed Fisheries Annex	May 2017
mix.bbi	Iberian Water Mixed Fisheries Annex	May 2015
mix.cs	Celtic Sea Mixed Fisheries Annex	May 2015

Annex 4: Audit reports

Bay of Biscay and Atlantic Iberian waters

Date: 7-11-2019
Auditor: Thomas BRUNEL

Summary of the advice

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

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

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

General comments

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

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

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

Differences where found between 1) the results of the forecasts for single-stocks done at WGBIE, 2) the attempt to reproduce these forecasts in FLBEIA, 3) stock specific mixed fisheries scenarios. Differences between 1 and 2 are mentioned in the report and on the advice sheet and can be expected as a result of the change in framework between WGBIE and WGMIXFISH (convert GADGET output to FLR stock). Differences between 2 and 3 are not explained in the report, and it is difficult to understand why they arise. In principle a scenario in which all the fleets catch their quota of, for example, hake should give the same outcome, for hake, as the single-stock short term forecast made using the same FLBEIA framework.

Technical comments

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

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

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

Advice sheet:

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

Report:

- In section 4.3. (stock input data) it could be interesting to make a comparison of the stock trajectories (SSB and Fbar) from the stock assessment model (WGBIE) and from the assessment transformed to the annual age-structured format used for MixFish, at least for the stocks assessed with a length-based model. This would give an idea of the discrepancy in the input data, and would be useful to understand discrepancies in forecasts. In fact, this would show that there are already large discrepancies in the historical part for hake SSB (up to 30%), although the discrepancy is small (1%) for the final assessment year (2018).
- Section 4.5.2.1. the baseline run is presented here as being "*the mixed fisheries scenarios that consider all fleets set their effort corresponding to their quota shares for each given species*" (second paragraph). I think (after discussing with expert) that this is not exact : the baseline consists in 1) transferring assessment into the FLR format, and 2) run the forecast for each stock individually, with the same settings as in the expert groups, using the deterministic forecast function of FLR. There is no mixed fisheries calculation (i.e. effort) involved at this step.

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

Conclusions

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

Qualitatively, the outcome of the projections makes sense: hake is the stock for which the single-stock advice is decreasing the most, and is identified as the most limiting stock for these mixed fisheries. Because of the discrepancies discussed above, it is difficult to judge to what level of uncertainty is attached to the results presented, and to what extent they can be used quantitatively.
The causes for the discrepancies observed in the forecast between the length-structured model used in the stock assessment EG and the age-structure model used in the MixFish EG should be further investigated, in collaboration with stock assessors for the relevant stocks.

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