

Mixed-fisheries advice for divisions 7.b–c and 7.e–k (Celtic Sea)

Summary

Mixed-fisheries considerations combine single-species stock assessments with information on the average catch composition and fishing effort of the fleets catching cod (cod.27.7e-k), haddock (27.7b-k), and whiting (27.7b-ce-k) in the Celtic Sea. In the absence of specific mixed-fisheries management objectives, ICES does not advise on unique mixed-fisheries catch opportunities for the individual stocks.

Mixed-fisheries scenarios are based on the central assumption that the fishing patterns and catchability of a fleet in 2018 and 2019 are the same as the average of 2015–2017. A total of nine scenarios are presented, corresponding to different fleet behaviours for 2019 (described in Table 1). The forecasted scenarios are presented in terms of catch and the potential for quota over- and undershoot, which is driven by the most and the least restrictive single-stock fishing opportunities (Figure 1).

The 2019 forecasts indicate that no catch of haddock or whiting is consistent with the cod advice of zero catch. The ‘min’ scenario confirms that this mismatch is due to the fact that all fleets operating within the Celtic Sea catch cod to some extent, resulting in cod being a “choke” species for haddock and whiting; therefore, the ‘min’ scenario results in zero catch for all three gadoids. Because of the zero catch for cod the ‘cod_cs’ scenario results in the same outcome as the ‘min’ scenario, thus it is not presented here. Under the ‘max’ scenario, substantial overshoots for cod and for haddock are predicted if all fleets catch their quotas (Figure 1).

This year an additional scenario of cod catches under the MSY approach (‘cod_fmsy’) is presented. The low value of F (0.12) under the cod MSY approach (assuming a non-zero catch) results in substantial undershoots of both haddock and whiting, as fishing is stopped when the cod quota is reached.

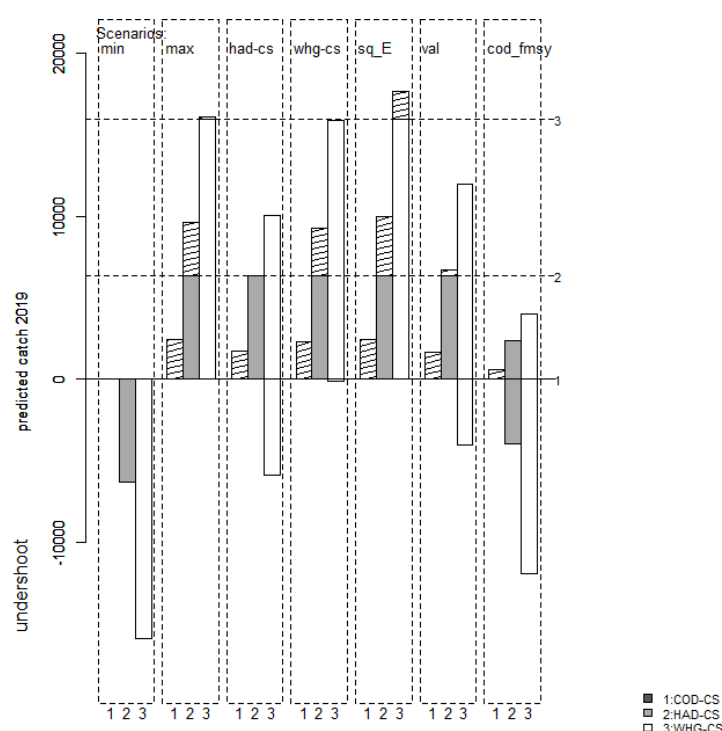


Figure 1 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential catches (in tonnes) by stock and by scenario (described in Table 1). Horizontal lines correspond to the single-stock catch advice for 2019. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

An eighth scenario, the 'range' scenario, minimizes the potential TAC mismatch in the catches of cod, haddock, and whiting in 2019 by setting target fishing levels within the F_{MSY} ranges. This scenario estimates a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2019, may reduce the gap between the most and least restrictive TACs, thus reducing the potential quota over- and undershoot. The 'range' scenario suggests that, with a zero cod TAC, the haddock and whiting TACs should be set at the bottom of their ranges (Figure 2a). This scenario was also run using a cod TAC corresponding to fishing mortality within the uncapped reduced range (F_{MSY} range [0.08–0.2]), which again resulted in haddock and whiting TACs being at the bottom of their respective F_{MSY} ranges (Figure 2b).

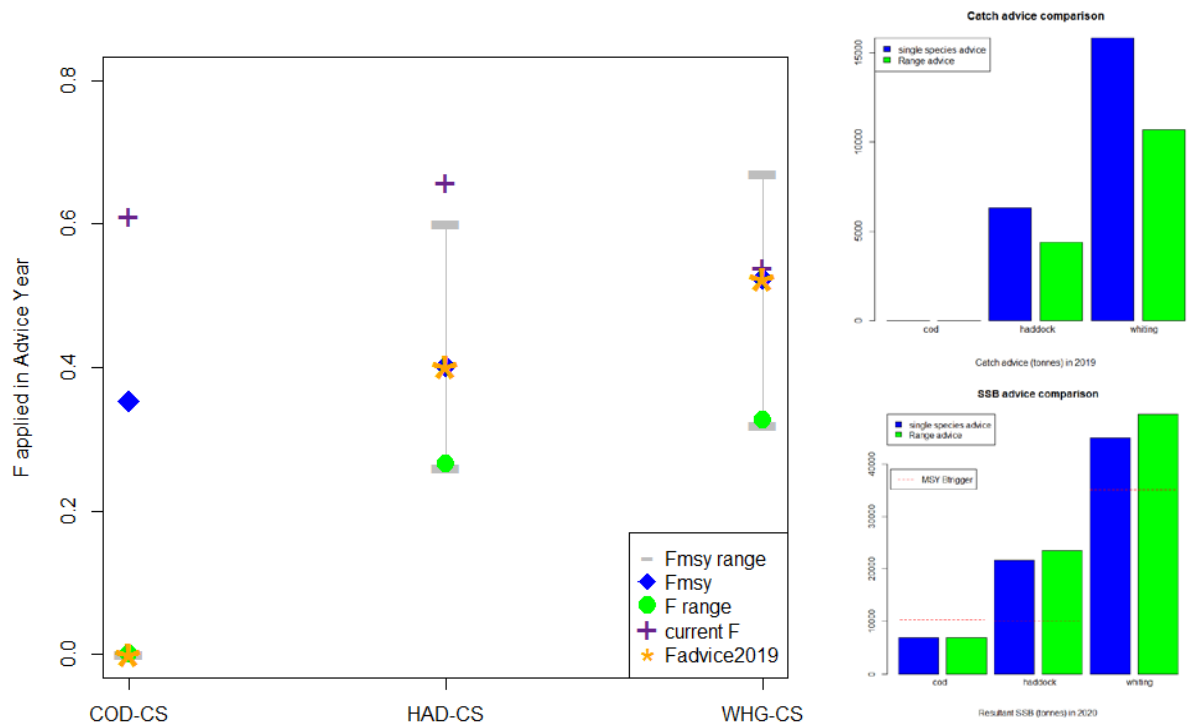


Figure 2a Range scenario advice for divisions 7.b–c and 7.e–k using the advised zero catches for cod. **Left:** the fishing mortality rates for each stock which reduce the mismatch between opportunities for the three stocks (green point), along with the current fishing mortality (purple cross), the fishing mortality corresponding to the single-stock advice (yellow star), and the F_{MSY} (blue rotated square) and the F_{MSY} ranges (grey lines). **Right:** Comparison of the outcomes in terms of total catches in 2019 (top) and SSB in 2020 (bottom) between the F_{MSY} -based single-stock advice and the F-range based forecast.

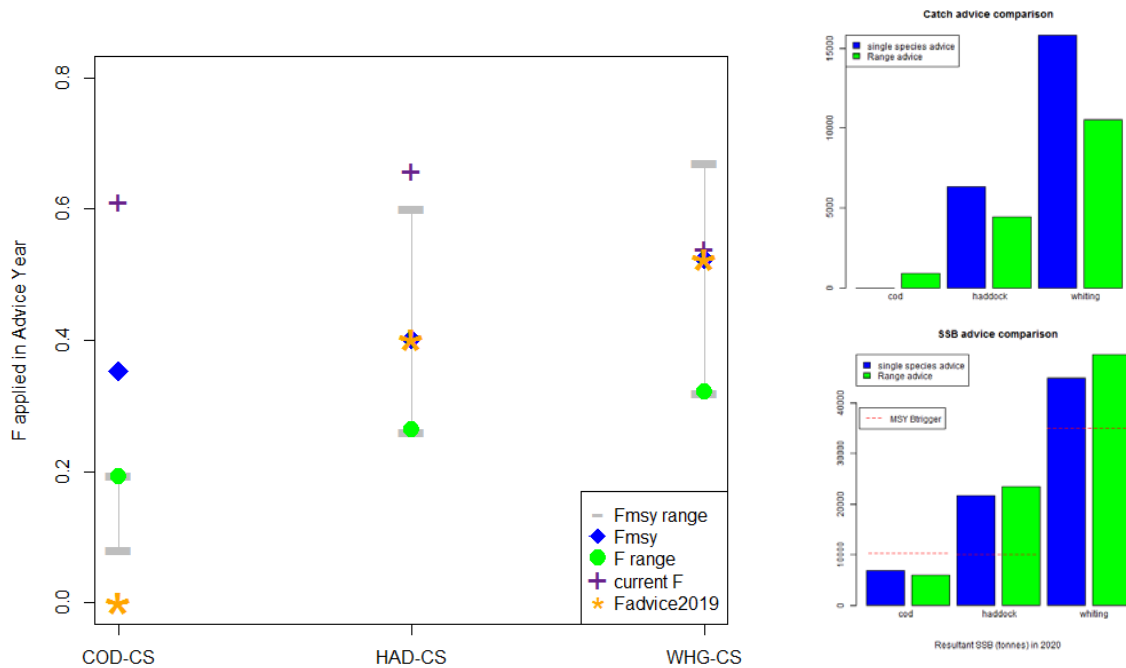


Figure 2b Range scenario advice for divisions 7.b–c and 7.e–k using the uncapped reduced F_{MSY} range for cod. **Left:** the fishing mortality rates for each stock that reduce the mismatch between opportunities for the three stocks (green point), along with the current fishing mortality (purple cross), the fishing mortality corresponding to the single-stock advice (yellow star), and the F_{MSY} (blue rotated square) and the F_{MSY} ranges (grey lines). **Right:** Comparison of the outcomes in terms of total catches in 2019 (top) and SSB in 2020 (bottom) between the F_{MSY} -based single-stock advice and the F -range based forecast.

The scenarios

Table 1 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Mixed-fisheries scenarios considered for the Celtic Sea gadoids.

Scenarios	Abbreviation	Explanation
Maximum	Max	For each fleet, fishing stops when all stocks have been caught up to the fleet's stock shares*. This option causes overfishing of the single-stock advice possibilities of most stocks.
Minimum	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.
Haddock MSY approach	Had	All fleets set their effort corresponding to that required to catch their haddock stock share, regardless of other catches.
Whiting MSY approach	Whg	All fleets set their effort corresponding to that required to catch their whiting stock share, regardless of other catches.
Status quo effort	Sq_E	The effort of each fleet is set equal to the effort in the most recently recorded year (2017) for which catch and effort data are available.
Value	Val	A simple scenario accounting for the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the fleet's stock shares of each of the stocks, weighted by the historical catch value of that stock (see example below). This option causes overfishing of some stocks and underutilization of others.
Cod F_{MSY}	Cod_fmsy	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} ($F = 0.12, F_{MSY} \times (SSB(2019) / MSY B_{trigger})$), regardless of other catches.

* 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 2019 and the historical proportion of the stock landings taken by the fleet.

Catch scenarios

Mixed-fisheries scenarios consider the implications of mixed fisheries operating under single-stock TAC regimes, taking into account the fishing patterns of the various fleets in 2015–2017 (i.e. the catchability for the different stocks and effort distribution among métiers as well as access to quota). The scenarios presented here do not assume any quota balancing in the forecast through changes in targeting behaviour in 2019. Catch scenarios are presented in Table 2 for the scenarios described in Table 1. The ‘minimum’ scenario is based on the assumption of a strictly implemented discard ban with the individual single-stock advice TACs. In 2019, the ‘minimum’ 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 ‘maximum’ 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 are exhausted, irrespective of the economic viability of such actions. In 2019, the ‘maximum’ scenario indicated that whiting is the least limiting quota for most fleets (9 of 11 fleets, representing 68% of the effort in 2017), while haddock is the least limiting quota for the remaining two fleets. It is important to note that the ‘*status quo* effort’ scenario shows catches higher than the ‘maximum’ 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 the results of 2019 show that it is not possible to achieve all management objectives simultaneously. ICES single-stock advice for demersal stocks (ICES, 2018a) is based on ICES maximum sustainable yield (MSY) approach. Any catch of cod in 2019 is not considered precautionary as the stock is estimated to be below B_{lim} . The ‘maximum’ and ‘*status quo* effort’ scenarios result in whiting and haddock being fished above F_{MSY} in 2019. Haddock is also overfished in the ‘whiting MSY approach’ and ‘Value’ scenarios.

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 utilize their catch opportunities without collectively exceeding single-stock fishing opportunities. Under the scenarios presented here, the ‘maximum’ scenario suggests that if all fleets’ stock shares are to be fully utilized, catches of cod and haddock would be considerably higher than advised in the single-stock advice, with whiting 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. A ‘cod F_{MSY} ’ scenario, presented as an additional scenario where the cod TAC is set at reduced F_{MSY} , still results in significant catches of cod, and in underutilizations of both the haddock and whiting single-stock TACs.

Of the presented scenarios, only the ‘minimum’ scenario meets the objective of all stocks being fished at or below F_{MSY} . In contrast to single-stock advice there is no single recommendation from the scenarios presented, but a range of plausible options. 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. This is not possible in 2019 due to the cod stock being $< B_{lim}$ in 2020, even with a zero cod catch in 2019 and any fisheries for haddock and whiting likely to result in some catches of cod.

The ‘minimum’ scenario assumes that all catch (including any unwanted catch) will be counted against the quota. The analysis highlights where fleets with a small share, but high discard rate, for a stock have their fishing activity limited by that stock, resulting in underutilization of their target stock(s). 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.

A ‘range’ scenario is presented, 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. 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 or maximizing fleets’ revenue or profit.

There are no specific management plans in place for cod, haddock, or whiting in the Celtic Sea.

Table 2 Mixed-fisheries advice in the Celtic Sea. Catch per mixed-fisheries scenario 2019, in absolute values.

Stock	Single-stock catch advice (2019)	Catch per mixed-fisheries scenario (2019)								
		Max	Min	Had	Whg	Status quo effort	Value	Cod_fmsy	Range (Zero-catch)	Range (F _{MSY})
cod.27.7e-k	0	2439	0	1717	2267	2453	1644	588	0	897
had.27.7b-k	≤ 6317	9593	0	6317	9245	9948	6718	2343	4381	4433
whg.27.7b-ce-k	≤ 15841	16089	0	10036	15841	17679	11995	3976	10668	10527

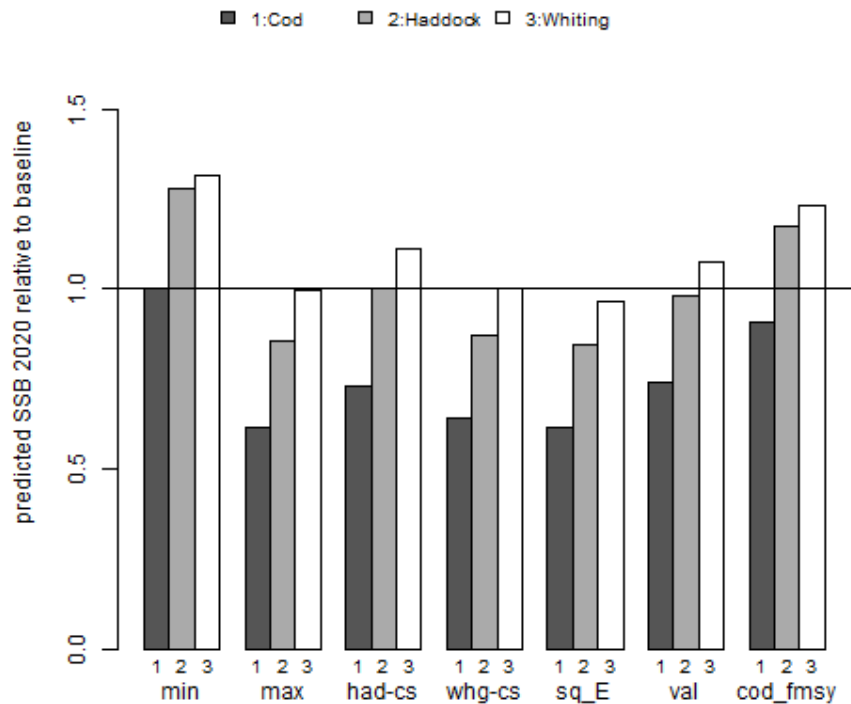


Figure 3 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential SSB at the start of 2020 by stock after applying the mixed-fisheries scenarios, relative to SSB resulting from the single-stock advice forecast (the horizontal line).

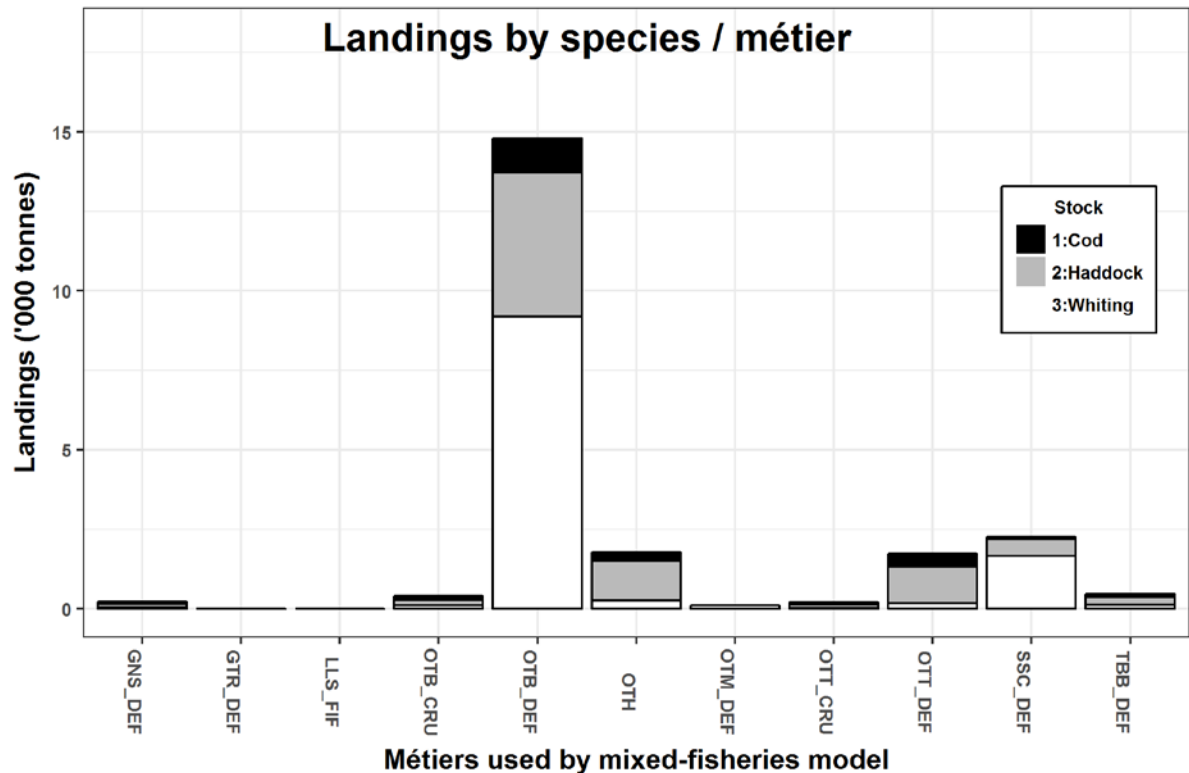


Figure 4 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Landings distribution of species by métier with landings consisting of $\geq 1\%$ of any of the stocks (see Table 6) in 2017 (list of métiers available in Table 4). Note: The 'other' (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings $< 1\%$ of any of the stocks 1–3 (Table 5) in 2017.

Table 3 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. TAC year (2019) fishing mortality forecast by scenario. The F range is averaged across the same ages as those used for the single-stock assessment. The color gradients of the legend show the forecast fishing mortality under the scenario in relation to reference points detailed in the legend.

Stock	Single-stock F advice (2019)	Fishing mortality per mixed-fisheries scenario (2019)								
		Max	Min	Had	Whg	Status quo effort	Value	Cod_fmsy	Range (Zero-catch)	Range (F _{msy})
cod.27.7e-k	0	0.62	0	0.4	0.56	0.62	0.38	0.12	0.00	0.193
had.27.7b-k	0.4	0.66	0	0.4	0.63	0.7	0.43	0.14	0.26	0.27
whg.27.7b-ce-k	0.52	0.53	0	0.31	0.52	0.59	0.37	0.11	0.33	0.32

legend

	F 2019 ≤ F _{MSY}
	F 2019 > F _{MSY} , < F _{pa}
	F 2019 > F _{pa}
	F 2019 > F _{lim}

Table 4 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. SSB results in 2020 from single-stock advice and different mixed-fisheries scenarios (see Figure 1). Weights in tonnes. The color gradients of the legend show the forecast SSB under the scenario in relation to reference points detailed in the legend.

Stock	Single-stock advice	SSB (2020) resulting from mixed-fisheries scenario applied in 2019								
		Max	Min	Had	Whg	Status quo effort	Value	Cod_fmsy	Range (Zero-catch)	Range (F _{MSY})
cod.27.7e-k	6906	4278	6906	5043	4459	4263	5129	6262	6905	5926
had.27.7b-k	21650	18560	27695	21650	18887	18228	21302	25441	23491	23442
whg.27.7b-ce-k	44943	44731	58900	49988	44943	43367	48336	55344	49434	49558

legend

	SSB 2020 > B _{pa} or MSY B _{trigger}
	SSB 2020 > B _{lim} , no B _{pa} defined
	SSB 2020 > B _{lim}
	SSB 2020 < B _{lim}

Table 5 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Métier categories used in the mixed-fisheries analysis.

Mixed-fisheries métiers	Gear	Target species
OTB_DEF	Otter trawls	Demersal fish
OTT_DEF	Twin otter trawls	Demersal fish
OTB_CRU	Otter trawls	Crustaceans
OTT_CRU	Twin otter trawls	Crustaceans
OTM_DEF	Midwater trawls	Demersal fish
GNS_DEF	Gillnets	Demersal fish
GTR_DEF	Trammelnets	Demersal fish
LSS_FIF	Longlines	Finfish
SSC_DEF	Scottish seines	Demersal fish
TBB_DEF	Beam trawls	Demersal fish
MIS_MIS / OTH	Other gears	Any

Methods and data

Mixed-fisheries considerations are based on the single-stock assessments combined with knowledge on the species composition in catches in the Celtic Sea fisheries, using the F_{cube} method (Ulrich *et al.*, 2011, 2017). Mixed-fisheries scenarios are based on central assumptions that fishing patterns and catchability in 2018 and 2019 are the same as those in 2017.

These mixed-fisheries forecasts are limited to three gadoid stocks with full analytical single-species assessments: cod, haddock, and whiting (Table 6). Forecasts are presented in terms of catch, and are based on current selection patterns observed in the fisheries (average 2015–2017), except for cod where reliable discard information is only available for part of the time-series. For cod, following the single-stock advice, an average discard rate of recent years (7.73%) is used to ‘top-up’ the predicted landings to a predicted catch for each scenario. The reference points for the included stocks can be found in the 2018 single-stock advice sheets (ICES, 2018b, 2018c, and 2018d), and the 2017 relative catch distribution is shown in Table 7.

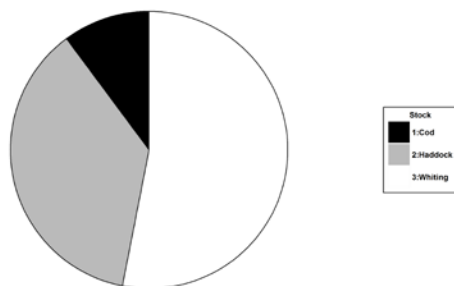
Further work is ongoing to include additional analytical stocks (e.g. the Norway lobster stocks, anglerfishes, megrims, and hake) which will be progressed at the October 2018 methods meeting (WGMIXFISH-METHODS). In the future, consideration will be given to the inclusion of other flatfish, such as plaice and sole. Methods to include stocks without analytical assessments in the mixed-fisheries forecasts, based on catch per unit of effort (CPUE), are also being considered to take account of the potential “choke” species for fleets operating under a landing obligation. Pelagic species (e.g. herring, mackerel, and horse mackerel) are not included as they are mainly taken by fisheries subject to little technical interaction.

Table 6 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Advice and management area for the three gadoid species considered.

Species	ICES single-stock advice area	Management area
Cod	divisions 7.e–k	EU TAC divisions 7.b–c, 7.e–k and subareas 8–10; EU waters of CECAF 34.1
Haddock	divisions 7.b–k	EU TAC divisions 7.b–k and subareas 8–10; EU waters of CECAF 34.1.1
Whiting	divisions 7.b–c and 7.e–k	EU TAC divisions 7.b–k

Table 7 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Landings distribution.

Total Landings by Stock



Total landings (2017) of all species considered in the mixed-fishery advice were 22 027 tonnes, with:

- ~89% landed by otter trawls and seines;
- ~2% landed by beam trawls;
- ~1% by gill- and trammelnets; and
- ~8% by other gears.

Total discards (not shown in the plot) were 12 480 tonnes (36% by weight of total catch). Cod discards are not included in values, but landings in the analysis are raised by the average discard rate.

The mixed-fisheries scenarios and forecasts are produced using data requested as part of an ICES data call, issued formally under the EU Data Collection Framework (DCF) regulations. This provides consistency in catch and effort totals. Additionally, separate data files containing total weight of landings and effort in kW-days by fleet and métier are requested. Fleet and métier categories used in the mixed-fisheries analysis are based on DCF level 4 and 5 categories, respectively, but merging over DCF categories has been performed to aggregate over “small” métiers (defined as a métier with less than 1.0% landed in 2017 for each of the stocks considered).

Table 8 Mixed-fisheries advice for divisions 7.b–c and 7.e–k. The basis of the assessment.

ICES stock data category	1 (ICES, 2016).
Assessment type	F_{cube} (FLR) (Ulrich <i>et al.</i> , 2011).
Input data	Assessments on the relevant stocks in the Celtic Sea Ecoregion fisheries working group (WGCSE) (ICES, 2018a); catch and effort by fleet and métiers.
Discards and bycatch	Included as in the single-stock assessments.
Indicators	None.
Other information	This assessment was first presented in 2014 at the MIXFISH-METHODS (ICES, 2015). No one scenario is presented as advice, as scenarios result in trade-offs between different fisheries that are informed by more than scientific considerations. The scenarios indicate which stocks will limit, and thus influence, the fisheries most.
Working group report	Working Group on the Assessment of Demersal Stocks in the Celtic Sea Ecoregion (WGCSE) and Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE) (ICES, 2018e).

Quality considerations

The quality of catch data, disaggregated by métier, has improved in recent years. This is due to the single ICES data call, which combines data needs and ensures common data storage in InterCatch and Accessions.

Mixed-fisheries projections for the Celtic Sea build on full analytical single-stock assessments. Single-stock forecasts are also reproduced independently as part of the mixed-fisheries analyses, allowing additional quality control of both processes. The quality of the individual forecasts of the single stocks may affect the results of the mixed-fish scenarios. An error or bias in the forecast of one stock could lead to an inappropriately low or high TAC for this stock. This would, in turn, affect the estimated effort required for each métier to land this TAC. If the effort required to land the TAC for this stock is pivotal in any of the scenarios examined, this would affect the exploitation prognoses of the other stocks in this scenario. In other words, the quality of the mixed-fisheries model is limited by the stock which has the most biased assessment, if that stock is the limiting factor in a mixed-fisheries scenario. To maintain consistency with the single-stock advice, the mixed-fisheries analysis is based on total catch (landings and discards) for haddock and whiting, while cod catch forecasts are based on landings with a ‘top-up’ for discards that are assumed to be 7.73% of total catch under each scenario.

Mixed-fisheries scenarios are based on central assumptions that fishing patterns and catchability in 2019 are the same as those averaged over a three-year period (2015–2017) (similar to procedures in single-stock forecasts where growth and selectivity are assumed constant). A key assumption in the forecast is that catchability for fleets remains constant, but this is heavily dependent on fishing patterns, which may change over time – particularly in response to significant changes in policy, such as the introduction of a landing obligation. At present 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 and minimum mesh size, depending on the target composition and/or area. More recently square mesh panels (SMP) were introduced. The aims of these technical measures is to change catchability by improved selection within the Celtic Sea fisheries, reducing catches of small whiting and haddock. Depending on the efficacy of the measures as implemented in practice there will be short-term changes in catchability that are assumed to be fixed in the mixed-fisheries forecast. The conclusion that cod is the most limiting species in the Celtic Sea mixed fisheries is robust to this because the SMP measures are least effective for cod.

Another assumption is that the selectivity is the same for all fleets (based on the F_{at-age} derived from the assessment). Therefore, changes in the relative contribution of each fleet to the total effort are not translated into specific changes in the relative F_{at-age} . This prevents the model from taking into account any improved selection patterns for some fleets (such as gillnetters) in achieving the MSY approach. The possibility of using catch-at-age by fleet through the InterCatch database is being investigated.

Sources and references

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