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

Summary

Mixed-fisheries considerations are based on the single-stock assessments combined with information on the average catch composition and fishing effort of the various fleets and fisheries 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 central assumptions that fleets' fishing patterns and catchability in 2017 and 2018 are the same as those in 2016 (similar to procedures in single-stock forecasts, where growth and selectivity are assumed constant).

Mixed-fisheries projections are presented in terms of catch. The mixed-fisheries forecast for the Celtic Sea in 2018 shows an imbalance in the restrictive quotas for haddock (the most limiting stock) and cod (limiting for a quarter of fleets), and the least restrictive quota for whiting (the least limiting quota). Under the 'max' scenario, substantial overshoots for cod and haddock are predicted if all fleets catch their whiting quotas, while under the 'min' scenario, undershoots of cod and whiting are predicted (Figure 1).
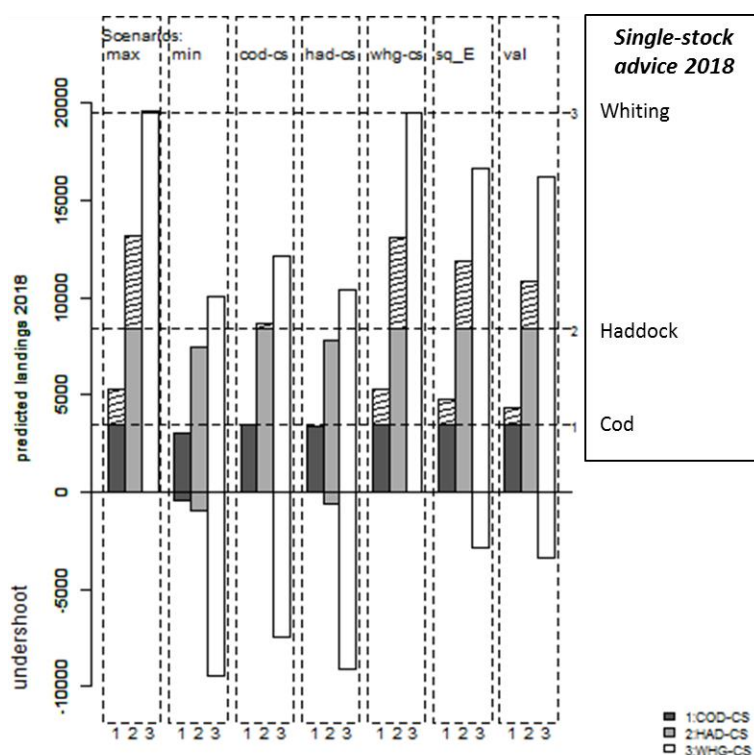
Figure 1   Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential catches (in tonnes) by stock and by scenario (described in Table 1). Horizontal lines correspond to the single-stock catch advice for 2018. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

A "range" scenario is presented (Figure 2), where the potential TAC mismatch in 2018 are minimized by setting target fishing levels within the F_{MSY} ranges. This scenario returns a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2018, may reduce the gap between the most and least restrictive TACs, thus reducing the potential quota over- and undershoot. The 'range' scenario suggests that TAC for cod is set slightly higher than the single-stock advice, the haddock TAC is set between the F_{MSY} estimate and the upper end of the range and the TAC for whiting set lower than the single stock advice, at the bottom of its range.
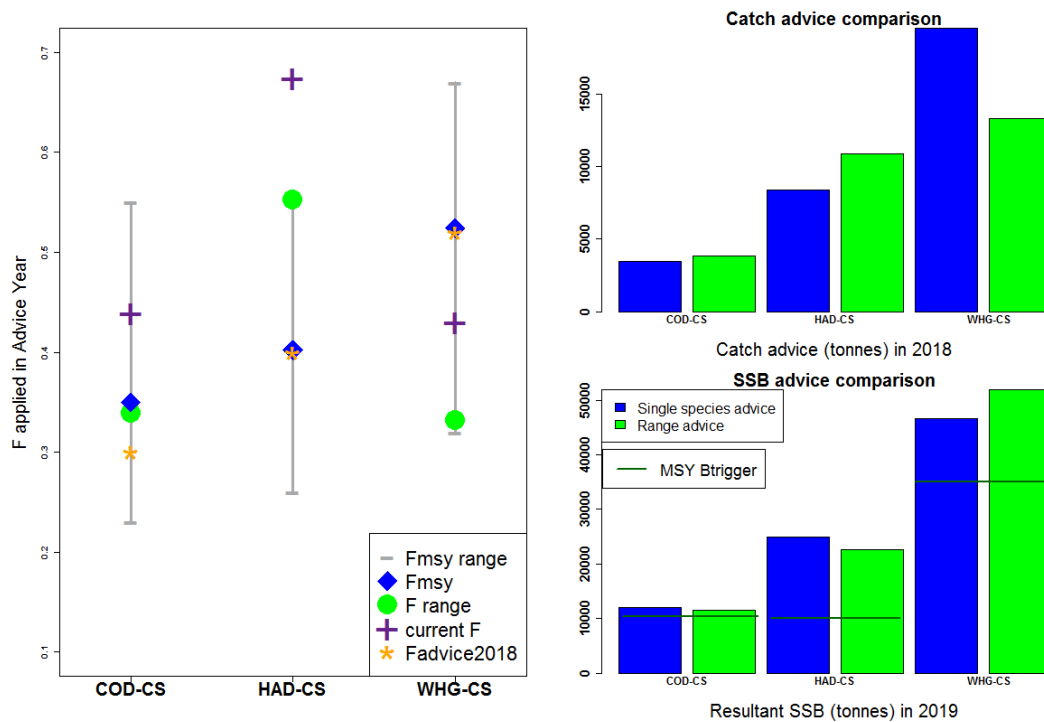
Figure 2   Range scenario advice for divisions 7.b–c and 7.e–k. **Left**: the fishing mortality rates for each stock which reduce the mismatch between opportunities for the three stocks (green point), along with the current fishing mortality (purple cross), the fishing mortality corresponding to the single stock advice (yellow star) and the F_{MSY} (blue rotated square) and the F_{MSY} ranges (grey lines). **Right**: Comparison of the outcomes in terms of total catches in 2018 (top) and SSB in 2019 (Bottom) between the F_{MSY}-based single-stock advice and the F-range based forecast.

The potential for quota over- and undershoot linked to the most- and least restrictive single-stock fishing opportunities for 2018 is presented Figure 1. Seven projections are presented, corresponding to different fleet scenarios for 2018 (described in Table 1).

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.
Cod MSY approach	Cod	All fleets set their effort corresponding to that required to catch their cod stock share, regardless of other catches.
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 (2016) 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 further below). This option causes overfishing of some stocks and underutilization of others.

*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 2017 and the historical proportion of the stock landings taken by the fleet.

Catch options

Mixed-fisheries advice considers the implications of mixed fisheries operating under single-stock TAC regimes, taking into account the fishing patterns of the various fleets in 2016 (i.e. changes in catchability and/or in effort distribution) and/or changes in access to quota. The scenarios presented here do not assume any quota balancing through changes in targeting behaviour. Catch options are presented in Table 2 under the scenarios described in Table 1. The "minimum" scenario is based on the assumption of a strictly implemented discard ban. In 2018, the "minimum" scenario indicates that haddock is the most limiting stock for most fleets (representing 64% of effort in 2016), while cod is the limiting stock for the remaining fleets (24% of fleet effort). In addition to the "minimum" scenario, a "maximum" scenario is included. 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. For 2018, the "maximum" scenario gives very similar results to the "whiting" scenario, indicating this is the least limiting quota for most fleets.

Mixed-fisheries catch options can take specific management priorities into account. Scenario results show that it is not possible to achieve all management objectives simultaneously. The ICES single-stock advice for demersal stocks (ICES, 2017a) is based on the ICES maximum sustainable yield (MSY) approach. All scenarios except "minimum" and "cod" result in cod being fished above F_{MSY}, while all the scenarios except "minimum" and "haddock" result in haddock being fished above F_{MSY}. Whiting is fished at or below F_{MSY} in 2018 in all scenarios except "maximum", reflecting that whiting is the least limiting stock for most fleets.

The scenarios do not assume any amount of quota swapping or balancing or adaptation of fishing behaviour. Scenarios that result in under- or overutilization are useful in identifying imbalance between the fishing opportunities of the various stocks. They indicate in which direction 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. A significant change to the exploitation pattern for cod and haddock (i.e. a reduction in catches relative to whiting) would be required in 2018 to avoid overexploitation of these stocks, or underexploitation of whiting.

Of the presented scenarios, only the "minimum" and "haddock" scenarios meet the objective of all stocks being fished at or below F_{MSY}. This implies reducing effort levels by 42% compared to those observed in 2016. It also means the whiting

and cod TACs at F$_{MSY}$ cannot be fully utilized in the mixed gadoid fisheries if haddock is to be fished at F$_{MSY}$. In contrast to single-stock advice there is no single recommendation, 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.

The "minimum" scenario assumes that all catch (including any discards) 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, spatio-temporal management measures, or reallocation of stock shares, may be required if fishing opportunities are to be fully taken under a fully implemented landing obligation.

This year, 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 largely driven by the restrictive nature of haddock this year, needing to bring the stocks fishing mortality to within the F$_{MSY}$ range, which imply that many mixed fisheries should reduce their effort to avoid over-catching this stock. Other "range" could be computed in the future, for example scenarios minimising 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 2018, in absolute values.

Stock	Single-stock catch advice (2018) *	Catch per mixed-fisheries scenario (2018)							
		Maximum	Minimum	*Cod*	*Had*	*Whg*	*Status quo effort*	Value	Range
Cod in 27.7e–k	3428	5291	3036	3429	3412	5252	4760	4295	3834
Had in 27.7b–k	8358	13193	7455	8701	7806	13112	11864	10853	10913
Whg in 27.7b–ce–k	19429	19595	10064	12097	10432	19548	16640	16174	13348

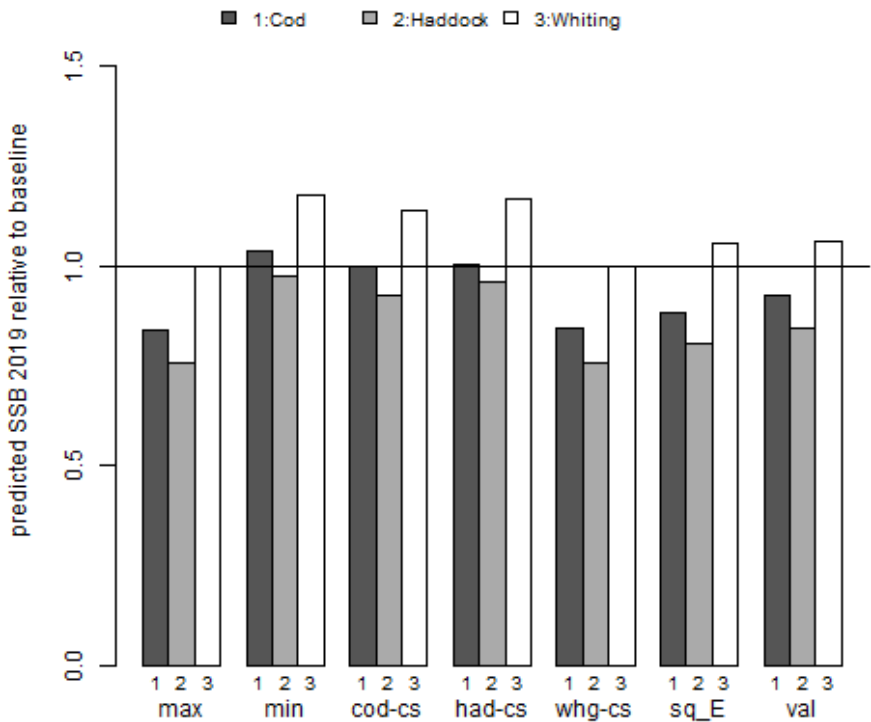* Advised catches no more than the indicated value.

Figure 3   Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Estimates of potential SSB at the start of 2019 by stock after applying the mixed-fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line indicates the SSB resulting from the single-stock advice (at the start of 2019).
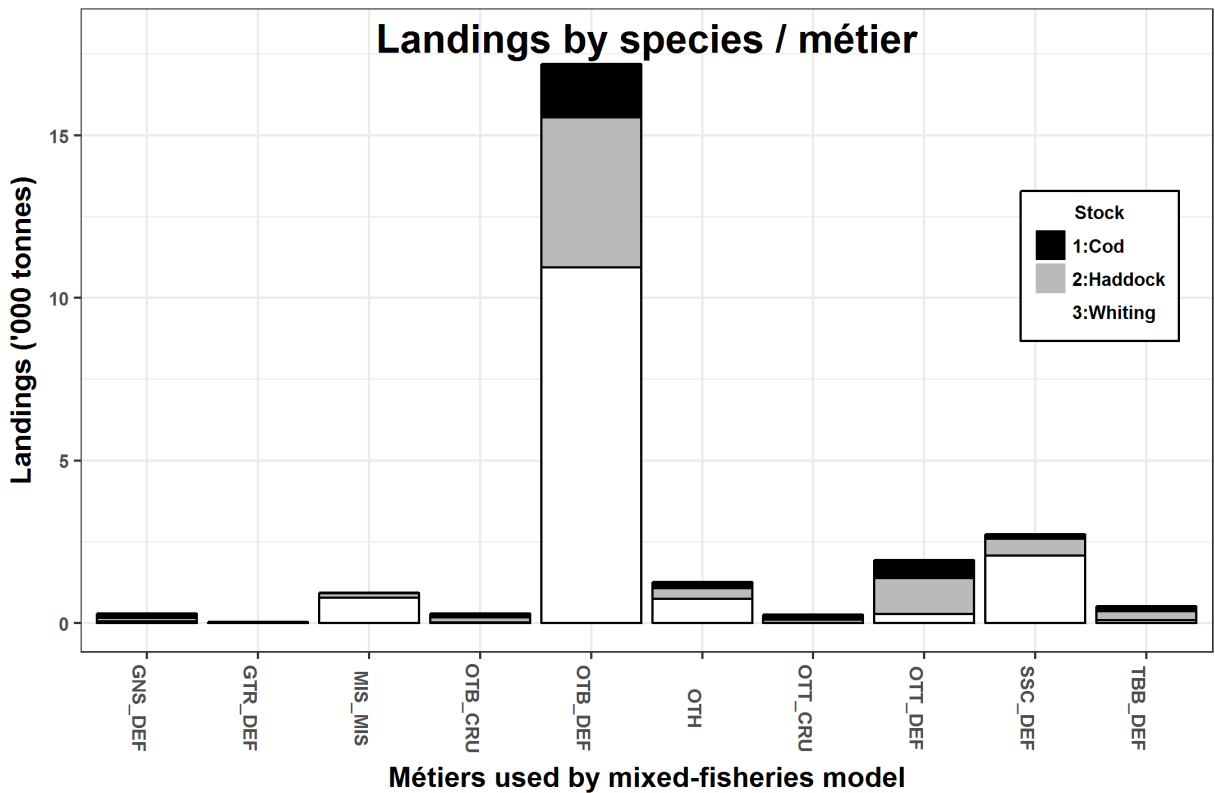

Figure 4   Mixed-fisheries advice for divisions 7.b–c and 7.e–k. Landings distribution of species by métier with landings consisting of ≥1% of any of the stocks (see Table 6) in 2016 (list of métiers available in Table 4). Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings 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 2016.

Table 3   Mixed-fisheries advice for divisions 7.b–c and 7.e–k. TAC year (2018) fishing mortality forecast by scenario. The F range is averaged across the same ages as those used for the single-stock assessment.

Stock	Single-stock F advice (2018)	Fishing mortality per mixed-fisheries scenario (2018)							
		Maximum	Minimum	Cod	*Had*	*Whg*	*Status quo* effort	Value	Range
Cod in 27.7e–k	0.3	0.5	0.26	0.3	0.29	0.5	0.44	0.39	0.34
Had in 27.7b–k	0.4	0.77	0.38	0.46	0.4	0.77	0.67	0.6	0.55
Whg in 27.7b–ce–k	0.52	0.52	0.24	0.3	0.25	0.52	0.43	0.42	0.33

legend[†]

(white)	$F\ 2018 \leq F_{MSY}$
(light grey)	$F\ 2018 > F_{MSY}, < F_{pa}$
(dark grey)	$F\ 2018 > F_{pa}$
(black)	$F\ 2018 > F_{lim}$

Table 4   Mixed-fisheries advice for divisions 7.b–c and 7.e–k. SSB results in 2019 from single-stock advice and different mixed-fisheries scenarios (see Figure 1). Weights in tonnes.

Stock	Single-stock advice	SSB (2019) resulting from mixed-fisheries scenario applied in 2017							
		Maximum	Minimum	Cod	*Had*	*Whg*	*Status quo* effort	Value	Range
Cod in 27.7e-k	12009	10063	12423	12009	12027	10104	10615	11100	11583
Had in 27.7b-k	24953	18803	24213	23031	23880	18878	20047	20998	22550
Whg in 27.7b-ce-k	46685	46544	54705	52949	54386	46584	49055	49452	51873

legend[†]

(white)	SSB 2019 > B_{pa} or MSY $B_{trigger}$
(light grey)	SSB 2019 > B_{lim}, no B_{pa} defined
(dark grey)	SSB 2019 > B_{lim}
(black)	SSB 2019 < 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
SSC_DEF	Scottish seines	Demersal fish
GNS_DEF	Gillnets	Demersal fish
TBB_DEF	Beam trawls	Demersal fish
OTB_CRU	Otter trawls	Crustaceans
OTT_CRU	Twin otter trawls	Crustaceans
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 2017 and 2018 are the same as those in 2016.

[†] Version 2: Year corrected for F and SSB

This mixed-fisheries forecast is limited to three gadoid stocks with full analytical single-species assessments, cod, haddock, and whiting (Table 6). Projections are presented in terms of catch. Total catch is forecast based on current selection patterns observed in the fisheries (in 2016), except for cod where discards are uncertain. For cod, following the single stock advice, an average discard rate of recent year (10.2%) is used to "top-up" the predicted landings to a predicated catch for each scenario. The reference points for the included stocks can be found in the 2017 single-stock advice sheets (ICES, 2017c, 2017d, and 2017e) and the 2016 relative catch distribution is shown in Table 7. Plaice and sole were also considered for inclusion but are thought to have limited technical interaction with the gadoid stocks (ICES, 2015). Pelagic species (e.g. herring, mackerel, horse mackerel) are not included as they are mainly taken by fisheries subject to little technical interaction.

Further work is ongoing to include additional analytical stocks (e.g. the Norway lobster stocks). Methods to include stocks without analytical assessments in the mixed-fisheries forecasts based on catch per unit of effort (cpue) are also being considered in order to take account of the potential "choke" species for fleets operating under a landing obligation.

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	Division 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

Stock
■ 1:Cod
▨ 2:Haddock
□ 3:Whiting
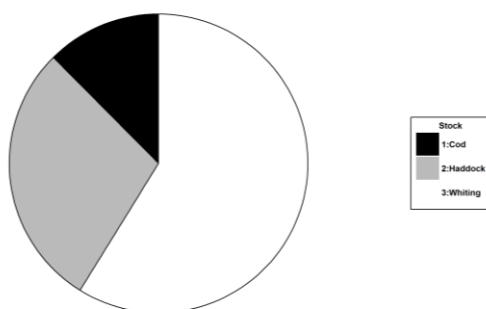
Total landings (2016) of all species considered in the mixed-fisheries advice were 25 504 t, with:
~ 88% landed by otter trawls and seines;
~ 2% by beam trawls;
~ 1% by gill- and trammelnets; and
~ 9% by other gears.
Total discards (not shown in the plot) were 18 388 t (42% by weight of total catch). Cod discards are not included in the analysis.

The projections made use of data requested as part of an ICES data call, issued formally under the EU Data Collection Framework (DCF) regulations. This provides a much greater consistency between catch totals supplied to ICES. To allow consideration of fleets defined by length categories, separate data files containing total weight of landings and effort in kW-days by fleet and métier were also 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 2016 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, 2017a)
Assessment type	Fcube (FLR), (Ulrich *et al*., 2011)
Input data	Assessments on the relevant stocks in the Celtic Sea Ecoregion fisheries working group (WGCSE) (ICES, 2017a), catch and effort by fleet and métiers
Discards and bycatch	Included as in the single-stock assessments, where possible
Indicators	None
Other information	This assessment was first presented in 2014 at the MIXFISH-METHODS (ICES, 2015). As any scenario results in trade-offs between different fisheries that are informed by more than scientific considerations, no one scenario is presented as advice. 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, 2017b).

Quality considerations

To maintain consistency with the single-stock advice, the mixed-fisheries analysis is based on total catch (landings and discards) for haddock and whiting with cod catch forecasts based on landings with a "top-up" for discards which are assumed to be 10.2% of total catch under each scenario.

The quality of data on catch, disaggregated by métier, has improved in recent years because of the single ICES data call combining data needs and ensuring common data storage in Intercatch for single-stock assessment and mixed-fisheries forecasts.

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.

Mixed-fisheries scenarios are based on central assumptions that fishing patterns and catchability in 2018 are the same as those in 2016 (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 which 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 that the use of better selection patterns for some fleets (such as gillnetters) in achieving the MSY approach can be taken into account. The possibility of using catch-at-age by fleet through the Intercatch database is being investigated.

This year, the single stock advice for two of the stocks (cod and whiting) changed thee intermediate year assumption from an average fishing mortality (average F in past three years) to be based on a rescaled average fishing mortality (F 2014–2016, rescale to 2016). This had the consequence of a similar assumption between the F in the single stock advice and the F_{cube} forecasts (which are based on a *status quo* effort in the intermediate year). As such, mixed fisheries forecasts are based on *status quo* effort in the intermediate year, following by the mixed-fishery forecast scenario in the TAC year. Some differences still exist to haddock which remains based on an average F (2014–2016) in the single-stock intermediate year.

Sources and references

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