

Mixed-fisheries advice for Subarea 4, Division 7.d, and Subdivision 3.a.20 (North Sea, eastern English Channel, Skagerrak)

ICES advice

Mixed-fisheries considerations are based on the single-stock assessments, combined with information on the average catch composition and fishing effort of the demersal fleets and fisheries in the Greater North Sea catching 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 and sol.27.7d), and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4outFU). 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 limiting TAC will be the TAC for haddock, whiting, and to a lesser extent Norway lobster in FU 6, which are the stocks for which the TACs are almost entirely taken when assuming that fishing fleets stop fishing once they have reached their first quota (scenario "Min" in Figure 1 and Table 2). Otherwise substantial overshoot of TACs may occur ("Max" scenario).

For those demersal fish stocks for which the F_{MSY} range is available, a "range" scenario is presented (Figure 2) that minimizes the potential for TAC mismatches in 2018 within the F_{MSY} range. 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 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 2018 TAC in the lower part of the F_{MSY} range for Eastern English Channel plaice and saithe, and in the upper part of the range for cod and North Sea plaice.

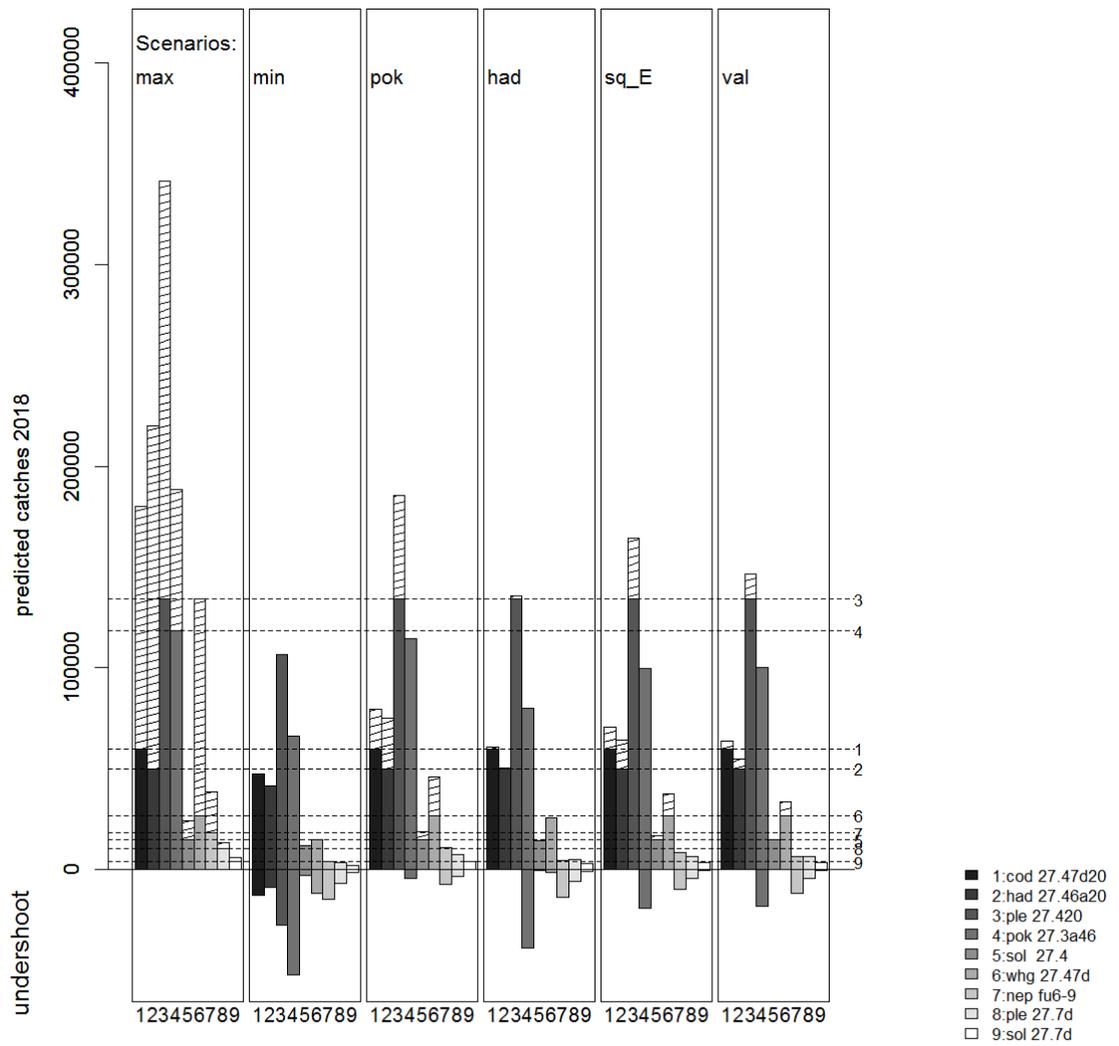


Figure 1 North Sea mixed-fisheries projections. Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2018. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice. Details for Division 7.d plaice and sole stocks are shown in Figure 7.

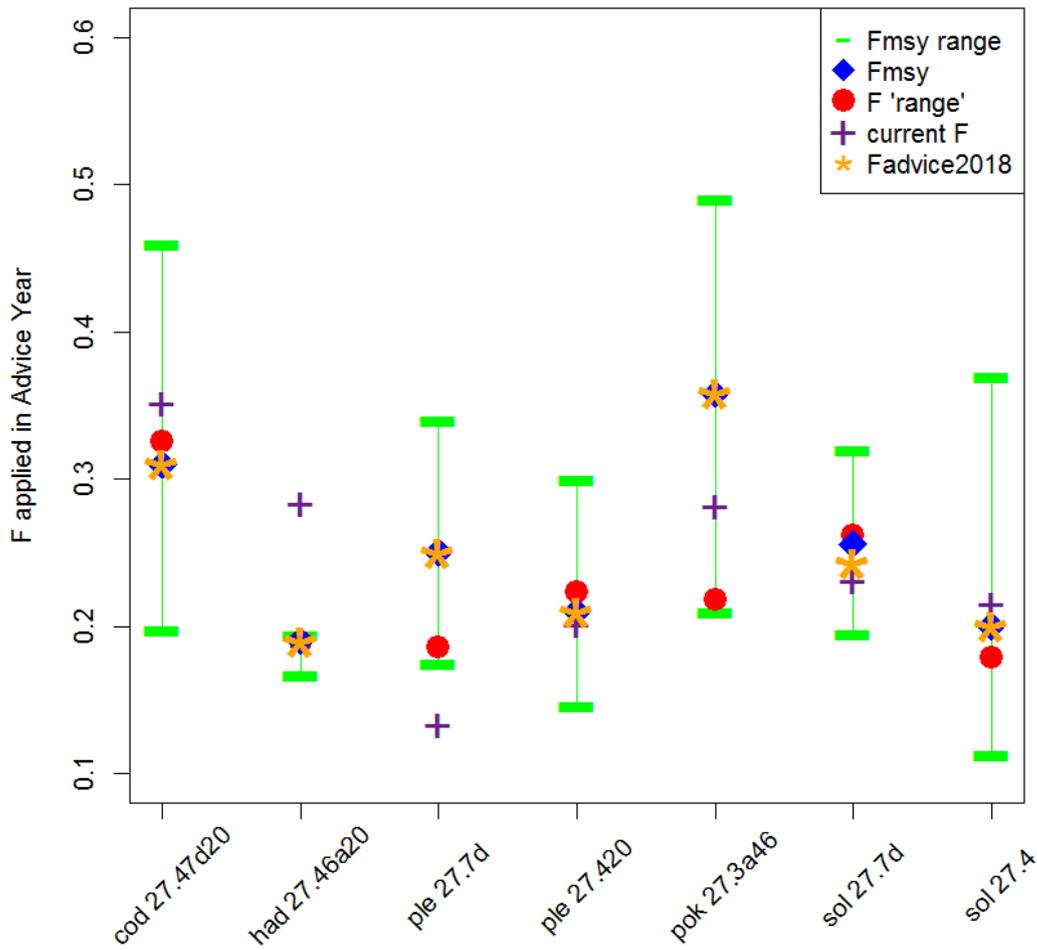


Figure 2 North Sea mixed-fisheries 2018 “range” fishing mortality within the F_{MSY} range, compared with F_{MSY} , current F (F in 2016), and F in the single-stock advice for 2018. The “range” F is the one giving the lowest difference in tonnage between the “Max” and the “Min” scenario across all stocks and fleets.

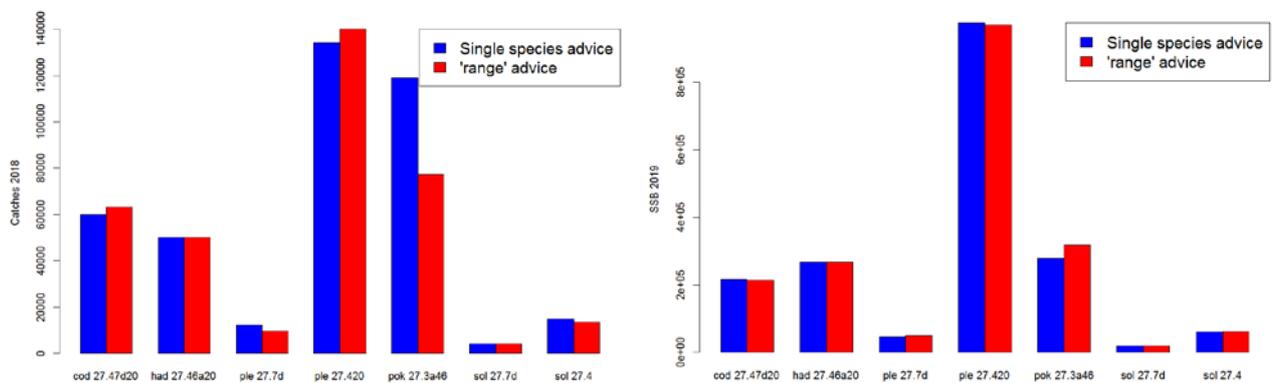


Figure 3 Comparison of the outcomes in terms of total catches in 2018 (left) and SSB in 2019 (right) between the F_{MSY} -based single-stock advice and the F_{range} -based forecast.

Table 1 F_{MSY} ranges used for the “range” scenario.

Stock	F _{MSY-lower}	F _{MSY-upper}
cod.27.47d20	0.198	0.46
had.27.46a20	0.167	0.194
pok.27.3a46	0.21	0.49
ple.27.420	0.146	0.30
ple.27.7d	0.175	0.34
sol.27.4	0.113	0.37
sol.27.7d	0.195	0.32

The potential for quota over- and undershoot linked to the most and the least restrictive single-stock fishing opportunities for 2018 is presented in Figure 1. Six projections are presented, corresponding to different fleet scenarios for 2017 and 2018 (described in Table 2). Table 2 and Figure 1 do not include the “range” scenario because the ranges of F_{MSY} are not available for all the stocks normally included in the mixed-fisheries model.

The mixed-fisheries results shown for Norway lobster are combined for several functional units (FUs) in plots, but stock status and fishing opportunities differ across FUs.

Table 2 Mixed-fisheries scenarios for the North Sea stocks.

	Scenarios
Max	“Maximum” : For each fleet, fishing effort in 2018 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.
Min	“Minimum” : For each fleet, fishing effort in 2018 stops when the most limiting of the stock shares of that fleet has been caught up. 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.
Sq_E	“Status quo effort” : The effort of each fleet in 2017 and 2018 is set equal to the effort in the most recently recorded year for which landings and discard data are available (2016).
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 further below). This option causes overfishing of some stocks and underutilization of others.
HAD	“Haddock MSY approach” : All fleets set their effort in 2017 and 2018 corresponding to their haddock stock share, regardless of other catches. (There are differences in the haddock catches between this scenario and the single-stock advice because of the slightly different forecast methods used.)
POK**	“Saithe MSY approach” : All fleets set their effort in 2017 and 2018 corresponding to their saithe stock share, regardless of other catches (There are differences in the saithe catches between this scenario and the single-stock advice because of the slightly different forecast methods used.)

* Throughout this document, the term “fleet’s stock share” or “stock share” is used to describe the share of the fishing opportunities of a stock for each particular fleet in 2018, assuming that the proportion of catches by fleet for that stock in 2017 and 2018 is the same as observed in 2016.

**POK is the international code for saithe (pollock).

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. The scenarios presented here do not assume any quota balancing through changes in targeting behaviour (i.e. changes in catchability and/or in effort distribution) and/or changes in access to quota, although the model used would allow investigating such alternative scenarios in the future.

The ICES single-stock catch advice for demersal stocks in 2018 (ICES, 2017) is based on either the existing management plans, the ICES maximum sustainable yield (MSY) approach, or the ICES precautionary approach. Mixed-fisheries catch options can take specific management priorities into account. Catch options are presented in Table 3 under the scenarios described in Table 2, with the resulting biomass at the beginning of 2018 shown in Table 7 and Figure 8. Scenario results show that it is not possible to achieve all management objectives simultaneously under the current fishing patterns. For instance, if decreasing the fishing mortality for haddock is the major objective and fleets would stop fishing after exhaustion of their haddock TAC, this could mean that the TAC for other species in the mixed fisheries may not be fully utilized. In consequence, scenarios that result in under- or overutilization are useful in identifying the main points of friction between the fishing opportunities of the various stocks, where limiting TACs can create potential

“choke species” effects. They indicate in which direction fleets may have to adapt to fully utilize these catch opportunities without increasing the risk of discards.

The 2018 single-stock advice for haddock and saithe assume that the 2017 TAC will be fully utilized. However, this implies a reduction of 35% of the fishing mortality for haddock in 2017 compared to 2016, and conversely an increase of 39% for saithe. These opposite directions will have implications for the mixed fisheries in 2017, and it can therefore not be assumed, as usually done in the mixed-fisheries projections, that the effort in 2017 will be similar to that of 2016. Consequently, the projections in the scenarios “Min”, “Max”, and “Val” assume that the “Val” scenario is applied in 2017, which means that the saithe-targeting fleets are assumed to increase their effort in 2017 in the model, while the haddock-targeting fleets are assumed to decrease their effort.

After many years of restrictive TAC, North Sea cod is no longer estimated to be the most limiting stock in the Greater North Sea mixed-fisheries model. For 2018, assuming a strictly implemented discard ban (corresponding to the “Minimum” scenario), whiting would be the most limiting stock, being estimated to constrain 24 out of 42 fleet segments. Haddock is the second most limiting stock, constraining eight fleet segments. Additionally, if Norway lobster was managed by separate TACs for the individual functional units (FUs), Norway lobster in FU 6 would be considered the most limiting stock for ten fleet segments. Conversely, in the “Maximum” scenario, saithe and Eastern Channel plaice would be the least limiting for 20 and 11 fleet segments, respectively. Finally, if Norway lobster was managed by separate TACs, Norway lobster in FUs 7, 5, 33, and 4.nonFU would be the least limiting for nine, two, one, and two fleet segments, respectively. The most and the least limiting species per fleet are shown in Figure 4.

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 limited range space and low F_{MSY} target for haddock, which imply that many mixed fisheries should reduce their effort to avoid over-catching these two stocks. Other “range” scenarios could be computed in the future, for example scenarios minimizing the potential for discards or maximizing the revenue or profit of fleets.

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 at least the SSB and/or F objectives of the single-stock advice simultaneously for all stocks considered. This is achieved in the “Minimum” scenario, which 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. While this can be considered an unlikely scenario as long as discarding is allowed, this scenario reflects the “choke-species” effect that may result from a strictly implemented discard ban without adaptation of the fleets. Fishing effort in 2018 should be reduced by 36% of its 2016 level to comply with this scenario, consistently with the reductions in fishing mortality advised for haddock, whiting, and Norway lobster in FU 6.

In contrast to the “Minimum” scenario, the “Maximum” scenario demonstrates the upper bound of potential fleet effort and stock catches. Clearly, the assumption that all fleets continue fishing until all their stock shares are exhausted irrespective of the economic viability of such actions does not make it a highly plausible scenario. Its purpose is mainly to illustrate where the imbalance lies. The different fleets have different opportunities and incentives for 2017 and 2018, depending on their historical catch composition and catchability patterns and on the differences in productivity across the various stocks that they exploit. In 2018 the fleets catching Norway lobster, saithe, and eastern English Channel plaice even as bycatch would have to double their effort to achieve their stock shares for these stocks, which would lead to potentially large overshoots of their shares for other stocks. This is a potentially unrealistic outcome for such fleets; the “Maximum” scenario indicates these fleets are unlikely to fully utilize their stock shares for Norway lobster and eastern English Channel plaice as these stocks require the highest effort.

Four intermediate scenarios reflect alternative mixed-fisheries hypotheses: “SQ_E”, “Value”, “HAD”, and “POK”.

The *status quo* “SQ_E” scenario sets the effort of each fleet in 2017 and in 2018 equal to the effort in the most recently recorded year for which data are available (2016). This scenario investigates the mixed-fisheries outcomes if the situation remains the same in terms of total effort and effort allocation among métiers. This situation presents potential for 2018 TAC overshoot for cod, haddock, North Sea plaice, and whiting, and of 2018 TAC undershoot for saithe, eastern Channel plaice, and a number of Norway lobster stocks.

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 needs 100 days of fishing to catch its share of

stock A, and 200 days of fishing to catch its share of stock B, and if the revenue of that fleet (tonnage × mean price in 2016) is 75% from stock A and 25% from stock B, then the resulting effort would be $(100 \times 0.75) + (200 \times 0.25) = 125$ days. Historically this scenario has been observed to predict effort levels closer to the realised effort than the “Minimum” and “Maximum” scenarios (Ulrich *et al.*, 2011), and for 2018 again, this scenario estimates results close to the *status quo* scenario.

This year, no “Cod” scenario is presented as cod is no longer a limiting stock. Instead, two additional scenarios are presented: “HAD” where effort would decrease in 2017 and 2018 compared to 2016 following the constraining haddock TACs; and “POK” where the effort would increase in 2017 and 2018 following the large saithe TACs. These scenarios reflect the fishing mortality corresponding to the single-stock advice for haddock and saithe, respectively (based on the ICES MSY approach), and the results present fishing opportunities for other stocks in a mixed-fisheries context. The outcomes of these two scenarios differ largely from each other, indicating in particular that it will be challenging to simultaneously achieve the management objectives for these two stocks. Additionally, as saithe is not caught only by selective targeted fisheries, the large increase in TAC for this stock increases the risk of TAC overshoot for several other stocks.

Table 3 Mixed-fisheries advice in the North Sea. Catch per mixed-fisheries scenario 2017, in absolute values.

Stock	Single-stock catch advice (2018) *	Catch per mixed-fisheries scenario (2018)						
		Maximum	Minimum	HAD	POK	Status quo effort	Value	Range
Cod in 4, 7.d, 3.a.20	59888	180241	47378	60863	79380	70421	63548	68276
Haddock in 4, 6.a, 3.a.20	50056	220293	41436	50284	75234	64286	54641	50056
Plaice in 7.d	10592	13189	3595	5007	7490	6338	6394	9637
Plaice in 4	134238	341557	106733	135962	185735	164199	146365	151711
Saithe in 4, 6, 3.a.20	118460	188427	66271	79769	114358	99571	100212	89748
Sole in 7.d	3866	6132	2254	3012	3909	3517	3664	3827
Sole in 4	14900	24210	11924	14363	18659	16679	15114	14900
Whiting in 4, 7.d	26804	134306	15153	25676	46139	37594	33833	NA
Norway lobster FU 5	1159	2404	240.5	297.7	678.1	522.5	407.5	NA
Norway lobster FU 6	1152	10153	978.1	1293	3084	2376	2074	NA
Norway lobster FU 7	13264	13157	1284	1551	3252	2506	1853	NA
Norway lobster FU 8	2745	9971	1042	1265	2969	2288	1705	NA
Norway lobster FU 9	1188	5176	543.2	653.7	1544	1190	887.6	NA
Norway lobster FU 10	40	84.68	8.471	10.49	23.89	18.41	14.36	NA
Norway lobster FU 32	496	1053	105.3	130.4	297	228.9	178.5	NA
Norway lobster FU 33	1257	2653	265.4	328.5	748.3	576.7	449.7	NA
Norway lobster FU 34	492	1038	103.8	128.6	292.9	225.7	176	NA
Norway lobster other in 4	525	1142	114.3	141.5	322.2	248.3	193.7	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.

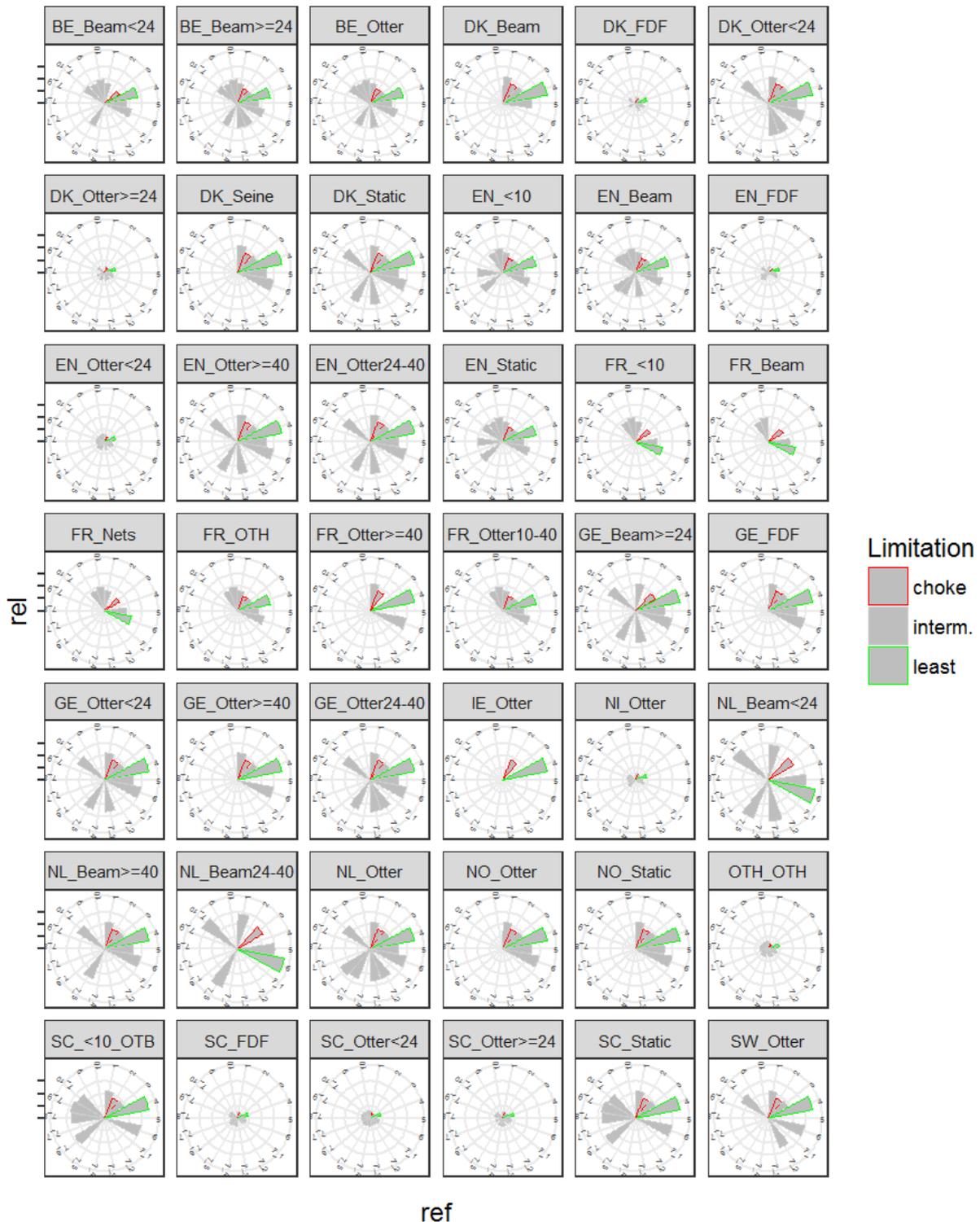


Figure 4 Mixed-fisheries advice in the North Sea. Estimates of effort by fleet needed to reach the single-stock advices. Red triangles highlight the most limiting species for that fleet in 2018 (“choke species”), whereas the green triangles highlight the least limiting species. (1: cod 27.47d20; 2: had 27.46a20; 3: Plaice 27.420; 4: pok 27.3a46; 5: sol 27.a; 6: whg 27.47d; 7_1: NEP10; 7_2: NEP32; 7_3: NEP33; 7_4: NEP34; 7_5: NEP35; 7_6: NEP6; 7_7: NEP7; 7_8: NEP8; 7_9: NEP9; 7_10: NEPOTH; 9: ple 27.7d; 10: sol 27.7d). Fleet names are given by country (BE = Belgium, DK = Denmark, EN = England, FR = France, GE = Germany, IE = Ireland, NI = Northern Ireland, NL = the Netherlands, NO = Norway, SC = Scotland, SW = Sweden, OTH = Others) and by meaningful combinations of main gear and vessel size differing across countries and based on homogeneous average fishing patterns. FDF = Fully Documented Fisheries vessels. Vessels in the various fleet segments can engage in several fisheries (métiers) over the year.

Quality considerations

Mixed-fisheries projections build on single-stock assessments, most of which are of high quality and precision. Single-stock forecasts are also reproduced independently as part of the mixed-fisheries analyses, allowing additional quality control of both processes.

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 both single-stock assessments and mixed-fisheries forecasts. It is therefore possible now to provide complete and consistent estimates of discard ratios and age or length distributions by stock for all fleets and métiers for the most recent years. In 2017, time-series of fishing effort, fishing capacity, and revenue were also revised, allowing for the analyses of changes in effort allocation and catchability over time.

A key assumption in the projections is that catchability by stock and métier and effort distribution in 2017 and 2018 remain constant at their 2016 level. But in reality fishing patterns may change over time – particularly in response to significant changes in policy, such as the introduction of the landing obligation and the revision of technical rules. In practice, such changes in catchability would affect the outcomes of mixed-fisheries projections. For example, an increase of catchability would imply that a stock can become more limiting in the “Minimum” scenario, as fewer fishing days would be required to fish up the fleets’ catch share. The more accurate mixed-fisheries dataset now allows for a better monitoring of the actual changes in effort and catchability over time, which can be used to measure the validity and the impact of the assumptions made in the model.

Issues relevant for the advice

The mixed-fisheries situation in the Greater North Sea in 2017 presents higher potential for quota mismatch compared to what has been observed in the previous years, as the 2017 TAC for Northern Shelf haddock is highly restrictive while the 2017 TAC for saithe can support an increase of fishing mortality for that stock. This mismatch will likely impact the mixed fisheries significantly in 2017, although the actual adaptation of the fleets cannot be predicted accurately. The ICES mixed-fisheries considerations for 2018 are therefore sensitive to the assumptions made on the 2017 fishing patterns.

This is the first time that ICES presents a “range” scenario in addition to the standard mixed-fisheries projections. This scenario is intended to illustrate possible mixed-fisheries catch options within the ranges of F_{MSY} provided by ICES, by investigating in which situations some deviations from the F_{MSY} -based single-stock advice could be considered.

Only demersal fish stocks from the Greater North Sea with available F_{MSY} ranges were included in the “range” scenario (see Table 1). The F_{MSY} range for whiting remains to be determined. The absence of an F_{MSY} range for whiting will likely impact the results from the “range” scenario as whiting is estimated to constrain 24 out of 42 fleet segments in the “Min” scenario.

In the absence of explicit mixed-fisheries objective the “range” criteria chosen here remains a subjective choice, and other choices including additional ecosystem and/or socio-economic considerations (Rindorf *et al.*, 2017) might be investigated on request from clients.

Norway lobster are managed on the basis of one TAC for the whole North Sea, while ICES advises on the basis of FUs. For example, catches of Norway lobster in FU 7 have long been much lower than advised, while catches in FU 6 have been significantly higher than advised since 2012. The mixed-fisheries analysis is based on the ICES catch advice for the individual FUs. As a consequence, fisheries behaviour between FUs will differ from the modelled runs and this influences the outcomes of the “Maximum” and “Minimum” scenarios.

Basis for the assessment

Table 4 Mixed-fisheries advice North Sea. The basis of the assessment.

Stock data category	Categories 1 and 4 (ICES, 2016).
Assessment type	Fcube (FLR).
Input data	Assessments on the relevant stocks in the North Sea fisheries working group (WGNSSK ; ICES, 2017a), catch and effort by fleet and métiers.
Discards and bycatch	Included as in the single-stock assessments.
Indicators	None.
Other information	This assessment was presented for the first time in 2012. As any scenario will result 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 have the greatest influence on the fisheries.
Working groups	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE).

Methods and data

Mixed-fisheries considerations are based on the single-stock assessments combined with knowledge on the species composition in catches in the Greater North Sea fisheries, using the Fcube method (Ulrich *et al.*, 2011, 2017; Table 4). Mixed-fisheries scenarios are based on central assumptions that fleets' fishing patterns (quota shares per stock, effort allocation to different métiers) and catchability in 2017 and 2018 are the same as those in 2016.

Table 5 Mixed-fisheries advice North Sea. Advice and management areas and management plans for the species considered.

Species	ICES single-stock advice area	Management area	Management plan ref(s)
Cod	Subarea 4, Division 7.d, and Subdivision 3.a.20 (North Sea, eastern English Channel, Skagerrak)	<ul style="list-style-type: none"> EU TAC Skagerrak EU TAC Division 7.d Subarea 4; EC waters of Division 2.a; the part of Division 3.a that is not covered by the Skagerrak and Kattegat 	<ul style="list-style-type: none"> Council Reg. (EC) No. 1342/2008 (EU, 2008) ^
Haddock *	Subarea 4, Division 6.a, and Subdivision 3.a.20 (North Sea, West of Scotland, Skagerrak)	<ul style="list-style-type: none"> EU TAC Division 3.a, EC waters of divisions 3.b, 3.c, and 3.d Subarea 4; EC waters of Division 2.a EC and international waters of divisions 5.b and 6.a 	<ul style="list-style-type: none"> NA
Plaice**	Subarea 4 (North Sea) and Subdivision 3.a.20 (Skagerrak)	<ul style="list-style-type: none"> Subarea 4; EC waters of Division 2.a; the part of Division 3.a that is not covered by the Skagerrak and the Kattegat Skagerrak 	<ul style="list-style-type: none"> Council Reg. (EC) No. 676/2007 (EU, 2007) ^
Saithe	Subareas 4 and 6 and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	<ul style="list-style-type: none"> Division 3.a and Subarea 4; EC waters of divisions 2.a, 3.b, 3.c, and 3.d Subarea 4; EC waters of Division 5.b; EC and international waters of subareas 12 and 14 	<ul style="list-style-type: none"> NA
Sole	Subarea 4 (North Sea)	<ul style="list-style-type: none"> EC waters of subareas 2 and 4 	<ul style="list-style-type: none"> Council Reg. (EC) No. 676/2007 (EU, 2007)
Whiting ***	Subarea 4 and Division 7.d (North Sea and eastern English Channel)	<ul style="list-style-type: none"> Subarea 4 EU TAC Subarea 7 	<ul style="list-style-type: none"> NA
Norway lobster	Functional units (FUs) in Subarea 4: 5, 6, 7, 8, 9, 10, 32, 33, 34, and other areas outside FUs	<ul style="list-style-type: none"> EU TAC Subarea 6 Norway: no TAC 	<ul style="list-style-type: none"> NA
Plaice	Division 7.d (eastern English Channel)	<ul style="list-style-type: none"> Divisions 7.d and 7.e 	<ul style="list-style-type: none"> NA
Sole	Division 7.d (eastern English Channel)	<ul style="list-style-type: none"> Division 7.d 	<ul style="list-style-type: none"> NA

* Prior to 2014 this stock was only assessed for Subarea 4 and Subdivision 3.a.20.

** Prior to 2015 this stock was only assessed for Subarea 4 (North Sea).

*** Advice for this stock includes human consumption and industrial landings.

^ Management plan or strategy is not used as the basis for advice.

The species considered here as part of the demersal mixed fisheries are cod, haddock, whiting, saithe, plaice, sole, and Norway lobster. A large number (12) of the stocks are assessed with analytical assessments. In addition, six Norway lobster stocks without analytical assessments, but for which quantitative advice is provided, are included. All stocks are not managed within the same management area or with the same management rules (MSY approach or management plan). Table 5 summarizes the advice area, management area, and management plan for the main stocks. Figure 5 illustrates the landings by species in the North Sea area per species. Landings by species and aggregated by métiers, as defined in Table 6, are presented in Figure 6. Methods to include stocks without analytical assessments in the mixed-fisheries forecasts are currently being developed in order to take account of the potential “choke” species for fleets operating under a landing obligation. Pelagic stocks (herring, mackerel) are not included as they are taken by fisheries subject to little technical interaction.

The projections are presented in terms of total catches. Haddock and sole have been under the landing obligation since 2016, and all catches for these species are assumed to count against the fleets’ stock shares. For Norway lobster stocks, a 6% *de minimis* discard ratio is assumed. Several other stocks are partly under the landing obligation in 2017 and 2018. For these, the projections follow the assumptions made in the single-stock forecasts in terms of balance between landings and discards.

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 used in mixed-fisheries and single-stock advice. 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 used. Fleet and métier categories used in the mixed-fisheries analysis are based on DCF level 6 categories, which are subsequently translated into the gear groups from the 2008 EU cod management plan (EU, 2008). Ultimately, a merging procedure takes place, which aggregates “small” métiers (a métier failing to land at least 1% in 2016 of at least one of the stocks considered) into an “Other” category.

Because of the different forecasting methods used, limited differences between catch forecasts estimated by single-stock and mixed fisheries can occur, but this does not affect the conclusions of the analyses. For example, there is a difference of 3672 tonnes (3.1%) between the single-species saithe advice and the saithe catches in the “POK” scenario in Figure 1.

Total landings (2016) of all species considered in the mixed-fisheries advice were 285 770 t, with:

- ~ 63% landed by otter trawls and seines;
- ~ 22% by beam trawls;
- ~ 5% by gill- and trammelnets;
- ~ 1% by longlines; and
- ~ 9% by other gears.

Total discards were 85 832 t (23% by weight of total catch).

Total Landings by Stock

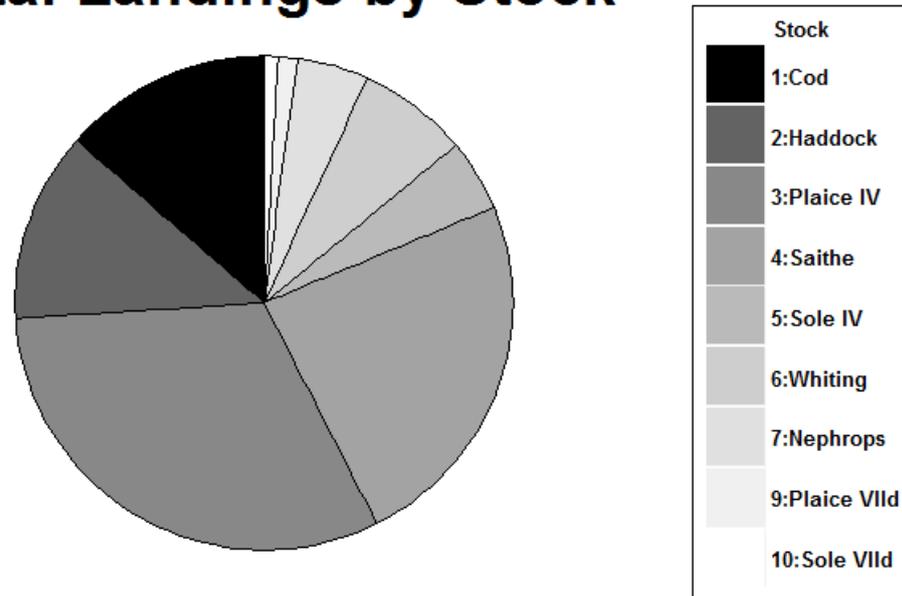


Figure 5 Mixed-fisheries advice in the North Sea. Catch distribution.

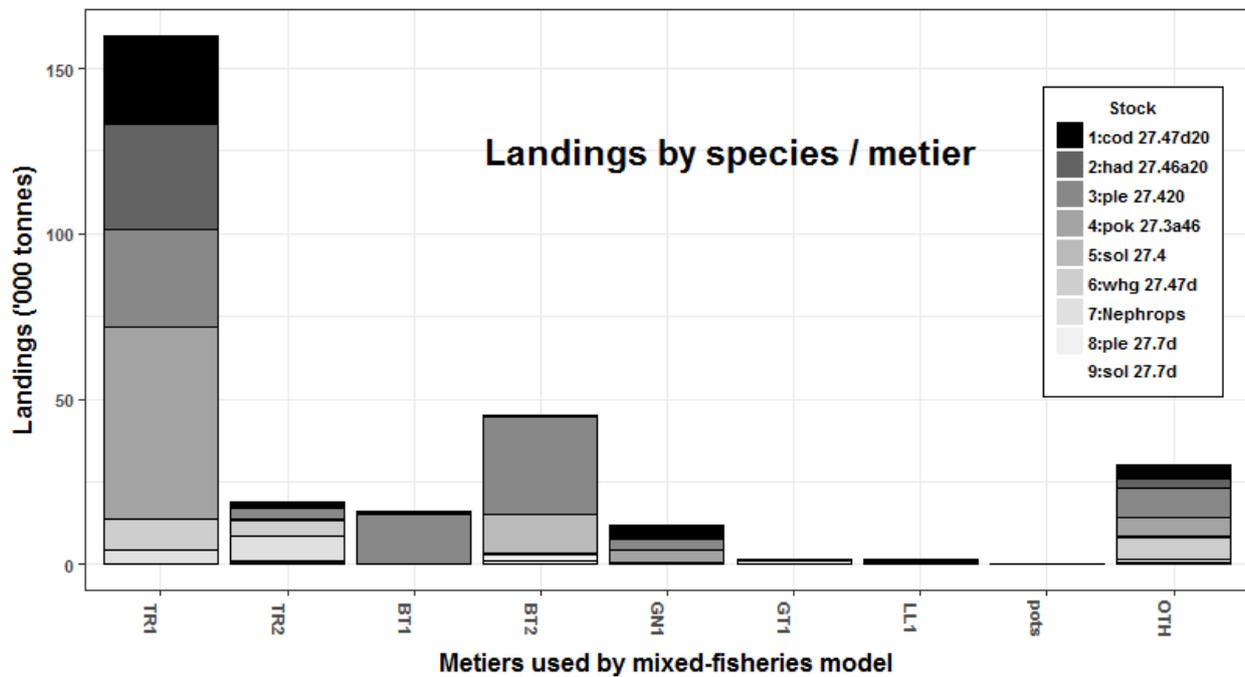


Figure 6 Mixed-fisheries advice in the North Sea. Landings distribution of species by métier, with landings consisting of $\geq 1\%$ of any of the stocks (see Figure 1) in 2016 (list of métiers available in Table 6). Note: The “other” (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings $< 1\%$ of any of the stocks 1–10 in 2016. 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 4 and Division 6.a, respectively.

Table 6 Mixed-fisheries advice North Sea. Métier categories used in the mixed-fisheries analysis.

Mixed-fisheries métiers	Gear	Mesh size
TR1	Otter trawl or demersal seine	≥100 mm
TR2	Otter trawl or demersal seine	≥70 mm and < 100 mm
BT1	Beam trawl	≥120 mm
BT2	Beam trawl	≥80 mm and < 120 mm
GN1	Gillnets	All possible mesh sizes
GT1	Trammelnets	All possible mesh sizes
LL1	Longlines	NA
Pelagic	Pelagic trawl or seine	
Pots	Pots	NA
OTH	Any gear type	

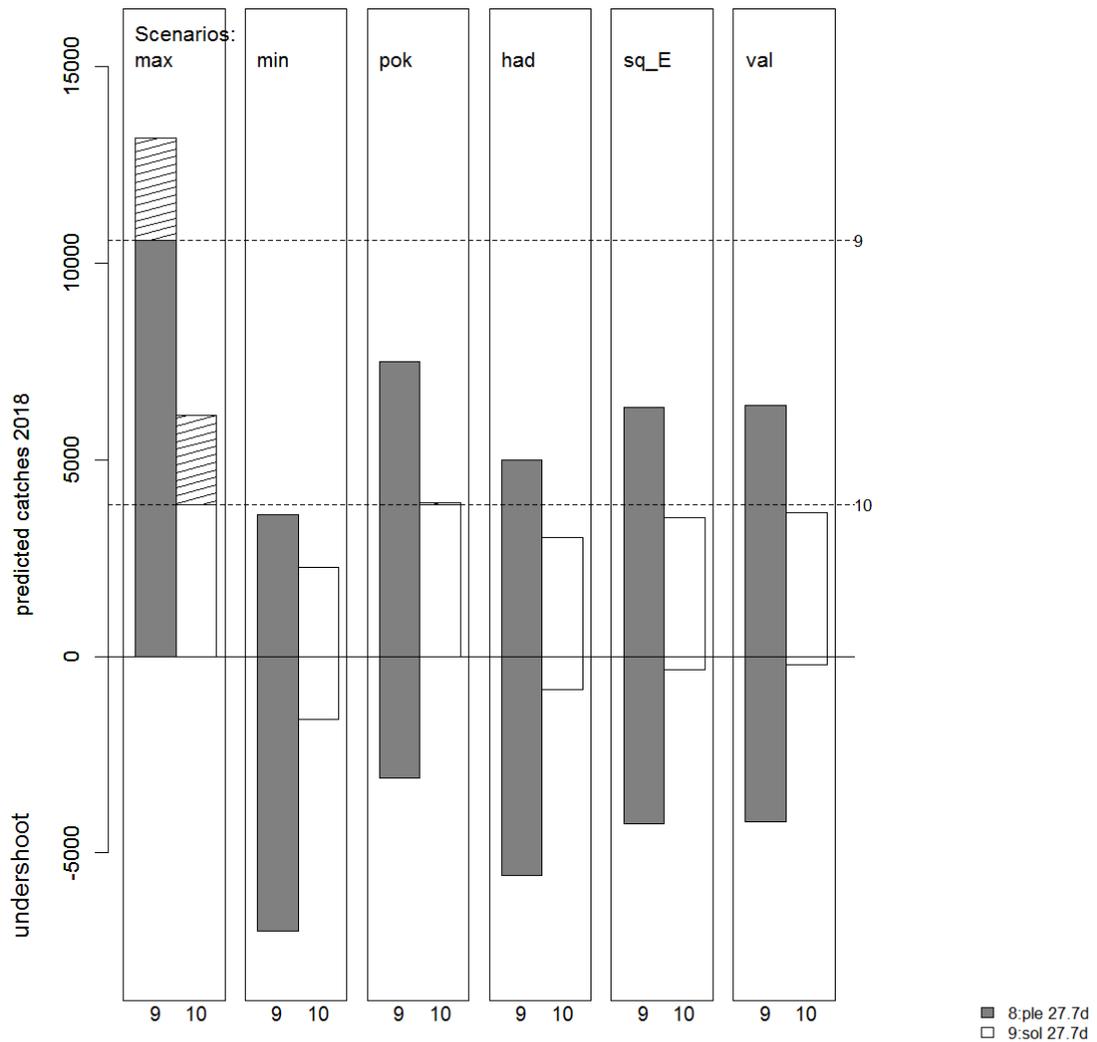


Figure 7 Mixed-fisheries projections for the stocks subject to lower catches (detail from Figure 1). Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock advice for 2018. Bars below the value of zero show the scale of undershoot (compared to single-stock advice) in cases where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

Summary of the assessment

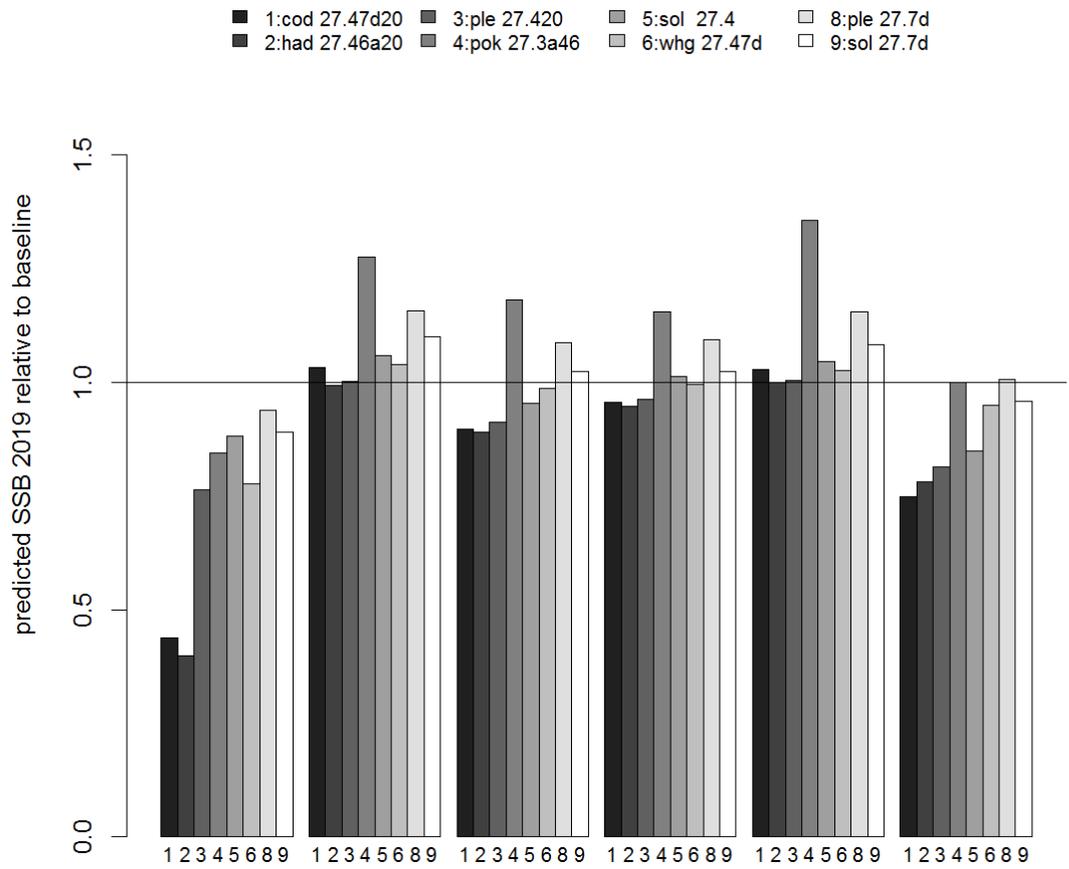


Figure 8 Mixed-fisheries advice in the North Sea. Estimates of potential SSB at the start of 2019 by stock after applying the mixed-fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2019). Norway lobster are not included as the abundance was not forecasted in the mixed-fisheries model.

Table 7 Mixed-fisheries advice in the North Sea. SSB results from single-stock advice and different mixed-fisheries scenarios (see Figure 8). Norway lobster are not included as the abundance is not forecasted in the mixed-fisheries model. All weights are in tonnes. Unless otherwise noted, SSB (2019) > B_{pa} or MSY B_{trigger}.

Stock	Single-stock advice	SSB (2018) resulting from mixed-fisheries scenario applied in 2017						
	SSB (2019)	Maximum	Minimum	had	pok	Status quo effort	Value	Range
Cod	216473	91380***	215196	214510	156291	187234*	199183	213162
Haddock	267865	106861**	266155	267716	208920	238305	253692	267865
Plaice in Division 7.d	46483	43802	54012	53909	46978	50709	51004	48978
Plaice in Subarea 4	975653	745833	978476	978944	794999	890225	938847	969778
Saithe	279689	226078	341644	362988	267781	316163	309074	319205
Sole in Division 7.d	18697**	16634**	20594	20251	17902**	19146**	19151**	18451**
Sole in Subarea 4	61164	56174	67469	66631	54211	60859	64530	62409
Whiting	354527	274853	367550	363256	335921	349038	352637	NA

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

* B_{lim} < SSB (2019) < B_{pa}.

** SSB (2019) < B_{pa}, B_{lim} not defined.

*** SSB (2019) < B_{lim}.

Sources and references

EU. 2007. COUNCIL REGULATION (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea. Official Journal of the European Union, L 157/1. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007R0676&from=EN>.

EU. 2008. COUNCIL REGULATION (EC) No. 1342/2008 of 18 December 2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks and repealing Regulation (EC) No. 423/2004. Official Journal of the European Union, L 348/21. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0020:0033:EN:PDF>.

ICES. 2017a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 26 April–5 May 2017, ICES Headquarters, Copenhagen, Denmark. ICES CM 2017/ACOM:21. In preparation.

ICES. 2017b. Report of the Working Group on Mixed Fisheries Advice (WGMIXFISH-Advice), 22–26 May 2017, ICES Headquarters, Copenhagen, Denmark. In preparation.

Rindorf, A., Dichmont, C. M., Levin, P. S., Mace, P., Pascoe, S., Prellezo, R., Punt, A. E., Reid, D. G., Stephenson, R., Ulrich, C., Vinther, M., and Worsøe Clausen, L. 2017. Food for thought: pretty good multispecies yield. ICES Journal of Marine Science. 74(2): 475–486. doi: 10.1093/icesjms/fsw071.

STECF. 2015. Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of management plans: Evaluation of the multi-annual plan for the North Sea demersal stocks (STECF-15-04). 2015. Publications Office of the European Union, Luxembourg, EUR 27232EN, JRC 95959. 152 pp.

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

Ulrich, C., Reeves, S. A., Vermard, Y., Holmes, S., and Vanhee, W. 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. ICES Journal of Marine Science, 68(7): 1535–1547. doi: 10.1093/icesjms/fsr060.

Ulrich, C., Vermard, Y., Dolder, P. J., Brunel, T., Jardim, E., Holmes, S. J., Kempf, A., Mortensen, L. O., Poos, J.-J., and Rindorf, A. 2017. Achieving maximum sustainable yield in mixed fisheries: a management approach for the North Sea demersal fisheries. ICES Journal of Marine Science, 74(2): 566–575. doi: 10.1093/icesjms/fsw126.