9.2   Greater North Sea Ecoregion – Fisheries overview, including mixed-fisheries considerations

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Executive summary

This fisheries overview contains details of mixed fisheries considerations for North Sea demersal and *Nephrops* stocks, and a description of the fisheries and their interactions within the ecoregion.

Mixed-fisheries considerations presents six example scenarios of fishing opportunities of eight fish stocks and 10 *Nephrops* stock units fished within the ecoregion: 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) taking into account the single-stock advice of those species. For this year the most limiting TAC in 2020 will be the TAC for cod for particular fleets.

Around 6600 fishing vessels are active in the Greater North Sea. Total landings peaked in the 1970s at 4 million tonnes and have since declined to about 2 million tonnes. Total fishing effort has declined substantially since 2003. Pelagic fish landings are greater than demersal fish landings. Herring and mackerel, caught using pelagic trawls and seines, account for the largest portion of the pelagic landings, while sandeel and haddock, caught using otter trawls/seines, account for the largest fraction of the demersal landings. Catches are taken from more than 100 stocks. Discards are highest in the demersal and benthic fisheries. The spatial distribution of fishing gear varies across the Greater North Sea. Static gear is used most frequently in the English Channel, the eastern part of the Southern Bight, the Danish banks, and in the waters east of Shetland. Bottom trawls are used throughout the North Sea, with lower use in the shallower southern North Sea where beam trawls are most commonly used. Pelagic gears are used throughout the North Sea.

In terms of tonnage of catch, most of the fish stocks harvested from the North Sea are being fished at levels consistent with achieving good environmental status (GES) under the EU's Marine Strategy Framework Directive; however, the reproductive capacity of the stocks has not generally reached this level. Almost all the fisheries in the North Sea catch more than one species; controlling fishing on one species therefore affects other species as well. ICES has developed a number of scenarios for fishing opportunities that take account of these technical interactions. Each of these scenarios results in different outcomes for the fish stocks. Managers may need to take these scenarios into account when deciding upon fishing opportunities. Furthermore, biological interactions occur between species (e.g. predation) and fishing on one stock may affect the population dynamics of another. Scenarios that take account of these various interactions have been identified by ICES and can be used to evaluate the possible consequences of policy decisions. The greatest physical disturbance of the seabed in the North Sea occurs by mobile bottom-contacting gear during fishery in the eastern English Channel, in nearshore areas in the southeastern North Sea, and in the central Skagerrak. Incidental bycatches of protected, endangered, and threatened species occur in several North Sea fisheries, and the bycatch of common dolphins in the western English Channel may be unsustainable in terms of population.

Introduction

The Greater North Sea ecoregion includes the North Sea, English Channel, Skagerrak, and Kattegat. The Greater North Sea is a relatively shallow sea on the European continental shelf, with the exception of the Norwegian Trench that extends parallel to the Norwegian shoreline, from Oslo to north of Bergen. Pelagic species (primarily herring and mackerel) account for a significant portion of the total commercial fish landings in the region. Landings of benthic and demersal finfish species (primarily haddock, sandeel, flatfish, and cod) are also significant.
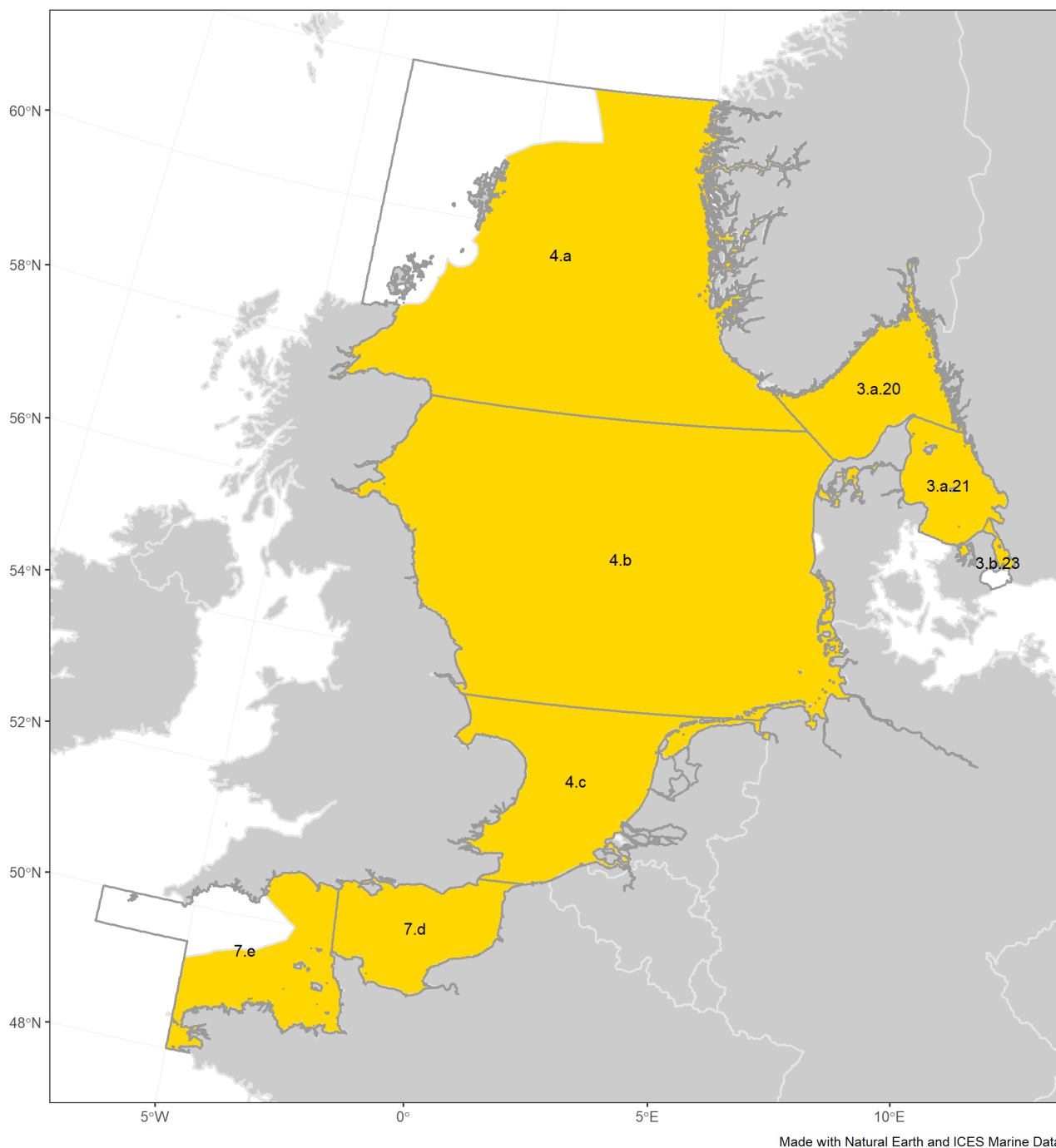

Made with Natural Earth and ICES Marine Data

Figure 1   The Greater North Sea ecoregion (in yellow) as defined by ICES. The relevant ICES statistical areas are shown.

All of the Greater North Sea ecoregion lies within the FAO Major Fishing Area 27; the prefix "27" in the ICES statistical area codes is therefore omitted in the following. This overview covers ICES Division 3.a, most of divisions 4.a, 4.b, 4.c, 7.d, and part of 7.e as well as Subdivision 3.b.23.

The overview does not include the fisheries in the western English Channel (Division 7.e) and in the Sound (south of Subdivision 3.a.21).

Mixed-fisheries considerations

Mixed-fisheries considerations are based on the single-stock assessments, combined with information on the catch composition and fishing effort of the demersal fleets and fisheries in the Greater North Sea which catch 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). In the absence of specific mixed-fisheries management objectives, ICES does not advise on specific mixed-fisheries catch opportunities for the individual stocks. 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.

Mixed-fisheries scenarios are based on central assumptions that fleet fishing patterns and catchability in 2019 and 2020 are the same as those in 2018 (similar to procedures in single-stock forecasts, where growth and selectivity are assumed constant). Beginning with this year's advice, the assumptions for the MIXFISH scenarios for the North Sea have been modified to more realistically reflect choke situations, i.e. where one or more national quotas are fully utilised, all fishing will cease for that Member State (MS). If a MS has unused quota for a given stock, that stock shall not be estimated to be a choke species for the fleets of that MS, making the hypothesis that national quotas are easier to reallocate between fleets than countries. To forecast catches, recent catchability and fishing mortality are calculated by national fleet.

Mixed-fisheries projections are presented in terms of catch (wanted + unwanted catch). 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). The mixed-fisheries results shown for Norway lobster are combined for several FUs in plots, but stock status and fishing opportunities differ across FUs.

For those demersal fish stocks for which the F_{MSY} range is available, a "range" scenario is presented that minimizes the potential for TAC mismatches in 2020 within the F_{MSY} range. This scenario estimates 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 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 potential for quota over- and undershoot linked to the most and the least restrictive single-stock fishing opportunities for 2020 is presented in Figure 1. Six projections are presented, corresponding to different fleet scenarios for 2019 and 2020 (described in Table 1). Norway lobster stocks are not yet included in the "range" scenario.

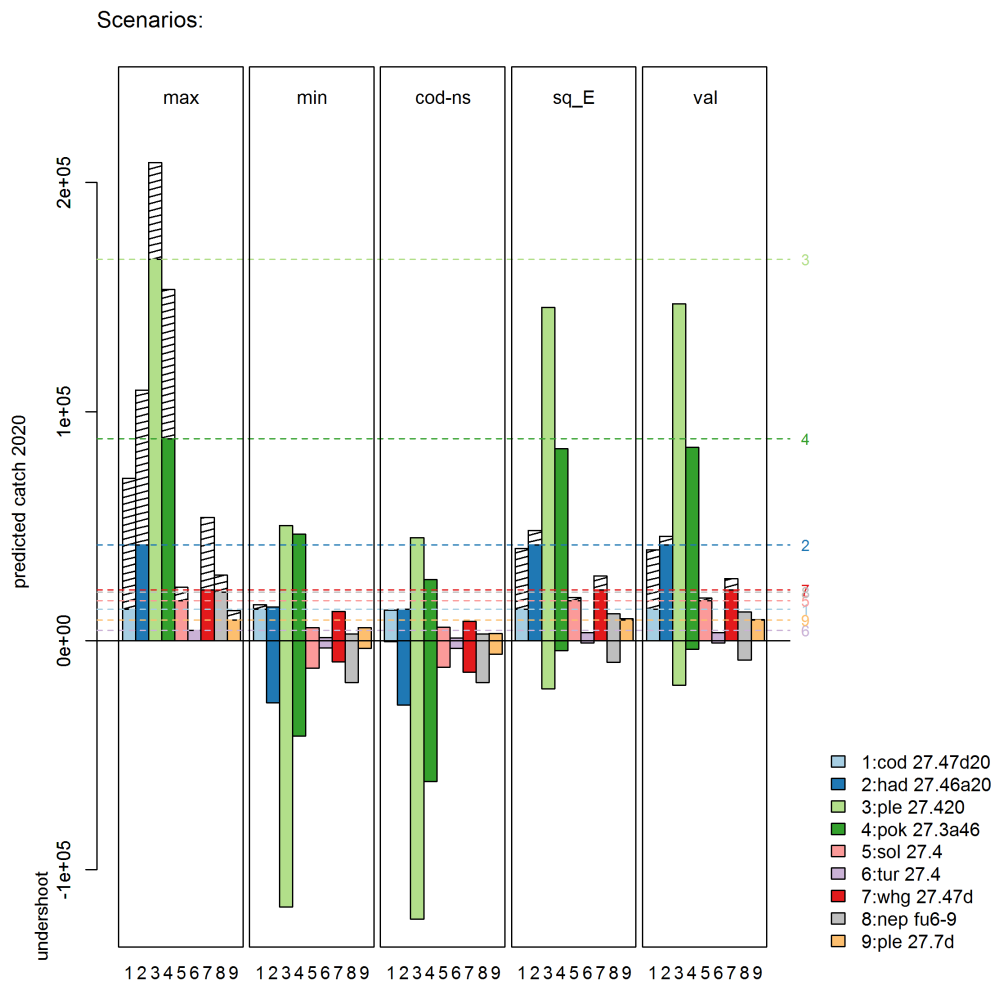**Figure 2**   Mixed fisheries for the North Sea. Mixed-fisheries projections. Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2020. Bars below the value of zero show undershoot (compared to single-stock advice) where catches are predicted to be lower when applying the scenario. Hatched columns represent catches that overshoot the single-stock advice.

Figure 3   Mixed fisheries for the North Sea. 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 4   Mixed fisheries for the North Sea. 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 F_{range}-based forecast.

Table 1   Mixed fisheries for the North Sea. Mixed-fisheries scenarios for the North Sea stocks.
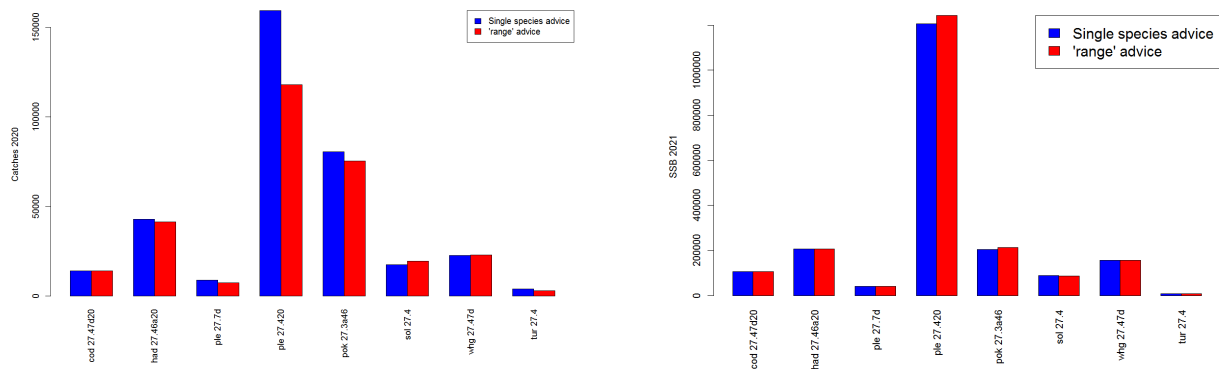
	Scenarios
Max	**"Maximum":** For each fleet, fishing effort in 2020 stops when all stock shares* of that fleet have been caught up. This option causes overfishing of the single-stock advice possibilities of most stocks.
Min	**"Minimum":** Choke species are assessed at the country level comparing the 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.
Sq_E	**"*Status quo* effort":** 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).
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.
COD-ns	**"Cod MSY approach":** 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.
range	**"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 limited in accordance with the MSY approach and the MAP for stocks below MSY $B_{trigger}$.

* Throughout this document, the term "fleet's stock share" or "stock share" describes the share of the fishing opportunities of a stock for each particular fleet in 2019, assuming that the proportion of catches by fleet for that stock in 2019 and 2020 is the same as observed in 2018.

Catch scenarios

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 2018. 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 2020 is based on either the existing management plans, the ICES maximum sustainable yield (MSY) approach, or the ICES precautionary approach. Mixed-fisheries catch scenarios can take specific management priorities into account. Catch scenarios are described in Table 1 and presented in Table 2, with the resulting spawning stock biomass (SSB) at the beginning of 2021 shown in Table 7 and Figure 7, and the F_{total} value for 2020 shown in Table 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 cod is the major objective and fleets stopped fishing after exhaustion of their cod TAC, this could mean that the TAC for other species in the mixed fisheries may not be fully utilized. As a consequence, scenarios that result in under- or overutilization are useful in identifying the main mismatches between the fishing opportunities of the various stocks, where limiting TACs can create potential "choke species" effects at fleet level. Such scenarios indicate the direction fleets may have to adapt to fully utilize these catch opportunities without increasing the risk of unwanted catch.

North Sea cod is estimated to be the most limiting stock in the Greater North Sea mixed-fisheries model. The assessment of cod has indicated that its SSB for 2019 is below Blim, with advised catch rates for 2020 below Fmsy in order to achieve an SSB > Blim in 2021. For 2020, assuming a strictly implemented landing obligation (corresponding to the "Min" scenario), cod is estimated to constrain 22 out of 42 fleet segments (Figure 5). Plaice stocks are the next most limiting stocks, constraining ten fleet segments (6 for North Sea plaice and 4 for Eastern Channel plaice). 9 fleet segment are assumed not to be limited by any stock (the quota is assumed not to be limiting for the species they are targeting). Conversely, in the "Max" scenario, North Sea plaice, saithe and turbot would be the least limiting for 20, 5 and 5 fleet segments, respectively.

Finally, if Norway lobster were managed by separate TACs, Norway lobster in FU 7 would be the least limiting for seven fleet segments. The most and the least limiting species per fleet are shown in Figure 5.

The "range" scenario (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. 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 and Eastern Chanel plaice and North Sea saithe, and at the highest possible value for cod in accordance with the MSY approach and the EU multiannual plan (MAP; EU, 2018). The outcomes of this scenario are largely driven by differences between the current F for cod and the highest possible F used in the adjusted range for cod (Figure 3), which implies that many mixed fisheries should reduce their effort to avoid over-catching this stock.

ICES single-stock advice provides TACs according to the ICES MSY approach or the MAP. 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 "Min" scenario, which assumes that fleets 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 "choke species" effect that may result from a strictly implemented landing obligation without adaptation of the fleets. Total fishing effort in 2020 should be reduced by 50% of its 2018 level to comply with this scenario, consistently with the reductions in fishing mortality advised for cod. For some fleets effort may need to be reduced much more than 50%.

In contrast to the "Min" scenario, the "Max" 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 2019 and 2020, depending on their historical catch composition and catchability, and on the differences in productivity across the various stocks that they exploit. In 2020 the fleets catching any amount of Norway lobster, saithe, and plaice would have to increase their effort on average by 65% to achieve their stock shares for these stocks, which would lead to potentially large overshoots of their shares for other stocks. This is an unrealistic outcome for such fleets, especially considering that the TAC for saithe and plaice is not fully taken at present (total catches were around 70% of the catch advice in 2018 for these two stocks).

Two intermediate scenarios reflect alternative mixed-fisheries hypotheses: "SQ_E" and "Value".

The *status quo* "SQ_E" scenario sets the effort of each fleet in 2019 and in 2020 equal to the effort in the most recently recorded year for which data are available (2018). This scenario investigates the mixed-fisheries outcomes if the situation remains the same in terms of total effort and effort allocation among métiers. This situation presents a potential 2020 TAC overshoot for cod, haddock, whiting, North Sea sole, Eastern Channel plaice, and a 2020 TAC undershoot for saithe, North Sea plaice, turbot, and a number of Norway lobster stocks.

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. This scenario usually predicts effort levels closer to the realised effort than the "Min" and "Max" scenarios (Ulrich *et al.*, 2011). For 2020, the "Value" scenario estimates results close to the *status quo* "Sq_E" scenario.

This year, a "COD-ns" scenario is presented. This scenario reflects the fishing mortality corresponding to the single-stock advice for cod (based on the ICES MSY approach), and the results present fishing opportunities for other stocks in a mixed-fisheries context.

A 'range' 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 other 'range' scenarios could be computed in the future, for example scenarios minimizing the potential for discarding or maximizing fleets' revenue or profit.

As not all fleets are limited by cod, the outcomes of that scenario are in-between those of the "Min" and "SQ_E" scenarios.

Table 2 Mixed fisheries for the North Sea. Catch per mixed-fisheries scenario 2020, in absolute values.

Stock	Single-stock catch advice (2020) *	Catch per mixed-fisheries scenario (2020)					
		Maximum	Minimum	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}.
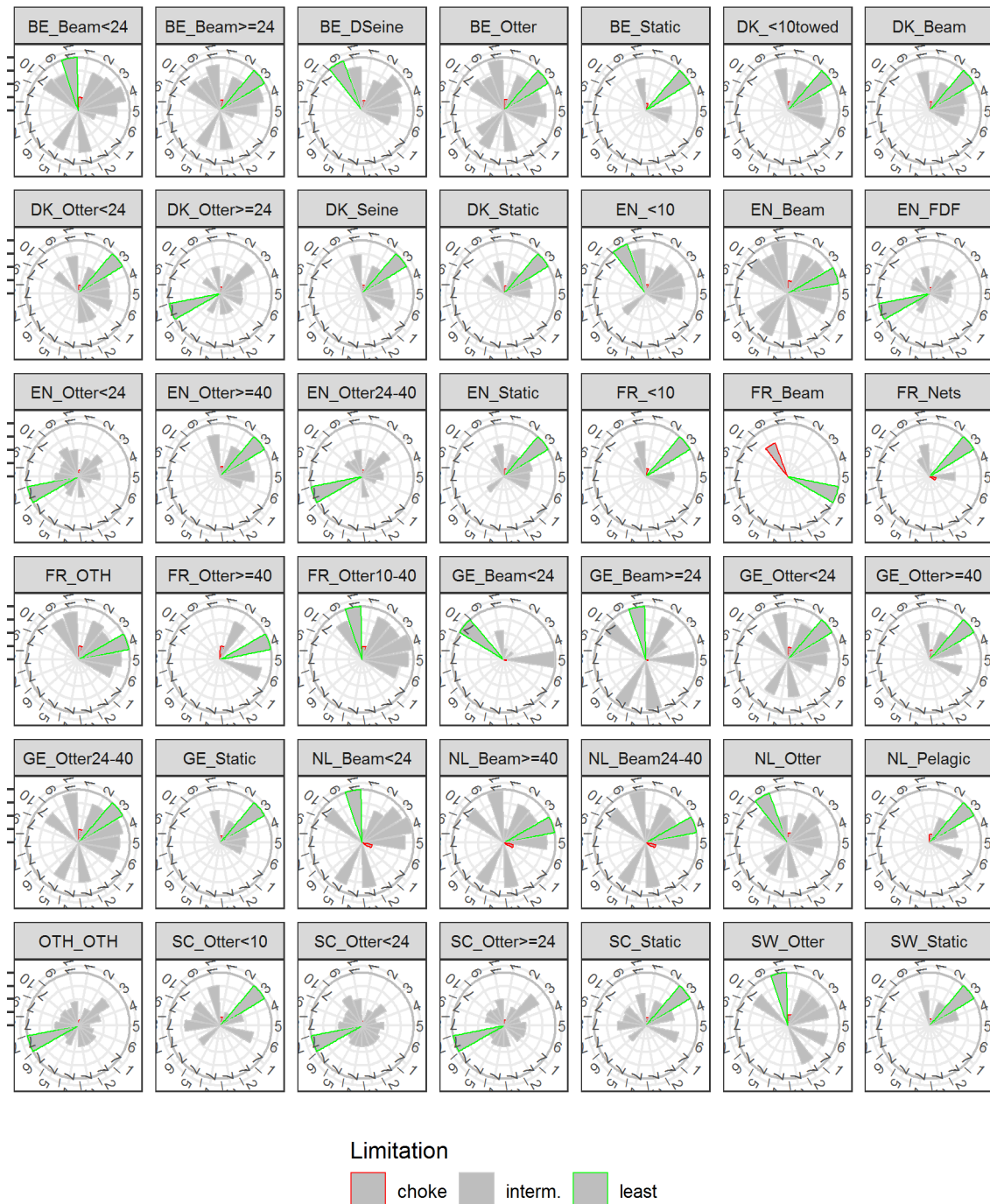
Figure 5 Mixed fisheries for the North Sea. Estimates of effort by fleet needed to reach the single-stock advices. Red triangles highlight the most limiting species for that fleet in 2019 ("choke species"), whereas the green triangles highlight the least limiting species. (1: cod.27.47d20; 2: had.27.46a20; 3: ple.7.420; 4: pok.27.3a46; 5: sol.27.4; 6: whg.27.47d; 7_1: nep.fu.10; 7_2: nep.fu.32; 7_3: nep.fu.33; 7_4: nep.fu.34; 7_5: nep.fu.35; 7_6: nep.fu.6; 7_7: nep.fu.7; 7_8: nep.fu.8; 7_9: nep.fu.9; 7_10: nep.27.4outFU; 9: ple.27.7d; 11: tur.27.4). Fleet names are given by country (BE = Belgium, DK = Denmark, EN = England, FR = France, GE = Germany, IE = Ireland, NI = Northern Ireland, NL = the Netherlands, 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 are based on single-stock assessments. Single-stock forecasts are also reproduced independently as part of the mixed-fisheries analyses, allowing additional quality control of both processes.

It is not possible to include Sole in 7d in the mixed fisheries analysis this year because the assessment was downgraded to Category 3 and could not be included this year.

Data provided on catches (wanted and unwanted catch) and effort are disaggregated by metier. Age and length distributions by stock for all fleets and métiers are available for the most recent years. In spite of the improvements made over time, and in particular the issuing of a specific data call, the compilation of the mixed-fisheries dataset does however remain a highly demanding process, combining several types of data provided by different sources and covering a large number of countries, stocks, and fishing activities. Various changes and updates in the data sources occur every year, and quality control is a major component of the work performed, and is considered suitable for providing advice.

Due to differences in the stochastic forecasts used by several single species assessments (i.e. saithe, cod, turbot, and whiting) versus the deterministic forecast done within MIXFISH, some discrepancies are to be expected. Normally these differences are small (< 5%), but can increase when uncertainties on outputs such as SSB and F are large. For this year substantial differences in SSB were observed in the advice year for cod. In order to better align the forecast with that of the single species advice, fishing mortality of the intermediate year (2019) was forced to 0.5 rather than estimating the F from the catch-constraint (F = 0.47).

Norway has not provided effort information since 2016, making it impossible to estimate catchability estimates. In consequence, Norwegian fleets are now included in the "Other fleets" segment (OTH_OTH in the model). Norway mainly contributes to North Sea cod and saithe catches (around 15% and 45% respectively).

A key assumption in the projections is that catchability by stock and métier and effort distribution (relative proportion of time spent by each fleet in the various métiers) in 2019 and 2020 remain constant at their 2018 level. In reality fishing patterns may change over time – particularly in response to significant changes in policy, such as the introduction of the EU 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 "Min" scenario, as fewer fishing days would be required to fish up the fleets' catch share.

Issues relevant for the advice

The intention with the "range" scenario is to illustrate possible mixed-fisheries catch scenarios within the ranges of F_{MSY} provided by ICES. In the absence of explicit mixed-fisheries objectives, the "range" criteria chosen here remain a subjective choice. Other choices, including additional ecosystem and/or socio-economic considerations, may be investigated if requested.

Norway lobster fisheries 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, model assumptions of fisheries behaviour differ if managed by Functional Unit than by management unit, and this influences the outcomes of the scenarios (Table 3).

Basis for the assessment

Table 3   Mixed fisheries for the North Sea. The basis of the assessment.

Stock data category	Categories 1 and 4 (ICES, 2018a).
Assessment type	F_{cube} (FLR)
Input data	Assessments on the relevant stocks in the North Sea fisheries working group (WGNSSK; ICES, 2019b); catch and effort by fleet and métiers.
Discards and bycatch	Included as in the single-stock assessments.
Indicators	None.
Other information	Mixed fisheries scenarios have been provided since 2012. As any scenario will result in trade-offs between different fisheries that are informed by more than scientific considerations, no single 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 F_{cube} method (Ulrich *et al.*, 2011, 2017). Mixed-fisheries scenarios are based on central assumptions that fishing patterns of fleets (quota shares per stock, effort allocation to different métiers) and catchability in 2019 and 2020 are the same as those in 2018.

The species considered here as part of the demersal mixed fisheries are cod, haddock, whiting, saithe, plaice, sole, turbot, 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 MAP). Table 4 summarizes the advice area, management area, and management plan for the main stocks. Table 5 gives the FMSY ranges that have been used in the "range" scenario. Figure 6 illustrates the landings by species in the North Sea area by métier. Table 7 describes the métiers used in the forecast for the different scenarios. Methods to include stocks without analytical assessments in the mixed-fisheries forecasts are currently being developed in order to account for the potential "choke" species for fleets operating under a landing obligation. Pelagic stocks (herring, mackerel) are not included because there are fewer mixed fisheries interactions.

The projections are presented in terms of total catches. All stocks are under the landing obligation since 2019, and all catches for these species are assumed to count against the fleets' stock shares each year.

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 scenario results.

Fleet and métier categories used in the mixed-fisheries analysis are based on EU Data Collection Framework (DCF) level 6 categories, which are subsequently translated into the gear groups from the 2008 EU cod management plan (EU, 2008). The "non-allocated" category collects the difference between the total landings used in the single-stock assessments and the sum of the landings allocated to all fleets and métiers. In 2017, this "non-allocated" part became very large as it includes all Norwegian landings for which effort data was not provided and which could therefore not be defined as fleets. The "Other" métier sums up the landings of all "small" métiers (i.e. all métiers failing to land at least 1% in 2017 of at least one of the stocks considered). Both the "Other" and the "non-allocated" métiers are afterwards merged into the "OTH-OTH" fleet in the model.

Total landings (2018) of all species considered in the mixed-fisheries advice were 230 141 tonnes, with:

~ 59% landed by otter trawls and seines;
~ 16% by beam trawls;
~ 3% by gill- and trammelnets;
~ < 1% by longlines; and
~ < 1 % by other gears.

The final 21% were non-allocated landings (including Norwegian landings).
Total unwanted catch was 85 100 tonnes (24% by weight of total catch).

Table 4   Mixed fisheries for the 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)	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	EC (2018)
Haddock *	Subarea 4, Division 6.a, and Subdivision 3.a.20 (North Sea, West of Scotland, Skagerrak)	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	EC (2018)
Plaice**	Subarea 4 (North Sea) and Subdivision 3.a.20 (Skagerrak)	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	EC (2019)
Saithe	Subareas 4 and 6 and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	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	EC (2018)
Sole	Subarea 4 (North Sea)	Union waters of subareas 2 and 4	EC (2018)
Turbot	Subarea 4 (North Sea)	Union waters of subareas 2 and 4	EC (2018)
Whiting ***	Subarea 4 and Division 7.d (North Sea and eastern English Channel)	Subarea 4 EU TAC Divisions 7.b–k	EC (2018)
Norway lobster	Functional units (FUs) in Subarea 4: 5, 6, 7, 8, 9, 10, 32, 33, 34, and other areas outside FUs	EU TAC Subarea 6 Norway: no TAC	EC (2018)
Plaice	Division 7.d (eastern English Channel)	Divisions 7.d and 7.e	EC (2018)

* 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.

Table 5   Mixed fisheries for the North Sea. F_{MSY} ranges used for the "range" scenario.

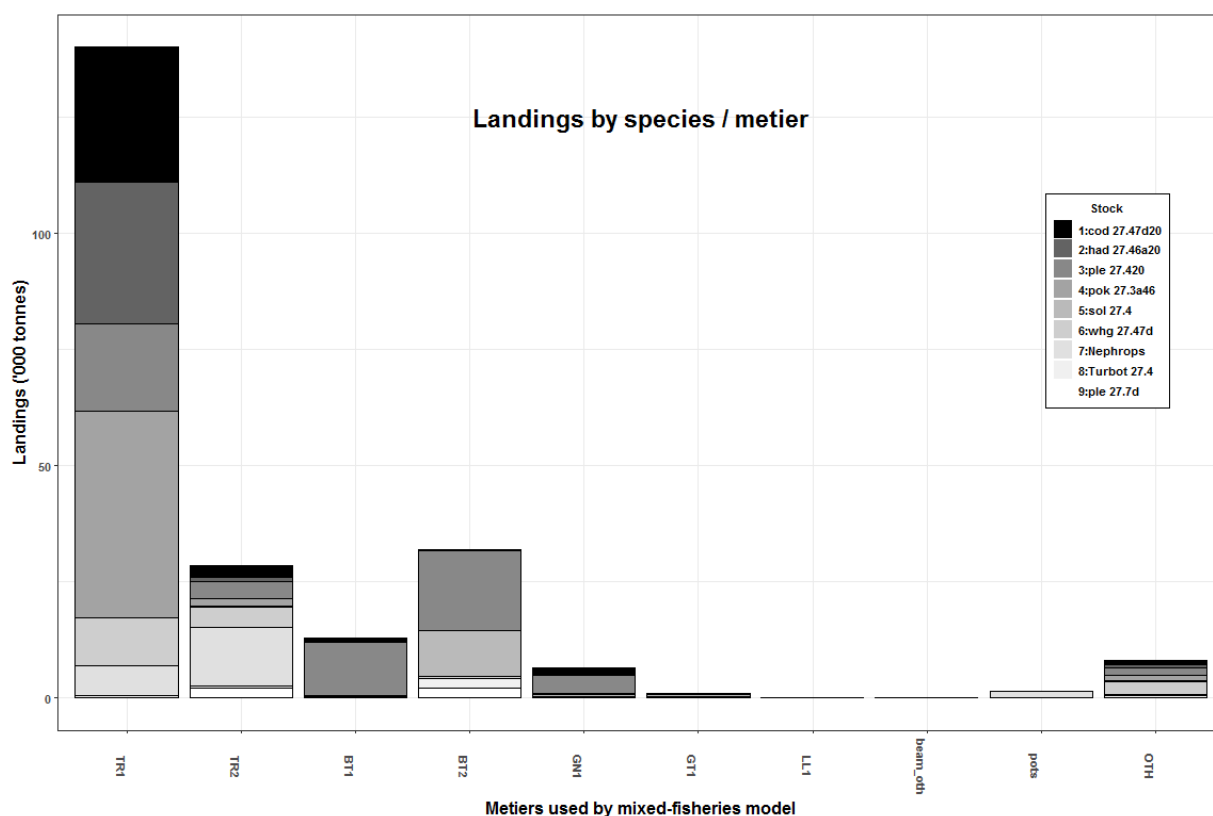| Stock	$F_{MSY-lower}$	$F_{MSY-upper}$
cod.27.47d20	0.112 = MAP $F_{MSY\ lower}$ × SSB (2020)/MSY $B_{trigger}$	0.175 = MAP F_{MSY} × SSB (2020)/MSY $B_{trigger}$
had.27.46a20	0.167	0.194
pok.27.3a46	0.210	0.536
ple.27.420	0.146	0.3
ple.27.7d	0.175	0.344
sol.27.4	0.113	0.367
tur.27.4	0.25	0.48
whg.27.47d	0.158	0.172

Figure 6   Mixed fisheries for the North Sea. Landings distribution of species by métier, with landings consisting of ≥ 1% of any of the stocks (see Figure 1) in 2018 (list of métiers available in Table 6). Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort (Including all Norwegian fleets) and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks 1–9 in 2018. The "non-allocated" is the differences between total landings used in the single-stock advice and mixed-fisheries advice.

Table 6   Mixed fisheries for the 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	-
Pelagic	Pelagic trawl or seine	-
Pots	Pots	-
OTH	Any gear type	-

Summary of the assessment
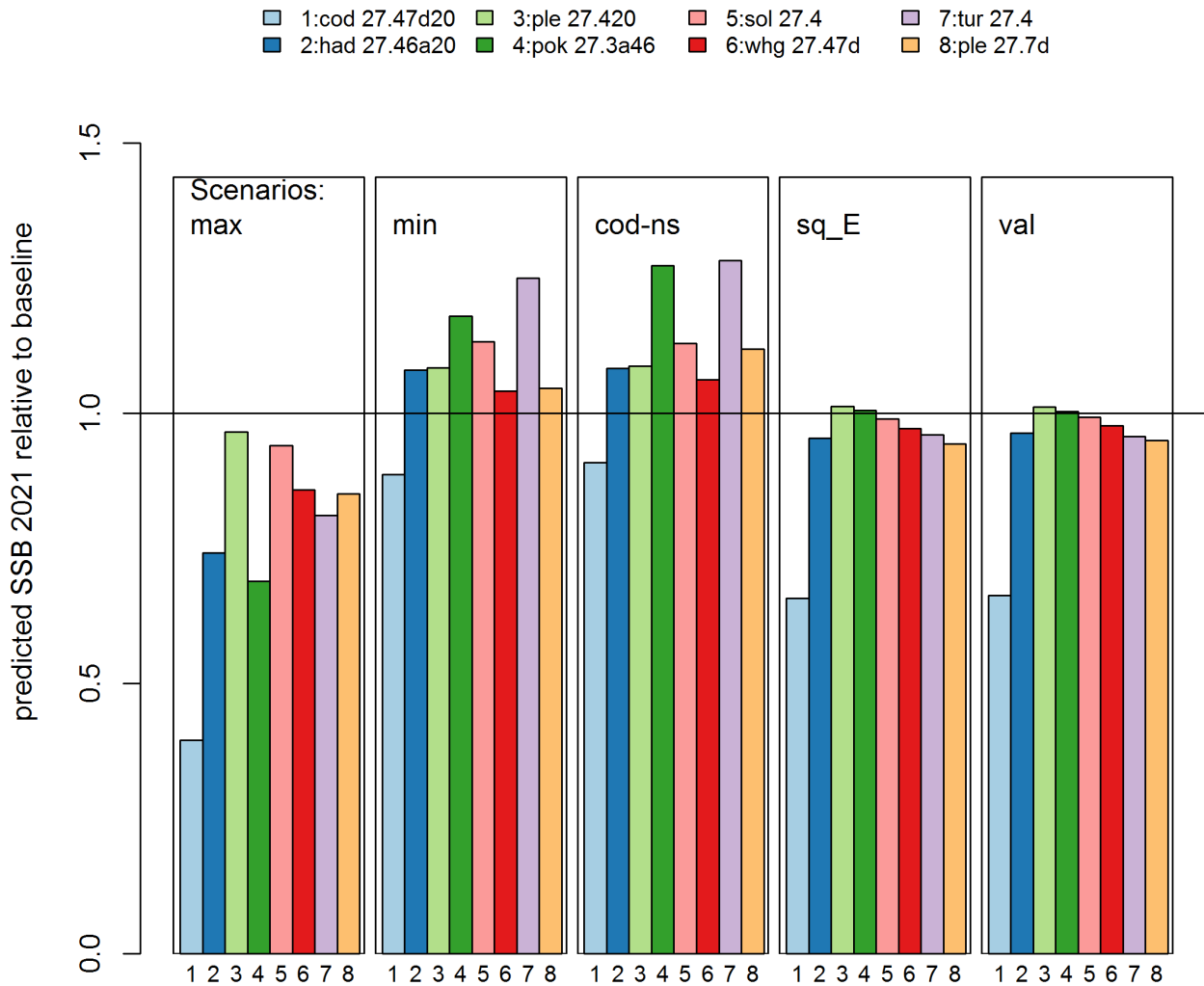

Figure 7   Mixed fisheries for the North Sea. Estimated SSB at the start of 2021 by stock after applying the mixed-fisheries scenarios, expressed as a ratio to the single-stock advice forecast. The horizontal line corresponds to the SSB resulting from the single-stock advice. Norway lobster are not included as the abundance was not forecasted in the mixed-fisheries model.

Table 7   Mixed fisheries for the North Sea. SSB results from single-stock advice and different mixed-fisheries scenarios (see Figure 6). 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 (2021) > B_{pa} or MSY $B_{trigger}$.

Stock	Single-stock advice	SSB (2021) resulting from mixed-fisheries scenario applied in 2020					
	SSB (2021)	Max	Min	COD-ns	Sq-E	Val	Range
Cod	107000*	42337**	95016**	97358**	70450**	71018**	107134 *
Haddock	196886	152575	222084	222768	196164	198217	207051
Plaice in Division 7.d	41084	34264	42109	45023	37972	38247	41942
Plaice in Subarea 4	1237188	1164807	1307371	1312113	1221513	1220136	1243934
Saithe	213159	141025*	241386	260511	205619	205155	213658
Sole in Subarea 4	89527^	84211	101386	101078	88569	88820	87780
Turbot4	7753	6307	9716	9972	7463	7437	8681
Whiting	156981	134031	162686	165908	151722	152545	155975

* B_{lim} < SSB (2021) < B_{pa}.

** SSB (2021) < B_{lim}.

^ 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 the SSB (2021), corresponding to fishing at F_{MSY} in 2020.

Table 8   Mixed fisheries for the North Sea. F_{total} resulting from single-stock advice and different mixed-fisheries scenarios. Norway lobster are not included as management is not applied at functional unit level.

Stock	Single-stock advice	F_{total} (2020) resulting from mixed-fisheries scenarios applied in 2020					
	F_{total} (2020)	Max	Min	COD-ns	Sq-E	Val	Range
Cod	0.170	1.49290	0.21436	0.18085	0.64547	0.63337	0.170
Haddock	0.194	0.55342	0.06485	0.06096	0.22328	0.20988	0.186
Plaice in Division 7.d	0.250	0.40106	0.16090	0.08425	0.28059	0.27220	0.202
Plaice in Subarea 4	0.210	0.28265	0.06194	0.05531	0.18951	0.19168	0.151
Saithe	0.363	0.77388	0.18405	0.10208	0.35772	0.36018	0.316
Sole in Subarea 4	0.200*	0.27610	0.06106	0.06458	0.21752	0.21423	0.225
Turbot	0.470	0.62999	0.15700	0.12924	0.44315	0.44698	0.350
Whiting	0.162	0.43029	0.08924	0.05724	0.20659	0.19728	0.164

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

Who is fishing

Around 6600 vessels from nine nations operate in the Greater North Sea, with the largest numbers coming from UK, Norway, Denmark, the Netherlands, and France. Total landings peaked in the early 1970s and have since declined. The proportion caught by each country of the total annual landings has varied over time (Figure 8). Since 2003, total fishing effort has declined (Figure 9). Profitability of many of the commercial fleets has increased in recent years due to the improved status of many fish stocks, reduced fleet sizes, lower fuel prices, and more efficient fishing gears. The following country paragraphs highlight features of the fleets and fisheries of each country and are not exhaustive descriptions.

Belgium

The Belgian fishing fleet is composed of about 70 vessels, primarily beam trawlers both above and below 24 m in length. Few vessels are smaller than 12 m. Most of the catch is demersal species; sole is the dominant species in value, and plaice the dominant species in volume. Other important species include lemon sole, turbot, anglerfish, rays, cod, shrimp, and scallops.

Denmark

The Danish fleet comprises 1400 vessels, of which 600 vessels operate in the Greater North Sea demersal fisheries. Smaller vessels (< 12 m) constitute the greatest proportion of the fleet, but account for less than 5% of the Danish fisheries catch value. The most important demersal fisheries target cod, plaice, saithe, northern shrimp, and *Nephrops* using bottom trawls and seines. The most important industrial and pelagic fisheries are prosecuted by around 30 large vessels (>40 m) and around 200 smaller (12–40 m) vessels; these fisheries target herring and mackerel for human consumption, and sandeel, sprat, and Norway pout for reduction purposes (i.e. fish meal and oils).

France

The French fleet in the North Sea is composed of more than 600 vessels. The demersal fisheries operate mainly in the eastern English Channel and southern North Sea and catch a variety of finfish and shellfish species. The largest fleet segments are gill- and trammel netters (10–18 m) targeting sole, demersal trawlers (12–24 m) catching a great diversity of fish and cephalopod species, and dredgers catching scallops. Smaller boats operate different gears throughout the year and target different species assemblages. There is also a fleet of six large demersal trawlers (>40 m) that target saithe in the northern North Sea and to the west of Scotland. The pelagic fishery is prosecuted by three active vessels catching herring, mackerel, and horse-mackerel.

Germany

The German North Sea fishing fleet comprises more than 200 vessels. Beam trawlers constitute the largest fleet component (around 180 vessels, 12–24 m) and target brown shrimp in the southern North Sea. Six large demersal trawlers (>40 m) target saithe in the northern North Sea (and in waters to the north of the North Sea). Several mid-sized otter trawlers and beam trawlers (24-40 m) target saithe, cod, sole, and plaice. Less than 10 vessels (mainly >40 m) operate in the North Sea pelagic and industrial fisheries that primarily target herring, but also catch horse mackerel, mackerel, sprat, and sandeel.

Netherlands

The Dutch fleet in the Greater North Sea consists of about 500 vessels. The main demersal fleet is the beam-trawl fleet (275 vessels, of which 85 are >24 m and 190 are < 24 m) that operates in the southern and central North Sea, targeting sole (dominant in value) and plaice (dominant in volume) as well as other flatfish species. Until the recent EU-wide ban on pulse-trawling most of the >24m beam trawlers have used pulse trawls. Many of these beam trawlers now use pulse trawls. Most of the smaller beam trawlers ("Eurocutters") seasonally target shrimp or flatfish. Pelagic freezer trawlers (7 vessels, >60 m) target pelagic species, mainly herring, mackerel, and horse mackerel.

Norway

The Norwegian North Sea fleet is composed of about 1585 vessels. 85% of these catch demersal species, including fish, crustaceans, cephalopods, and elasmobranchs, and 30% catch pelagic species, including herring, blue whiting, mackerel, and sprat. Approximately 60% of the fleet targeting demersal species are small vessels (< 10 m) that operate near the Norwegian coast using traps, pots, and gillnets, catching crabs, squid, and several fish species. Medium-sized vessels (10–24 m) mainly target *Nephrops* and crabs using pots and traps, shrimp using trawls, and cod, saithe, ling, and monkfish using gillnets. The industrial fleet (5 vessels of 24–40 m; 25 vessels >40 m) target Norway pout and sandeel for reduction purposes. The offshore fleet (>40 m) is predominantly otter trawlers, but also includes seiners and longliners. Larger vessels (>24 m) account for most of the landings of saithe, ling, cod, tusk, hake, haddock, herring, blue whiting, mackerel, and sprat.

Sweden

The Swedish fleet in the Greater North Sea comprises more than 400 vessels. The demersal fleet is highly diversified, catching several species in the Kattegat and Skagerrak, mainly Nephrops, northern shrimp, cod, witch, flounder, and saithe. The passive gear fleet is composed of around 300 vessels, of which 94 vessels (30 vessels of 10–18 m, 64 vessels < 10 m) target Nephrops. The 15 vessels in the pelagic fleet target sprat, herring, and sandeel.
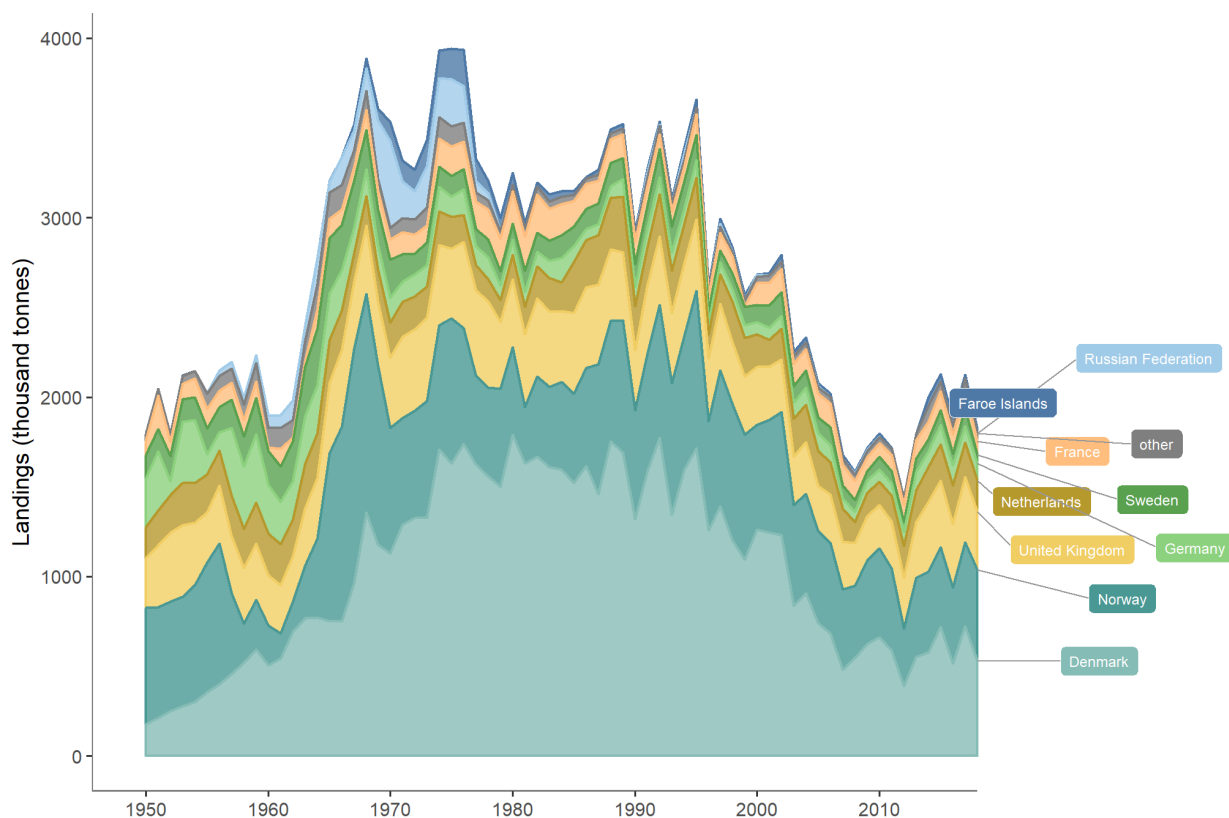
UK (England)

The English fleet in the Greater North Sea has more than 1140 vessels. Medium-size demersal trawlers (26 vessels, 18–24 m and 24–40 m) primarily target *Nephrops*, cod, and whiting. The small vessel (< 10 m) fleet (around 900 active vessels) operates in the eastern English Channel and coastal North Sea and catches a diversity of fish and shellfish species. Medium and large beam trawlers (about 40 vessels) account for the major share of the plaice landings. Three vessels (>50 m) operate in the pelagic fishery targeting mackerel, herring, and horse mackerel.

UK (Scotland)

The Scottish North Sea fleet comprises around 1000 vessels. More than 120 demersal trawlers (almost all >10 m) fish for mixed gadoids (cod, haddock, whiting, saithe, and hake,) and for groundfish such as anglerfish and megrim. A fleet of 139 trawlers fish mainly for *Nephrops* in the North Sea: 48 of these vessels (< 10 m) operate on the inshore grounds, while 91 (>10 m) operate over various offshore grounds. Pot or creel fishing is prosecuted by over 650 vessels (mostly < 10 m) targeting lobsters and various crab species on harder inshore grounds. Scallop fishing is carried out by around 80 dredgers (mostly >10 m). Limited amounts of longlining and gill netting are also conducted by Scottish vessels. Significant catches of pelagic species are harvested by 18 large vessels, primarily using pelagic trawls.

The Faroe Islands also fish in the Greater North Sea, but ICES does not have information on this fleet.

Historical Nominal Catches 1950-2010,
Official Nominal Catches 2006-2017
Preliminary Catches 2018
ICES, Copenhagen.

Figure 8   Landings (thousand tonnes) from the Greater North Sea in 1950–2018, by country. The nine countries having the highest landings are displayed separately and the remaining countries are aggregated and displayed as "other".

STECF 17-09, Accessed 2018/August.

Figure 9   Greater North Sea fishing effort (thousand kW days at sea) in 2003–2017, by EU nation. STECF data are not available after 2016.

Catches over time

Species caught in the fisheries are either landed or discarded. Landings and discards are considered separately below. Data on landings have been collected consistently for many years, whereas information on discards have only been collected consistently in the most recent years.

Landings

Fisheries in the Greater North Sea catch a large diversity of species. These have been categorized into species that are pelagic, demersal, benthic (e.g. flatfish), crustaceans, and elasmobranchs.

Total landings from the Greater North Sea varied between 2 and 3 million tonnes during the 1950s, then rose to between 3 and 4 million tonnes from the late 1960s to the mid-1990s (Figure 8). High catches of both pelagic species (mackerel and herring) and demersal species (cod and haddock) accounted for the increase in total landings in the late 1960s (Figures 10 and 11). Total landings declined after 1995 to a low of 1.4 million tonnes in 2012. This decline is attributed to overfishing and decreased productivity of important stocks such as cod and herring, but also to the successful reduction of fishing mortality to more sustainable levels after 2000.

Since 2003, the pelagic fisheries using pelagic trawl and purse seines have accounted for the largest proportion of the total landings, followed by the demersal and benthic fisheries (Figure 12). Overall landings increased slightly from 2011 after a rise in herring landings and again, most recently (in 2015), from increased catches of anchovy, sardine, and hake.

Recreational fisheries in the North Sea target a wide range of species, but few of these fisheries are monitored or evaluated. Recreational catches of seabass and salmon (including freshwater for the latter) are significant and are included in ICES assessment of these species. In contrast, the recreational fisheries of elasmobranchs is not widely monitored; however, the recreational harvest of these species (mainly dogfish and several species of skates and rays) appears to be negligible.

Historical Nominal Catches 1950-2010,
Official Nominal Catches 2006-2017
Preliminary Catches 2018
ICES, Copenhagen.

Figure 10   Landings (thousand tonnes) from the Greater North Sea in 1950–2018, by fish category. Table 1 in the Annex details which species belong to each fish category.

Historical Nominal Catches 1950-2010,
Official Nominal Catches 2006-2017
Preliminary Catches 2018
ICES, Copenhagen.

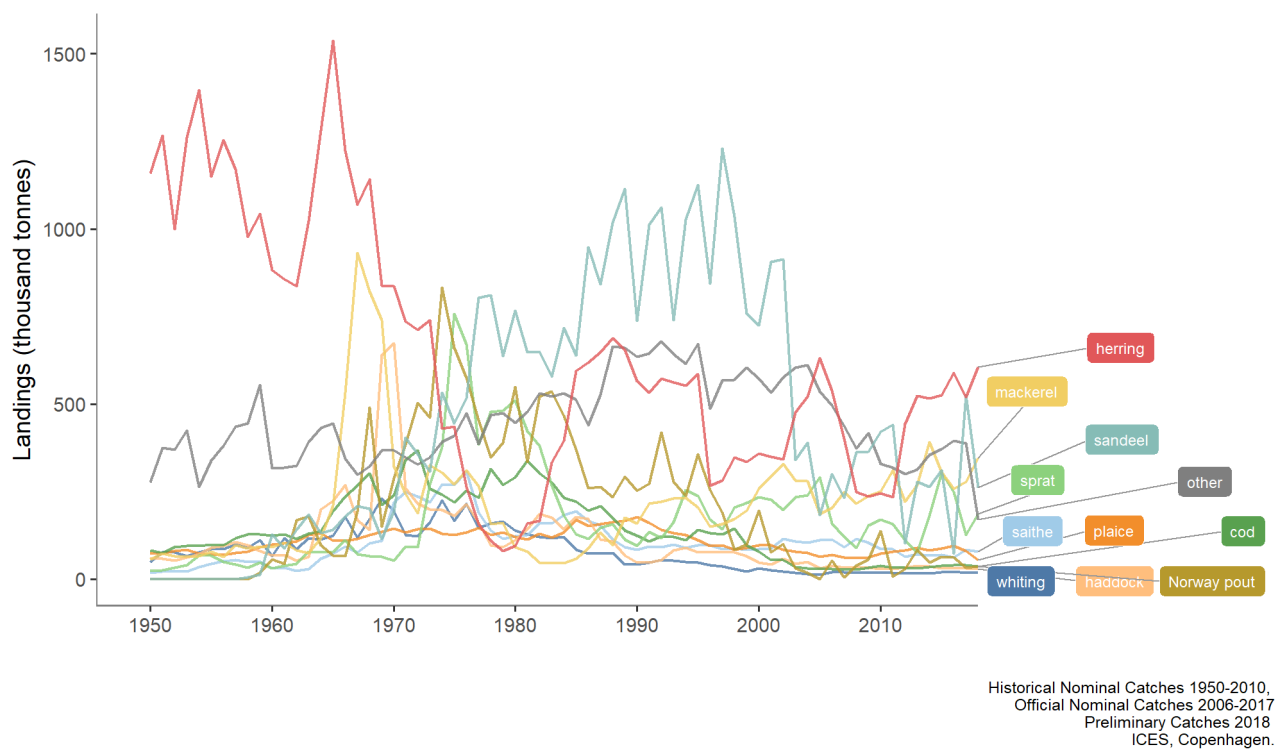**Figure 11**   Landings (thousand tonnes) from the Greater North Sea in 1950–2018, by species. The ten species having the highest landings are displayed separately; the remaining species are aggregated and labelled as "other".
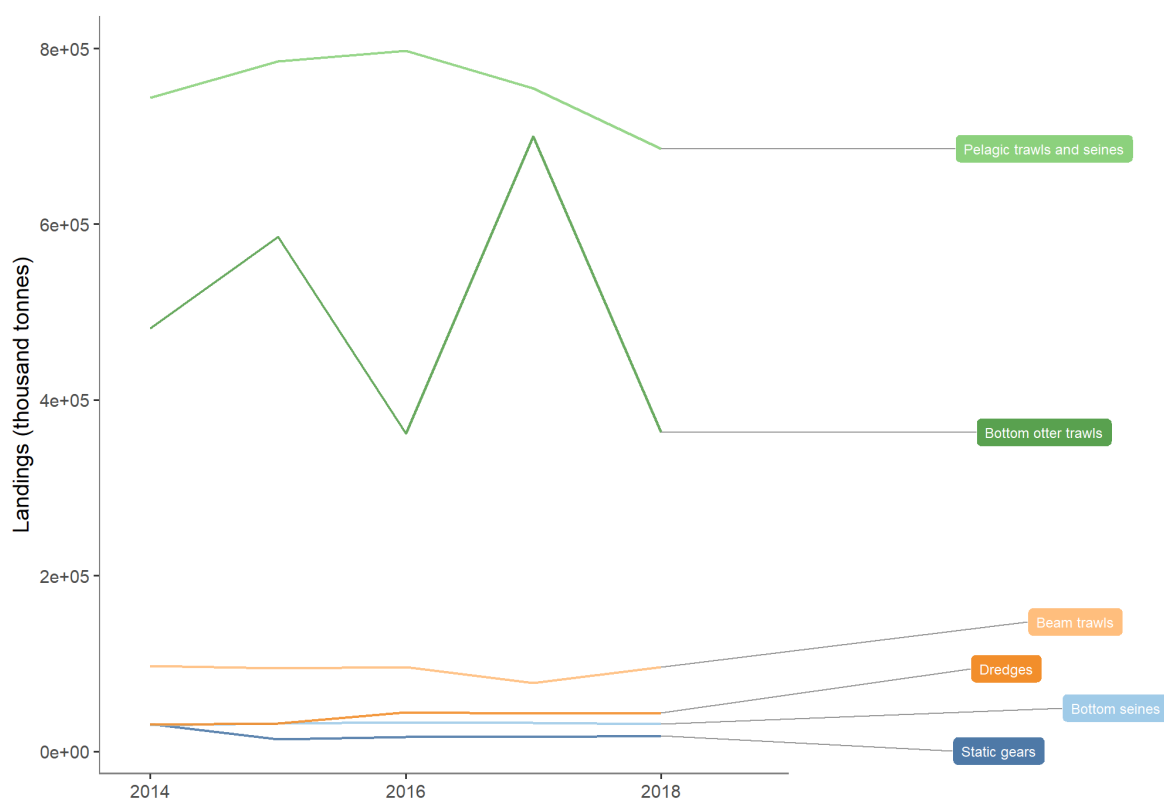

ICES VMS data, November 2019

Figure 12   Commercial landings (thousand tonnes) from the Greater North Sea in 2014–2018, by gear type. For vessels over 15m only.

Discards

Discard data have been collected for some North Sea fisheries since the mid-1970s. Since 2000, discard data from North Sea commercial fisheries have been collected from various observer programmes implemented under the EU Data Collection Framework (DCF). However, complete discard data are only available from 2012 onwards. In 2013–2017, discard rates of have remained relatively stable. Discard rates of pelagic species were close to zero (Figure 13). Discard estimates for several species of elasmobranch are highly uncertain due to low encounter probabilities, and are so not shown here.
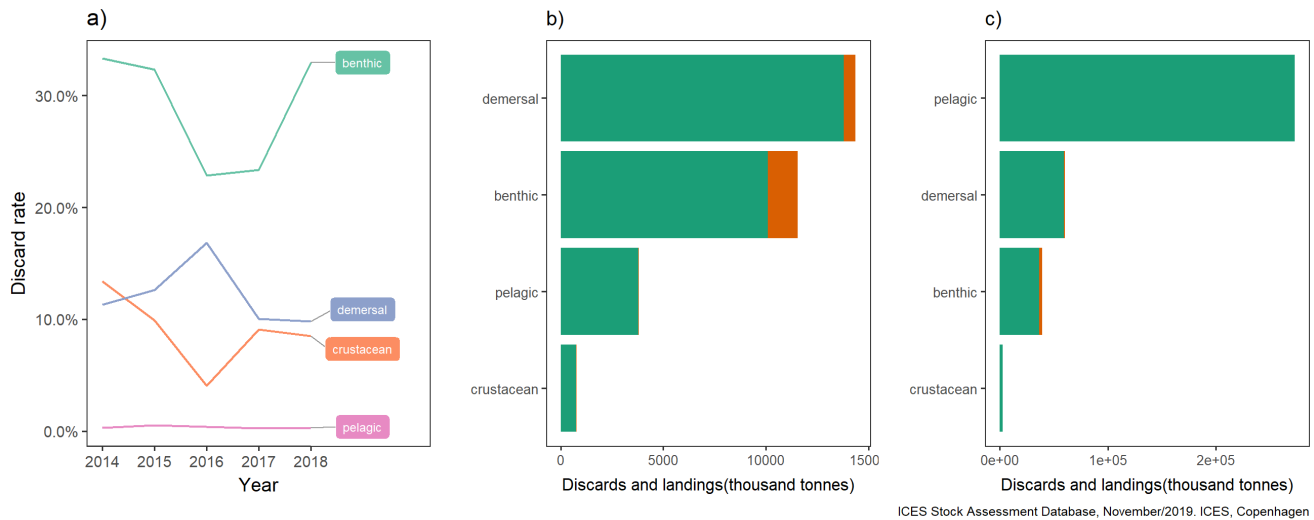

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

Figure 13   Left panel (a): Discard rates in 2014–2018 by fish category, shown as percentages (%) of the total annual catch in that category. Middle panel (b): Landings (green) and discards (orange) in 2018 by fish category (in thousand tonnes) of those stocks with recorded discards. Right panel (c): Landings (green) and discards (orange) in 2017 by fish category (in thousand tonnes). (Note that not all stock catches are disaggregated between landings and discards. In cases where discard data are unavailable for a given year, the discard rate in that year was assumed to be the same as in the previous year.) Elasmobranch data are highly uncertain and therefore not presented here.

Description of the fisheries

Fishery resources in the Greater North Sea ecoregion are harvested using a variety of fishing gears.

Otter trawl and beam trawls are the main gears used in the region's demersal fisheries, and pelagic trawls and seines are the primary gears used in the pelagic fisheries.

Demersal fishing effort has declined since 2003, while pelagic trawl and seine effort, after a decline, has increased again in recent years (Figure 14).

The spatial distribution of fishing effort by gear type is depicted in Figure 15[†]. The maps show the distribution of effort by vessels >12 m having vessel monitoring systems (VMS). Fishing effort by vessels < 12 m may be significant, especially in inshore areas. However, these vessels are not required to have VMS and ICES does not have information on the spatial distribution of their effort; they are therefore not included in Figure 15.

Some coastal waters in the North Sea ecoregion have fisheries targeting resident immature eels or migrating spawners. In addition, there are also fisheries targeting resident or migrating eel in some transitional waters.

Bottom otter trawl and seine fisheries

[†] Version 2: Figure number updated

Otter trawls are the most common gear types in the Greater North Sea and are used intensively in most parts of the region, including the Skagerrak and the English Channel. Otter trawls typically catch gadoids, other groundfish, plaice, and *Nephrops*; however, the species composition of the catch depends on the area and depth fished and the gear design, including codend mesh size. The mixed nature of most of the bottom fisheries and the spatial and temporal heterogeneity of target species challenge the simultaneous achievement of individual stock maximum sustainable yield (MSY) objectives, as well as the limitation of unwanted catches.

In the northern North Sea and the Skagerrak, otter trawls operate primarily with mesh sizes greater than 100 mm and target haddock, cod, whiting, anglerfish, megrim, and plaice, with economically important bycatches of *Nephrops* and some flatfish species. Some vessels target saithe in deeper waters in the north of the region. Otter trawlers using smaller mesh otter trawls (70–100 mm) primarily target *Nephrops* in soft mud areas. The proportion of *Nephrops* landings from mesh sizes greater than 100 mm has recently been increasing.

In the southern North Sea and the eastern English Channel, the otter trawl fleet operates with mesh sizes less than 100 mm, catching a varied mix of fish and shellfish species (including cephalopods) and, in muddy areas, *Nephrops*.

Bottom seine fisheries operate mainly in the Skagerrak, central North Sea, and in the eastern English Channel, with limited effort in the northern North Sea. Mesh sizes and targeted species are similar to the otter trawl fisheries in these areas.

Beam-trawl fisheries

Beam-trawl fisheries operate in the shallow parts of the southern and central North Sea, with particularly intense activity off the southeast coast of England. The most important species for beam trawlers are sole and plaice in terms of value and volume, respectively, and other flatfish species (e.g. turbot and brill). Because a relative small codend mesh size (80 mm) in used in beam trawls targeting flatfish, significant quantities of fish below minimum sizes are caught, resulting in high discard rates. Most small beam trawlers (< 24 m) target brown shrimp in the southern North Sea and coastal areas using a 20–25 mm codend mesh size.

Part of the beam-trawl fleet is changing its fishing practices, shifting from conventional beam trawl to electric pulse trawl to reduce fuel costs, seabed impacts, and unwanted catches.

Static gear fisheries (gillnet and longline)

Gillnet fisheries primarily operate in the shallower areas of the southern North Sea, the eastern English Channel, and in the Skagerrak. Small and medium-sized boats target flatfish and demersal fish, depending on the gear used. Gillnet fisheries conducted in deeper areas also target anglerfish. Discard rates in gillnet fisheries with larger mesh sizes (>100 mm) are generally low; however, bycatch of marine mammals and seabirds occurs. Gillnet fisheries with smaller mesh sizes (90 mm) usually target sole, and may have considerable discard rates of dab.

Longline fisheries operate mostly in the northern North Sea and target saithe, cod, haddock, ling, and tusk.

Pelagic trawl and pelagic seine fisheries

Pelagic trawl and seine fisheries operate throughout most parts of the North Sea, except in the eastern portion of the central North Sea. The small-meshed (< 32 mm codend) pelagic trawl fishery is prosecuted mainly by vessels >40 m and targets sandeel, Norway pout, sprat, and blue whiting for reduction purposes. The pelagic trawl fishery for human consumption is operated by refrigerated seawater trawlers (>40 m) and freezer trawlers (>60 m) and targets herring, mackerel, and horse mackerel. Some blue whiting is taken by these vessels in the northern North Sea.

Dredge fisheries

Significant dredge fisheries for scallops occur in inshore areas along the east coasts of Scotland and England and throughout the English Channel. These fisheries primarily occur on sand and gravel substrates and are affected by exclusion zones that protect sensitive habitats in some areas. Dredges are also used to harvest blue mussels in the nearshore southern and eastern North Sea.

Pot fisheries

Static gear pot fisheries, mainly for edible crab, lobster, and whelk operate in the inshore areas of several countries bordering the North Sea. Most of the vessels are small (< 10 m) however removals by larger (>15m) vessels can be substantial.

ICES VMS data, November 2019

Figure 14   Greater North Sea fishing effort (thousand kW hours at sea) in 2014–2018, by gear type (LL = longlines).

Average MW Fishing hours 2015-2018

Figure 15   Spatial distribution of average annual fishing effort (mW fishing hours) in the Greater North Sea during 2015–2018, by gear type. Fishing effort data are only shown for vessels >12 m having vessel monitoring systems (VMS).
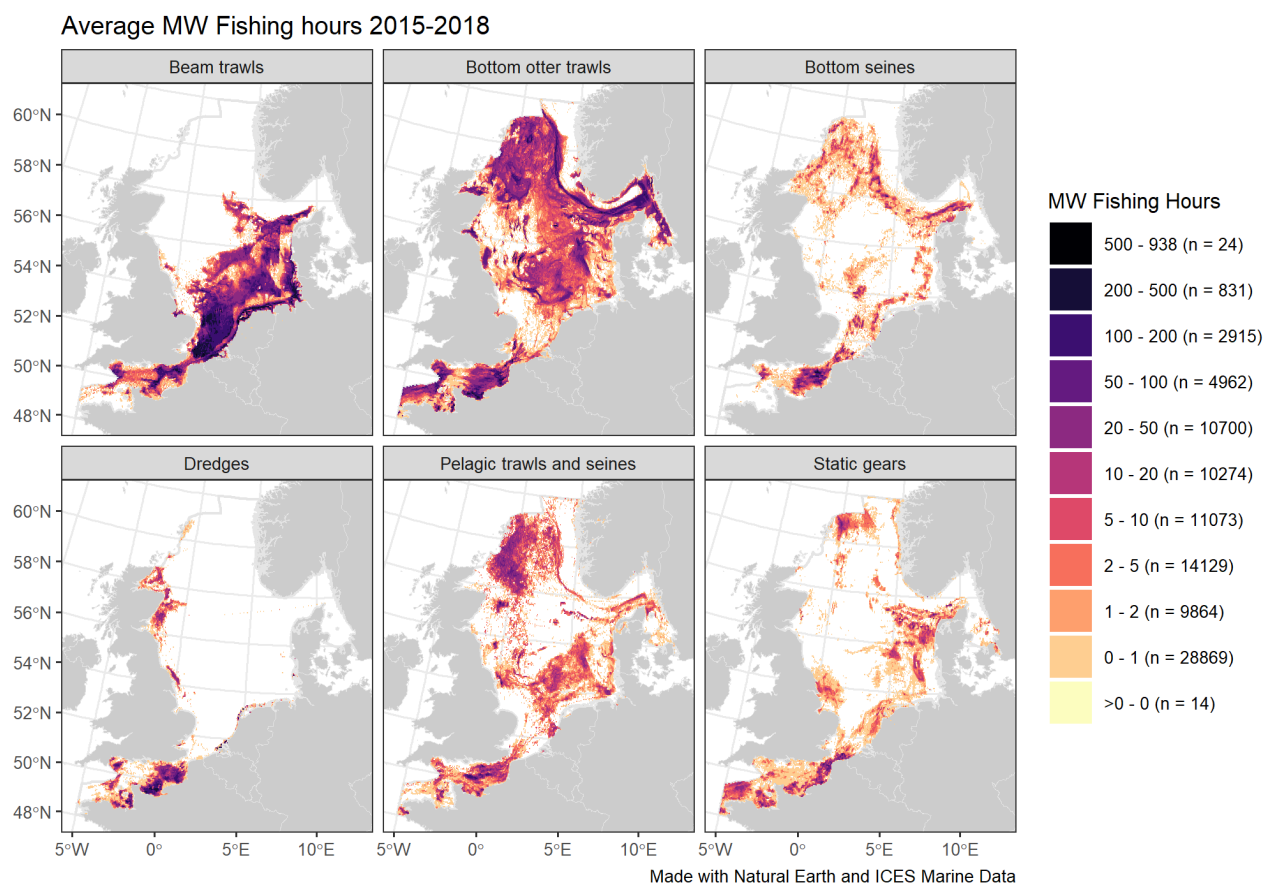
Fisheries management

Fisheries management in the Greater North Sea is conducted partly under the EU Common Fisheries Policy (CFP) and partly under Norway legislation. Within EU waters, management is conducted in accordance with the CFP and catching opportunities for stocks under EU competency are agreed during meetings of the Council of Ministers. Under the CFP's regionalization policy, proposals on certain issues (for example discard plans) are made by the North Sea Regional Fisheries Group (Scheveningen Group). National authorities manage activities in coastal waters (i.e. within 12 nautical miles) and activities on stocks under National competency (e.g. most shellfish stocks). In Norwegian waters, management of fishing activities in both offshore and inshore waters is conducted in accordance with Norwegian fisheries policy. For North Sea stocks shared between the EU and Norway (cod, haddock, whiting, saithe, herring, plaice, northern shrimp, and sprat), the EU–Norway agreements are based on an annual negotiation process agreeing on catch opportunities and the sharing of these. For more widely distributed stocks that occur in the North Sea (for example mackerel), management is discussed in coastal state consultations.

The North Atlantic Salmon Conservation Organization (NASCO) has managerial responsibility for the fisheries of salmon. Management of fisheries for large pelagic fish (e.g. tunas, etc.) is undertaken by the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Collective fisheries advice, particularly on the state of stocks and on catch forecasts, is provided by the International Council for the Exploration of the Sea (ICES). Within EU waters, the European Commission's Scientific Technical and Economic

Committee for Fisheries (STECF) provides broader advice that also covers technical and economic issues. Furthermore, the North Sea and Pelagic Advisory Councils also provide input to the management process.
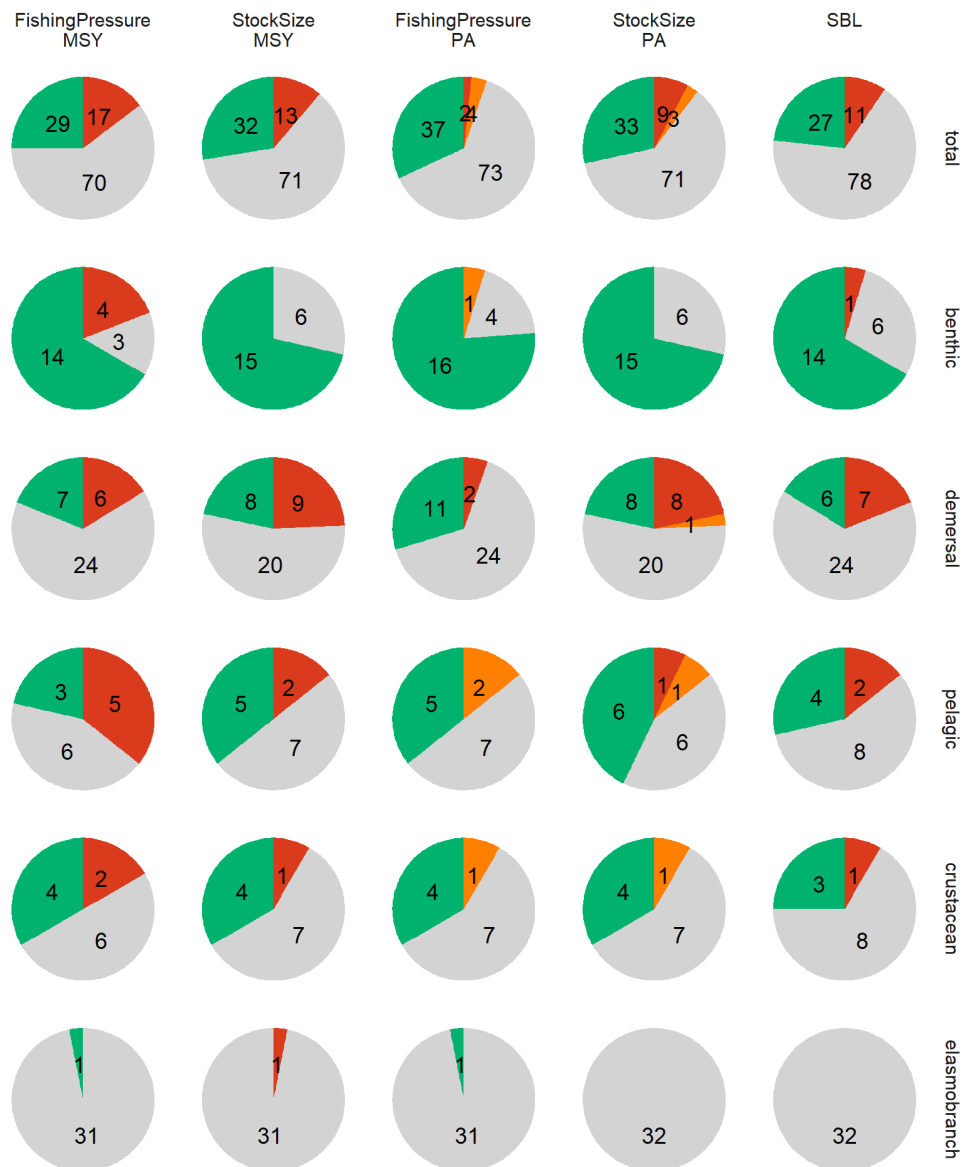
Management plans

A number of management plans have been implemented for North Sea fisheries. Separate plans covering cod, haddock, whiting, saithe, and herring were established as joint management plans between the EU and Norway. These variously provide harvest control rules, safeguards to ensure that stocks remain within safe biological limits, and annual TAC change constraints. Before adoption, these plans were evaluated by ICES to ensure they were precautionary in nature. A similar approach was established by the EU for management plans for North Sea plaice and sole.

Changes have occurred recently in the assessments of several North Sea stocks covered by management plans, including revisions to reference points and adjustments in stock boundaries. These changes imply a need to re-evaluate the existing management plans to ensure that they remain precautionary. As a consequence, ICES advice for these stocks has been provided in accord with its MSY approach. The exception is herring and sole, for which management plan advice was continued in 2017.

Under the EU CFP, a new multi-annual plan (MAP) approach is currently being developed for the North Sea. This seeks to apply a mixed-fisheries approach that accounts for technical interactions (see section below) and recognises that simultaneous achievement of stock-specific MSYs across all stocks harvested in mixed fisheries is likely not possible. The North Sea MAP was implemented in 2018. Norway is also developing new fishery management plans for North Sea stocks in its waters.

Status of the fishery resources

Fisheries exploitation and spawning-stock sizes of those North Sea stocks assessed by ICES have been evaluated against MSY and precautionary approach (PA) reference points, and the most recent status of these stocks is presented relative to safe biological limits (Figures 16 and 17). Most (29 of 46) of the North Sea stocks that are analytically assessed are exploited at rates at or below F_{MSY}. Mean fishing mortality for crustacean, demersal, and benthic fish stock groups have declining trends since the late 1990s (Figure 18). Mean spawning-stock biomass (SSB) for all groups of stocks is above MSY $B_{trigger}$. Note that though the mean fishing mortality and biomass ratios are in a desirable condition, this does not infer that all stocks are in that condition. However, several North Sea stocks have current fishing mortality rates above F_{MSY} (e.g., cod, whiting, haddock, mackerel, and blue whiting). For stock-specific information, see Annex 1.

ICES Stock Assessment Database, November 2019. ICES, Copenhagen

Figure 16   Status summary of Greater North Sea stocks relative to ICES maximum sustainable yield (MSY) approach and precautionary approach (PA). Grey represents unknown reference points. *For the MSY approach*: green represents a stock that is fished at or below F_{MSY} while the stock size is equal to or greater than MSY $B_{trigger}$; red represents a stock status that is fished above F_{MSY} or the stock size is lower than MSY $B_{trigger}$. *For the PA*: green represents a stock that is fished at or below F_{pa} while the stock size is equal to or greater than B_{pa}; orange represents a stock that is fished between F_{pa} and F_{lim} or has a stock size between B_{lim} and B_{pa}; red represents a stock that is fished above F_{lim} or has a stock size lower than B_{lim}. Stocks having a fishing mortality below or at F_{pa} and a stock size at or above B_{pa} are defined as being inside safe biological limits. If this condition is not fulfilled the stock is defined as being outside safe biological limits. For stock-specific information, see Table 1 in the Annex.

ICES Stock Assessment Database, November 2019. ICES, Copenhagen

Figure 17   Status summary of Greater North Sea stocks in 2019 relative to the EU Marine Strategy Framework Directive (MSFD) good environmental status (GES) assessment criteria of fishing pressure (D3C1) and stock reproductive capacity (D3C2). Green represents the proportion of stocks fished below F_{MSY} or where stock size is greater than MSY $B_{trigger}$, for criteria D3C1 and D3C2. Red represents the proportion of stocks fished above F_{MSY} or where stock size is lower than MSY $B_{trigger}$ for criteria D3C1 and D3C2. Grey represents the proportion of stocks lacking MSY reference points. For stock-specific information, see Table A1 in the Annex.

Temporal trends (1960 onwards) in F and spawning-stock biomass (SSB) relative to MSY reference points are shown in Figures 18 and 19 for North Sea benthic, crustacean, demersal, and pelagic stocks. For most benthic and demersal stocks, marked improvements in stock status (i.e. having SSB greater than MSYB$_{trigger}$) have occurred since 2000 as F has been reduced. Similar, but less dramatic, changes are also evident for pelagic species. For crustaceans, annual changes in stock status have been more variable and there is a less obvious trend in F reductions.

benthic

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

crustacean

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

demersal

Legend:
- bli.27.5b67
- bss.27.4bc7ad-h
- cod.27.47d20
- cod.27.7e-k
- had.27.46a20
- had.27.7b-k
- hke.27.3a46-8abd
- MEAN
- pok.27.3a46
- whg.27.47d
- whg.27.7b-ce-k

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

pelagic

Legend:
- her.27.1-24a514a
- her.27.20-24
- her.27.3a47d
- hom.27.2a4a5b6a7a-ce-k8
- mac.27.nea
- MEAN
- whb.27.1-91214

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

Figure 18   Temporal trends in F/F_{MSY} and SSB/MSY $B_{trigger}$ for North Sea benthic, crustacean, demersal, and pelagic stocks. Only stocks with defined MSY reference points are considered. For full stock names, see Table A1 in the Annex.

The stock status relative to F_{MSY} and MSY $B_{trigger}$ is shown for all stocks and partitioned by stock groups in Figure 13. This shows that the hake stock has the best status among all stocks (around 5 times MSY $B_{trigger}$ and fished below F_{MSY}). Six stocks (North Sea cod, Celtic Sea cod, Celtic Sea whiting, horse mackerel, herring 20-24 and prawns in 3a4a) are in the bottom right quadrant having their SSB below MSY $B_{trigger}$ and F > F_{MSY}. This indicates that these stocks need to be rebuilt and that fishing mortality remains too high. Note that the Celtic Sea cod and whiting stocks are mainly distributed outside the North Sea Ecoregion. Blue whiting and mackerel account for the highest landings. Fishing mortality for both stocks is higher than F_{MSY}, and for mackerel the SSB is below MSY $B_{trigger}$. Two stocks are in the bottom left quadrant, indicating that while fishing mortality is lower than F_{MSY}, stock size remains below MSY $B_{trigger}$.

All stocks

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

benthic

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

crustacean

ICES Stock Assessment Database, November/2019. ICES, Copenhagen

demersal

ICES Stock Assessment Database, November/2019. ICES, Copenhagen
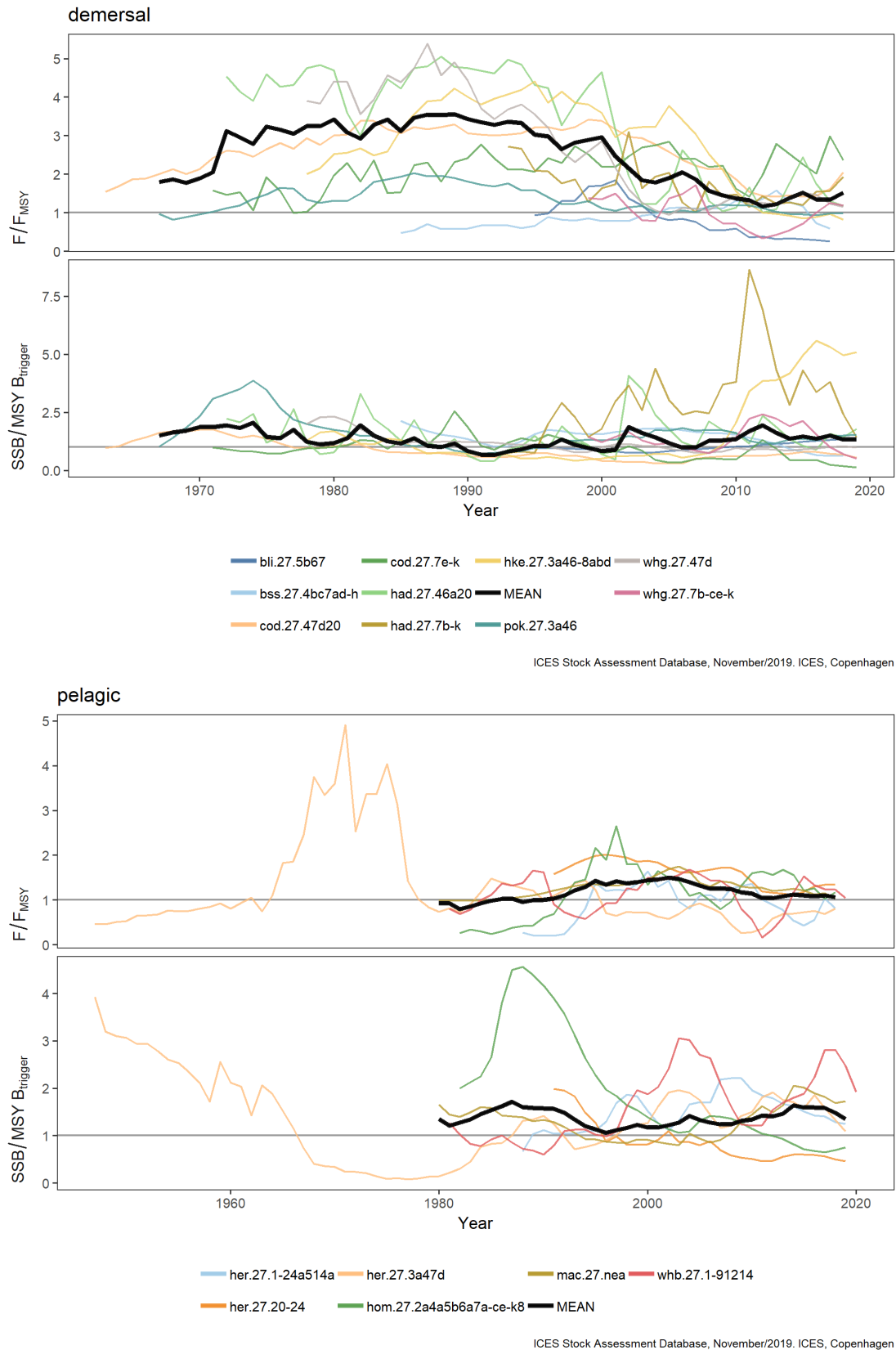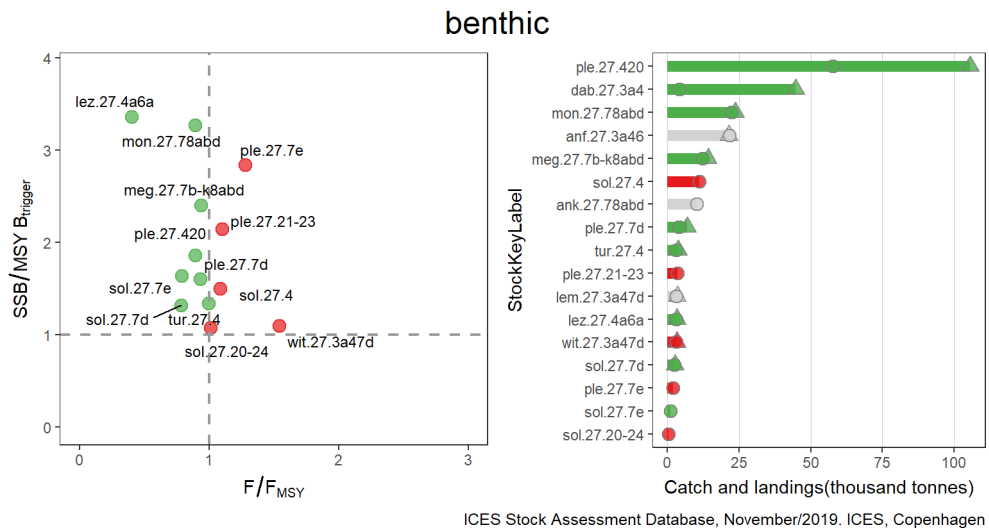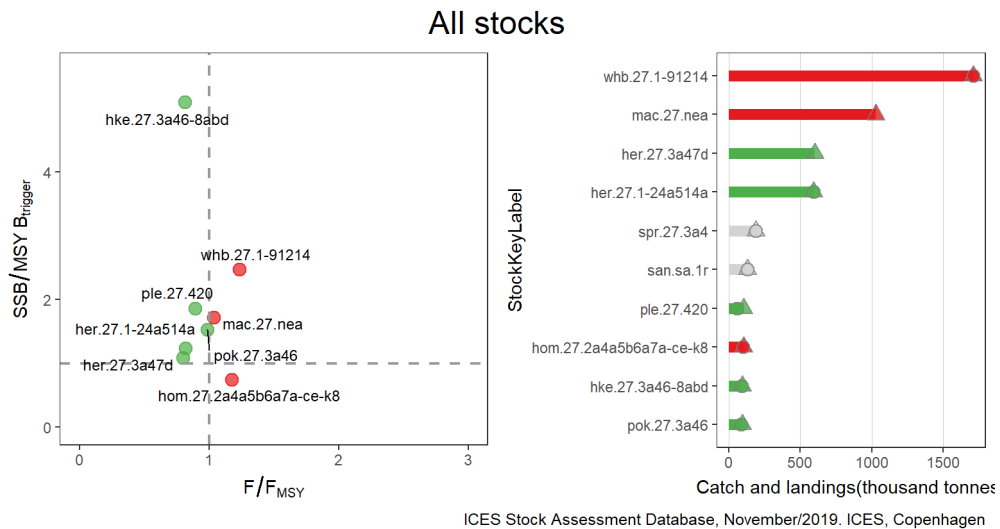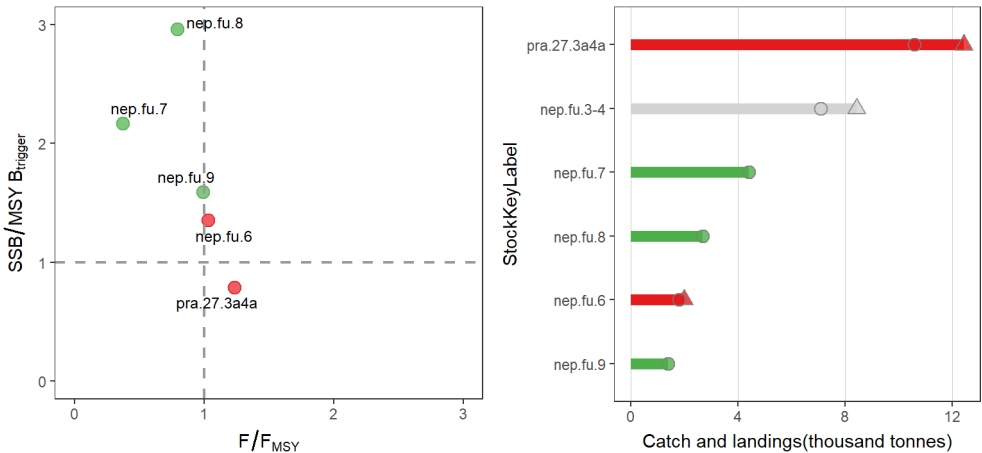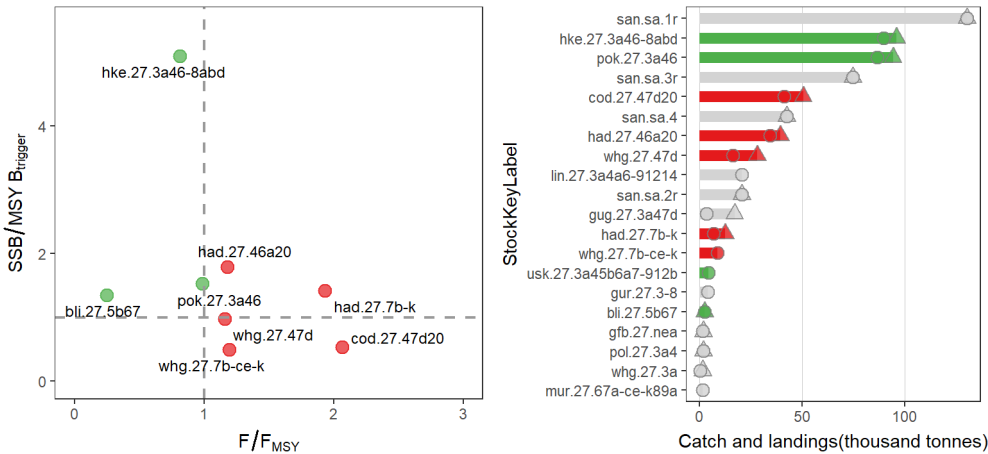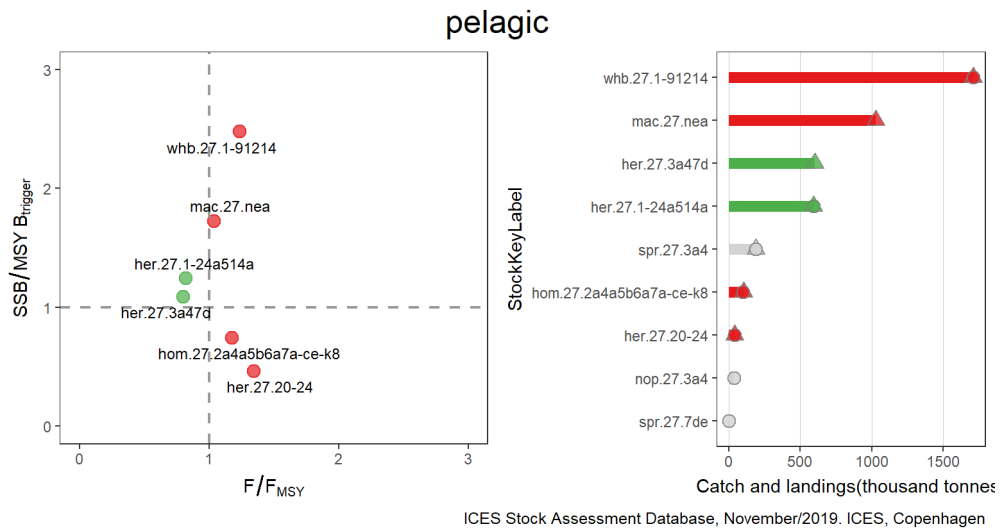
Figure 19   Status of North Sea stocks relative to the joint distribution of exploitation (F/F_{MSY}) and stock size (SSB/ MSY $B_{trigger}$) [left panels, by individual stocks] and catches (triangles) / landings (circles) from these stocks in 2017 [right panels]. The left panels only include stocks for which MSY reference points have been defined (MSY where available). Stocks in green are exploited at or below F_{MSY} while the stock size is also at or above MSY $B_{trigger}$. Stocks in red are either exploited above F_{MSY} or the stock size is below MSY $B_{trigger}$, or both. Stocks in grey have unknown/undefined status in relation to reference points. "All stocks" refers to the ten stocks with highest catch and landings across fisheries guilds in 2018. For full stock names, see Table A1 in the Annex.

Several of the stocks such as North Sea sprat, sandeels, and Norway pout are stocks of short-lived species that experience high natural mortality. The ICES MSY approach for these stocks is aimed at achieving a high probability of having a minimum biomass left to spawn the following year so that the stock is capable of producing MSY. For catch advice, ICES uses a different approach than for longer-lived species and defines a biomass reference point, MSY $B_{escapement}$, which is the biomass that should remain after the fishery has taken place. For some short-lived stocks, an F reference point, F_{cap}, is also used to limit exploitation when biomass is high as large biomasses are often estimated with greater uncertainty.

For some short-lived species, assessments are so sensitive to incoming recruitment that the amount of biomass in excess of the target escapement cannot be reliably estimated until data are available on the incoming year class. In such cases, the ICES catch advice is often provided just prior to, or at the beginning of the fishing season.

A consequence of this approach is that the reference points for short-lived stocks cannot be readily compared and dealt with in the same way as those for longer-lived stocks. In Figure 19, this is reflected in the short-lived species being assigned a "grey" colouration. However, this does not mean that little is known about these stocks, that they are not being managed effectively, or that they are incapable of producing MSY.

European eel cannot be assessed against any PA or MSY reference points. Recruitment of European eel has declined sharply in recent decades due to a range of potential threats.

Mixed fisheries

Many fishing gears catch more than one species, so "technical interactions" between stocks occur when multiple stocks are captured in the same gear during fishing operations. Because these interactions may vary in time and space (e.g. interactions can differ between day and night, occur at different times of the year, and among different areas), it would be ideal if these could be identified at very small temporal and spatial scales. However, as most fisheries data are aggregated based on species, gear, mesh size range, ICES square, and calendar quarter, subtle interactions may be missed.

ICES has evaluated technical interactions between species captured together in demersal fisheries by examining their co-occurrence in the landings at the scale of gear, mesh size range, ICES statistical rectangle, and quarter (hereafter referred to as "strata"). The percentage of landings of species A, where species B is also landed and constitutes more than 5% of the total landings in that stratum, has been computed for each pair of species. Cases in which species B accounts for less than 5% of the total landings in a stratum were ignored.

To illustrate the extent of the technical interactions between pairs of species, a qualitative scale was applied to each interaction (Figure 20). In this figure, rows represent the share of each species A that was caught in fisheries where species B accounted for at least 5% of the total landing of the fisheries. For example, a high proportion of the catches of lemon sole was for example taken in fisheries where plaice landings where at least 5% of the total landings. The amounts of lemon sole caught in fisheries where cod, haddock, hake or saithe accounted for at least 5% of the total landings were medium. The amount of lemon sole caught in fisheries where lemon sole constituted 5% or more of the total landings were low, indicating that there is no (or very limited) target lemon sole fishery.

The columns illustrate the degree of mixing and can be used to identify the main fisheries (target fisheries) and the degree of mixing in these fisheries. Fisheries where plaice (species B) constitute 5% or more of the total landings account for a high share (red cells) of the total landings of dab, lemon sole, plaice, sole, turbot, flounder, brill, haddock, and which, and a medium share (orange cells) of the landings of whiting, hake and *Nephrops*. This shows that the plaice fishery is a central fishery in the North Sea with a high degree of mixing. The lemon sole column shows that the landings of lemon sole in fisheries where the species constituted 5% or more of the total landing were low and the relative landings of other species in this fisheries were also low. This confirms that there is no or very limited target lemon sole fishery.

Technical interactions in North Sea pelagic fisheries are relatively low. For example, in the Danish small-mesh fishery targeting sprat, herring bycatch has varied between 4% and 16% during the last ten years (2007–2016).

Figure 20   Technical interactions amongst Greater North Sea demersal stocks. The rows of the figure illustrate the fisheries where the species A was caught. Red cells indicate the species B with which species A are frequently caught. Orange cells indicate medium interactions and yellow cells indicate weak interactions. The column shows the degree of mixing in fisheries where species B account for at least 5% of the total landings. A more detailed explanation of the figure is provided in the text.

The species interactions and relative proportions of catches in mixed fisheries are not likely to change greatly between years. Generally the interactions between species and the selectivity of fisheries change gradually over time.

Multispecies considerations

Fish species are part of the marine foodweb and interact in various ways, including through predation and competition. Natural mortality is becoming more significant in the North Sea because fishing mortality has been markedly reduced on many stocks. Hence, natural processes are now having a relatively greater effect on the dynamics of these stocks. Predation mortality can occur from other fish, seabirds, and marine mammals. The abundance of larger fish and some mammal species has been increasing in the North Sea, while seabird populations have broadly decreased. Consumption of fish by these predators has been modelled and for several North Sea stocks (cod, haddock, whiting, sprat, sandeel, and herring), predation mortality is now directly included in the assessments of these stocks. This ensures that temporal changes in natural mortality are explicitly accounted for in these assessments, as well as in the setting of stock-specific reference points.

The modelling results indicate that the yields of many North Sea stocks are strongly affected by the abundance of cod, saithe, and mackerel, which are the main predator fish species. Changes in fishing mortality on these species therefore influences the abundance and yield of other fish stocks. Indirect predation effects are also important. For example, reduced fisheries exploitation on cod increases cod biomass, which not only leads to reductions in SSB and yields of whiting and haddock (direct predation effect) but also to increases in SSB and yield of herring, sandeel, Norway pout, and sprat. The SSB increases for these prey species are due to the reduction in predation pressure from whiting and haddock, which more than compensates for the increase in direct predation from a larger cod stock (indirect effect).

According to model simulations, it is not possible for all stocks to be simultaneously maintained above precautionary single-species biomass reference points. Whiting is the most extreme example of this. Small whiting are subjected to high predation by grey gurnard, and a strong recovery of the cod stock (another significant predator of whiting) increases the probability that the whiting stock will decline below its precautionary biomass reference point.

Any potential target multispecies F_{MSY} depends on management objectives and SSB constraints. No single maximum sustainable yield solution exists in a multispecies context, and policy choices (i.e. trade-offs) have to be made. However, model simulations show that fishing mortalities leading to close-to-maximum average yield (e.g. at least 95% of MSY) and which have a low probability of causing stocks to decline below B_{lim} can be estimated in a multispecies context. The simulations show that in the long term, cod and saithe could be fished at slightly higher Fs to limit predation pressure on their prey, thereby maintaining high SSB and yields of these prey species. In the case of cod, this would also avoid too much loss in cod yield due to cannibalism. The target F_{MSY} depends on managers defining agreed constraints and acceptable risk levels. ICES multispecies simulations of identified scenarios can be used to evaluate the possible consequences of different policy decisions.

Effects of fisheries on the ecosystem

Two different effects of fisheries on the ecosystem are described in this section: (1) Physical disturbance of benthic habitats by bottom trawl fishing gear; and (2) fisheries bycatch of protected, endangered, and threatened species.

The extent, magnitude, and impact of mobile bottom-contacting fishing gear on the seabed and benthic habitats varies geographically across the North Sea (Figure 21). These maps are calculated in terms of a swept area ratio. Swept area is calculated as hours fished × average fishing speed × gear width. Values for each of these factors were derived from VMS data and other sources. The swept area ratio is calculated for all 0.05 × 0.05 degree grid cells in the North Sea and is the sum of the swept area divided by the area of each grid cell. The resultant values indicate the theoretical number of times the entire grid cell area would have been swept if effort was evenly distributed within each cell. The swept area ratio is separately calculated for surface and subsurface contact. Different gear types interact with the seabed in different ways and thus exert different levels of physical disturbance, in terms of the substrate areas affected and the penetration depth. Surface abrasion is defined as the damage to seabed surface features; subsurface abrasion as the penetration and/or disturbance of the substrate beneath the seabed surface. For further information on these effects, see the Greater North Sea ecosystem overview.

Average surface swept area ratio 2015-2018

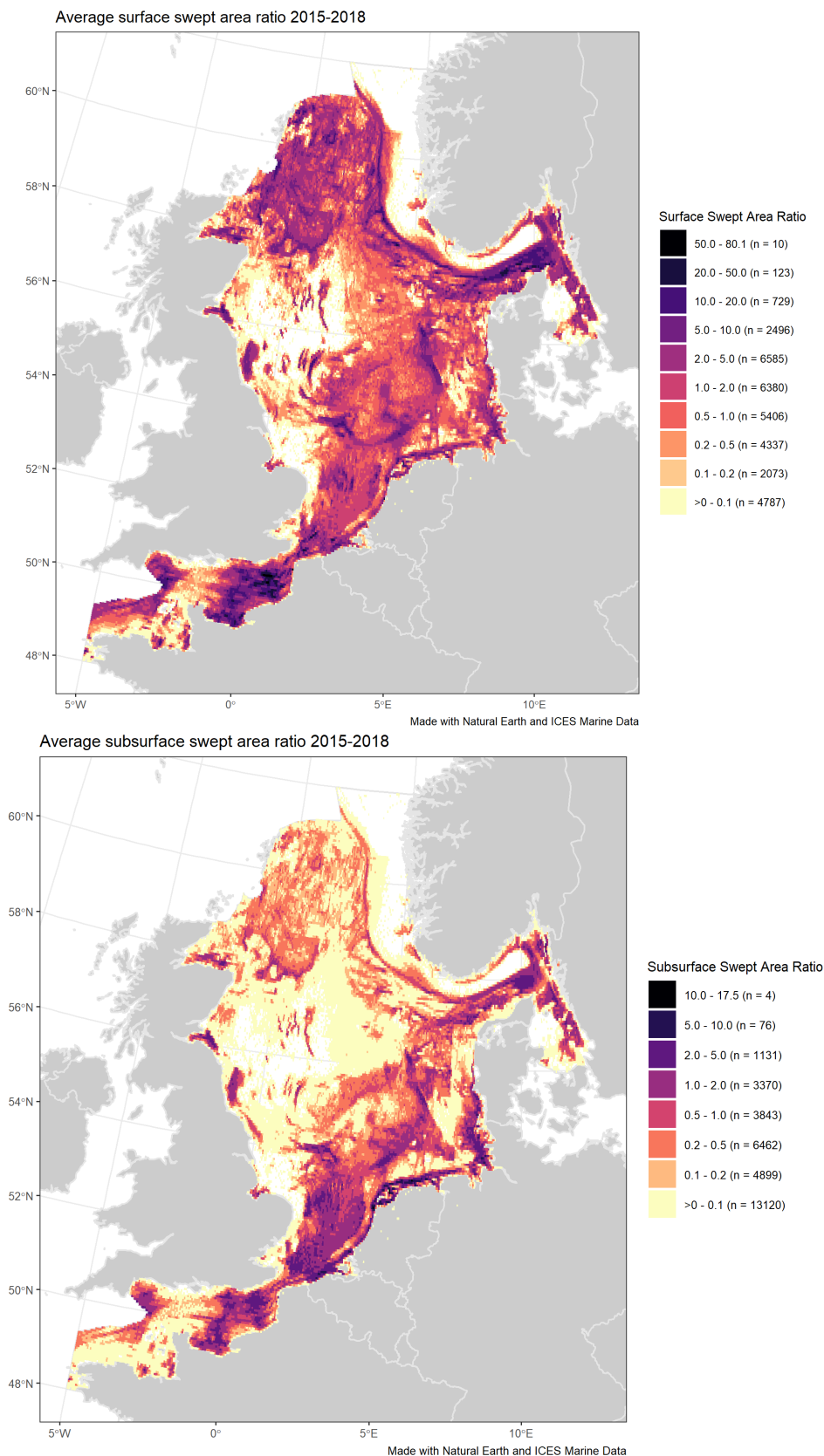Average subsurface swept area ratio 2015-2018

Figure 21   Average annual subsurface (top) and surface (bottom) disturbance by mobile bottom contacting fishing gear (bottom otter trawls, bottom seines, dredges, beam trawls) in the Greater North Sea during 2015–2018, expressed as average swept-area ratios (SAR).

Some fisheries have the potential to take protected, endangered, or threatened species (i.e., seabirds and marine mammals) as non-targeted bycatch. Recording of the catch of these species has been undertaken in a few North Sea fisheries, where there is perceived particular risk of such bycatch. A recent EU-funded project (fishPi project, 2016) analysed risk from various gears to seabirds and marine mammals and determined that observations were most needed in fisheries using set gillnets, trammelnets, driftnets, and bottom trawls.

Based on patchy observer information with an unknown amount of bias, ICES has advised that bycatch of common dolphins in the western English Channel (the far southwestern part of the Greater North Sea) may be unsustainable in population terms, while the bycatch of harbour porpoise in the Greater North Sea is below assumed unsustainable levels. No recent assessment has been made of bird bycatch in the Greater North Sea; there was some evidence of large bycatches of seabirds in coastal gillnets in the past, but the fisheries with high bycatch have either been closed or have subsequently managed to reduce their bycatch risk.

Eight species of elasmobranchs that occur in the Greater North Sea are listed on OSPAR's list of threatened and declining species. Some of these are rare (e.g. basking shark, angel shark) and seldom caught in fisheries. Other species (e.g. spotted ray, thornback ray) are harvested in some targeted fisheries. Most often, elasmobranchs are taken as incidental bycatch and then discarded (Figure 7), particularly when there is a zero TAC for a species.

Sources and references

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: 20–33. http://data.europa.eu/eli/reg/2008/1342/oj

EU. 2018. Regulation (EU) 2018/973 of the European Parliament and of the council of 4 July 2018 establishing a multiannual plan for demersal stocks in the North Sea and the fisheries exploiting those stocks, specifying details of the implementation of the landing obligation in the North Sea and repealing Council Regulations (EC) No 676/2007 and (EC) No 1342/2008. Official Journal of the European Union, L. 179. 13 pp. http://data.europa.eu/eli/reg/2018/973/oj

fishPi project. 2016. Regional cooperation in fisheries data collection, strengthening regional cooperation in fisheries data collection. Report to the European Commission in Fulfilment of Grant Award: EU MARE/2014/19. 617 pp. https://www.masts.ac.uk/research/fishpi-projects/, accessed 28 November 2019.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp. https://doi.org/10.17895/ices.pub.5322

ICES. 2014. Second Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 10–13 June 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/SSGSUE:05. 102 pp. https://doi.org/10.17895/ices.pub.5683

ICES. 2016. Greater North Sea Ecoregion – Ecosystem overview. *In* Report of the ICES Advisory Committee, 2016. ICES Advice 2016, Book 6, Section 6.1. 22 pp. https://doi.org/10.17895/ices.advice.5702

ICES. 2018a. Advice basis. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, Book 1, Section 1.2. https://doi.org/10.17895/ices.pub.4503.

ICES. 2018b. Mixed-fisheries advice for Subarea 4, Division 7.d, and Subdivision 3.a.20 (North Sea, eastern English Channel, Skagerrak). *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018. 16 pp.

https://doi.org/10.17895/ices.pub.4469

ICES. 2019a. Greater North Sea Ecoregion – Fisheries overview data. https://doi.org/10.17895/ices.data.5700 [‡]

ICES. 2019b. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 1:7. http://doi.org/10.17895/ices.pub.5402

STECF. 2016. Scientific, Technical and Economic Committee for Fisheries (STECF) – Fisheries Dependent Information (STECF-16-20). Publications Office of the European Union, Luxembourg; EUR 27758 EN. 858 pp. http://dx.doi.org/10.2788/502445

[‡] Version 2: DOI updated

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. https://doi.org/10.1093/icesjms/fsr060

Ulrich, C., Vermard, Y., Dolder, P. J., Brunel, T., Jardim, E., Holmes, S. J., Kempf, A., et al. 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. https://doi.org/10.1093/icesjms/fsw126

Annex

Supporting data used in the Greater North Sea Fisheries overview is archived at ICES (2019a).

The following annex table is a status summary of the Greater North Sea stocks in 2019.

Table A1 Status summary of Greater North Sea stocks in 2019 relative to maximum sustainable yield (MSY) and the ICES precautionary approach (PA). Grey represents unknown reference points. For MSY: green represents a stock that is fished below F_{MSY} or the stock size is above MSY $B_{trigger}$; red represents a stock that is fished above F_{MSY} or the stock size is lower than MSY $B_{trigger}$. For PA: green represents a stock that is fished below F_{pa} or the stock size is above B_{pa}; yellow represents a stock that is fished between F_{pa} and F_{lim} or the stock size is between B_{lim} and B_{pa}; red represents a stock that is fished above F_{lim} or the stock size is below B_{lim}. Stocks having a fishing mortality rate at or below F_{pa} and a stock size above B_{pa} are defined as being inside safe biological limits. Grey represents stocks for which reference points are unknown. SBL = safe biological limits; MSFD = Marine Strategy Framework Directive; D3C1 = MSFD indicator for fishing mortality; D3C2 = MSFD indicator for spawning-stock biomass; GES = good environmental status.

Stock Key	Stock Description	Fisheries Guild	Data Category	Assessment Year	Advice Category	SBL	GES	Reference point	Fishing Pressure	Stock Size	D3C1	D3C2
ank.27.78abd	Black-bellied anglerfish in Subarea 7 and divisions 8.a-b and 8.d	Benthic	3.2	2019	PA	❓	❓	MSY	✅	❓	✅	❓
								PA	❓	❓	❓	❓
aru.27.123a4	Greater silver smelt in subareas 1, 2, and 4, and in Division 3.a	Pelagic	3.2	2019	PA	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
bli.27.5b67	Blue ling in subareas 6-7 and Division 5.b	Demersal	1	2018	MSY	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
bli.27.nea	Blue ling in Subareas 1, 2, 8, 9, and 12, and Divisions 3.a and 4.a	Demersal	5.3	2019	PA	❓	❌	MSY	❓	❌	❓	❌
								PA	❓	❌	❓	❌
bll.27.3a47de	Brill in Subarea 4 and divisions 3.a and 7.d-e	Benthic	3.2	2019	PA	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
bss.27.4bc7ad-h	Seabass in Divisions 4.b-c, 7.a, and 7.d-h	Demersal	1.2	2018	MSY	❌	❌	MSY	✅	❌	✅	❌
								PA	✅	❌	✅	❌
cod.27.47d20		Demersal	1	2019	MSY	❌	❌	MSY	❌	❌	❌	❌

Stock Key	Stock Description	Fisheries Guild	Data Category	Assessment Year	Advice Category	SBL	GES	Reference point	Fishing Pressure	Stock Size	D3C1	D3C2
	Cod in Subarea 4, Division 7.d, and Subdivision 20							PA	❌	❌	❌	❌
cod.27.7e-k	Cod in divisions 7.e-k	Demersal	1	2019	MSY	❌	❌	MSY	❌	❌	❌	❌
								PA	❌	❌	❌	❌
dab.27.3a4	Dab in Subarea 4 and Division 3.a	Benthic	3.2	2019	PA/Stock status only	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
dgs.27.nea	Spurdog in Subareas 1-10, 12 and 14	Elasmobranch	1.2	2018	MSY/PA	❓	❌	MSY	✅	❌	✅	❌
								PA	✅	❓	✅	❓
ele.2737.nea	European eel throughout its natural range	Demersal	3.14	2018	PA	❓	❓	MSY	❓	❓	❓	❓
								PA	❓	❓	❓	❓
fle.27.3a4	Flounder in Subarea 4 and Division 3.a	Benthic	3.2	2019	PA/Stock status only	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
gug.27.3a47d	Grey gurnard in Subarea 4 and divisions 7.d and 3.a	Demersal	3.2	2018	PA/Stock status only	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
had.27.46a20	Haddock in Subarea 4, Division 6.a, and Subdivision 20	Demersal	1	2019	MSY	✅	❌	MSY	❌	✅	❌	✅
								PA	✅	✅	✅	✅
had.27.7b-k	Haddock in Divisions 7.b-k	Demersal	1	2019	MSY	✅	❌	MSY	❌	✅	❌	✅
								PA	✅	✅	✅	✅
her.27.1-24a514a	Herring in subareas 1, 2, 5 and divisions 4.a and 14.a, Norwegian spring-spawning herring	Pelagic	1	2019	MP	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
her.27.20-24	Herring in subdivisions 20-24, spring spawners	Pelagic	1.2	2019	MSY	❌	❌	MSY	❌	❌	❌	❌
								PA	🟡	❌	🟡	❌
her.27.3a47d	Herring in Subarea 4 and divisions 3.a and 7.d, autumn spawners	Pelagic	1	2019	MSY	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅

Stock Key	Stock Description	Fisheries Guild	Data Category	Assessment Year	Advice Category	SBL	GES	Reference point	Fishing Pressure	Stock Size	D3C1	D3C2
hke.27.3a46-8abd	Hake in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d, Northern stock	Demersal	1	2019	MSY	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
hom.27.2a4a5b6a7a-ce-k8	Horse mackerel in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a-c,e-k	Pelagic	1	2019	MSY	❌	❌	MSY	❌	❌	❌	❌
								PA	🟠	🟠	🟠	🟠
hom.27.3a4bc7d	Horse mackerel in divisions 3.a, 4.b-c, and 7.d	Pelagic	3.2	2019	PA	❓	❌	MSY	❌	❓	❌	❓
								PA	❓	❓	❓	❓
lem.27.3a47d	Lemon sole in Subarea 4 and divisions 3.a and 7.d	Benthic	3.2	2019	PA	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
lez.27.4a6a	Megrim in divisions 4.a and 6.a	Benthic	1	2019	MSY	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
lin.27.3a4a6-91214	Ling in Subareas 6-9, 12, and 14, and Divisions 3.a and 4.a	Demersal	3.2	2019	PA	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
mac.27.nea	Mackerel in subareas 1-8 and 14 and division 9.a	Pelagic	1	2019	MSY	✅	❌	MSY	❌	✅	❌	✅
								PA	✅	✅	✅	✅
meg.27.7b-k8abd	Megrim in divisions 7.b-k, 8.a-b, and 8.d	Benthic	1	2019	MP	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
mon.27.78abd	White anglerfish in Subarea 7 and divisions 8.a-b and 8.d	Benthic	1	2019	MP	✅	✅	MSY	✅	✅	✅	✅
								PA	✅	✅	✅	✅
nep.fu.3-4	Norway lobster in Division 3.a, Functional units 3 and 4	Crustacean	1	2019	FMSY Ranges	❓	❓	MSY	✅	❓	✅	❓
								PA	✅	❓	✅	❓
nep.fu.6	Norway lobster in Division 4.b, Functional Unit 6	Crustacean	1	2019	FMSY Ranges	❓	❌	MSY	❌	✅	❌	✅
								PA	❓	✅	❓	✅

Stock Key	Stock Description	Fisheries Guild	Data Category	Assessment Year	Advice Category	SBL	GES	Reference point	Fishing Pressure	Stock Size	D3C1	D3C2
nep.fu.7	Norway lobster in Division 4.a, Functional Unit 7	Crustacean	1	2019	FMSY Ranges	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
nep.fu.8	Norway lobster in Division 4.b, Functional Unit 8	Crustacean	1	2019	FMSY Ranges	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
nep.fu.9	Norway lobster in Division 4.a, Functional Unit 9	Crustacean	1	2019	FMSY Ranges	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
nop.27.3a4	Norway pout in Subarea 4 and Division 3.a	Pelagic	1	2019	MSY	?	?	MSY	?	?	?	?
								PA	?	✓	?	✓
ple.27.21-23	Plaice in subdivisions 21-23	Benthic	1	2019	PA	✓	✗	MSY	✗	✓	✗	✓
								PA	✓	✓	✓	✓
ple.27.420	Plaice in Subarea 4 and Subdivision 20	Benthic	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
ple.27.7d	Plaice in Division 7.d	Benthic	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
ple.27.7e	Plaice in Division 7.e	Benthic	3.2	2019	PA	✓	✗	MSY	✗	✓	✗	✓
								PA	✓	✓	✓	✓
pok.27.3a46	Saithe in Subareas 4, 6 and Division 3.a	Demersal	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
pra.27.3a4a	Northern shrimp in divisions 3.a and 4.a East	Crustacean	1	2019	MSY	✗	✗	MSY	✗	✗	✗	✗
								PA	O	O	O	O
san.sa.1r	Sandeel in Divisions 4.b and 4.c, Sandeel Area 1r	Demersal	1	2019	MSY	✗	✗	MSY	?	✗	?	✗
								PA	?	✗	?	✗
san.sa.2r	Sandeel in Divisions 4.b and 4.c, and Subdivision 20, Sandeel Area 2r	Demersal	1.2	2019	MSY	✗	✗	MSY	?	✗	?	✗
								PA	?	✗	?	✗
san.sa.3r	Sandeel in Divisions 4.a and 4.b, and	Demersal	1	2019	MSY	?	?	MSY	?	✓	?	✓
								PA	?	✓	?	✓

Stock Key	Stock Description	Fisheries Guild	Data Category	Assessment Year	Advice Category	SBL	GES	Reference point	Fishing Pressure	Stock Size	D3C1	D3C2
	Subdivision 20, Sandeel Area 3r											
san.sa.4	Sandeel in divisions 4.a and 4.b, Sandeel Area 4	Demersal	1	2019	MSY	?	?	MSY	?	✓	?	✓
								PA	?	✓	?	✓
sol.27.20-24	Sole in subdivisions 20-24	Benthic	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
sol.27.4	Sole in Subarea 4	Benthic	1	2019	FMSY Ranges	✓	✗	MSY	✗	✓	✗	✓
								PA	✓	✓	✓	✓
sol.27.7d	Sole in Division 7.d	Benthic	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
sol.27.7e	Sole in Division 7.e	Benthic	1	2019	MSY	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
spr.27.3a4	Sprat in Division 3.a and Subarea 4	Pelagic	1	2019	NA	?	?	MSY	?	✓	?	✓
								PA	?	✓	?	✓
tur.27.4	Turbot in Subarea 4	Benthic	1	2019	PA	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
usk.27.3a45b6a7-912b	Tusk in subareas 4 and 7-9 and divisions 3.a, 5.b, 6.a, and 12.b	Demersal	3.2	2019	PA	✓	✓	MSY	✓	✓	✓	✓
								PA	✓	✓	✓	✓
whb.27.1-91214	Blue whiting in subareas 1-9, 12, and 14	Pelagic	1	2019	MP	✓	✗	MSY	✗	✓	✗	✓
								PA	✓	✓	✓	✓
whg.27.47d	Whiting in Subarea 4 and Division 7.d	Demersal	1	2019	MSY	✗	✗	MSY	✗	✗	✗	✗
								PA	✓	O	✓	O
whg.27.7b-ce-k	Whiting in divisions 7.b-c and 7.e-k	Demersal	1	2019	MSY	✗	✗	MSY	✗	✗	✗	✗
								PA	✓	✗	✓	✗
wit.27.3a47d	Witch in Subarea 4 and divisions 3.a and 7.d	Benthic	1	2019	MSY	✗	✗	MSY	✗	✓	✗	✓
								PA	O	✓	O	✓

Table A2   List of those stocks in the Greater North Seas ecoregion in 2018 that do not have a full set of reference points.

Stock code	Stock name	Fish category	Data category	Year of Assessment	Reference Point
agn.27.nea	Angel shark in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
alf.27.nea	Alfonsinos in subareas 1-10, 12 and 14	Demersal	5.2	2018	PA
anf.27.3a46	Anglerfish in Subareas 4 and 6, and Division 3.a	Benthic	3.2	2019	PA
aru.27.6b7-1012	Greater silver smelt in subareas 7-10 and 12, and Division 6.b	Pelagic	3.2	2019	PA
boc.27.6-8	Boarfish in subareas 6-8	Pelagic	3.2	2019	PA
bsf.27.nea	Black scabbardfish in subareas 1, 2, 4-8, 10, and 14, and divisions 3.a, 9.a, and 12.b	Pelagic	3.2	2018	PA
bsk.27.nea	Basking shark in Subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
cod.27.21	Cod in Subdivision 21	Demersal	3.2	2019	PA
cyo.27.nea	Portuguese dogfish in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
gag.27.nea	Tope in subareas 1-10, 12 and 14	Elasmobranch	5.2	2019	PA
gfb.27.nea	Greater forkbeard in subareas 1-10, 12 and 14	Demersal	3.2	2018	PA
guq.27.nea	Leafscale gulper shark in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
gur.27.3-8	Red gurnard in subareas 3-8	Demersal	6.2	2019	PA
ldb.27.7b-k8abd	Four-spot megrim in divisions 7.b-k, 8.a-b, and 8.d	Benthic	5.9	2019	PA/Stock status only
mur.27.3a47d	Striped red mullet in Subarea 4 and divisions 7.d and 3.a	Demersal	3.2	2019	PA
mur.27.67a-ce-k89a	Striped red mullet in subareas 6 and 8, and divisions 7.a-c, 7.e-k, and 9.a	Demersal	5.2	2017	PA
nep.fu.10	Norway lobster in Division 4.a, Functional Unit 10	Crustacean	4.14	2018	PA
nep.fu.32	Norway lobster in Division 4.a, Functional Unit 32	Crustacean	4.14	2018	PA
nep.fu.33	Norway lobster in Division 4.b, Functional Unit 33	Crustacean	4.14	2018	PA
nep.fu.34	Norway lobster in Division 4.b, Functional Unit 34	Crustacean	4.14	2018	PA
nep.fu.5		Crustacean	4.14	2018	PA

Stock code	Stock name	Fish category	Data category	Year of Assessment	Reference Point
	Norway lobster in divisions 4.b and 4.c, Functional Unit 5				
ory.27.nea	Orange roughy in subareas 1-10, 12 and 14	Demersal	6.3	2016	PA
pol.27.3a4	Pollack in Subarea 4 and Division 3.a	Demersal	5.2	2018	PA/Stock status only
pol.27.67	Pollack in subareas 6-7	Demersal	4.12	2018	PA
por.27.nea	Porbeagle in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
pra.27.4a	Northern shrimp in Division 4.a West	Crustacean	6.3	2018	PA
raj.27.3a47d	Rays and skates in Subarea 4 and in divisions 3.a and 7.d	Elasmobranch	6.9	2019	PA
raj.27.67a-ce-h	Rays and skates in Subarea 6 and divisions 7.a-c and 7.e-h	Elasmobranch	6.9	2018	No advice
rja.27.nea	White skate in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
rjb.27.3a4	Common skate complex and flapper skate in Subarea 4 and Division 3.a	Elasmobranch	6.3	2019	PA/Stock status only
rjb.27.67a-ce-k	Common skate complex and flapper skate in Subarea 6 and divisions 7.a–c and 7.e–k	Elasmobranch	6.3	2018	PA/Stock status only
rjc.27.3a47d	Thornback ray in Subarea 4 and in divisions 3.a and 7.d	Elasmobranch	3.2	2019	PA
rjc.27.7e	Thornback ray in Division 7.e	Elasmobranch	5.2	2018	PA
rje.27.7de	Small-eyed ray in divisions 7.d and 7.e	Elasmobranch	5.2	2018	PA
rjf.27.67	Shagreen ray in subareas 6-7	Elasmobranch	5.2	2018	PA
rjh.27.4a6	Blonde ray in Subarea 6 and Division 4.a	Elasmobranch	5.2	2019	PA
rjh.27.4c7d	Blonde ray in divisions 4.c and 7.d	Elasmobranch	3.2	2019	PA
rjh.27.7e	Blonde ray in Division 7.e	Elasmobranch	5.2	2018	PA
rji.27.67	Sandy ray in subareas 6-7	Elasmobranch	5.2	2018	PA
rjm.27.3a47d	Spotted ray in Subarea 4 and Divisions 3.a and 7.d	Elasmobranch	3.2	2019	PA
rjm.27.7ae-h	Spotted ray in divisions 7.a and 7.e-h	Elasmobranch	3.2	2018	PA
rjn.27.3a4	Cuckoo ray in Subarea 4 and Division 3.a	Elasmobranch	3.2	2019	PA
rjn.27.678abd	Cuckoo ray in subareas 6-7 and divisions 8.a-b and 8.d	Elasmobranch	3.2	2018	PA
rjr.27.23a4	Starry ray in Subareas 2 and 4, and Division 3.a	Elasmobranch	3.14	2019	PA

Stock code	Stock name	Fish category	Data category	Year of Assessment	Reference Point
rju.27.7de	Undulate ray in divisions 7.d and 7.e	Elasmobranch	3.2	2018	PA
rng.27.1245a8914ab	Roundnose grenadier in subareas 1, 2, 4, 8, and 9, Division 14.a, and in subdivisions 14.b.2 and 5.a.2	Demersal	6.2	2019	PA
rng.27.3a	Roundnose grenadier in Division 3.a	Demersal	3.2	2018	PA
rng.27.5b6712b	Roundnose grenadier in subareas 6-7 and divisions 5.b and 12.b	Demersal	5.2	2018	MSY
san.sa.5r	Sandeel in Division 4.a, Sandeel Area 5r	Demersal	5.3	2019	PA
san.sa.6	Sandeel in subdivisions 20-22, Sandeel Area 6	Demersal	5.2	2019	PA
san.sa.7r	Sandeel in Division 4.a, Sandeel Area 7r	Demersal	5.3	2019	PA
sbr.27.6-8	Blackspot seabream in subareas 6-8	Demersal	6.3	2018	PA
sck.27.nea	Kitefin shark in subareas 1-10, 12 and 14	Elasmobranch	6.3	2019	PA
sdv.27.nea	Smooth-hound in subareas 1-10, 12 and 14	Elasmobranch	3.2	2019	PA
sho.27.67	Black-mouth dogfish in subareas 6 and 7	Elasmobranch	3.9	2019	PA/Stock status only
san.27.6a	Sandeel in Division 6.a	Demersal	6.3	2018	No advice
spr.27.7de	Sprat in divisions 7.d and 7.e	Pelagic	3.2	2019	PA
syc.27.3a47d	Lesser spotted dogfish in Subarea 4 and divisions 3.a and 7.d	Elasmobranch	3.9	2019	PA
syc.27.67a-ce-j	Lesser spotted dogfish in Subarea 6 and divisions 7.a-c and 7.e-j	Elasmobranch	3.9	2019	PA
syt.27.67	Greater-spotted dogfish in subareas 6 and 7	Elasmobranch	3.9	2019	No advice
tur.27.3a	Turbot in Division 3.a	Benthic	3.2	2019	PA/Stock status only
whg.27.3a	Whiting in Division 3.a	Demersal	5.2	2019	PA/Stock status only

Table A3   Scientific names of species.

Alfonsinos *Beryx* spp.
Angel shark *Squatina squatina*
Anglerfishes *Lophius budegassa, Lophius piscatorius*
Basking shark *Cetorhinus maximus*
Black-bellied anglerfish *Lophius budegassa*
Black-mouth dogfish *Galeus melastomus*
Black scabbardfish *Aphanopus carbo*
Blackspot seabream *Pagellus bogaraveo*
Blonde ray *Raja brachyura*
Blue ling *Molva dypterygia*
Blue whiting *Micromesistius poutassouu*
Boarfish *Capros aper*
Brill *Scophthalmus rhombus*
Cod Gadus morhua
Common dolphin (Long-finned) *Delphis delphinus*
Common skate complex *Dipturus batis*-complex incl. flapper skate *Dipturus cf. Flossada* and blue skate *Dipturus cf. intermedia*
Cuckoo ray *Leucoraja naevus*
Dab *Limanda limanda*
European eel *Anguilla anguilla*
Flounder *Platichthys flesus*
Four-spot megrim *Lepidorhombus boscii*
Greater forkbeard *Phycis blennoides*
Greater silver smelt *Argentina silus*
Greater-spotted dogfish *Skyliorhinus stellaris*
Grey gurnard *Eutrigla gurnardus*
Haddock *Melanogrammus aeglefinus*
Harbour porpoise *Phocoena phocoena*
Hake *Merluccius merluccius*
Horse mackerel *Trachurus trachurus*
Herring *Clupea harengus*
Kitefin shark *Dalatias licha*
Leafscale gulper shark *Centrophorus squamosus*
Lemon sole *Microstomus kitt*
Lesser-spotted dogfish *Scyliorhinus canicula*
Ling *Molva molva*
Mackerel *Scomber scombrus*
Megrim *Lepidorhombus whiffiagonis*
Megrims *Lepidorhombus* spp.

Northern shrimp *Pandalus borealis*
Norway lobster *Nephrops norvegicus*
Norway pout *Trisopterus esmarkii*
Orange roughy *Hoplostethus atlanticus*
Plaice *Pleuronectes platessa*
Pollack *Pollachius pollachius*
Porbeagle *Lamna nasus*
Portuguese dogfish *Centroscymnus coelolepis*
Queen scallop *Chlamys opercularis*
Rays and skates *Rajidae*
Red gurnard *Chelidonichthys cuculus*
Roughhead grenadier *Macrourus berglax*
Roughsnout grenadier *Trachyrincus scabrus*
Roundnose grenadier *Coryphaenoides rupestris*
Saithe *Pollachius virens*
Sardine *Sardina pilchardus*
Sandeel *Ammodytes* spp.
Sandy ray *Leucoraja circularis*
Seabass *Dicentrarchus labrax*
Shagreen ray *Leucoraja fullonica*
Small-eyed ray *Raja microocellata*
Smooth-hound *Mustelus* spp.
Sole *Solea solea*
Spotted ray *Raja montagui*
Sprat *Sprattus sprattus*
Spurdog *Squalus acanthias*
Starry ray *Amblyraja radiata*
Striped red mullet *Mullus surmuletus*
Thornback ray *Raja clavata*
Tope *Galeorhinus galeus*
Turbot *Scophthalmus maximus*
Tusk *Brosme brosme*
Undulate ray *Raja undulata*
White anglerfish *Lophius piscatorius*
White skate *Rostroraja alba*
Whiting *Merlangius merlangus*
Witch *Glyptocephalus cynoglossus*