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Executive summary

The ICES Working Group on Mixed Fisheries Advice [WGMIXFISH-ADVICE] (Chair: Youen Vermard (FR)) met at ICES HQ, 23–27 May 2016 to produce mixed fisheries fore-casts for the North Sea, the Celtic Sea and the Iberian waters.

Mixed fisheries advice highlights the potential implications of single stock (Total Allowable Catch and Effort) management on the catches of multiple stocks caught together in mixed fisheries. It takes into account past fishing patterns and catchability of the different fleets and the TAC advice produced by the single stock advice groups for 2017 to provide quantitative forecast of over- and under- exploitation of the different stocks given mixed fishery interactions. All forecasts were based on the "FCube" (Fleet and Fishery Forecasts) methodology with a range of potential management scenarios relevant for the specific regional fisheries.

For the North Sea (Term of Reference 'a') the species considered as part of the demersal mixed fisheries were cod, haddock, whiting, saithe, plaice, sole, and *Nephrops norvegicus*, as well as plaice 7.d and sole 7.d. The impact of mixed fisheries scenarios on seven further stocks; brill, dab, flounder, hake, lemon sole, red mullet, turbot and witch were considered on the basis of catch-per-unit-effort without their incorporation into the mixed fisheries projections. The lack of final haddock assessment did not allow finalizing Mixed Fisheries options that are to be done in November after the potential reopening of the forecast for the North Sea stocks. The results presented in this report are then preliminary and will be updated after WGMIXFISH-METH.

For the Celtic Sea (Term of Reference 'b') the species considered as part of the gadoid fisheries were cod, haddock and whiting. The most limiting stock (i.e. the stock where the first quota is reached for most fleets) in the Celtic Sea gadoid mixed fisheries in 2016 was cod. The least limiting stock (i.e. the stock which was the last quota to be fulfilled) was whiting.

The meeting produced a Celtic Sea Mixed Fisheries Advice sheet and included outcomes of the mixed fisheries scenarios in the single species advice sheets (for those stocks considered) for consideration by the ACOM advice drafting group. The meeting also developed a mixed fisheries annex for the region and considered how *Nephrops* stocks could be included in future mixed fisheries forecasts.

For the Iberian waters (Term of reference 'c') the species considered as part of the demersal mixed fisheries were hake, four-spot megrim, megrim and white anglerfish. The most limiting stocks (i.e. the stock where the first quota is reached for most fleets) in the Iberian waters mixed fisheries were the stocks of hake and four-spot megrim. The least limiting stock (i.e. the stock which was the last quota to be fulfilled) was the white anglerfish.

1 Introduction

1.1 Background

The **Working Group on Mixed Fisheries Advice** [WGMIXFISH-ADVICE] (Chair: Youen Vermard (FR)) met at ICES HQ, 23–28 May 2016 to apply mixed fisheries forecasts to the North Sea, Celtic Sea and Iberian waters single species advice. WGMIXFISH advice is considered by the relevant advice drafting group alongside the single species advice, and so the WG can only consider preliminary single stock advice. The output from this group applies the methodology developed by the ICES Workshop on Mixed Fisheries Advice for the North Sea [WKMIXFISH] (ICES 2009a) and Ad hoc Group on Mixed Fisheries Advice for the North Sea [AGMIXNS] (ICES 2009b) which met in 2009.

The current interest in fleet- and fishery-based approaches has its origins around 2002, when the conflicting states of the various demersal stocks in the North Sea made the limitations of the traditional, single-species approach to advice particularly apparent. The history of the adoption and development of the FCube approach (after Fleet and Fishery Forecast) used by this WG is detailed in ICES (2009a). At WGMIXFISH 2011 the WG considered steps to fuller integration of mixed fisheries forecasts into single stock advice. Most of the steps recommended have been implemented starting in 2012.

Mixed fishery advice is based on the Common Fisheries Policy (CFP) TAC regime and is consistent with relative stability. The circumstances of 2002 have also lead to the introduction of effort restrictions alongside TACs as a management measure within EU fisheries and there has been an increasing use of single-species multi-annual management plans, partly in relation to cod recovery, but also more generally.

The 2014 revision of the CFP introduced a landings obligation in EU demersal fisheries from 2016 alongside regional multi-annual (mixed fishery) management plans. These developments are of key importance for the general approach to mixed-fisheries advice, which must build on the existing legal and management system. While mixed fisheries objectives are under development and therefore cannot yet be incorporated in the mixed fisheries forecasts, the introduction of the landings obligation will fundamentally change how fisheries are managed in the EU. As such, this year the advice was provided in the context of catch, rather than landings as in previous years. This reflects the move towards a landings obligation for EU fisheries in a phased approach started in 2016.

The mixed fisheries advice has greatly benefited in recent years from the joint single stock and mixed fisheries data calls. From 2015, ICES introduced a single combined data call across all working groups which further improved consistency between the fleet and fishery data used by MIXFISH and the single stock data provided through InterCatch. The latest data call used by WGMIXFISH can be found here: http://www.ices.dk/marine-data/tools/Pages/Data-calls.aspx.

1.2 Definitions

Two basic concepts are of primary importance when dealing with mixed-fisheries, the Fleet (or fleet segment), and the Métier. Their definition has evolved with time, but the most recent official definitions are those from the CEC's Data Collection Framework (DCF, Reg. (EC) No 949/2008 and Commission Decision 2010/93/UE), which we adopt here:

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

A Métier is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterized by a similar exploitation pattern.

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

1.3 Terms of Reference

The terms of reference for WGMIXFISH were as follows:

WGMIXFISH-ADVICE – Working Group on Mixed Fisheries Advice

2015/2/ACOM22 The **Working Group on Mixed Fisheries Advice** (WGMIXFISH-ADVICE), chaired by Youen Vermard*, France, will meet at ICES Headquarters, 23–27 May 2016 to:

a) Carry out mixed demersal fisheries projections for the North Sea taking into account the single species advice for cod, haddock, whiting, saithe, plaice, sole, turbot, *Nephrops norvegicus*, sole VIId and plaice VIId that is produced by WGNSSK in May 2016, and the management measures in place for 2017;

b) Carry out mixed demersal fisheries projections for the Celtic Sea taking into account the single species advice for cod, haddock, and whiting that is produced by WGCSE in 2016, and the management measures in place for 2017 and further develop advice for the region;

c) Carry out mixed fisheries projections for the Iberian waters taking into account the single species advice for hake, four-spot megrim, megrim and white anglerfish that is produced by WGBIE in May 2016, and the management measures in place for 2017 and further develop advice for the region;

i) Produce a draft mixed-fisheries section for the ICES advisory report 2015 that includes a dissemination of the fleet and fisheries data and forecasts for the North Sea, Celtic Sea [and where possible the Iberian waters].

WGMIXFISH will report by 3 June 2016 for the attention of ACOM.

Supporting Information

Priority:	The work is essential to ICES to progress in the development of its capacity to provide advice on multispecies fisheries. Such advice is necessary to fulfil the requirements stipulated in the MoUs between ICES and its client commissions.

Scientific justification and relation to action plan:	The issue of providing advice for mixed fisheries remains an important one for ICES. The Aframe project, which started on 1 April 2007 and finished on 31 march 2009 developed further methodologies for mixed fisheries forecasts. The work under this project included the development and testing of the Fcube approach to modelling and forecasts. In 2008, SGMIXMAN produced an outline of a possible advisory format that included mixed fisheries forecasts. Subsequently, WKMIXFISH was tasked with investigating the application of this to North Sea advice for 2010. AGMIXNS further developed the approach when it met in November 2009 and produced a draft template for mixed fisheries advice. WGMIXFISH has continued this work since 2010.
Resource requirements:	No specific resource requirements, beyond the need for members to prepare for and participate in the meeting.
Participants:	Experts with qualifications regarding mixed fisheries aspects, fisheries management and modelling based on limited and uncertain data.
Secretariat facilities:	Meeting facilities, production of report.
Financial:	None
Linkages to advisory committee:	ACOM
Linkages to other committees or groups:	SCICOM through the WGMG. Strong link to STECF.
Linkages to other organizations:	This work serves as a mechanism in fulfilment of the MoU with EC and fisheries commissions. It is also linked with STECF work on mixed fisheries.

2 North Sea

2.1 Background

2.1.1 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in Annex XVII of Council Regulation 2341/2002 and amended by Council on an annual basis. In 2008 the system was radically redesigned. For 2009 effort limits were changed to be on the basis of KWdays effort pots assigned per nation per fleet effort category. The baselines assigned in 2009 were based on track record per fleet effort category averaged over 2004–2006 or 2005–2007 depending on national preference. The latest effort allocations available by nation and gear are given in Appendix 1 of Annex IIa of Council Regulation **(EU) 2016/72**. The totals in 2016 are unchanged from those in 2012. Member states are permitted slightly larger allocations of effort in cases where that effort involves low cod catches, e.g. through the implementation of more selective gears or cod avoidance measures. Full details are given in Article 13 of Council Regulation (EC) 1342/2008.

2.1.2 Stock-based management plans

The majority of the stocks considered here as part of the demersal mixed fisheries of the North Sea are subject to multi-annual management plans[1]. These plans all consist of harvest rules to derive annual TACs depending on the state of the stock relative to biomass reference points and target fishing mortality. The harvest rules also impose constraints on the annual percentage change in TAC.

These plans have been discussed, evaluated and adopted on a stock-by-stock basis, involving different timing, procedures, stakeholders and scientists, and as such have never been evaluated in an integrated approach.

In 2015, the assessment for plaice in area 4 incorporated area 3.aN (Skagerrak), which was previously a separate stock, as evidence suggests they should be managed together as a single unit. However, given the small amount of Skagerrak catches compared to the North Sea, the current management plan is still considered appropriate.

The full details and references of these plans are not always easy to find. The most important points of these plans are therefore reproduced in Annex 3.

In the frame of the new CFP, the EU is currently working on designing and evaluating mixed-fisheries management plans, that would eventually replace the current single-stock LTMPs by a unique framework defining objectives and constraints for both target and bycatch demersal species. A public consultation was opened from February to May 2015 (http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/north-sea-multiannual/index_en.htm) with potential outcomes of a mixed-fisheries plan evalu-

[1] The exceptions are haddock, plaice VIId, sole VIId and the *Nephrops* stocks. For these stocks the ICES MSY approach or Data Limited Stock (DLS) approach is used as the basis of advice.

ated by STECF in March 2015 (http://stecf.jrc.ec.europa.eu/documents/43805/969556/2015-05_STECF+15-04+-+NSMAP_JRCxxx.pdf). Until further progresses are reached with this initiative, the current LTMP are still in effect.

And is now under national parliament's consultation

https://epthinktank.eu/2016/10/05/multiannual-plan-for-north-sea-demersal-fisheries-eu-legislation-in-progress/

2.2 Fcube

2.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.* (2007); www.flr-project.org; FLCore 2.5.0, FLAssess 2.5.0, Flash 2.5.0) running with R 3.1 (R Development Core Team, 2011). All forecasts were projected using the same fwd() function in the Flash Package. The Fcube method is developed as a stand-alone script using FLR objects as inputs and outputs. Software used in the single species assessments and forecasts was as outlined in the text table below.

Species	Assessment	Forecast
COD 4, 3.a and 7.d	SAM	SAM
HADDOCK 4, 3.a and 7.d	TSA	MFDP
PLAICE 4	FLR 2.3, FLXSA	FLR2.3, FLSTF
SAITHE 4, 3.a and 6	SAM	SAM
SOLE 4	FLR 2.3, FLXSA	FLR 2.3, FLSTF
WHITING 4 and 7.d	FLR 2.x, FLXSA	MFDP
PLAICE 7.d	AAP	FLR 2.x, FLSTF
SOLE 7.d	XSA	MFDP

2.2.2 Scenarios

The Fcube model has been presented and described in Ulrich *et al.* (2008; 2011). Brief details are presented below and a summary of the methodology is incorporated in the Mixed Fisheries Annex (Annex 7).

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

Single-species ICES advice is given according to a single preferred option; management plan if implemented, MSY approach otherwise. The basis for each single-stock advice is retained in the current mixed-fisheries framework.

A complicating factor when incorporating *Nephrops* is the fact that the species is found in a number of distinct areas or functional units (FU), only some of which receive an abundance estimate (necessary to calculate a catchability). This WG followed the approach adopted by ICES (2009b) which is to perform the normal Fcube prediction for those FUs with absolute abundance estimates, then to calculate a ratio of change (R) from the current yields to the ICES advice for the same FUs. For those FUs without absolute abundance estimates, landings resulting from the Fcube run were simply taken to be the most recently recorded landings multiplied by the same ratio R. To do

this, landings for each métier had to be apportioned across the FUs. This was facilitated by the supply of effort and catch data by FU.

Prior to 2009, precursors to WGMIXFISH compiled age-disaggregated data over a large number of categories. Analyses in 2008 highlighted that the age composition of landings showed distinct differences to that supplied to the single species stock assessment working group (WGNSSK) and therefore WGMIXFISH runs projections on the basis of total landings and discards alone. Since 2012 age distribution by métier and area have been increasingly available to WGNSSK in InterCatch. For 2015 data, the match between InterCatch and fleet data was very good, and age-specific fleet projections will be performed in October 2016 during WGMIXFISH-METH.

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

1) **max**: The underlying assumption is that fishing stops for a fleet when all quota species are fully utilized for that fleet with quotas set corresponding to single-stock exploitation boundary for each species.

   min: The underlying assumption is that fishing stops for a fleet when the catch for the first quota species for that fleet meets the corresponding single-stock exploitation boundary.

2) **cod**: The underlying assumption is that all fleets set their effort at the level corresponding to their cod quota share, regardless of other stocks.

3) **sq_E**: The effort for each fleet is set equal to the effort in the most recently recorded year for which landings and discard data were available.

4) "**Value**": this is a simple scenario incorporating elements of the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the quota of each of the stocks, weighted by the historical catch value of that stock. This option causes overfishing of some stocks and underutilisation of others

The "Value" scenario is a simple proxy balancing fishing opportunities by stock with their potential market value, in the absence of a formal economic behaviour model. For example, if a fleet would need 100 days fishing for catching its share of stock A, and 200 days fishing for catching its share of stock B, and if the value (tonnage × mean price in 2014) of that fleet's stock shares is 75% from stock A and 25% from stock B, then the resulting effort would be (100 × 0.75) + (200 × 0.25) = 125 days.

2.3 Stock input data and recent trends

2.3.1 Stocks

2.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGNSSK (2016). Similar to last year, all stock inputs formatted as FLStock objects were directly provided to WGMIXFISH by the respective stock coordinators, and this eased greatly the quality of the process of collecting stock data.

An increasing number of WGNSSK stocks are being assessed using stochastic assessments (SAM model for North Sea cod and saithe, TSA for Northern shelf haddock). These also make use of stochastic projections, which cannot easily be fully replicated

in the deterministic Fcube software. However, Fcube projections are routinely compared to the median projections of the single species stochastic forecasts on which single-stock advice is based and results are very similar (see Section 2.5.2.1); as such WGMIXFISH does not consider the difference impacts significantly on the mixed fisheries advice.

Nephrops stocks were incorporated in the evaluation by functional unit. For the *Nephrops* stocks in FU5, FU6, FU7, FU8, FU9, FU32, FU33, FU34 and *Nephrops* from areas outside the functional units, the ICES advices were taken for the F_{msy} approach.

The functional units with separate stock indices from underwater surveys (FU6, FU7, FU8 and FU9) were treated as separate *Nephrops* identities in the projections whereas the five other functional units (FU 5, 10, 32, 33 and 34) and catches outside the functional units in the North Sea were omitted in the projections.

2.3.1.2 Trends and advice

This advice is drafted by the WGNSSK-2016 before considerations by ACOM.

Recent trends are described on a stock-by-stock basis in ICES (2016a), and latest advice by stock is available on the ICES website. In order to give a global overview of all North Sea demersal stocks at one time, this information is summarized below. It should be noted that although there is only one advice, additional management considerations are also listed in the single species advice. Table 2.3.1.2 lists the final advised TACs for 2017 and expected SSBs in 2018.

2.3.1.2.1 Analytical stocks

Species	Area	Stock status	Summary	Advice 2017
Cod	Subarea 4 (North Sea) and Divisions 7.d (Eastern Channel) and 3.a West (Skagerrak)		Fishing mortality (F) declined from 2000 but is estimated to be above FMSY. Spawning-stock biomass (SSB) has increased from the historical low in 2006 to a level above Blim and remains below MSY Btrigger. Recruitment since 1998 remains poor despite an increase in biomass.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 47 431 tonnes. If this stock is not under the EU landing obligation in 2017 and discard rates do not change from 2015, this implies landings of no more than 38 691 tonnes.
Haddock	Subarea 4 (North Sea) and Divisions 7.d (Eastern Channel) and 6.a (West of Scotland)			
Plaice	Subarea 4 (North Sea) and Division 3.a West (Skagerrak)		The combined North Sea and Skagerrak stock is well above MSY Btrigger, increased in the past ten years, and has been at a record high for the last 5 years. Recruitment has been around the long-term average since the mid-90s. In recent years, fishing mortality (F) has been estimated around FMSY.	ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2017 should be no more than 214 738 tonnes in Subarea 4 and SubDivision 3aN (Skagerrak) combined. If discard rates do not change from the average (2013–2015), this implies landings of no more than 165 142 tonnes.
Sole	Subarea 4 (North Sea)		The spawning stock biomass (SSB) has increased since 2007 and is estimated to be above MSY Btrigger in 2016. Fishing mortality (F) has declined since 1997 and is estimated to be at FMSY in 2015.	ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2017 should be no more than 15 251 tonnes.
Saithe	Subarea 4 (North Sea) and Divisions 3.a (Skagerrak) and Subarea 6 (West of Scotland and Rockall)			

Species	Area	Stock status	Summary	Advice 2017
Whiting	Subarea 4 (North Sea) and Division 7.d (Eastern Channel)		Spawning-stock biomass (SSB) and fishing mortality (F) have been relatively stable since 2003. Recruitment (R) has been low since 2003, with recruitment in 2014 and 2015 above previous years.	ICES advises that when the MSY approach is applied, is applied, total catches in 2017 should be no more than 23 527 tonnes. If discard and industrial bycatch rates do not change from the average (2013–2015), this implies human consumption landings of no more than 12 679 tonnes.
Sole	Division 7.d (Eastern Channel)		The spawning-stock biomass (SSB) has fluctuated without trend and is predicted to drop below MSY Btrigger in 2016. Fishing mortality (F) has always been above FMSY and increased in 2013 and 2014 and is above Flim in 2015. Recruitment has been fluctuating without trend. Recruitment in 2012 to 2014 is among the lowest of the time series, which has resulted in a decrease in recent SSB.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2353 tonnes
Plaice	Division 7.d (Eastern Channel)		Fishing mortality (F) has declined since the mid-1990s and is presently among the lowest in the time-series. Spawning–stock biomass (SSB) has increased since 2008 and is currently the historical high.	ICES advises that when the MSY approach is applied, catches of the Division 7d plaice stock in 2017 should be no more than 12805 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2013–2015), this implies landings of the Division 7d plaice stock of no more than 7550 tonnes. Assuming the same proportion of the Division 7e and Subarea 4 plaice stocks is taken in Division 7d as during 2003–2015, this will correspond to catches of plaice in Division 7d in 2016 of no more than 14864 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2013–2015), this implies landings of plaice in Division 7d of no more than 8764 tonnes.

2.3.1.2.2 Nephrops stocks

Species	Area	Stock status	Summary	Advice 2017
Nephrops	Botney Gut-Silver Pit (FU 5)		The state of this stock is unknown. Preliminary stock surveys (2010 and 2012) indicate relatively high density compared to neighbouring FUs. New discard data indicate that total catch numbers are considerably higher than previously assumed, implying current harvest rates above those associated with MSY for other North Sea Nephrops stocks.	ICES advises on the basis of ICES precautionary approach that catches should be no more than 1391t. Assuming the landing obligation continues with the de minimis allowance of 6% of catch for animals below the Minimum Conservation Reference Size, this implies landings of no more than 1334 t (comprising 594t wanted and 741t previously unwanted >MCRS).
Nephrops	Farn Deeps (FU 6)		The stock size has been generally declining since 2005 and has been below MSY Btrigger since 2012. The 2015 abundance estimate is the lowest of the time series. Harvest rates have been above FMSY for all years except 2008.	ICES advises that when the MSY approach is applied, catches in 2016 (assuming a full landing obligation applies) should be no more than 742 tonnes, implying wanted catch of 660t. Under the assumption that a 6% de minimis exemption is continued for Nephrops below Minimum Conservation Reference Size and that fishery selection patterns do not chance from the average (2013-2015), total catches should not exceed 752 tonnes, which would imply wanted catch of 673t.
Nephrops	Fladen Ground (FU 7)		The stock size has declined from the highest observed value in 2008 and is just below the MSY Btrigger. The 2015 abundance estimate is the lowest of the time-series. The harvest rate has declined in recent years and remains well below FMSY.	ICES advises that when the MSY approach is applied, catches in 2017 (assuming zero discards) should be no more than 6843 tonnes. If instead discard rates continue at recent values (average of 2013–2015), and there is no change in assumed discard survival rate, this implies landings of no more than 6820 tonnes. Under the assumption that a 6% de minimis exemption is continued for Nephrops below Minimum Conservation Reference Size and that fishery selection patterns do not chance from the average (2013-2015), total catches should not exceed 6844 tonnes, which would imply wanted catch of 6822 tonnes.

Species	Area	Stock status	Summary	Advice 2017
Nephrops	Firth of Forth (FU 8)		The stock size is above MSY Btrigger. The harvest rate decreased in 2015 to 16.8% and is just above FMSY.	ICES advises that when the MSY approach is applied, catches in 2017 (assuming zero discards) should be no more than 2062 tonnes. If instead discard rates continue at recent values (average of 2013–2015), and there is no change in assumed discard survival rate, this implies landings of no more than 1773 tonnes. Under the assumption that a 6% de minimis exemption is continued for Nephrops below Minimum Conservation Reference Size and that fishery selection patterns do not chance from the average (2013-2015), total catches should not exceed 2122 tonnes, which would imply wanted catch of 1826 tonnes.
Nephrops	Moray Firth (FU 9)		The stock has declined in 2006 and has remained stable just above the MSY Btrigger since then. The harvest rate has fluctuated around FMSY for the last decade.	ICES advises that when the MSY approach is applied, catches in 2017 (assuming zero discards) should be no more than 1060 tonnes. If instead discard rates continue at recent values (average of 2013–2015), and there is no change in assumed discard survival rate, this implies landings of no more than 1008 tonnes. Under the assumption that a 6% de minimis exemption is continued for Nephrops below Minimum Conservation Reference Size and that fishery selection patterns do not chance from the average (2013-2015), total catches should not exceed 1070 tonnes, which would imply wanted catch of 1018 tonnes.
Nephrops	Noup (FU 10)		The state of the stock is unknown. UWTV surveys in FU 10 have been conducted sporadically and indicated that the density is relatively low (0.13 Nephrops m−2). Landings in FU 10 are at a historical minimum, suggesting harvest rates below those associated with MSY for other North Sea Nephrops stocks.	ICES advises on the basis of ICES approach to data-limited stocks that catches should be no more than 40 t. If discard patterns do not change from the assumed rate and assuming the landing obligation continues with the de minimis allowance of 6% of catch for animals below the Minimum Conservation Reference Size, this implies landings of no more than 38 t.
Nephrops	Norwegian Deep (FU 32)		The state of this stock is unknown. Harvest ratios are thought to be low for this stock even if a low density is assumed (e.g., the lowest observed density in the North Sea is in FU 7, Fladen Ground). Catches have been decreasing since 2006. The Danish fishery has contracted into the southernmost part of the functional unit where a decreasing Danish lpue indicates that fishing pressure may be increasing.	ICES advises that when the precautionary approach is applied, catches in 2017 (assuming a landing obligation applies) should be no more than 496 tonnes. If this stock is not under the EU landing obligation in 2017 and discard rates do not change from the average of the period 2006–2015, this implies landings of no more than 464 tonnes.
Nephrops	Horn's Reef (FU 33)			

Species	Area	Stock status	Summary	Advice 2017
Nephrops	Devil's Hole (FU 34)		The state of this stock is unknown. Harvest rates are thought to be low for this stock even if a low density is assumed (e.g., the lowest observed density in the North Sea is in FU 7, Fladen Ground). Catches have been relatively stable since 2004, fluctuating without trend around 1000 tonnes.	ICES advises on the basis of ICES approach to data-limited stocks that catches should be no more than 1257 t. If discard patterns do not change from the observed rate (2015) and assuming the landing obligation continues with the de minimis allowance of 6% of catch for animals below the Minimum Conservation Reference Size, this implies landings of no more than 1257 t.

2.3.1.2.3 Ancillary stocks

Species	Area	Stock status	Summary	Advice 2017
Brill	Subarea 4 (North Sea) and Divisions 3.a (Skagerrak), 7.d and 7.e (English Channel)		The stock size indicator shows an increase from 2007 to 2012 and some decline since then.	ICES advises that when the precautionary approach is applied, catches should be no more than 2756 tonnes in each of the years 2016 and 2017. If discard rates do not change from the average of the last three years (2012–2014), this implies landings of no more than 2563 tonnes.
Dab	Subarea 4 (North Sea) and Division 3.a (Skagerrak)	Not available	Survey indices show a highly variable abundance without a trend.	ICES advises that when the precautionary approach is applied, catches should be no more than 76 075 tonnes for each of the years 2016 and 2017. If discard rates do not change from the average of the last three years (2012–2014), this implies landings of no more than 7608 tonnes.
Flounder	Subarea 4 (North Sea) and Division 3.a (Skagerrak)		The available survey information indicates no clear trend in stock biomass, although it has been lower for the last four years.	ICES advises that when the precautionary approach is applied, catches should be no more than 5228 tonnes in each of the years 2016 and 2017. If discard rates do not change from the average of the last three years (2012–2014), this implies landings of no more than 2876 tonnes.
Turbot	Subarea 4 (North Sea)		Recruitment is variable without a trend. Fishing mortality (F) is estimated to have increased over time. Spawning-stock biomass (SSB) has decreased and in recent years has stabilised at a low level.	ICES advises that when the precautionary approach is applied, catches should be no more than 1995 tonnes in each of the years 2016 and 2017. If discard rates do not change from 2014, this implies landings of no more than 1925 tonnes.

2.4 Fleets and métiers

2.4.1 Catch and effort Data

Prior to 2012, catch (landings and discards) and effort data were submitted to WGMIXFISH as comma separated files structured around the distinction of gear, mesh size and vessel length categories (based to a large extent on the format used by the STECF for the evaluation of effort management). From 2012 to 2014 a joint WGNSSK/WGMIXFISH data call has been issued, with age and discards data by métier (consistent with the DCF definition of métiers) to be submitted to InterCatch, and landings and effort data by métier and vessel length class to be submitted as .csv files. The process and the quality of data have continuously improved over time.

From 2015, ICES generalized the data call to most stocks and regions. As a result, the data collation process went much smoother than any time before. Data were provided on time and in the right format, and with only few exceptions, the métiers were consistently used between the InterCatch data and the MIXFISH data.

The relative size of catches of the stocks incorporated in the mixed fisheries projections is shown in Figure 2.4.1.

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

The consistency between DCF and EU Cod plan categories had been investigated by WGMIXFISH 2011 and during the pilot data call performed in autumn 2011. There it had been shown that most DCF métiers as sampled by individual nations could automatically be allocated to a corresponding EU Cod plan métier, with two exceptions: the TBB_DEF_70-99_0_0 métier in the North Sea (as the corresponding BT2 métier is only defined for the mesh sizes 80—99) and the OTB_DEF (or CRU)_90-119_0_0 métier in the Skagerrak, which straddles over the TR1 (>=100 mm) and TR2 (70—99 mm) categories. As in previous years, the TBB_DEF_70-99_0_0 métier was assumed equivalent to BT2, and the Skagerrak 90-119_0_0 was assumed as TR2, to maintain consistency with previous data. Since 2012 the Swedish *Nephrops* fishery with an escapement grid, OTB_CRU_70-89_2_35 has been kept distinct from the other DCF métiers.

As previously, data for 2009 was not available from France and had to be assumed equal to 2008 values. Points of note regarding data by nation are contained in Annex 2 of the report.

The final dataset extracted from InterCatch for use by WGNSSK includes discards estimates (either imported or raised) for all stocks and métiers. These Intercatch estimates have been used to estimate a discard ratio by métier, which allows allocating discards for all WGMIXFISH fleets and métiers with matching names, such that;

$$d^* = \frac{Dl}{L}$$

Where d* is the discard value for the métier used by Fcube, l is the weight of landings for the métier used by Fcube and L and D are the weight of landings and discards entered for the (vessel length aggregated) métier in InterCatch.

2.4.2 Definitions of fleets and métiers

The procedure for establishing fleets and métiers was not revised in 2016, and has therefore been the same since 2012. Nevertheless, as the procedure is applied to the last data year, the number of fleets and métiers can vary slightly from one WGMIXFISH report to the next.

In summary, the procedure follows a number of steps:

- Matching DCF métiers with definitions used in the cod long-term management plan
- Establishing fleets by country, gear type and, when deemed necessary, vessel length group
- Matching consistency between effort and catch data files. Métiers without catch of any of the modelled stocks in the last data year (now 2015) are not retained.
- Aggregating "small" métiers to reduce the number of units in the modeling. A métier failing to catch at least 1.0% of at least one of the stocks considered in the most recent data year is classified as small. Within each fleet, all these small métiers are then aggregated by fleet in one "Other" métier (OTH). Further, all small fleets (i.e. containing only the "OTH" métier), are aggregated into one single "OTH" fleet.

In 2016, the final data used contained 39 national fleets (plus the OTH fleet) from nine countries, from 2003 to 2015. These fleets engage in one to five different métiers each, resulting in 105 combinations of country*fleet*métier*area catching cod, haddock, whiting, saithe, plaice, sole and *Nephrops* (Table 2.4.2.a). The balance of landings of the stocks across gear categories is shown in Figure 2.4.2.a.

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

2.4.3 Trends

A number of overview graphs (using the Lattice package in R) were produced to aid quality checking of the data once compiled into the final fleets object. Some are useful to show the relative importance of the fleets chosen and trends in their effort and catches. Effort by fleet in absolute levels (Figure 2.4.3.a) and relative trends (Figure 2.4.3.b), effort share by métier and fleet (Figure 2.4.3.c) and landings by fleet and stock (Figure 2.4.3.d) are included in this report.

2.5 Mixed fisheries forecasts

2.5.1 Description of scenarios

2.5.1.1 Baseline Runs

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

1) reproduce as closely as possible the single species advice produced by ACOM, and

act as the reference scenario for subsequent mixed fisheries analyses.

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

Some differences can occur in the forecast calculations, (sometimes because of the diversity of single-stock assessment methods used) and the WG always investigates in depth the reasons for potential discrepancies. Adjustments to the Fcube forecasts are made if necessary to minimize discrepancies to the largest extent possible.

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

2.5.1.2 Mixed fisheries runs

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

However, since 2013, the working group adopted a forecast approach for the intermediate year on the basis of *Status quo* effort. As a roll-over of effort limitations from the cod management plan has been adopted by the EC since 2013, a *status quo* effort assumption is considered a plausible assumption and is more in line with the standard single-stock short-term forecasting approach (which apply a *status quo* F, unless a TAC constraint is used). Therefore the mixed fishery analysis used a *status quo* effort assumption for the intermediate year (2016), with the Fcube scenarios used for the TAC year (2017).

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

This year, the projections were run assuming a full and perfect implementation of a discard ban in 2017 (i.e. all quota species caught must be landed, with no exemptions,

de minimis or inter-species flexibilities) for species under Landing Obligation (i.e. Haddock, Sole and *Nephrops*). The TAC was lifted up with the 2015 discards estimates for these species and all catches are assumed to be landed and to count against the quota.

While WGMIXFISH was aware that the landings obligation may not be implemented for all stocks in 2017, and that discards will not disappear overnight, it was considered that this option would bring new insights to where the choke effects will lie. The main implication of this change in the results would be that stocks for which some fleets had high discards in the past may become more limiting for those fleets, due to the mismatch between their catches (which now all count against the fleets' stock shares) and their stock shares based on historical landings.

In summary, the Fcube runs followed the scheme below:

Single-stock assessment 2016 (data up to 2015)

Management Plan/ MSY approach

Status quo **sq_E**

2016 ↓

Catch in 2016 and SSB at start of 2017

Single-stock Management FCUBE 2017

Plans applied to FCUBE (sq_E) results

↓

min *max* *cod* *sq E* *Ef Mgt* *Value*

↓ ↓ ↓ ↓ ↓ ↓

Potential Over / Under catch against single stock advice

(Difference between single species advised catch and expected catch)

2.5.2 Results of Fcube runs

2.5.2.1 Baseline run

The rationale behind the single species baseline runs is given in Section 2.3.1.2. Table 2.5.2.1.a contains the outputs from these runs.

The Figure 2.5.2.1.a summarises the trends arising from the various single-stocks advice for finfish for 2017, displaying at once which stocks have an advice expecting a

reduction in F (and thus in effort) and which have an expected increase. Eastern Channel sole, haddock and whiting are likely to be the most limiting finfish stocks.

The issues and problems encountered in replicating the single species advice for each species are given below. The results from these baseline runs are compared with the results from the corresponding ICES runs in Tables 2.5.2.1.b and 2.5.2.1.c, and summarized at Figure 2.5.2.1.b.

Cod: The North Sea cod assessment and forecast was based on the SAM assessment package and this had important consequences for the WG's ability to reproduce it in Fcube. The cod forecast in WGNSSK is stochastic, produced internally in SAM by generating 1000 stochastic replicates drawn within the confidence interval of the F-at-age, N-at-age and Catch multiplier estimates, while the WGMIXFISH forecast is only a deterministic projection. As the median of the forecasted assessment may be slightly different from the forecast of the median assessment, small discrepancies may appear. Additionally, the SAM model has a process error (deviations of N-at-age from the survival equation) which is carried on into the forecast. The projections carried out in SAM do not follow equation used in the deterministic forecast carried out at WGMIXFISH, which also generate differences between the two forecasts.

In 2016, the F assumption in the intermediate year was *status quo* F on the basis that there has been no reduction in effort ceiling since 2013. For the TAC year, ICES decided to use the MSY strategy as the basis for advice, instead of the management plan, which is not considered precautionary and appropriate anymore after the important changes in the stock's dynamics and in the reference points following the 2015 benchmark and WGNSSK.

Some small differences were observed (−0.13% and -3.03% in the estimated landings in 2016 and 2017 respectively and −4.84% difference in SSB in 2018). Nevertheless, the FCube forecast was considered sufficiently close that it could be used as a satisfactory basis for the mixed-fisheries projection.

Haddock: In 2015 the haddock assessment used TSA as the assessment basis and MDFP as the forecasting software. The method developed in WGNSSK to parameterize future selectivity and weight-at-age for haddock are sometimes quite specific and do not always follow common standards (e.g. weights–at-age in the forecasted period produced by a growth model instead of the commonly used assumption of constant weights equal to the average over the recent years). Those specific values could not be reproduced in the forecasting procedure of FCube and were therefore entered manually.

In addition, the survivors at the start of 2016 produced by the TSA assessment model used as the initial abundance-at-age in the MFDP short-term forecast were slightly different from the initial numbers at age computed by the forecasting procedure in FLR.

The forecast results were slightly different with a -2.15% and -1.86% discrepancy between SSB projections in 2017 and 2018 respectively. Forecasted landings in 2016 and 2017 showed a 3.5%% and 0.03% difference respectively. The FLR forecast was considered sufficiently close for use in the mixed-fisheries projection.

Whiting: The WGNSSK forecast treats the industrial bycatch separately from the landings for human consumption, with specific future weights-at-age and selectivity. The FCube forecast used at WGMIXFISH did not allow for multiple fleets and therefore the industrial bycatch is included in the landings component. The future landings selectivity and weights-at-age were recalculated as the weighted means of the values in the landings for human consumption and industrial by catch.

This difference in forecast procedure resulted in small discrepancies in the output with differences in landings of −0.74% and +0.51% for 2016 and 2017 respectively, and of -0.05% and -.25% in 2017 and 2018 respectively for the SSB.

Saithe: As for cod, the 2016 saithe assessment and forecast were carried out using the SAM assessment model. The difference in forecast procedure compare to WGMIXFISH resulted in differences in the output of 5.16% in the Fbar value for 2016 resulting from the TAC constraint, -2.58% in the 2017 landings and -0.69 % in the 2018 SSB. The FLR forecast was considered sufficiently close for use in the mixed-fisheries projection.

North Sea Plaice: Straightforward, no problems encountered.

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

The results from the FCube forecast were identical to the results from WGNSSK.

North Sea Sole: Straightforward, no problems encountered.

English Channel Sole: Straightforward, no problems encountered.

***Nephrops*:** The forecasts applied the recommended harvest rates to the most recent abundance estimates available for the relevant FUs (FU 6, 7 8 and 9). The ICES advice for 2017 is given assuming that the landing obligation is applied in 2017 for all FUs (except the FU32), with a 6% *de minismis* exception for the Nephrops below the Minimum Conservation Reference Size. In addition, the survival rate of the discards below the MCRS is also taken into account in the ICES advice.

The WGNSSK procedure was reproduced as closely as possible in FCube. Nevertheless, some small discrepancies where found, with differences up to 7.5% in the forecasted 2017 landings.

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

First, there is a difference in the assumed harvest ratio in the intermediate year. Whereas WGNSSK assumes that the harvest ratio is equivalent to the average ratio of the most recent three years, the WGMIXFISH value is based on a share of the 2015 TAC applied to the abundance estimates in 2015 for that particular FU (equal to proportion of the North Sea TAC that was taken from the FU in the most recent year). This can cause pronounced differences if the harvest ratio has a steep decrease or increase in the most recent year. The assumption taken in WGMIXFISH may be more appropriate, as it is quicker to react to changes in biomass or exploitation patterns where activity moves between FUs; however, it has no consequence either for WGNSSK or WGMIXFISH TAC year harvest ratio or TAC advice as the harvest ratio in 2015 is not used in the forecasts for 2016.

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

2.5.2.2 Mixed fisheries analyses

The full overview of the Fcube projections to 2017 is presented in Table 2.5.2.2.a and Figures 2.5.2.2.a – 2.5.2.2.c. The results for 2017 can be compared to each other as in a single-species option table. For ease of comparison, it was decided to also include a table with the landings relative to the single-stock advice. This is presented as Table 2.5.2.2.c.

For example, the baseline run for **cod**, which follows the single-stock ICES advice, assumes landings of 44779 tonnes in 2016, and catches of 37519tonnes in 2017. The resulting SSB in 2018 is estimated to be 173958tonnes. WGMIXFISH assumes *status quo* effort (**sq_E**) in 20165 resulting in a slight decrease in F compared to 2016 and landings of 44779tonnes in 2016. If it is assumed the **sq_E** scenario was used as the basis for the single species advice instead of the actual single species basis the MSY strategy would lead to TAC advice of 37519tonnes, representing the same F value but applied to a smaller biomass than in the baseline. The resulting SSB in 2018 is estimated to be 182807tonnes, 5% lower than the resulting SSB following the single species advice according to the cod Management Plan.

The outcomes of the "minimum" and "maximum" scenarios are driven by which of the stocks will be most and least limiting for each individual fleet. For the first time, cod was not estimated to be the most limiting stock in the "Minimum" scenario. For 2017, assuming a strictly implemented landings obligation (i.e. a discard ban where all catches of quota species must be counted against quota, with no flexibilities such as exemptions, *de minimis* allowed discards or inter-species flexibility, as the "Minimum" scenario represents), haddock, cod Eastern Channel sole would be the most limiting stocks, constraining 91% 5% and 4% of the 2015 effort, respectively.

Conversely, in the "Maximum" scenario, if *Nephrops* was managed by separate TACs for the individual functional units (FU), many Nephrops FU would be considered as being the least limiting stocks. *Nephrops* FU 33, FU 5, FU 32, FU 7 and FU Others would be least limiting for fleets representing to 32%, 16%, 10%, 4% and 17% of the 2015 effort respectively. Eastern Channel plaice and saithe would be least limiting for fleets representing 12% and 9% of the 2015 effort respectively. The "Minimum" scenario assumes that fleets would stop fishing when their first quota share is exhausted, regardless of the actual importance of this quota share, thus leading to a distorted perception of plausible fleet behaviour. While this can be considered an unlikely scenario as long as discarding is allowed, this scenario reflects the constraints that result from a strictly implemented discard ban.

In contrast to the "Minimum" scenario, the "Maximum" scenario demonstrates the upper bound of potential fleet effort and stock catches. However, through assuming all fleets continue fishing until all their quotas are exhausted irrespective of the economic viability of such actions, this is also considered a scenario with low plausibility.

Four intermediate scenarios are included reflecting current management measures, and also the *status quo* option. The "Value" scenario is a simple proxy balancing fishing opportunities by stock with their potential market value, in the absence of a formal economic behaviour model. For example, if a fleet would need 100 days fishing for catching its share of stock A, and 200 days fishing for catching its share of stock B, and if the value (tonnage × mean price in 2014) of that fleet's stock shares is 75% from stock A and 25% from stock B, then the resulting effort would be (100 × 0.75) + (200 × 0.25) = 125 days. For 2016, this scenario estimates effort levels close to the *status quo*, and historically this scenario has been observed to predict effort levels closer to the realised effort than the other scenarios (Ulrich *et al.*, 2011). In this scenario, some

overshoot of cod, whiting, and sole, and undershoot of plaice and haddock fishing opportunities are predicted.

The "Cod" 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. According to the single-stock advice, a reduction of 15% in cod F is required (from 0.39 in 2016 to 0.33 in 2017). In this scenario it is assumed that effort reductions in fleets (to achieve new partial Fs) apply equally to all fleets with any cod catch, including those where it represents a small bycatch component. Similar scenarios based on the single-stock advice for the other finfish stocks could be provided by ICES, but the "Cod" scenario is considered here because cod has systematically been the limiting species since the beginning of mixed-fisheries analysis in 2006. For the first time in a decade, cod has not been estimated to be the most limiting stock.

The stocks of sole and plaice in the Eastern English Channel have low landings compared to other stocks and the results for these stocks are presented in detail in Figure 2.5.2.2. The decrease in the 2017 single-stock advice for Eastern Channel sole is restrictive for the fishery at *status quo* effort.

Mixed-fisheries results for *Nephrops* are displayed after combining over functional units (FUs) in plots, but stock status and fishing opportunities differ widely across FUs. In particular, FU6 (Farn Deep) is currently exploited over the MSY target, and this FU acts therefore as a limiting stock for some fleets in the mixed-fisheries advice 2017. Conversely, FU7 (Fladen Ground) is exploited well below the MSY target, and acts as a least limiting stock. In order to ensure *Nephrops* stocks are exploited sustainably in the different FUs, management should therefore be implemented at the FU level. Potential undershoot of catch opportunities for FU7 should not be transferred to other FUs.

To get an overview of the amount of total catches for the various scenarios, Figure 2.5.2.2.a displays the catch by scenario for each of the species. Potential overshoot/undershoot on this figure are calculated by comparing the single species catch advice for 2017 with the mixed-fisheries catch estimates.

The anticipated SSBs in 2018 of the Fcube scenarios are shown in Figure 2.5.2.2.c. North Sea sole and Eastern Channel sole suffer the greatest shortfalls in SSB compared to the level predicted compatible with their single species advice if *status quo* effort and catchabilities are assumed (**sq_E** scenario).

Figures 2.5.2.2.d and 2.5.2.2.e show the level of effort required by each fleet to catch their quota share of the single species TAC advice for each stock for finfish species and *Nephrops* FUs respectively. From Figure 2.5.2.2.d it is clear whiting and sole are the limiting species for many of the fleets, and cod the remainder.

2.5.2.2.1 Ancillary stocks

The revised CFP includes a commitment to introduce a landing obligation (excepting some defined exceptions) in EU demersal fisheries in a phased approach from 2016 until 2019. As such, there is increasing interest in the other stocks which may potentially limit fishing activity under the new regulatory regime. The impact of mixed fisheries scenarios on eight further stocks; brill, dab, flounder, hake, lemon sole, red mullet, turbot and witch were considered without their incorporation into the mixed fisheries projections. The working group considers technical issues prevent these stocks from being incorporated into the mixed fisheries projections but, using catch per unit effort

measured in 2015, catches of these stocks were calculated once the mixed fisheries projections had determined fleet effort levels in order to provide an indication of the levels of under- and over-quota landings of these stocks under a plausible range of effort levels.

Figure 2.5.2.2.1 shows the outcome. All TACs of these stocks except the North Sea component of the hake TAC and turbot were predicted to be underutilized under assumption of *status quo* effort, while hake quota was predicted to be almost fully utilised under the '**min**' scenario, and overutilised in all other scenarios, highlighting its potential as a 'choke' species for the fisheries.

2.5.2.2.2 Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input is calculated as the average landing share by fleet and stock in 2015. In previous years, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results showed only minor deviations across all scenarios, except for the **Ef_Mgt** scenario. This year, as total catches are used rather than landings, some distortions occur, as the proportion of catches does not reflect the proportion of landings since discards rates differ across fleets (Figure 2.5.2.2.2). This illustrates some of issues that will arise with the implementation of the landings obligation.

Table 2.3.1.2 Summary of the 2017 landings and target Fs/harvest ratios, resulting from the Advice Approaches considered by ICES. Target Fs are left justified; harvest ratios are right justified. Where a stock/Functional Unit does not have a management plan, the landings follow ICES advice.

Species	Agreed TAC (summed TACs) – 2016	Catch – advice for 2017	Wanted catch – advice for 2017	F/Harvest ratio for 2016	F/Harvest ratio for 2017	SSB 2017	SSB 2018	Rational
Cod 3.a-4-7.d	4807 + 33 651 + 1961 = 40 419 (IIIa+IV+VIId)	< 47 431 t	< 38 691 t	0.39	0.33	174 300 t	182 807 t	MSY approach
Haddock 3.a-4-6.a	3926 + 61 933 + 6462 = 72 321 (IIIa+IV+VIa)	< t	< t			t	t	
Plaice 3.a-4	11 766 +131 714 = 143 480 (IIIa+IV)	< 214 738 t	< 165 142 t	0.17	0.265	1 033 466 t	1 008 386 t	MP
Sole 4	13 262	< 15 251t	< 14 187 t	0.16	0.17	77 202 t	76 196 t	MP
Saithe 3.a-4-6	65696 + 6448 = 72 144 (IV+VI)	< t	< t			t	t	
Whiting 4-7.d	13 678 / 0.77 = 17 764 (Landings ratio IV-VIId)	< 23 527 t	< 12 679 t	0.228	0.15	310 3631 t	327 559 t	MSY approach
Sole 7.d	3258	< 235 t	< 2154 t	0.46	0.29	7785 t	9504 t	MSY approach
Plaice 7.d	12446 x 0.767 = 9546 (Landings ratio VIId-VIIe)	< 12 805 t	< 7550 t	0.27	0.25	61 116 t	59 077 t	MSY approach
Turbot 4	4488 x 0.54 =2424 (Landings ratio Turbot-Brill)*	< 1995 t	< 1925 t					Precautionary approach
Brill 4	4488 x 0.46 = 2064 (Landings ratio Turbot-Brill)*	< 1720 t**	< 1599 t**					Precautionary approach
Dab 4	18 434 x 0.74 = 13 641 (Landings ratio Dab-Flounder)*	< 66 718 t**	< 6672 t**					Precautionary approach
Flounder 4	18 434 x 0.26 = 4793 (Landings ratio Dab-Flounder)*	< 4737 t**	< 2606 t**					Precautionary approach
Nephrops in Botney Gut (FU 5)		< 1391 t	< 1334 t					Precautionary approach
Nephrops in Farn Deeps (FU 6)		< 742 t	< 660 t	15.50	5.30			MSY approach
Nephrops in Fladen Ground (FU 7)		< 6843 t	< 6820 t	2.00	7.00			MSY approach
Nephrops in Firth of Forth (FU 8)		< 2062 t	< 1773 t	16.80	16.30			MSY approach
Nephrops in Moray Firth (FU 9)		< 1060 t	< 1008 t	9.10	11.80			MSY approach
Nephrops in Noup (FU 10)		< 40 t	< 38 t					Data limited approach
Nephrops in Norwegian Deep (FU 32)		< 496 t	< 464 t					Precautionary approach
Nephrops in Horn's Reef (FU 33)		< 1257 t	< 1257 t					Data limited approach
Nephrops in Devil's Hole (FU 34)		< 492 t	< 459 t					Data limited approach
Nephrops in other rectangles (NEPOTH)		< 610 t	< 610 t					Data limited approach
Nephrops in Division 3.a		< 13099 t	< 12 715 t	3.60	7.90			MSY approach

***Proxy TAC based on landings split in 201**

****based on split IIIa-IV-VIId,e landingsTable 2.4.2.1 Métiers consistent with the cod long-term management plan and AER database.**

Gear	Mesh Size	fleet	Métier
Gillnet		Static	GN1
Pots			OTH
Longlines			LL1
Trammel			GT1
Pelagic Trawl		Pelagic	OTH
Pelagic Seine			OTH
Demersale Seine	>=120	Dseine	TR1
	110-119		
	90-99		TR2
	80_89		
	70-79		
	16-31		TR3
Otter	>=120	Otter	TR1
	110-119		
	90-99		TR2
	80_89		
	70-79		
	16-31		TR3
Beam	>=120	Beam	BT1
	110-119		BT2
	90-99		
	80_89		
Dredge		Dredge	OTH

Table 2.4.2.a Final fleet and métier categories used in the mixed fishery analysis. 4, 3AN and 7D refer to ICES area.

Fleet	Metier	Effort	Catch	Fleet	Metier	Effort	Catch
BE_Beam<24	BT2.4	441.41	1357.23	FR_Otter>=40	OTH	1147.08	17.59
	BT2.7D	281.27	841.57		TR1.4	5099.72	8459.59
	OTH	664.69	26.34	FR_Otter10-40	OTH	1315.32	108.81
BE_Beam>=24	BT1.4	1457.18	5827.74		TR2.4	1436.60	4128.15
	BT2.4	1321.52	3356.25		TR2.7D	8418.56	7512.97
	BT2.7D	1965.28	2036.54	FR_U10m	OTH	104.88	26.00
BE_Otter	OTH	167.55	1052.60		TR2.7D	144.05	231.08
	TR2.4	584.99	3196.76	GE_Beam>=24	BT2.4	959.86	2442.17
BE_Static	GT1.7D	44.85	57.72		OTH	61.57	284.68
	OTH	63.46	32.60	GE_FDF	OTH	21.78	169.03
DK_Beam	BT1.4	355.93	1434.41		TR1.4	433.85	4352.92
	OTH	70.66	283.31	GE_Otter<24	OTH	15.81	96.34
DK_FDF	OTH	15.47	74.81		TR1.4	128.21	1736.16
	TR1.3AN	297.83	2605.87		TR2.4	124.17	3047.13
	TR1.4	1691.25	7371.62	GE_Otter>=40	OTH	5.85	45.83
	TR2.4	63.77	313.16		TR1.4	458.51	4146.21
DK_Otter<24	OTH	438.26	181.47	GE_Otter24-40	OTH	38.09	141.48
	TR1.3AN	304.66	1947.88		TR1.4	394.27	2861.54
	TR1.4	309.97	2383.52		TR2.4	109.82	1319.03
	TR2.3AN	1931.14	3476.85	NL_Beam<24	BT2.4	230.25	1621.27
	TR2.4	102.52	769.51		OTH	4.17	46.97
DK_Otter24-40	OTH	1173.60	1134.08	NL_Beam>=40	BT1.3AN	162.81	1141.35
	TR1.4	672.23	3217.83		BT1.4	800.68	3732.71
	TR2.4	212.59	1560.88		BT2.4	15771.64	44623.00
DK_Seine	TR1.3AN	319.28	4234.85		OTH	2288.70	65.53
	TR1.4	551.83	3631.57	NL_Beam24-40	BT2.4	9.71	6977.26
DK_Static	GN1.3AN	290.73	912.57	NL_Otter	OTH	89.97	5.64
	GN1.4	1416.05	5768.72		TR1.3AN	1004.01	960.97
	OTH	58.77	195.07		TR1.4	1286.98	6544.98
EN_Beam	BT1.4	1576.60	6707.23		TR2.4	927.29	9902.53
	BT2.4	1548.14	4959.73		TR2.7D	2032.64	1138.87
	BT2.7D	185.71	372.96	NO_Otter<40	OTH	1959.41	958.94
	OTH	2.21	3.68		TR1.4	5155.91	11425.94
EN_FDF	OTH	0.54	26.59	NO_Otter>=40	TR1.4	681.67	28718.40
	TR1.4	1342.56	11370.27	NO_Static	GN1.4	671.28	4384.89
EN_Otter<24	OTH	156.54	79.78		LL1.4	4.82	2124.28
	TR1.4	112.84	500.77		OTH	50379.59	199.00
	TR2.4	936.59	2155.58	OTH_OTH	OTH	3.17	12143.20
EN_Otter>=40	OTH	72.08	225.62	SC_FDF	OTH	1956.76	14.98
	TR1.4	586.46	1797.80		TR1.4	0.93	17230.89
EN_Otter24-40	OTH	173.52	481.66	SC_Otter<24	OTH	3901.88	2.89
	TR1.4	301.30	2282.54		TR1.4	3183.89	18445.99
EN_U10	GN1.7D	732.40	729.22		TR2.4	4281.56	11689.65
	GT1.7D	353.34	410.84	SC_Otter>=24	TR1.4	148.94	28090.73
	OTH	3357.10	841.16		TR2.4	678.24	570.31
	TR2.4	553.11	1667.86	SC_Static	OTH	4244.73	148.98
	TR2.7D	121.51	158.28		pots.4	2.24	35.18
FR_Beam	BT2.7D	247.89	305.40	SC_U10_OTB	OTH	447.40	6.53
	OTH	28.91	108.70		TR2.4	3609.65	727.86
FR_Nets	GT1.4	801.56	956.82	SW_Otter	OTH	236.05	2365.17
	GT1.7D	2691.92	2812.15		TR1.4	9777.00	1502.24
	OTH	103.83	105.27				

Table 2.5.2.1.a Baseline run outputs from the Fcube FLR package.

		COD-NS	HAD	PLE-EC	PLE-NS	POK	SOL-EC	SOL-NS	WHG-NS
2016	Fbar	0.385	0.352	0.266	0.173	0.326	0.463	0.16	0.227
	FmultVsF15	1	0.828	2.18	1	0.906	0.817	0.795	1
	landings	44779	51469	8224	109277	68601	2957	12021	20028
	catch	55572	63808	14083	151362	75189	2957	13269	33621
	ssb	163247	56362	63535	945709	195236	7054	64312	266970
2017	Fbar	0.33	0.2	0.25	0.19	0.36	0.292	0.200	0.15
	FmultVsF15	0.858	0.471	2.045	1.095	1.001	0.515	0.995	0.66
	landings	37519	33625	7550	122451	80197	2167	16800	14558
	catch	45881	33625	12820	159783	88360	2167	18064	24223
	ssb	170422	167328	61115	1033466	202412	7785	77201	310196
2018	ssb	173958	134012	59076	1065323	212289	9491	73428	326741

		NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH-NS
2016	Fbar		0.129	0.021	0.224	0.114					
	FmultVsF15		1.114	1.045	1.331	1.247					
	landings	3929	1681	1970	2430	977	18	219	1278	506	692
	catch	9231	1869	1970	2829	1043	19	227	1477	529	
2017	Fbar		0.053	0.07	0.163	0.118					
	FmultVsF15		0.457	3.5	0.97	1.297					
	landings	1398	755	6331	20243	1052	40	464	1257	492	376
	catch	1391	762	6502	2032	1068	39	443	1219	477	

Table 2.5.2.1.b Comparison between baseline run and ICES advice for finfish. Figures for 2015 compare results from the baseline run to the ICES intermediate year results. The baseline run uses the same assumptions for F in the intermediate year as the forecasts leading to ICES advice.

		STOCK	COD–NS	HAD	PLE–EC	PLE–NS	POK	SOL–EC	SOL–NS	WHG–NS
2016	landings	ICES	44837	49660	8223	109282	68601	2957	12021	20177
		base line	44779	51469	8224	109277	68601	2957	12021	20028
		% difference	-0.13	3.5	0.01	0	0	0	0	-0.74
	Fbar	ICES	0.39	0.352	0.27	0.17	0.31	0.463	0.16	0.228
		base line	0.385	0.352	0.266	0.173	0.326	0.463	0.16	0.227
		% difference	-1.28	0	-1.48	1.76	5.16	0	0	-0.44
	SSB	ICES	161135	57070	63535	945709	199173	7054	64312	266998
		base line	163247	56362	63535	945709	195236	7054	64312	266970
		% difference	1.31	-1.24	0	0	-1.98	0	0	-0.01
2017	landings	ICES	38691	33741*	7550	121523	82321	2154	16800	14484
		base line	37519	33625	7550	122451	80197	2167	16800	14558
		% difference	-3.03	0.03	0	0.76	-2.58	0.6	0.00	0.51
	Fbar	ICES	0.33	0.2	0.25	0.19	0.36	0.29	0.20	0.15
		base line	0.33	0.2	0.25	0.19	0.36	0.292	0.20	0.15
		% difference	0	0	0	0	0	0.69	0	0
	SSB	ICES	174300	171000	61116	1033466	211158	7785	77202	310363
		base line	170422	167328	61115	1033466	202412	7785	77201	310196
		% difference	-2.22	-2.15	0	0	-4.14	0	0	-0.05
2018	SSB	ICES	182807	136556	59077	1065323	213772	9504	73429	327559
		base line	173958	134012	59076	1065323	212289	9491	73428	326741
		% difference	-4.84	-1.86	0	0	-0.69	-0.14	-0.00	-0.25

*** value corresponding to catches, not landings. For HAD, SOL-NS and SOL-EC, a landing obligation is implemented in 2017 in the forecast. The landings for 2017 are equal to the catches.**

Table 2.5.2.1.c Comparison between baseline run and ICES advice for *Nephrops*. The values for *Nephrops* FUs that do not receive an absolute ICES abundance estimate are set according to the ICES approach for data-limited *Nephrops* stocks. No 'ICES advice' values are given for *Nephrops* in the intermediate year because the baseline run uses values based on recorded landings in the previous year which can vary significantly from the advice for each FU.

		STOCK	NEP5	NEP6	NEP7	NEP8	NEP9	NEP10	NEP32	NEP33	NEP34	NEPOTH–NS
2017	landings	ICES	1334	738	6841	2029	1059	38	464	1257	490	376
		base line	1398	755	6331	2024	1052	39	443	1219	477	376
		% difference	4.8	2.3	-7.46	-0.25	-0.66	2.63	-4.53	-3.02	-2.65	0

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

Table 2.5.2.2.a Results of Final Fcube runs.

			COD-NS	HAD	PLE-NS	POK	SOL-NS	WHG-NS	NEP10	NEP32	NEP33	NEP34	NEP5	NEP6	NEP7	NEP8	NEP9	NEPOTH-NS	NEP tot	PLE-EC	SOL-EC
landings	2016	baseline	44779.00	51469.00	109277.00	72144.00	12021.00	20028.00	18.00	219.00	1278.00	506.00	3929.00	1681.00	1970.00	2430.00	977.00	692.00	13700.00	8224.00	2957.00
Fbar	2015	baseline	0.39	0.43	0.17	0.36	0.20	0.23						0.12	0.02	0.17	0.09			0.12	0.57
	2016	baseline	0.39	0.35	0.17	0.35	0.16	0.23						0.13	0.02	0.22	0.11			0.27	0.46
	2017	baseline	0.33	0.20	0.19	0.36	0.17	0.15						0.08	0.08	0.16	0.12			0.25	0.29
		cod-ns	0.33	0.34	0.17	0.30	0.17	0.15						0.10	0.02	0.14	0.08			0.10	0.46
		max	1.05	1.49	0.36	0.62	0.26	0.51						0.43	0.08	0.67	0.38			0.25	1.12
		min	0.20	0.20	0.11	0.18	0.12	0.08						0.04	0.01	0.06	0.03			0.06	0.28
		sq_E	0.41	0.42	0.22	0.37	0.21	0.18						0.12	0.02	0.17	0.10			0.13	0.57
		val	0.32	0.30	0.19	0.31	0.19	0.14						0.08	0.01	0.12	0.06			0.11	0.50
FmultVsF15	2016	baseline	1.00	0.83	1.00	0.96	0.80	1.00						1.11	1.05	1.33	1.25			2.18	0.82
		sq_E	1.07	1.01	1.24	1.03	1.04	0.80						1.16	1.00	1.13	1.10			1.04	1.00
	2017	baseline	0.86	0.47	1.10	1.00	0.82	0.66						0.70	3.75	0.97	1.30			2.05	0.52
		cod-ns	0.86	0.80	0.99	0.83	0.84	0.64						0.84	0.82	0.83	0.85			0.84	0.81
		max	2.73	3.50	2.07	1.72	1.28	2.23						3.74	3.99	3.98	4.13			2.06	1.97
		min	0.53	0.47	0.66	0.50	0.61	0.37						0.33	0.40	0.35	0.37			0.51	0.50
		sq_E	1.07	1.00	1.24	1.03	1.04	0.80						1.05	1.02	1.04	1.06			1.04	1.00
		val	0.84	0.70	1.08	0.87	0.93	0.62						0.70	0.64	0.70	0.71			0.91	0.89
landings	2016	baseline	44779	51469	109277	72144	12021	20028	18	219	1278	506	3929	1681	1970	2430	977	692	13700	8224	2957
		sq_E	47358	60984	133235	76737	15380	16209	16	205	1192	472	3662	1764	1885	2068	861	645	12769	4155	3460
	2017	baseline	37519	33625	122451	79040	14194	14558	40	492	1257	492	1391	1178	7071	2063	1084	376	15444	7550	2161
		cod-ns	36631	50419	107738	65912	13724	14473	19	230	588	230	650	1384	1542	1711	690	176	7219	3746	2931
		max	88958	138746	208406	119892	20049	44982	88	1087	2778	1087	3074	6136	7523	8166	3363	831	34135	8659	5533
		min	23893	31612	72609	42004	10201	8610	8	100	255	100	282	534	751	724	300	76	3130	2331	1967
		sq_E	44200	60503	132118	79708	16740	17826	23	287	733	287	811	1725	1922	2134	861	219	9001	4597	3473
		val	35850	44816	116093	68752	15170	14132	15	189	484	189	535	1157	1212	1438	580	145	5945	4038	3167
discards	2016	cod-ns	11361	14733	51126	7178	1603	10909												2975	0
		sq_E	11361	14733	51126	7178	1603	10909												2975	0
	2017	cod-ns	8208	0	33000	6651	1047	9458												2526	0
		max	20948	0	62665	12378	1538	30818												5794	0
		min	5307	0	22373	4202	776	5579												1575	0
		sq_E	9961	0	40295	8086	1280	11706												3096	0
		val	8029	0	35508	6945	1158	9230												2721	0
Ld_MgtPlan	2017	sq_E	36631	31612	117829	77542	15259	14943	40	492	1257	492	1391	1178	7071	2063	1084	376	15444	8599	2063
ssb	2016	baseline	163247	56362	945709	195236	64312	266970												63535	7054
	2017	baseline	170422	167328	1033466	198697	77201	310196												61115	7785
	2018	baseline	173958	134012	1065323	209030	76187	326741												59076	9413
ssb	2016	sq_E	163247	56362	945709	195236	64312	266970												63535	7054
	2017	sq_E	166675	155529	999857	193892	73586	315633												69405	7250
	2018	cod-ns	170591	108855	1043965	216788	72701	330446												75716	8006
		max	101006	33357	912988	161847	66010	287116												66001	5211
		min	188051	126267	1090146	241614	76435	338710												78563	9050
		sq_E	160296	99652	1012053	202588	69508	325713												74013	7420
		val	171657	114011	1033016	213856	71170	330928												75131	7751
ssb_MgtPlan	2018	cod-ns	170591	126267	1030742	204811	71075	329784												66117	8946

Table 2.5.2.2.c Landings under the mixed fisheries scenarios relative to the single-stock advice.

	SINGLE-STOCK	CATCH PER MIXED-FISHERIES SCENARIO 2017				
	catch					
Stock	advice 2016*	"Max"	"Min"	"Cod"	"Sq_E"	"Val"
Cod IIIaN, IV, VIId	47431	2.317	0.6156	0.9454	1.142	0.9251
Haddock IIIaN, IV, VIa	33741	4.112	0.9369	1.494	1.793	1.328
Plaice VIId	12805	1.129	0.305	0.4898	0.6008	0.5278
Plaice IV	158201	1.713	0.6004	0.8896	1.09	0.9583
Saithe IIIaN, IV, VI	87427	1.513	0.5285	0.83	1.004	0.8658
Sole VIId	2353	2.351	0.836	1.246	1.476	1.346
Sole IV	18064	1.195	0.6077	0.8177	0.9976	0.9039
Whiting IV, VIId	23527	3.222	0.6031	1.017	1.255	0.993
Nephrops FU 5	1391	2.21	0.2027	0.4675	0.5828	0.3849
Nephrops FU 6	762	8.052	0.7012	1.816	2.264	1.518
Nephrops FU 7	6844	1.099	0.1098	0.2252	0.2808	0.1771
Nephrops FU 8	2122	3.848	0.3413	0.8065	1.006	0.6778
Nephrops FU 9	1070	3.143	0.2803	0.6453	0.8045	0.5416
Nephrops FU 10	40	2.21	0.2027	0.4675	0.5828	0.3849
Nephrops FU 32	496	2.192	0.201	0.4637	0.5781	0.3818
Nephrops FU 33**	1257	2.21	0.2027	0.4675	0.5828	0.3849
Nephrops FU 34	492	2.21	0.2027	0.4675	0.5828	0.3849
Nephrops other IV**	376	2.21	0.2027	0.4675	0.5828	0.3849

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

**** Advised catches for these stocks are reported as wanted catch rather than total catch.**

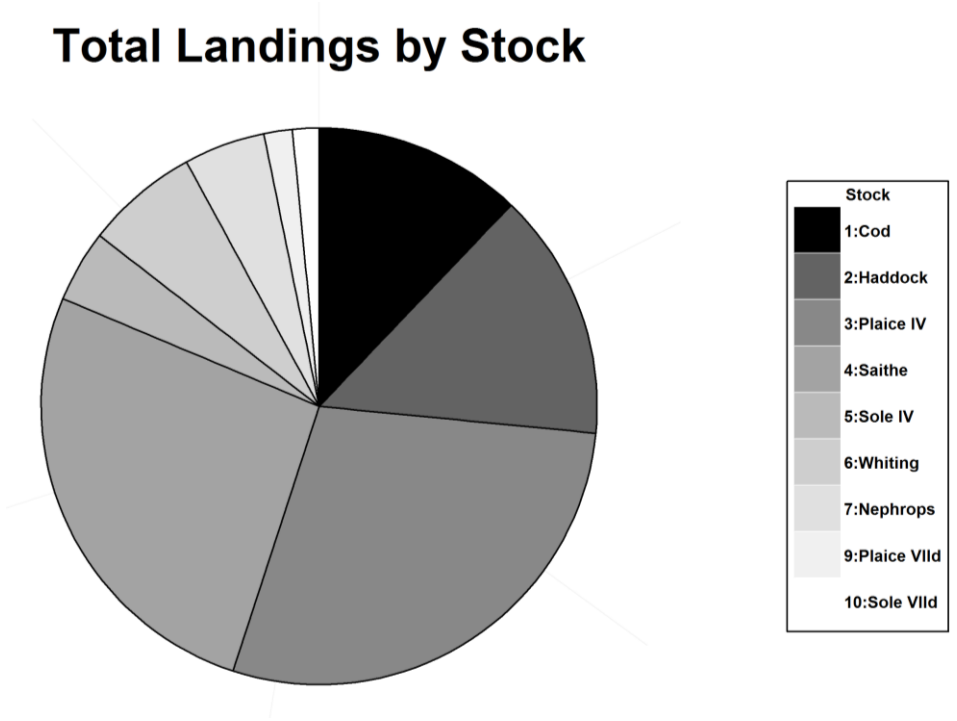


Figure 2.4.1. Distribution of landings of those stocks included in the mixed fisheries projections.

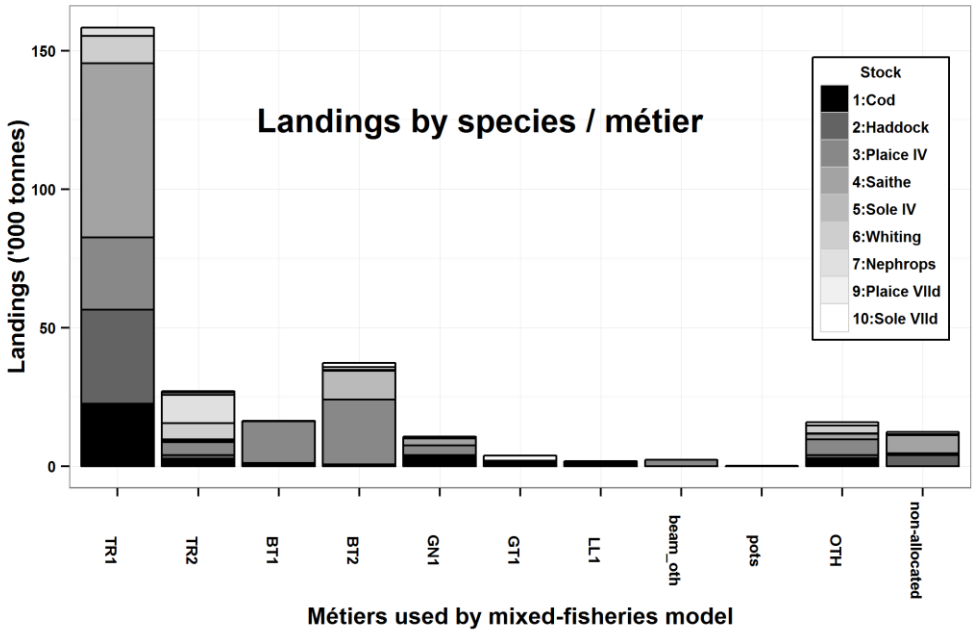


Figure 2.4.2.a. Landings distribution of species by métier with landings consisting of ≥ 1% of any of the stocks 1–10 in 2014 Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks 1–10 in 2014. The "non-allocated" is the differences between total landings used in single-stock advice and mixed-fisheries advice, such as saithe and haddock landings in Subarea 6 and 6.a respectively.

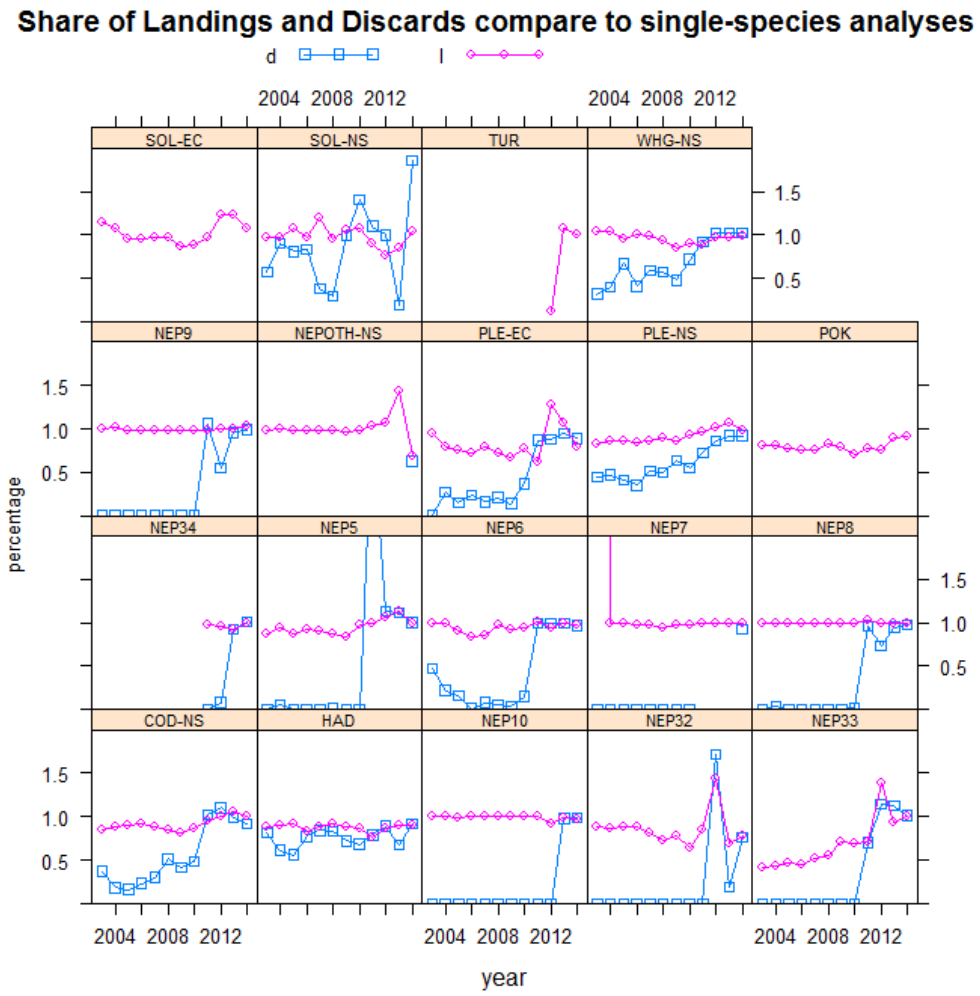


Figure 2.4.2.c. Ratio between the sum of landings and discards across fleets used in the MIXFISH analysis and the landings and discards estimated by the WGNSSK stock assessments.

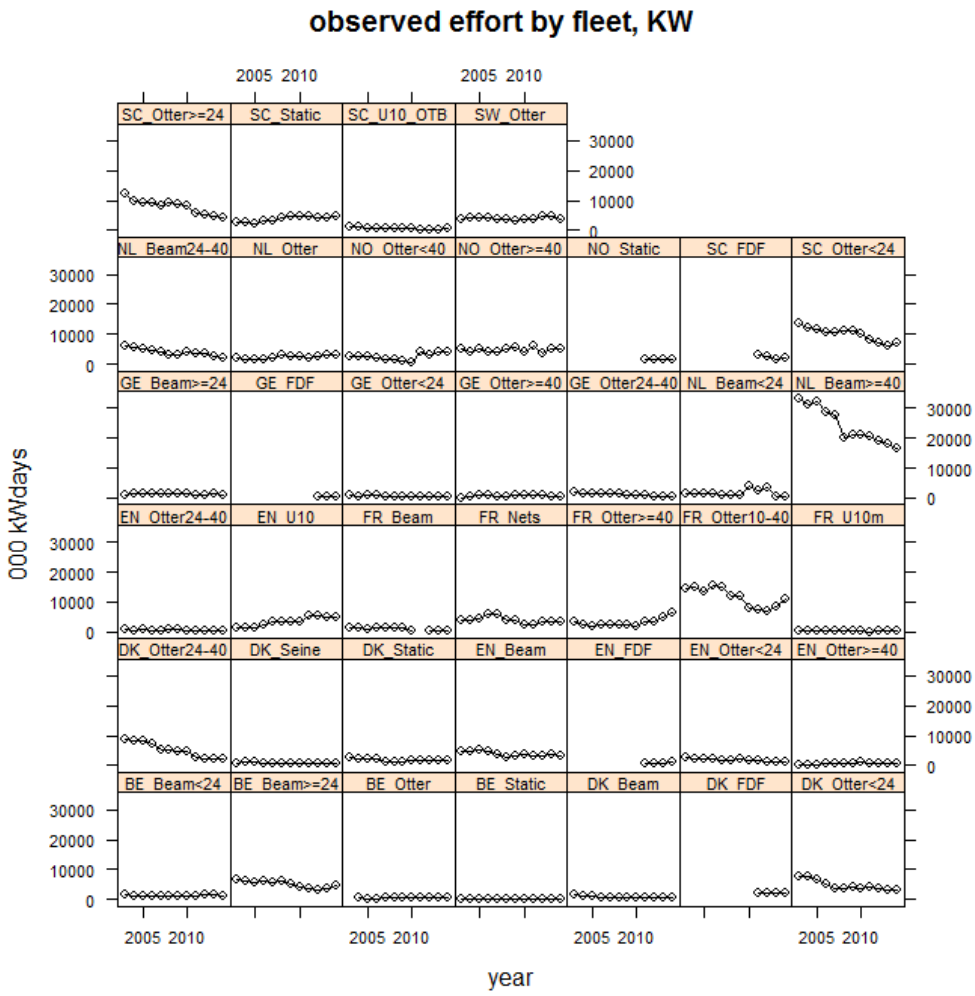


Figure 2.4.3.a. Effort by fleet and year for the North Sea demersal fleets, in '000 KWdays. Data for French fleets in 2009 were not available.

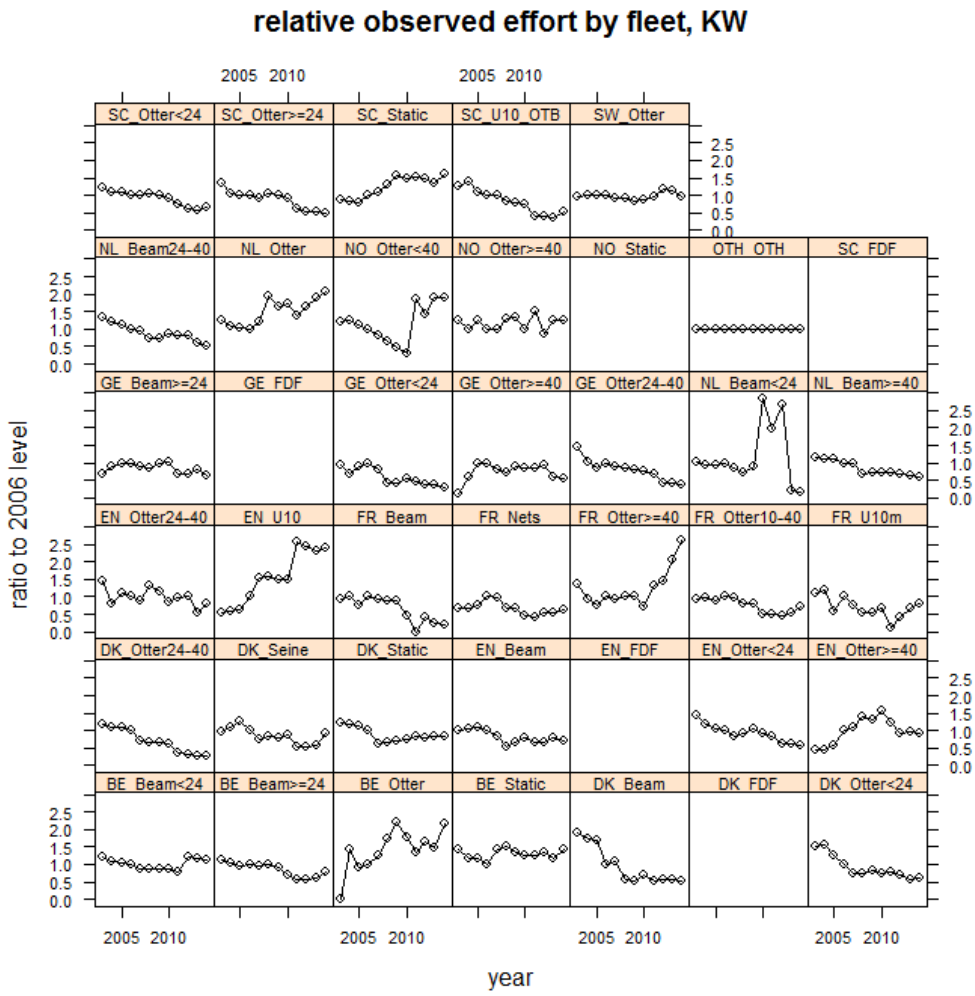


Figure 2.4.3.b. Relative trends (compared to the 2006 value) in effort (KW Days) by fleet and year for the North Sea demersal fleets. Data for French fleets in 2009 were not available.

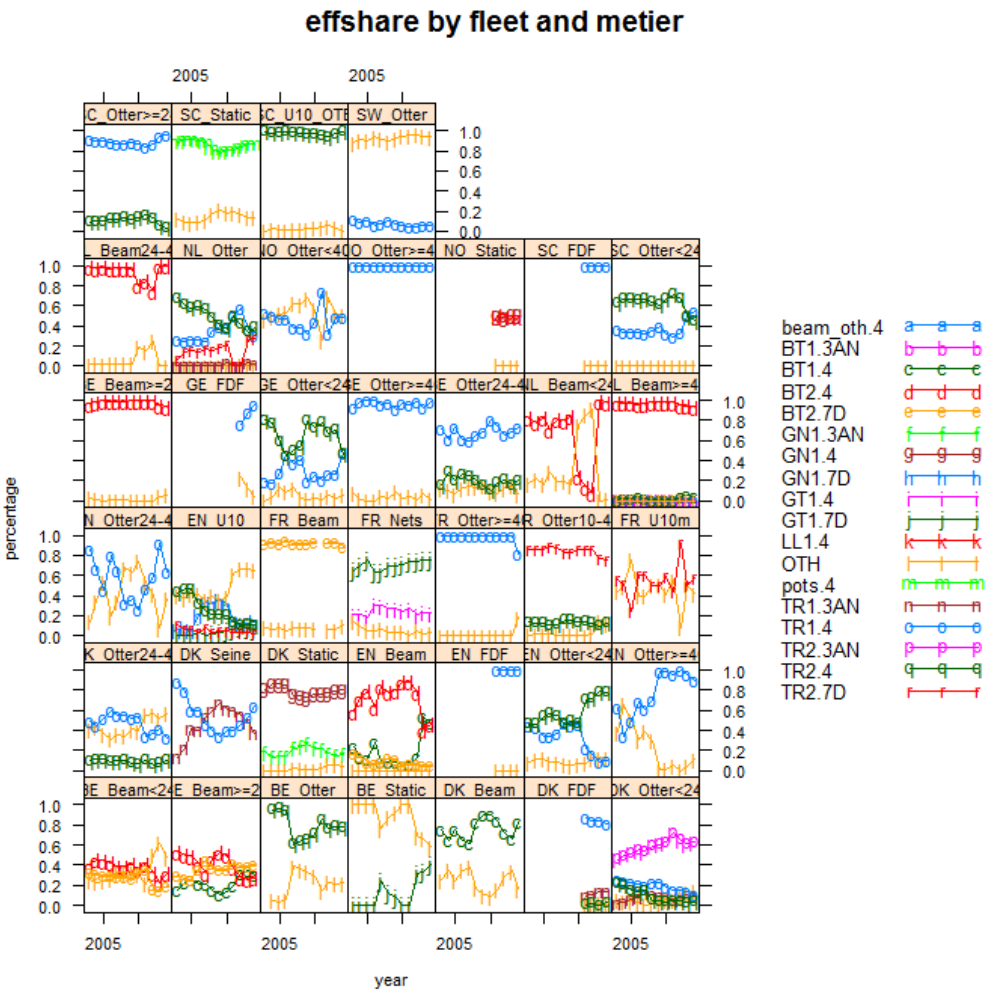


Figure 2.4.3.c. Effort share (in proportion) by métier for each fleet.

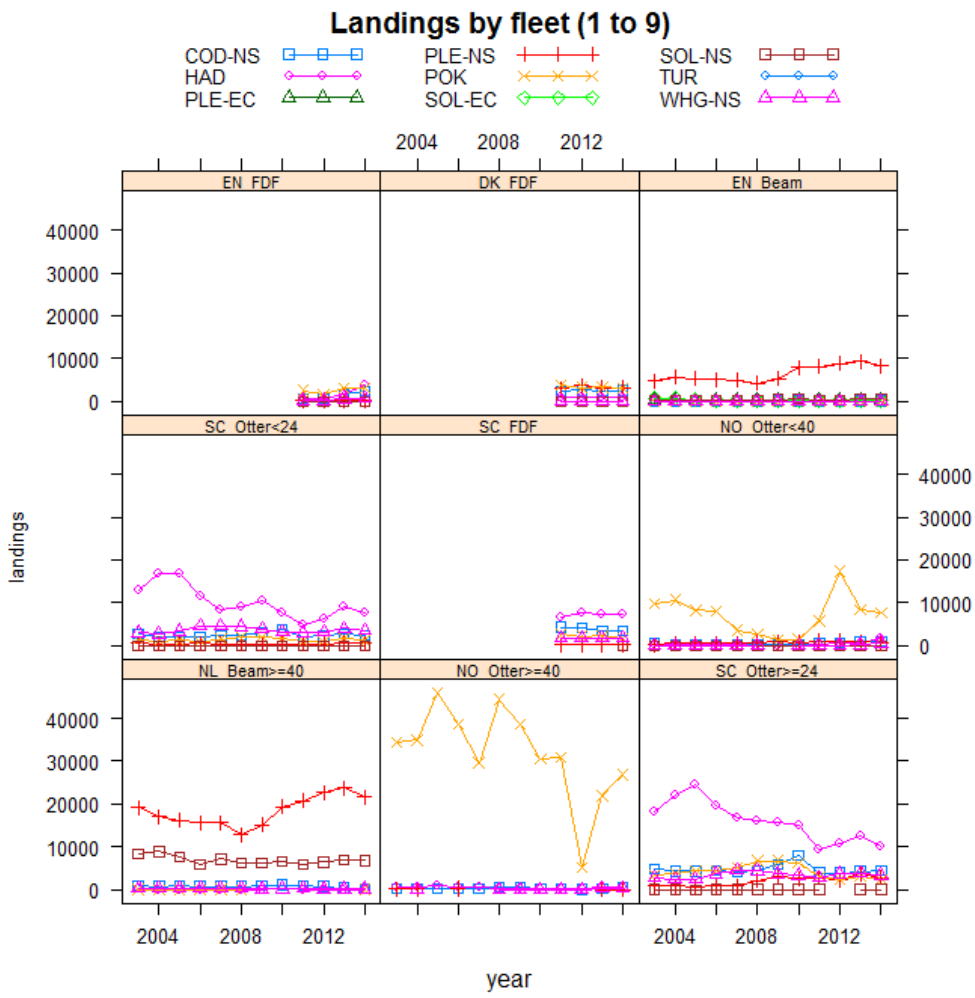


Figure 2.4.3.d. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales.

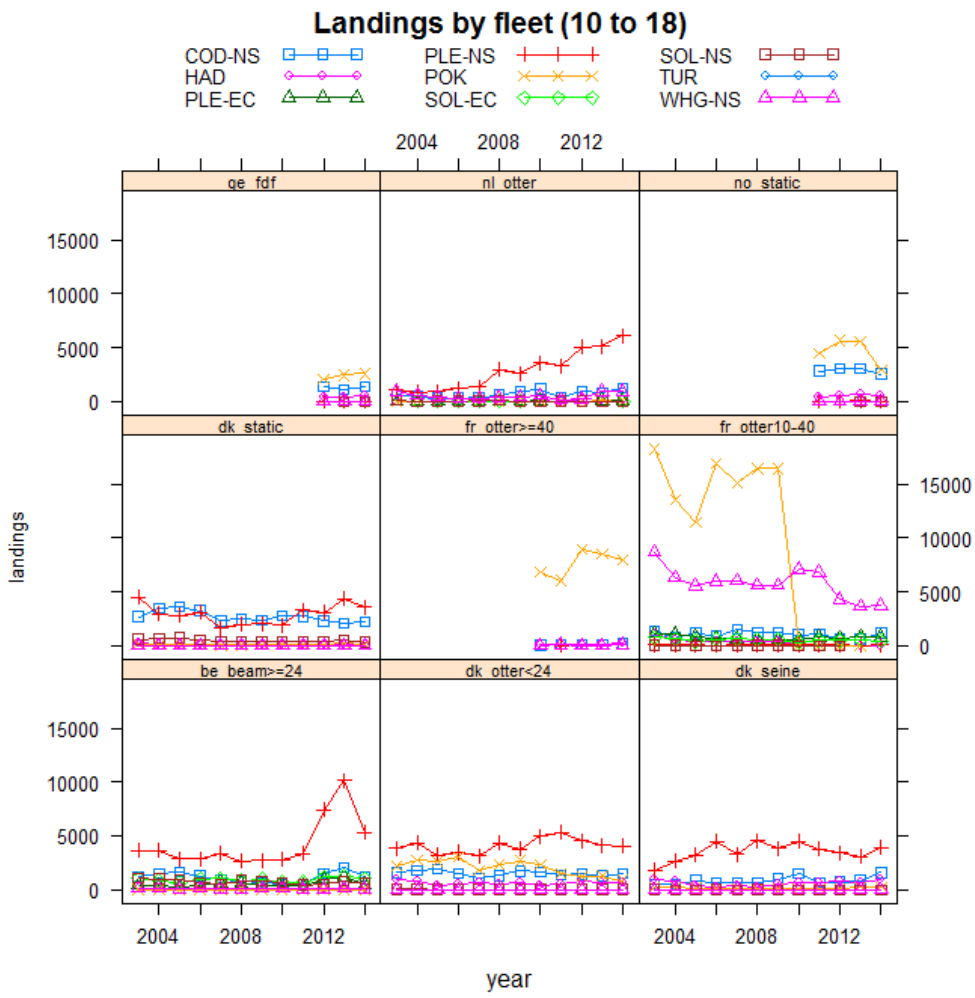


Figure 2.4.3.d (cont). Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales.

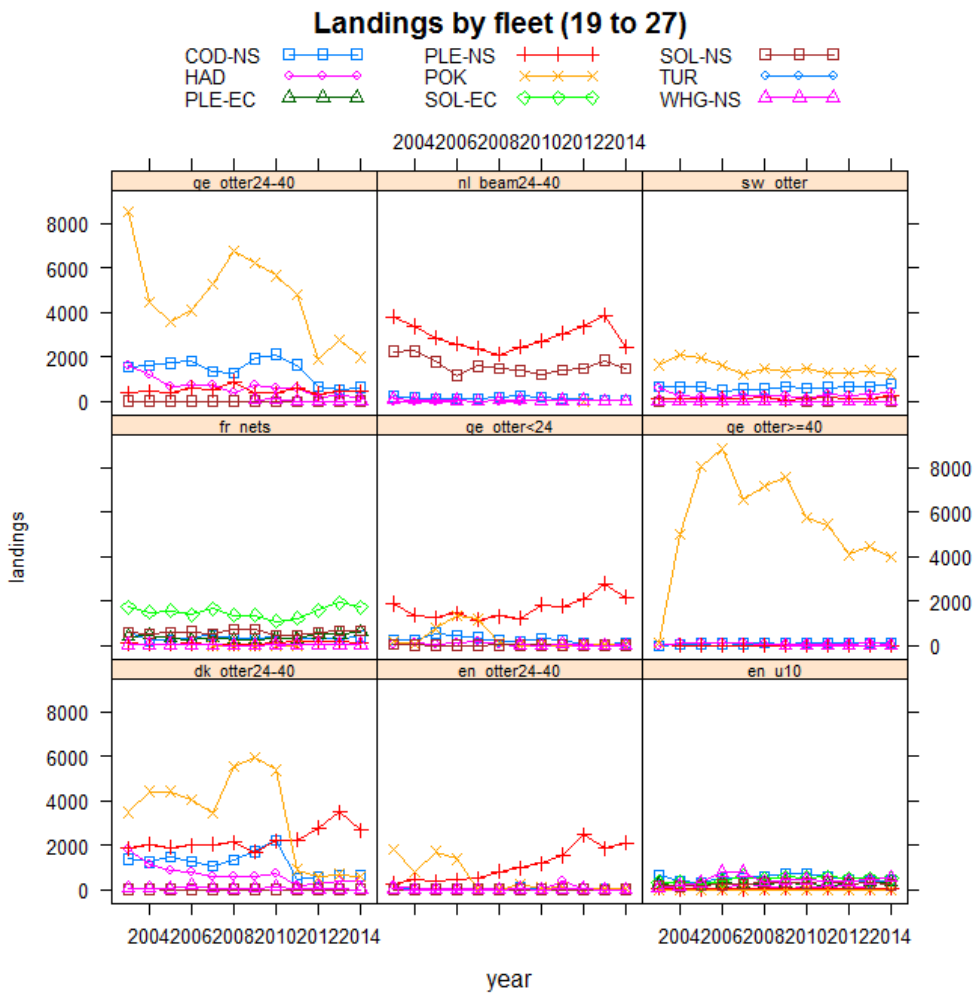


Figure 2.4.3.d (cont). Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales.

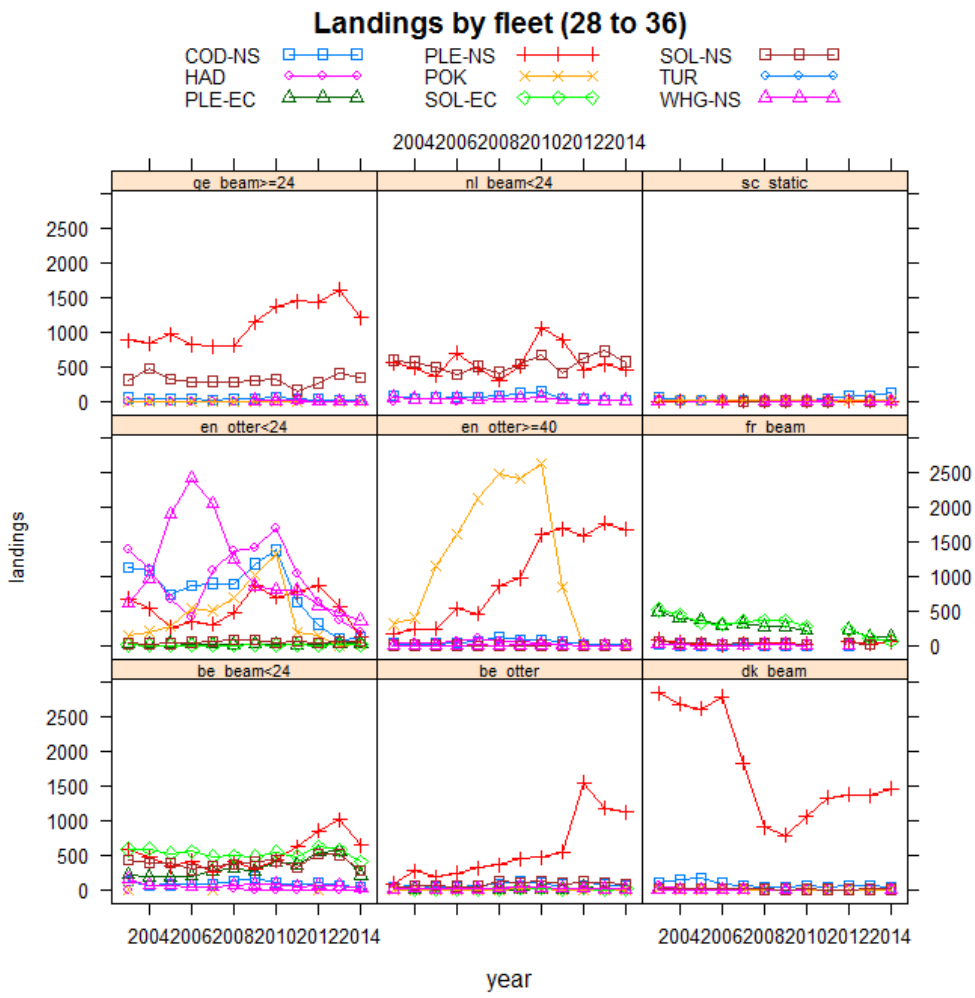


Figure 2.4.3.d (cont). Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales.

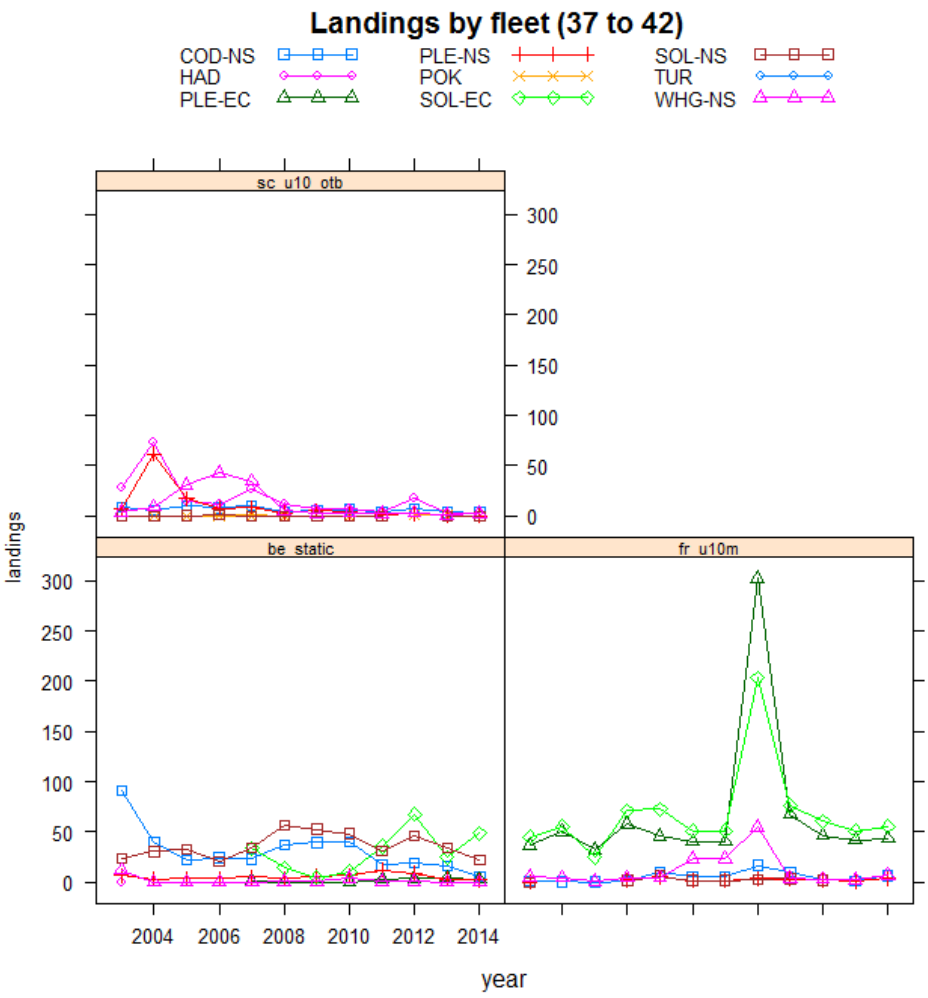


Figure 2.4.3.d (cont). Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales.

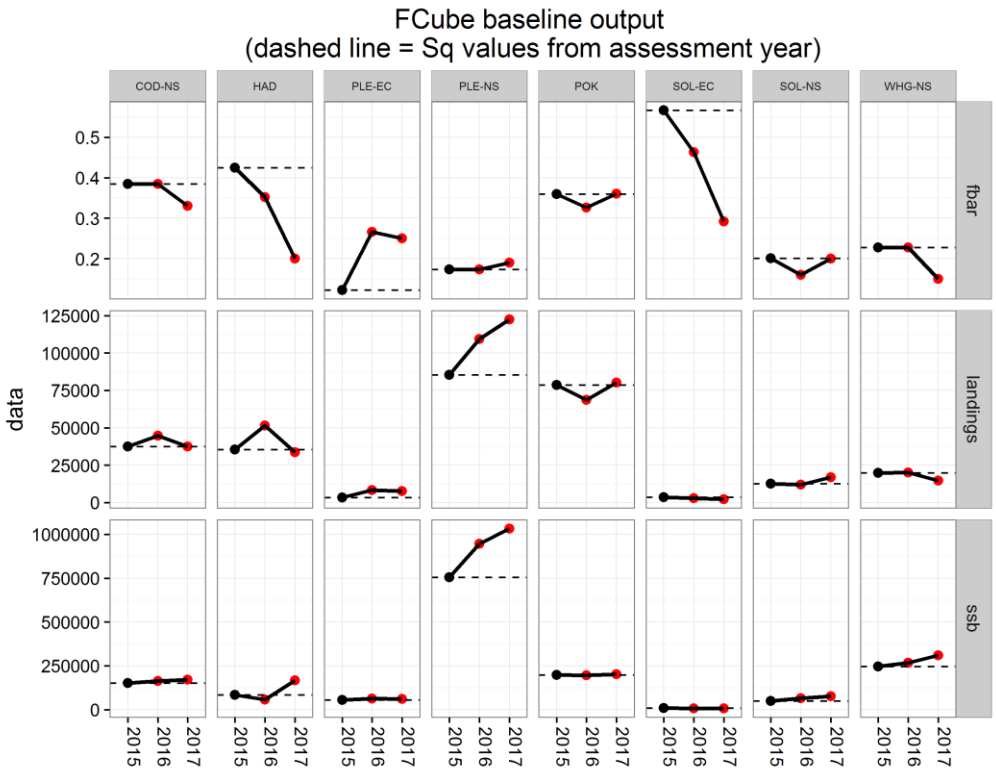


Figure 2.5.2.1.a Summary of the relative changes in the single-stock advice for 2016 compared to the situation in 2014.

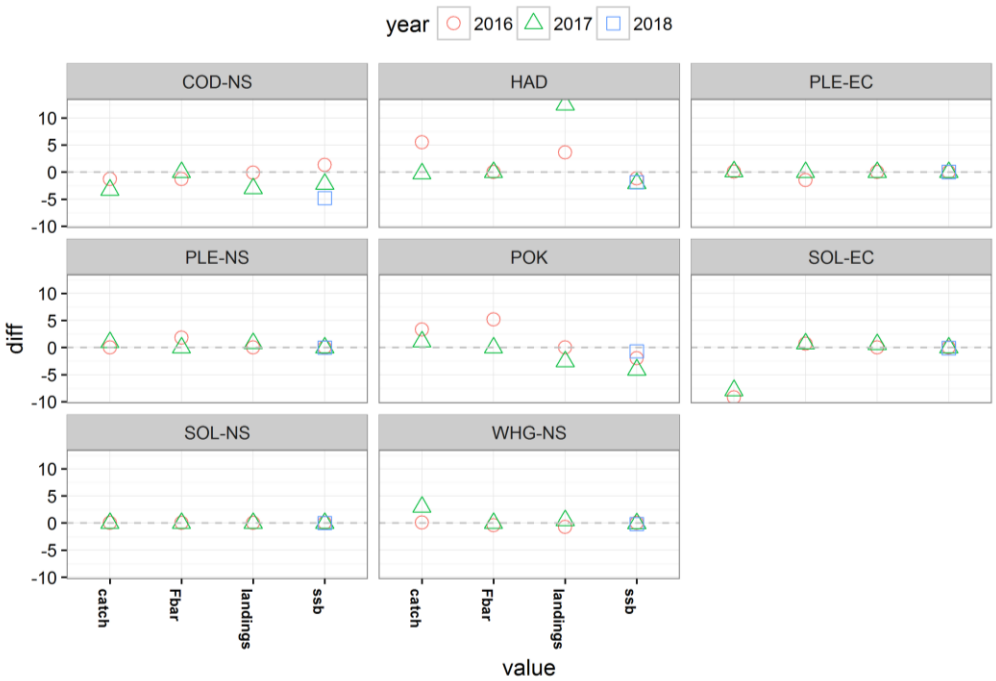


Figure 2.5.2.1.b Difference between Fcube baseline run and Single Species advice for finfish stocks, showing Fbar (2016—2017), landings (2065—2076) and SSB (2017—2018).

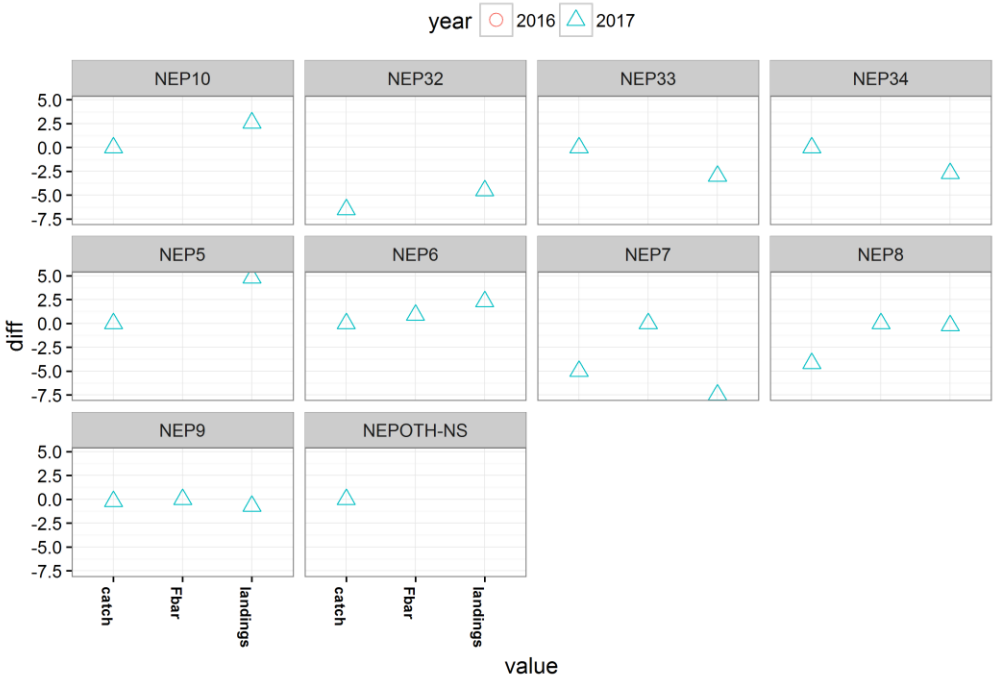


Figure 5.2.1.2b Difference between FCube baseline run and single species advice for *Nephrops* stocks. Catch, FBar and landings in 2017 only shown as harvest in intermediate year is not directly comparable. Fbar not shown for some stocks as they are non-analytical assessments.

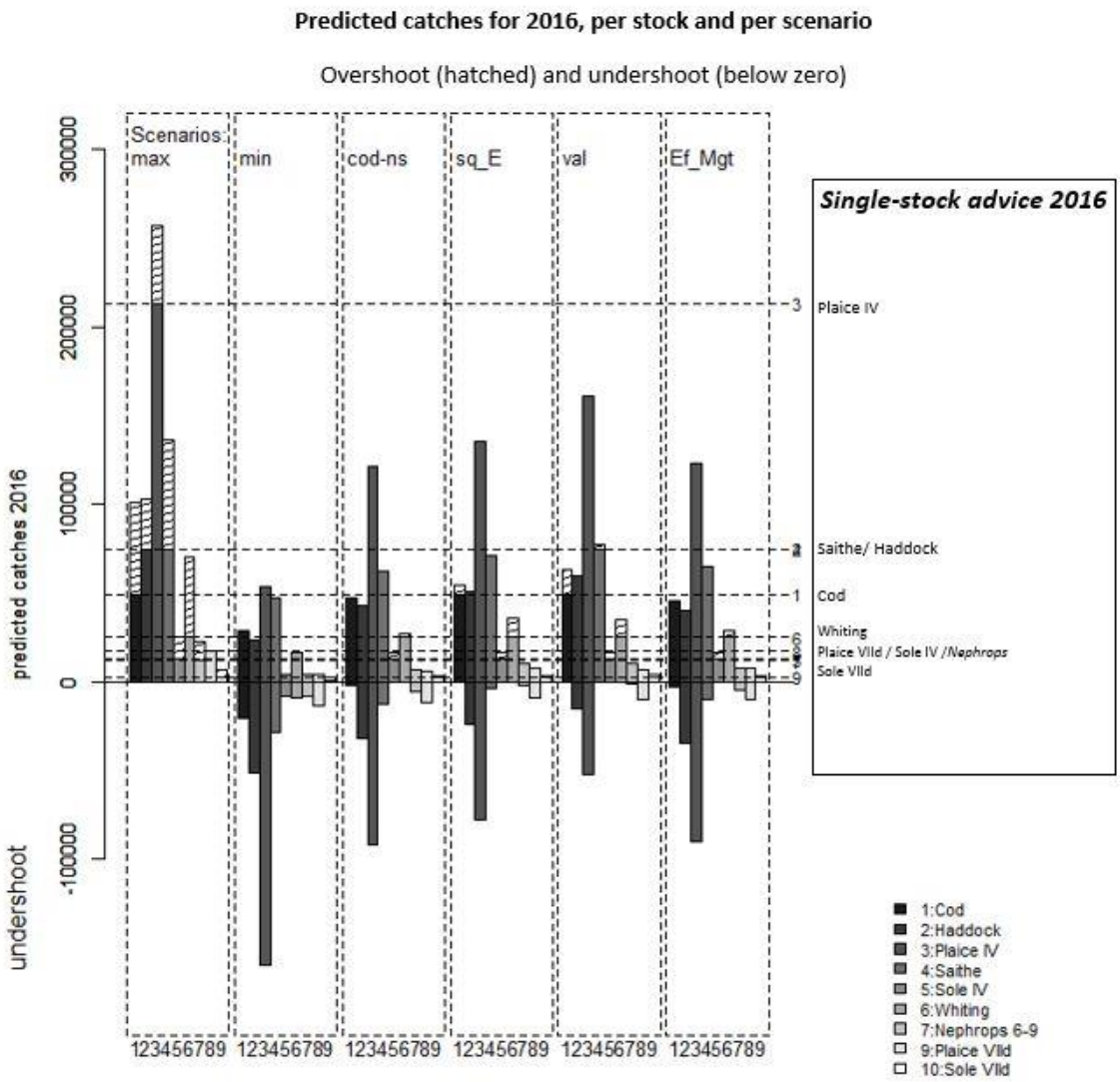


Figure 2.5.2.2.a TAC year results (2016). Fcube estimates of potential catches by stock after applying the *status quo* effort scenario to all stocks in the intermediate year followed by the Fcube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single species catch advice) in cases where catches are predicted to be lower when applying the scenario.

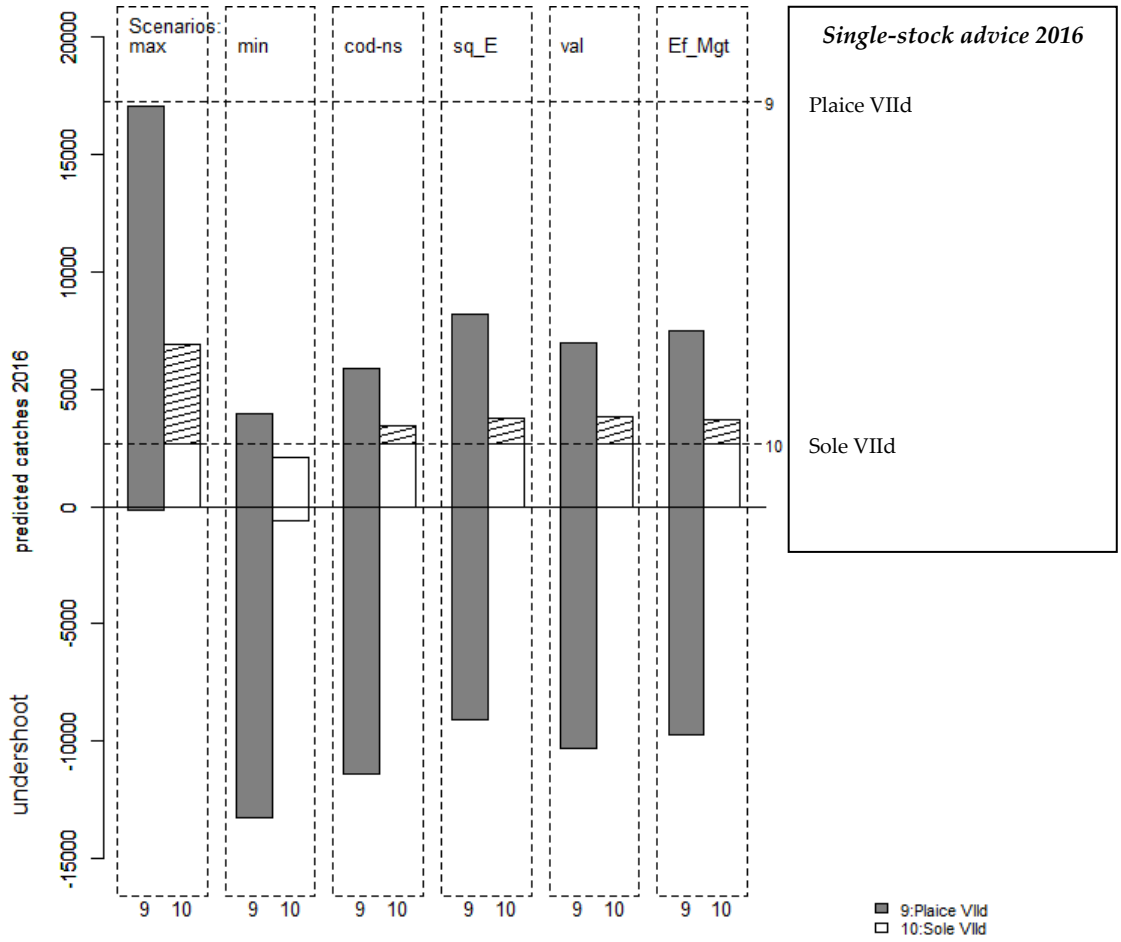


Figure 2.5.2.2.b TAC year results for the stocks subject to lower landings (detail from Figure 4.2.2.2.1). Estimates of potential catches (in tonnes) by stock and by scenario. Horizontal lines correspond to the single-stock catch advice for 2016. Bars below the value of zero show the scale of undershoot (compared to single-stock catch advice) in cases where catches are predicted to be lower when applying the scenario. Hatched columns represent catches in overshoot of the single-stock catch advice.

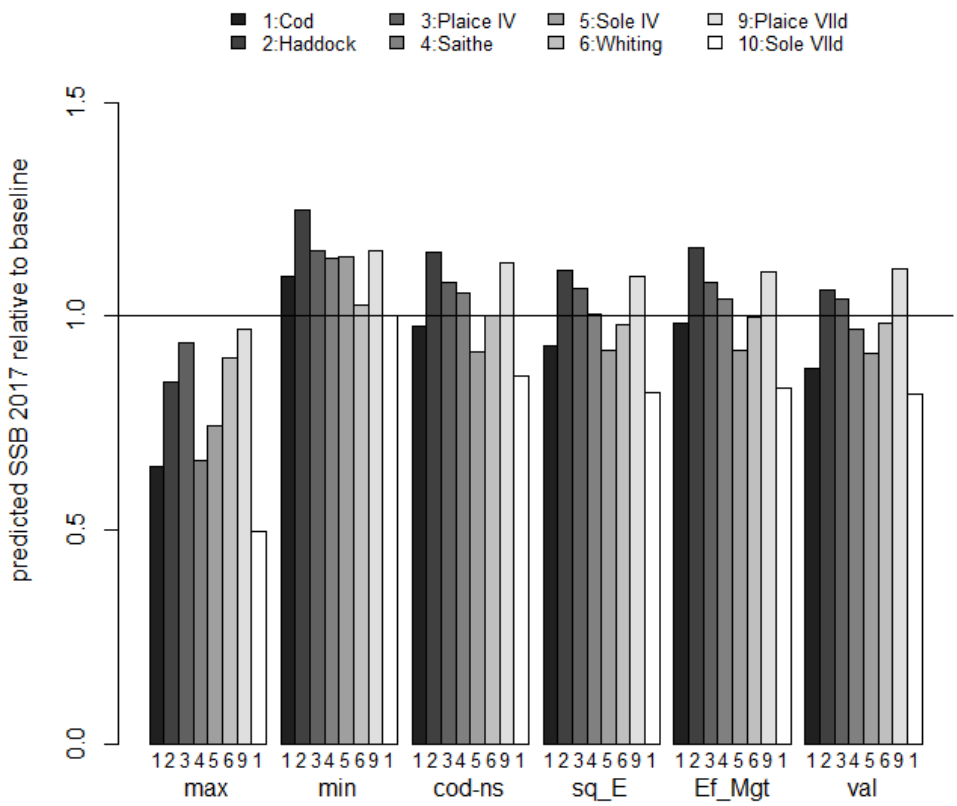


Figure 2.5.2.2.c Estimates of potential SSB at the start of 2017 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2017). *Nephrops* are not included as abundance is not forecast from the mixed fisheries model.

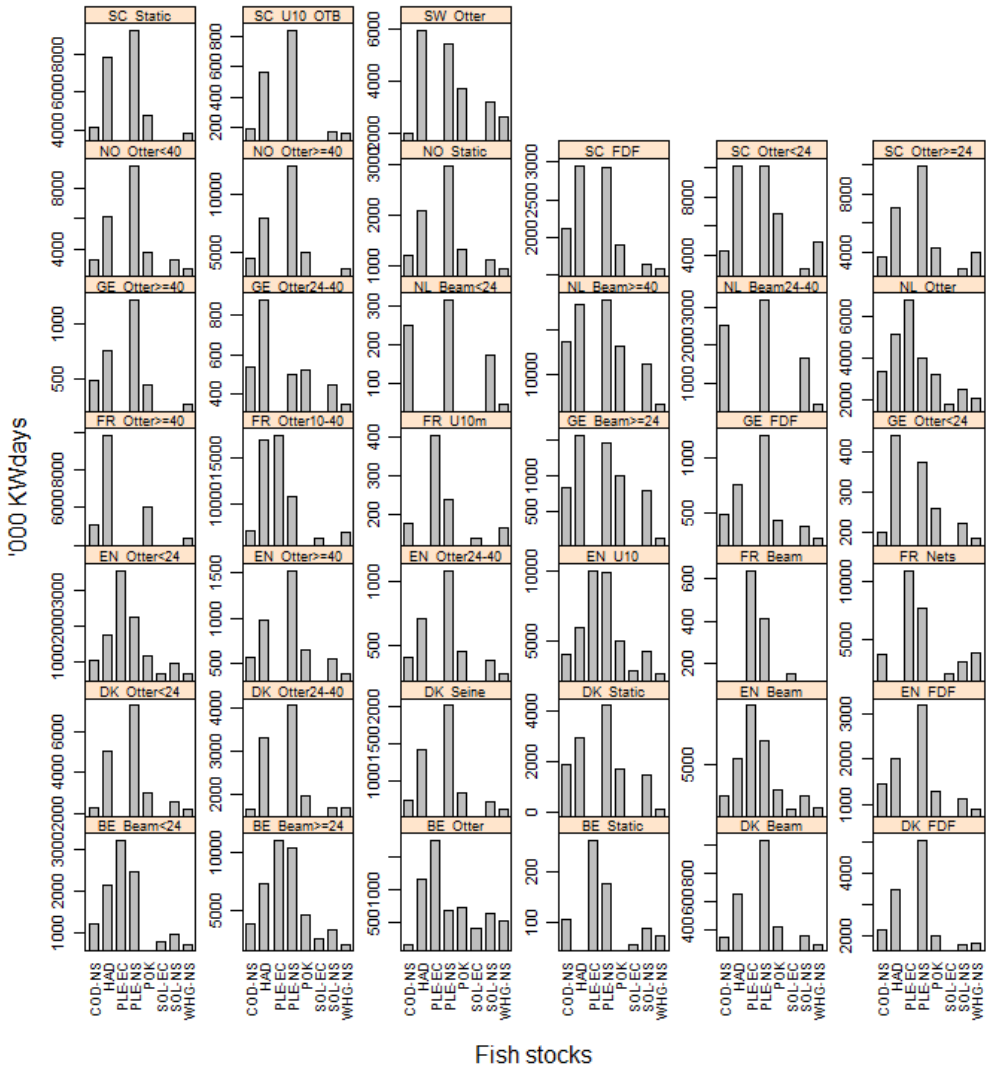


Figure 2.5.2.2.d TAC year results (2016). Fcube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2016 (baseline run). Finfish species.

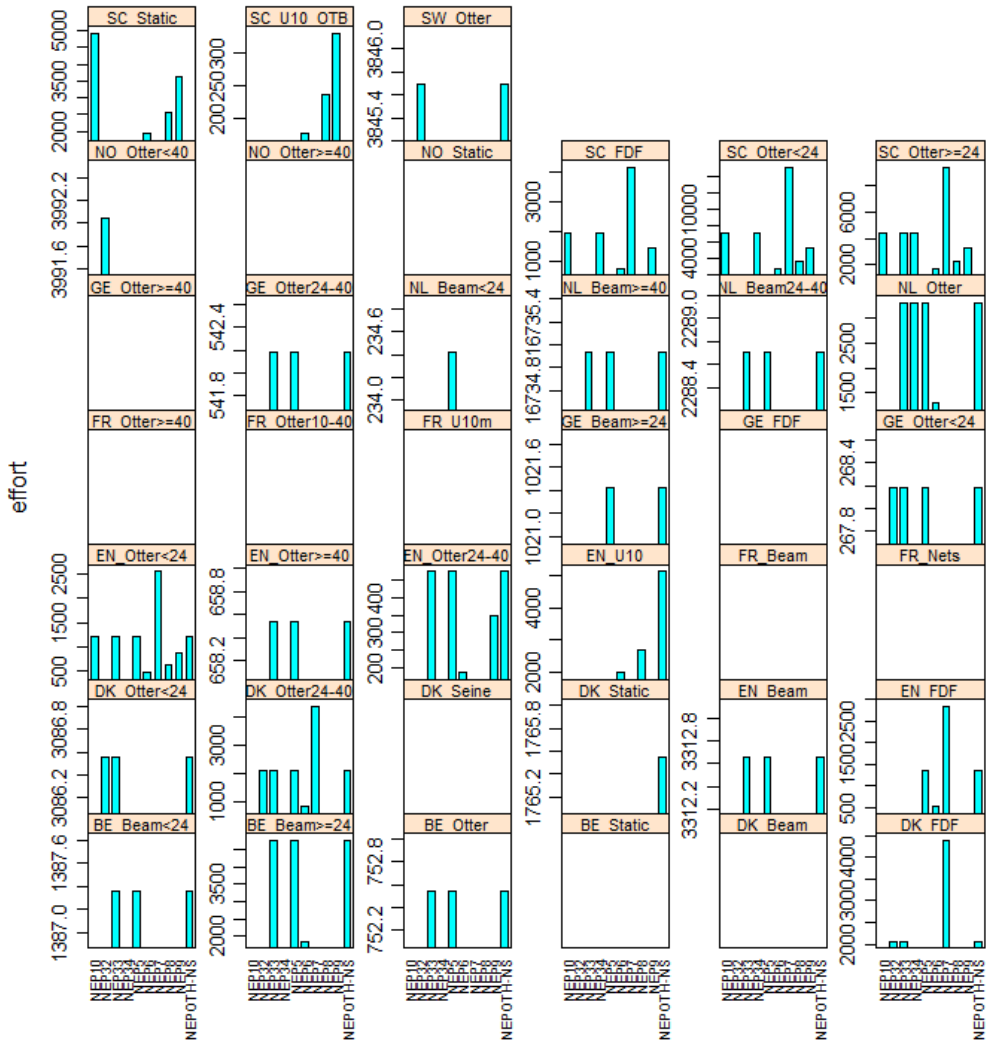


Figure 2.5.2.2.e. TAC year results (2016). Fcube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2016 (baseline run). ***Nephrops*** **FUs.**

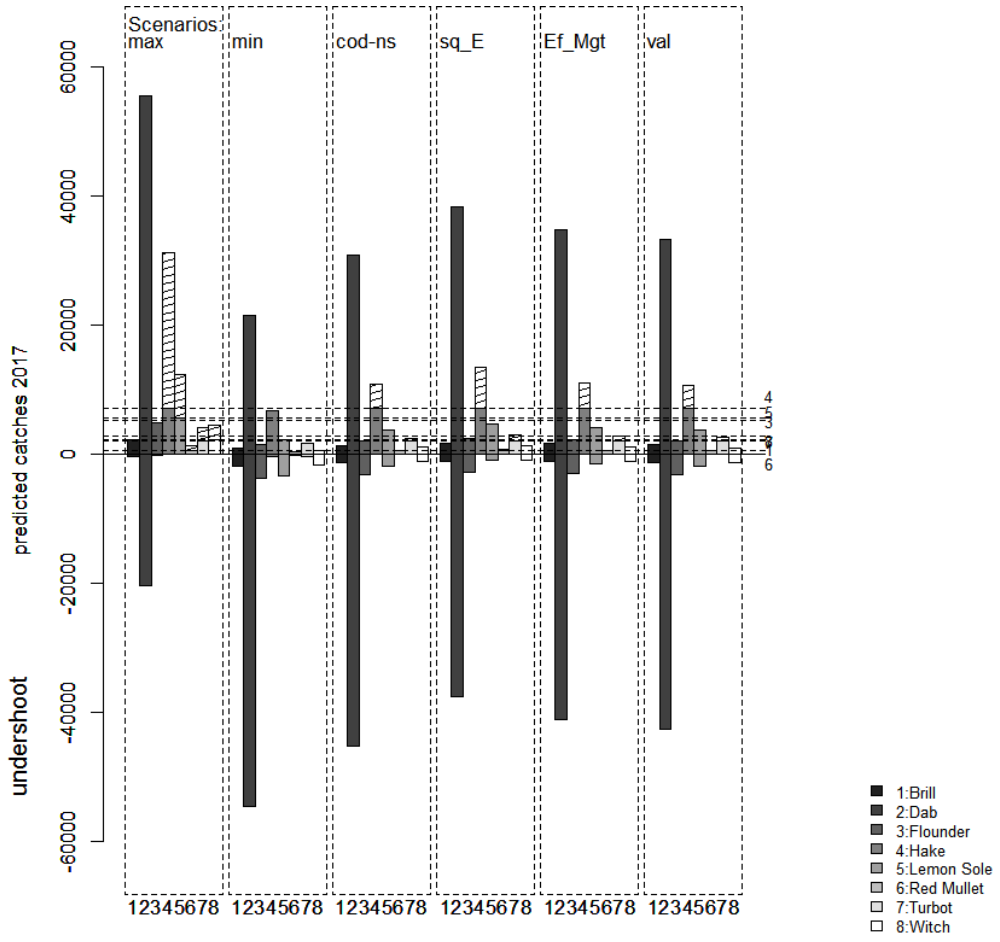


Figure 2.4.2.2.1. TAC year results. Estimates of potential catch by stock after applying the *status quo* effort scenario in the intermediate year followed by the Fcube scenarios. Stocks shown do not influence the mixed fisheries projections but potential catches are calculated using fleet effort results from the scenarios and the cpue of métiers from the final data year. Horizontal lines correspond to the single-stock catch advice. Bars below the value of zero show the scale of undershoot (compared to the single species catch advice) in cases where catches are predicted to be lower when applying the scenario.

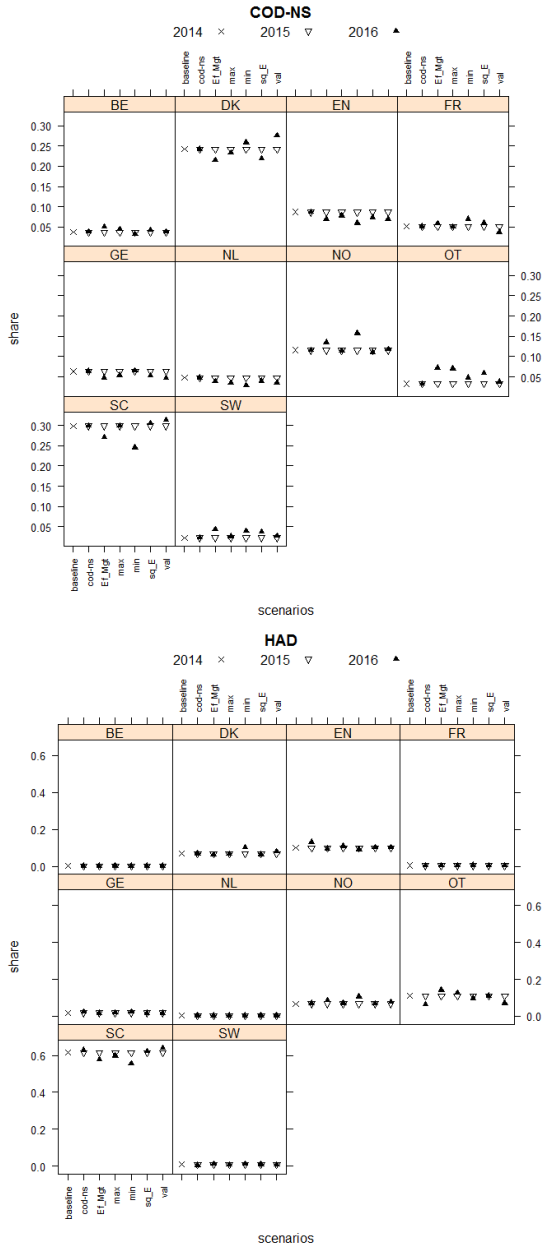


Figure 2.5.2.2.2. Test for relative stability. Changes of relative share of species' landings by country in 2015 and 2016 compared to the 2014 share, for the 'baseline' and 6 Fcube scenarios.

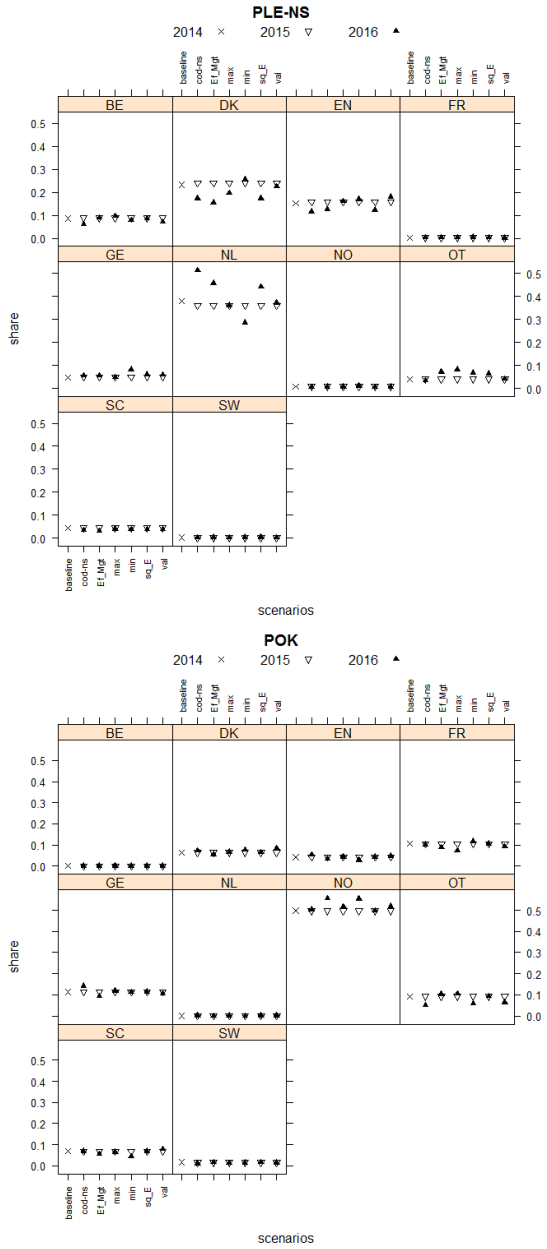


Figure 2.5.2.2.2 (cont). Test for relative stability. Changes of relative share of species' landings by country in 2015 and 2016 compared to the 2014 share, for the 'baseline' and 6 Fcube scenarios.

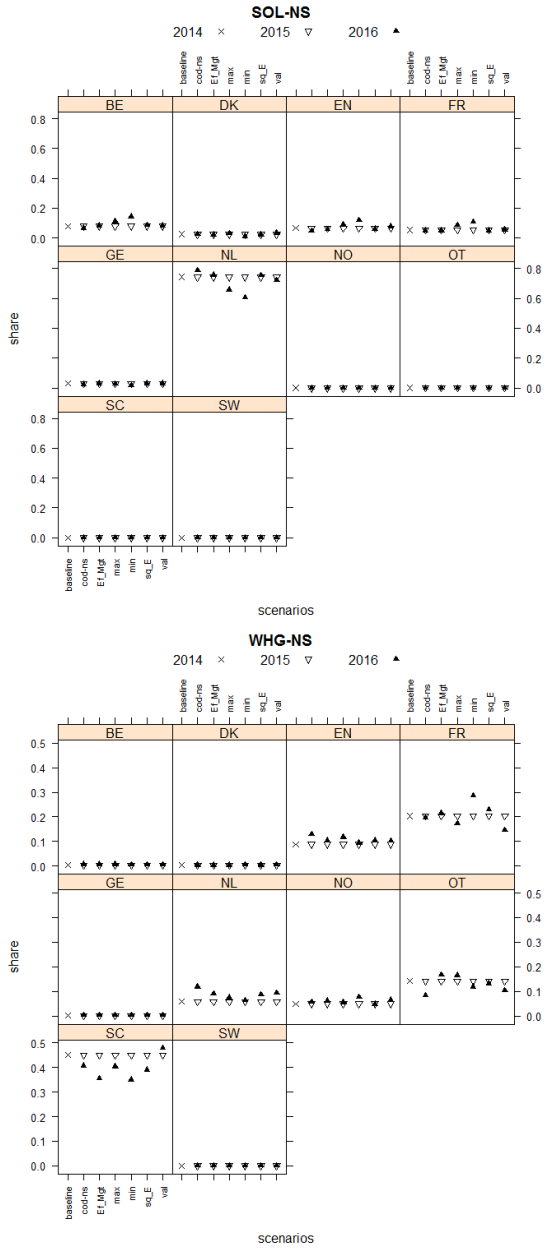


Figure 2.5.2.2.2 (cont). Test for relative stability. Changes of relative share of species' landings by country in 2015 and 2016 compared to the 2014 share, for the 'baseline' and 6 Fcube scenarios.

3 Celtic Sea

3.1 Background

Fisheries in the Celtic Sea are highly mixed, targeting a range of species with different gears. Otter trawl fisheries take place for mixed gadoids (cod, haddock, and whiting), *Nephrops*, hake, anglerfishes, megrims, rays as well as cephalopods (cuttlefish and squid). Beam trawl fisheries target flatfish (plaice, sole, turbot), anglerfishes, megrim and cephalopods (cuttlefish and squid) while net fisheries target flatfish, hake, pollack, cod, anglerfishes as well as some crustacean species. Beam trawling occurs for flatfish (in 7.e and 7.fg) and rays (7.f). The fisheries are mainly prosecuted by French, Irish, and English vessels with additional Belgian beam trawl fisheries and Spanish trawl and net fisheries along the shelf edge (7.hjk).

The mixed gadoid fishery predominately takes place in ICES areas 7.f and 7.g with these areas responsible for > 75% of the landings of each cod, haddock and whiting. Landings are predominately by French and Irish vessels, though UK vessels also take significant landings of these species.

3.1.1 Management measures

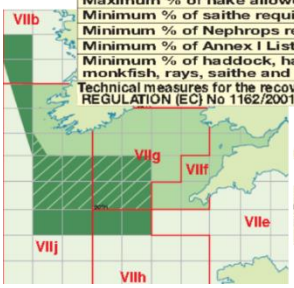
ICES advice in 2016is given in terms of MSY for most Celtic Sea stocks. There are no single-species or mixed fisheries management plans for the gadoid stocks in the Celtic Sea. There are two single species plans relevant to the fisheries; a recovery plan for hake (Council Regulation (EC) No 811/2004) which implements a Total Allowable Catch (TAC) annually based on a defined Harvest Control Rule (HCR) and a management plan with both a HCR and effort management element for sole in the Western channel (7.e; Council Regulation (EC) No 509/2007). There are also a number of effort, technical and area closure measures in place summarised below.

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

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

	VII (Celtic Sea & West of Ireland)								
	Area VII Outside restricted areas				Celtic Sea Protection Zone				HAKE BOX
Mesh size (mm)	70-79	80-89	90-99	100+	70-79 [6]	80-89 [6]	90-99 [6]	100+ [6]	100+
Twine thickness	4mm double or single 6mm								
Headline Panel (mm) (Beam Trawlers see footnote 1)	-	-	-	-	-	-	-	-	-
Square mesh panel (mm)	80	-	-	-	120	120	120	120	-
Maximum number of meshes in codend circumference	120	120	100	100	120	120	100	100	100
Catch Composition	-	Either - Or		-	Either - Or		-	-	-
Maximum % of cod allowed. (Council Reg 72/2016)	-	-	-	-	-	-	-	-	-
Maximum % cod, haddock, saithe allowed	-	-	30	-	-	-	30	-	-
Maximum % of hake allowed	20	20	20	-	20	20	20	-	-
Minimum % of saithe required	-	-	-	-	-	-	-	-	-
Minimum % of Nephrops required	35	30	-	-	35	30	-	-	-
Minimum % of Annex I List (see footnotes)	-	-	70 [2]	-	-	-	70 [2]	-	-
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and Nephrops	-	-	-	-	-	-	-	-	-

Technical measures for the recovery of the stock of hake in ICES sub-areas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e. COMMISSION REGULATION (EC) No 1162/2001. COMMISSION REGULATION (EC) No 2602/2001. COMMISSION REGULATION (EC) No 494/2002. COMMISSION IMPLEMENTING REGULATION (EU) 737/2012, 2015/741



2. Sole , plaice, megrim, whiting, brill, white pollack, lemon sole, dogfish, witch, John Dory, Queen scallop, monkfish, rays, turbot, grenadiers

6. Vessels using a codend mesh size between 70 and 119mm whose catch in any fishing trip east of 8°W comprises at least 55% whiting may use a square mesh panel of at least 100mm provided the trawl or seine is of a single mesh size larger than 100mm. Specific authorisation from the Member State must have been issued before going to sea.

Since 2005, three ICES rectangles (30E4, 31E4, and 32E3) have been closed during the first quarter (Council Regulations 27/2005, 51/2006, and 41/2007, 40/2008 and 43/2009) known as the Trevose closure, with the objective of reducing fishing mortality on cod. A second area closure is in place to reduce fishing mortality on *Nephrops* within FU16, the Porcupine bank fishery. This currently month long closure in May (Council Regulation (EU) No 43/2014) has been in operation since 2009.

As of the 1st January 2016 a European demersal species landings obligation was introduced (Commission Delegated Regulation (EU) 2015/2438). This regulation prevents the discarding of certain species on a fishery by fishery approach. Within the Celtic Sea the regulation applies to the below fisheries:

Fishery	Area	Gear	Landing obligation applies to:
Cod, haddock, whiting, saithe	7.b,c,e,f-k	Trawls & seines	whiting for vessels where landings in 2013 and 2014 consist of more than 25% cod, haddock, whiting and saithe combined
Nephrops	7	Trawls, seines, pots, traps, & creels	Nephrops for vessels where landings in 2013 and 2014 consist of more than 30% Nephrops
Hake	6, 7, & EU 5.b	Trawls & seines	Hake for vessels where landings in 2013 and 2014 consist of more than 30% hake
Hake	6, 7, & EU 5.b	All gill nets	All catches of hake
Sole (solea solea)	7.b,c,f-k	All beam trawls	Sole for vessels where landings in 2013 and 2014 consist of more than 5% of Sole. As no Irish vessels reached the 5% threshold in 2013and 2014 in 7.b,c,f,g the landing obligation only applies in 7.h,j,k for Irish vessels in 2016.
Sole (solea solea)	7.b,c,f-k	All trammel nets & gill nets	All catches of sole

3.2 Fcube

3.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.* (2007); www.flr-project.org; FLCore 2.5.20151202, FLFleet 2.5.20140531,FLAssess 2.5.20130716, Flash 2.5.2) running with R3.1.0 (R Development Core Team, 2011). All forecasts were projected using the same fwd() function in the Flash Package. The Fcube method is developed as a stand-alone script using FLR objects as inputs and outputs.

Software used in the single species assessments and forecasts was as outlined in the text table below.

Stock	Assessment	Forecast
Cod VIIe-k	Age-bases analytical assessment (FLR 2.x FLXSA)	FLR STF
Haddock VIIbc,e-k	ASAP (Age Structured Assessment Programme; NOAA toolbox)	FLR STF
Whiting VIIbc,e-k	Age-based analytical assessment (XSA)	FLR STF

3.2.2 Scenarios

The Fcube model has been presented and described in Ulrich *et al.* (2008; 2011). Brief details are presented below and a summary of the methodology is incorporated in the Mixed Fisheries Annex (Annex 7).

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

In 2016, single-species ICES advice was given according to MSY approach for all three stocks. The basis for each single-stock advice was retained in the current mixed-fisheries framework.

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

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

1) **max**: Fishing stops when all stocks considered have been caught up to the ICES single-stock advice. This option causes overfishing of the single-stock advice possibilities of most stocks.

2) **min**: Fishing stops when the catch for any one of the stocks considered meets the single-stock advice. This option is the most precautionary option, causing under-utilisation of the single-stock advice possibilities of other stocks.

3) **cod**: All fleets set their effort corresponding to that required to land their quota share of cod, regardless of other catches.

4) **had:** All fleets set their effort corresponding to that required to land their quota share of haddock, regardless of other catches.

5) **whg:** All fleets set their effort corresponding to that required to land their quota share of Whiting, regardless of other catches.

6) **sq_E**: The effort is set equal to the effort in the most recently recorded year for which landings and discard data are available.

A preliminary run was undertaken including the *Nephrops* stocks (FUs 16, 17, 18, 19, 20-21 and 22) in the Celtic Sea in the mixed fisheries forecasts. This was not completed for the advice sheet, but as a separate proof-of-concept. A complicating factor when incorporating *Nephrops* is the fact that the species is found in a number of distinct areas or functional units (FU), only some of which receive an abundance estimate (necessary to calculate a catchability). Further, for the Celtic Sea stocks, the TAC covers the entire ICES Area 7 including 7.a where most of the TAC landings are taken (but is not covered by the mixed fisheries advice). The details of the approach taken are in Section X.

3.3 Stock input data and recent trends

3.3.1 Stocks

3.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGCSE (2016b). All stock inputs formatted as FLStock objects were directly provided to WGMIXFISH by the respective stock coordinators, and this eased greatly the quality of the process of collecting stock data.

3.3.1.2 Trends and advice

This advice is drafted by the WGCSE-2016before considerations by ACOM.

Recent trends are described on a stock-by-stock basis in ICES (2016b), and latest advice by stock is available on the ICES website. In order to give an overview of the Celtic Sea demersal stocks considered for mixed fisheries analysis, this information is summarized below. Table 3.3.1.2 list the final advised TACs for 2017 and forecast SSBs in 2018.

3.3.1.2.1 Analytical stocks

			Fishing pressure				Recruitment has been highly variable over time. Recent recruitment has been weak with the exception of the 2013 year class which is above average. The 2014 year class is the lowest observed in the time series. Spawning-stock biomass (SSB) is below Blim in 2014 and 2015. Fishing mortality (F) has declined between 2005 and 2011 and has fluctuated in recent years remaining well above FMSY.	ICES advises that when the MSY approach is applied, wanted catch1 in 2017 should be no more than 1,455 tonnes. ICES advises that when the MSY approach is applied, wanted catch1 in 2017 should be no more than 1,455 tonnes. ICES cannot quantify the corresponding total catches because of variable discard rates in the recent past.
			2013	2014	2015			
		F_{MSY}	✗	✗	✗	Above		
		F_{pa}, F_{lim}	✗	○	✓	Harvested sustainably		
Cod	VIIe-k	F_{MGT}	-	-	-	Not applicable		
			Stock size					
			2014	2015	2016			
		MSY	✗	✗	✗	Below trigger		
		B_{pa}, B_{lim}	✗	✗	○	Increased risk		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing pressure				The spawning-stock biomass (SSB) peaked in 2011 as the very strong 2009 year class matured; this cohort was followed by three years of below-average recruitment which led to a rapid decline in SSB after 2011. Recent recruitment has varied around the average and SSB appears to have stabilised. Fishing mortality (F) has been above F_{MSY} for the entire time-series.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 12444 tonnes. If discard rates do not change from the average of the full time-series (1993–2015), this implies landings of no more than 7751 tonnes.
			2013	2014	2015			
		F_{MSY}	✗	✗	✗	Above		
		F_{pa}, F_{lim}	✓	✓	✓	Harvested sustainably		
		F_{MGT}	-	-	-	Not applicable		
Haddock	VIIbc, e-k		Stock size					
			2014	2015	2016			
		MSY $B_{trigger}$	✓	✓	✓	Above trigger		
		B_{pa}, B_{lim}	✓	✓	✓	Full reproductive capacity		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing pressure				ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 25 125 tonnes. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average of the last three years (2013–2015), this implies landings of no more than 19 825 tonnes.	The spawning-stock biomass (SSB) shows an increasing trend from 2008 and remains above MSY $B_{trigger}$. Fishing mortality (F) has been below F_{msy} since 2008 and is increasing in recent years. Recruitment has been below average since 2010 with the exception of the 2013 year class which is estimated to be the second highest in the series.
			2013	2014	2015			
		F_{MSY}	✓	✓	✓	Appropriate		
		F_{pa}, F_{lim}	✓	✓	✓	Harvested sustainably		
		F_{MGT}	-	-	-	Not applicable		
Whiting	VIIbc, e-k		Stock size					
			2014	2015	2016			
		MSY $B_{trigger}$	✓	✓	✓	Above trigger		
		B_{pa}, B_{lim}	✓	✓	✓	Full reproductive capacity		
		SSB_{MGT}	-	-	-	Not applicable		

3.3.1.2.2 Nephrops stocks (not included in May advice – note stock status comes from 2015advice)

Species	Area	Stock Status					Summary	Advice
			Fishing pressure				Stock abundance estimates between 2012 and 2014 are relatively stable. No UWTV survey could be carried out in 2015. The harvest rate calculated as (landings + dead discards)/(abundance estimate) is estimated to be below the FMSY proxy.	NA
			2012	2013	2014			
		F_{MSY}	✔	✔	✔	Below		
		F_{pa}, F_{lim}	✔	✔	✔	Below possible reference points		
Nephrops	FU16	F_{MGT}	-	-	-	Not applicable		
			Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	?	?	?	Undefined		
		B_{pa}, B_{lim}	?	?	?	Undefined		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing pressure				The abundance shows an overall decreasing trend over time and is currently at MSY Btrigger. The harvest rate, calculated as (landings + dead discards)/(abundance estimate), has been above the FMSY proxy since 2012.	NA
			2012	2013	2014			
		F_{MSY}	✘	✘	✘	Above		
		F_{pa}, F_{lim}	?	?	?	Undefined		
		F_{MGT}	-	-	-	Not applicable		
Nephrops	FU17		Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	✘	✘	✔	At trigger		
		B_{pa}, B_{lim}	?	?	✔	Above possible reference points		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing pressure				The historical harvest rate, calculated as (landings + dead discards)/(abundance estimate), is below the FMSY proxy in 2014. Stock abundance has been relatively stable since 2011.	NA
			2012	2013	2014			
		F_{MSY}	✘	✘	✔	Below		
		F_{pa}, F_{lim}	?	?	✔	Below possible reference points		
Nephrops	FU19	F_{MGT}	-	-	-	Not applicable		
			Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	?	?	?	Undefined		
		B_{pa}, B_{lim}	?	?	?	Undefined		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing pressure				The stock has increased between 2013 and 2015. The harvest rate, calculated as (landings + dead discards)/(abundance estimate), is considered to be below any possible reference points.	NA
			2012	2013	2014			
		F_{MSY}	?	?	?	Undefined		
		F_{pa}, F_{lim}	?	?	?	Undefined		
		F_{MGT}	-	-	-	Not applicable		
		Qualitative evaluation	?	✔	✔	Below possible reference points		
Nephrops	FU20-21		Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	?	?	?	Undefined		
		B_{pa}, B_{lim}	?	?	?	Undefined		
		SSB_{MGT}	-	-	-	Not applicable		
		Qualitative evaluation	?	↗	→	Stable		
			Fishing pressure				The historical harvest rates, calculated as (landings + dead discards)/(abundance estimate), have decreased since 2007 and have been below the FMSY proxy since 2011. The UWTV abundance index is relatively stable.	NA
			2012	2013	2014			
		F_{MSY}	✔	✔	✔	Appropriate		
		F_{pa}, F_{lim}	✔	✔	✔	Below possible reference points		
Nephrops	FU22	F_{MGT}	-	-	-	Not applicable		
			Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	?	?	?	Undefined		
		B_{pa}, B_{lim}	?	?	?	Undefined		
		SSB_{MGT}	-	-	-	Not applicable		
			Fishing press				The state of Nephrops in functional unit (FU) 18 and other rectangles outside the functional units is unknown. Landings since 1995 have been around an average of 300 tonnes.	NA
			2012	2013	2014			
		F_{MSY}	?	?	?	Undefined		
		F_{pa}, F_{lim}	?	?	?	Undefined		
		F_{MGT}	-	-	-	Not applicable		
Nephrops	FU VII oth	-	?	?	?	Unknown		
			Stock size					
			2013	2014	2015			
		MSY $B_{trigger}$	?	?	?	Undefined		
		B_{pa}, B_{lim}	?	?	?	Undefined		
		SSB_{MGT}	-	-		Not applicable		
		-	?	?	?	Unknown		

3.4 Fleets and métiers

3.4.1 Catch and effort Data

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

The WGMIXFISH information was requested with the same DCF métier-based definitions as those to InterCatch, but separated into vessel length categories specified to match fleet segments from the STECF AER (Annual Economic Report) and provided directly as comma separated files. The only exception was for Ireland, where data was submitted to InterCatch at DCF level 4 only (gear only) and further disaggregation of landings to the target species level was desirable to distinguish the fisheries in the mixed fisheries forecasts.

Discard data were not requested by vessel length categories, as national observer sampling programmes do not distinguish between vessel lengths, so discard ratios for the various métiers aggregated across all vessel lengths could be extracted from InterCatch and applied to the landings of the corresponding métiers in the vessel length specific data. In the case of discard raising of Irish landings, the same proportion discards were applied to the gear irrespective of target species, consistent with the data submitted to InterCatch (and the single-stock advice raising procedures).

Age distribution by métier and area, which is now available in InterCatch, was not integrated in the MIXFISH data, but ultimately it is the aim to include them in future. The relative size of catches of the stocks incorporated in the mixed fisheries projections is shown in Figure 3.4.1.a.

The final dataset extracted from InterCatch for use by WGCSE includes discards estimates (either imported or raised) for all stocks and métiers. These Intercatch estimates have been used to estimate a discard ratio by métier, which allows allocating discards for all WGMIXFISH fleets and métiers with matching names, such that;

$$d^* = \frac{Dl}{L}$$

Where d* is the discard value for the métier used by Fcube, l is the weight of landings for the métier used by Fcube and L and D are the weight of landings and discards entered for the (vessel length aggregated) métier in InterCatch.

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

3.4.2 Definitions of fleets and métiers

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

- Fleets were defined by aggregating catch and effort across country, gear group (e.g. OTB_DEF and OTB_CRU combined) and vessel length (where applicable).
    - Any fleet catching < 1% of any of the stocks included the analysis was binned into an "others" ("OTH") fleet to reduce the dimensions of the model.
    - Effort and catch files were matched to ensure consistency, métiers with effort and no catch were aggregated to the OTH fleet.
- Within a fleet, a métier was defined as a combination of gear, target species (e.g. demersal fish, DEF, or crustaceans, CRU) and ICES sub-area (e.g. 7.b).
    - A similar aggregating procedure as for the fleets was performed, where any métier catching< 1% of a métiers catch of each stock was aggregated into an "OTH" métier.

The final data used contained 17 national fleets (plus the OTH fleet) from four countries, covering catch and effort for the years 2014 and 2015. These fleets engage in one to eight different métiers each, resulting in 68 combinations of country*fleet*métier*area catching cod, haddock, and whiting (Table 4.4.2.2.2). The balance of catches of the stocks across gear categories is shown in Figure 3.4.1.b.

Fleet definitions in the final selection are summarised as follows:

- Belgium: Retention of a single fleet, 24–40m vessels utilizing beam trawls to target demersal species, the primary Belgium fleet within the Celtic Sea
- England: Beam trawling vessels 24–40m for demersal species; otter trawlers of 10–24m differentiating between demersal and crustacean targeting. Division of the static gear fleet into set gillnet, and trammel net fleets both targeting demersal fish in addition to retention of longline finfish fishing.
- France: Use of six fleets, three where the gear (and target species) are not specified which are then distinguished by vessel lengths, into 10–24m, 24–40m and "all" (other lengths, mostly < 10 m) vessels. The remaining three fleets use otter trawls distinguished by vessel length, 10–24m and 24–40m which both target demersal fish, the last contains vessels of all lengths targeting "other" species.
- Ireland: Distinction between 10–24m and 24–40m otter trawling fleets each having segments targeting demersal fish, crustaceans, and "others". Two additional fleets were retained: 24–40m beam trawling vessels targeting demersal fish, and a static gear fleet with segments targeting demersal fish with set gillnets and an "others" gear category.
- Northern Ireland: Retention of a single fleet of 24–40m vessels utilising unspecified gears.

All the WGMIXFISH métiers for the Celtic Sea are defined as combinations of gear, target species (level 5; see table 3.4.2.a) and area (7.b, 7.c, 7.e, 7.f, 7.g, 7.h, 7.j, 7.k). The list of fleets, métiers with their catch (tonnes, all species) and effort are provided in table 3.4.2.b.

As a cross check of the data, the total landings and discards across all fleets was compared to the values estimated from the single species stock assessments (Table 3.4.2 and Figure 3.4.2). Some landings may not be allocated to fleets, due to for example missing countries or areas or national landings with missing logbook information that

cannot be allocated to a fleet. The landings coverage for all fish stocks is very high (above 95% of landings of each fish stock for each of the years 2014 and 2015 could be allocated to one of the fleets). To address the remaining small inconsistencies between fleet data used by WGMIXFISH and stock data, the differences between them were pooled into the "OTH" fleet (both landings and discards).

3.4.3 Trends

A series of tables and figures were produced to aid quality checking of the data once compiled into the final fleets object. Some are useful to show the relative importance of the fleets chosen in their effort and catches. Effort by fleet in absolute levels (Table 3.4.2; not presented in figure due to short time series), effort share by métier and fleet (Figure 3.4.3.a) and landings by fleet and stock (Figure 3.4.3.b) are included in this report.

3.5 Mixed fisheries forecasts

3.5.1 Description of scenarios

3.5.1.1 Baseline Runs

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

1) reproduce as closely as possible the single species advice produced by ACOM,

and

2) act as the reference scenario for subsequent mixed fisheries analyses.

The various single-stock forecasts presented by WGCSE are performed using different software and setups (see 3.2.1 above). However, for the purpose of the mixed-fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the 'fwd()' method in FLR (Flash R add-on package). The same forecast settings as in WGCSE are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (MSY approach).

Some differences can occur in the forecast calculations, (because of the diversity of single-stock assessment methods used) and the WG always investigates in depth the reasons for potential discrepancies. Adjustments to the FCube forecasts are made if necessary to minimize discrepancies to the largest extent possible.

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

3.5.1.2 Mixed fisheries runs

3.5.1.2.1 Fcube analyses of the intermediate year (2016)

In a departure from last year (where *status quo effort* was assumed in the intermediate year), the assumption for the forecast was based on *status quo F* (unscaled average 2013 – 2015). The reason for this change is because of the pronounced trends in F for some stocks (see Figure 3.5.1.2.1) which led to different catch advice in the TAC year (2017) compared to the single species runs. To ensure more consistency, FCube was only run for the TAC year.

3.5.1.2.2 Fcube analyses for the TAC year (2017)

The working group adopted a forecast approach for the intermediate year on the basis of *Status quo F*. A *status F* assumption is more consistent with the single-stock short-term forecasting approach used by WGCSE for the stocks (ICES, 2016x). The FCube scenarios were used for the TAC year only (2017).

In summary, the Fcube runs followed the scheme below:

Single-stock assessment 2016(data up to 2015)

Management Plan/ MSY approach

Status quo

2016

status quo F (2013 – 2015)

Catch in 2016and SSB at start of 2017

Single-stock Management Plans applied to FCUBE (sq_E) results

FCUBE 2017

min *max* cod-cs had-cs whg-cs *sq* E

Potential Over / Under quota utilization

(Difference between single species advise TAC and expected landings)

3.5.2 Results of Fcube runs

3.5.2.1 Baseline run

The rationale behind the single species baseline runs is given in Section 3.5.1.1. Table 3.5.2.1.a contains the outputs from these runs. Figure 3.5.2.1.a also shows the required change in fishing mortality for the different stocks from 2015 through the intermediate year and into the TAC year. It can be seen from Figure 3.5.2.1.a that cod requires the biggest reduction in F, indicating the potential for it to be the 'choke' species for the fisheries that catch cod. The change in F on cod from 2015 to 2017 implies a change in fishing effort (from F = 0.527 in 2014 to F = 0.212 in 2016) of –60% which is a level of fishing effort lower than to catch the other stocks. Conversely, whiting F in 2015 (F = 0.382) is below FMSY (0.52) requires which implies a change in fishing effort in 2017 of around + 35 %to catch the quota, higher effort than required to catch haddock or cod.

No issues were encountered in replicating the single species advice. The results from these baseline runs are compared with the results from the corresponding ICES runs in Tables 3.5.2.1.b and summarized at Figure 3.5.2.1.b. The replicated forecast for all stocks were almost identical to the single stocks advices.

3.5.2.2 Mixed fisheries analyses

3.5.2.2.1 Intermediate year baseline

The full overview of the Fcube projections to 2017 is presented in Table 3.5.2.2.a and Figures 3.5.2.2.a and 3.5.2.2.b. The results for 2017 can be compared to each other as in a single-species option table. For ease of comparison, a table with the landings relative to the single-stock advice is also presented on Table 3.5.2.2.b.

The baseline run for **cod**, which follows the single-stock ICES advice, assumes landings of 4865 tonnes in 2016 (F2016 assumed to equal F2013 - 2015), and 1447 tonnes in 2017. The resulting SSB in 2018 is estimated to be 8310 tonnes. WGMIXFISH also assumed *status quo F* in 2016.

The baseline run for **haddock**, which follows the single-stock ICES advice, assumes catches of 13542 tonnes in 2016 (F2016 assumed to equal F2013 - 2015), and 12444 tonnes in 2017. The resulting SSB in 2018 is estimated to be 34408 tonnes. WGMIXFISH also assumed *status quo F* in 2016.

The baseline run for **whiting**, which follows the single-stock ICES advice, assumes catches of 16787 tonnes in 2016 (F2016 assumed to equal F2013 - 2015), and 25125 tonnes in 2017. The resulting SSB in 2018 is estimated to be 49360 tonnes. WGMIXFISH also assumed *status quo F* in 2016.

3.5.2.2.2 TAC year FCube runs

The outcomes of the "minimum" and "maximum" scenarios are driven by which of the stocks will be most and least limiting for each individual fleet. In the "Minimum" scenario, the most limiting stocks are cod and haddock for fleets representing 95% and 5% of the effort in 2015 respectively. In the "Maximum" scenario, the least limiting stock is whiting and haddock for fleets representing 75%, and 25% of the effort in 2015, respectively. The maximum scenario is close to the "whiting" scenario.

The min scenario assumes that fleets would stop fishing when their first quota share is exhausted, regardless of the actual importance of this quota share, thus leading to a distorted perception of plausible fleet behaviour. It is included to demonstrate the

lower bound of potential fleet effort and stock catches. Similarly, the max scenario demonstrates the upper bound of potential fleet effort and stock catches but, through assuming all fleets continue fishing until all their quotas are exhausted irrespective of the economic viability of such actions, this is also considered a scenario with low plausibility. The **min** and **cod** scenarios do, however, give similar results (Table 3.5.2.2.b and Figure 2.5.2.2.a) because cod is the limiting species for such a high percentage of fleet effort.

Other scenarios represent intermediate plausible scenarios reflecting basic current management measures and also the *status quo* option. ICES WGMIXFISH has not conducted work to assess which of these scenarios may represent the most likely outcome, but hindcasting projections should be investigated as those previously made for the North Sea runs (Ulrich *et al.*, 2011).

The anticipated SSBs in 2018 of the Fcube scenarios are shown in Figure 3.5.2.2.b. The **min** and **cod** scenarios result in SSBs slightly higher than the respective single stock forecasts for all stocks (cod under the cod scenario is the same as the single stock advice). The **max**, **whg** and **sq_E** scenarios result in SSBs lower than the stocks respective single-stock forecasts except for whiting, which is either the same (for the whiting scenario) or higher (under status quo effort).

Figure 3.5.2.2.c shows the level of effort required by each fleet to catch their quota share of the single species TAC advice for each stock. This highlights the much lower effort required to fulfil the cod quota in 2017 than for haddock, which is again much lower than that for whiting highlighting the incompatibility of the effort levels (and quotas) required to catch each of the three stocks in 2017.

3.5.2.2.3 Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input is calculated as the average landing share by fleet and stock in 2015. As a cross check, the landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input (Figure 3.5.2.2.2). The results show some deviations across all scenarios which arise because (under the assumption of a full discard ban), fleets with a small share of a stock but high discard rate have their fishing activity limited by that stock, resulting in underutilization of their target stock(s) This can translate to underutilization at the national level, as seen by the change in landings share of the stocks by EU Member States in the mixed fisheries forecasts.

3.6 Incorporation of Nephrops in the Celtic Sea mixed fisheries advice

Initial investigation indicated it would be possible to include the *Nephrops* FUs in the Celtic Sea as all have under-water television (UWTV) survey estimates of abundance, harvest rates and MSY targets (WGMIXFISH-ADVICE Report, 2015). However, there are two complicating factors which first need to be addressed;

i) The latest abundance estimates (and single stock advice sheets) are produced following the summer UWTV surveys, after WGMIXFISH meets.

ii) A single *Nephrops* TAC applies to the entire Area 7, which includes two FUs in the Irish Sea (sub-area 7.a, FUs 15 and 16), which are outside the area the Celtic Sea demersal fisheries operate, but contribute to ~60% of the landings of the Area 7 TAC.

The issues were treated as follows:

i) The UWTV abundance estimates and stock weights from surveys undertaken in 2015 were used for abundance in the forecasts in 2016 and 2017. Landings weights, discard weights and discard ratios from 2014 (from advice delivered in 2015), combined with preliminary landings (tonnage) estimates for 2015 were used to estimate landings and discard numbers in 2015, and calculate a harvest ratio in 2015.

ii) The same target harvest ratios from the advice in 2015 (for quotas in 2016) were used for the TAC year forecasts (2017). The assumption of constant abundance in 2015, 2016 and 2017 is the same assumption as used for the North Sea advice where UWTV surveys in 2016 are not incorporated in the 2017 advice (though for the North Sea harvest ratios and landings and discard weights may be updated for the 2017 advice).

iii) The Celtic Sea *Nephrops* TAC component (ICES Area 7 excluding 7.a) was assumed to be equal to the split of the landings between the two areas. Total Area 7 landings in 2015 were 15 818, with 378 t from FU 14 and 8 632 t from FU 15, leaving 6 808 t from Area 7–7.a (43 % of the overall Area 7 landings). For the 2016 TAC, this implied 10 040 t (Area 7 TAC = 23 348 t * 0.43).

iv) In addition, because there was no combined ICES area & FU landings data for the fleets, the area was dropped from the métier definition – so that each metier was only described by gear type and target species (e.g. OTB_DEF). This should not affect the analysis as fleets are assumed to have a fixed proportion of effort in each métier in the forecasts.

Preliminary results are presented in Figure 3.6. *Nephrops* landings are under the pseudo-TAC in all scenarios, indicating they are not limiting in 2017 but may drive effort above the single-stock advice for the demersal stocks.

Table 3.3.1.2. Celtic Sea. Summary of the 2017landings and target Fs/harvest ratios, resulting from the Advice Approaches considered by ICES. Target Fs are left justified; harvest ratios are right justified. Where a stock/Functional Unit does not have a management plan the landings follow ICES advice.

Species	Agreed TAC (summed TACs) 2016	Catch–advice for 2017	Landings–advice for 2017	F/Harvest ratio for 2016	F/ Harvest ratio for 2017	SSB 2017	SSB 2018	Rational
Cod 7.e-k	4 565**		1 455	0.73	0.21	6 202	8 303	MSY
Haddock 7.bc, 7.e-k	7 258^	12 444	7 751	0.52	0.40	33 560	34 408	MSY
Whiting 7.bc, 7.e-k	22 778*	25 125	19 825	0.29	0.36	57 746	49360	MSY
Nephrops FU16	1 850			5.0				MSY
Nephrops FU17	23 348***			8.5				MSY
Nephrops FU19	23 348***			8.1				MSY
Nephrops FU20-21	23 348***			5.7				Conservative
Nephrops FU22	23 348***			10.9				MSY
Nephrops FU18+7OTH	23 348***							na

**** Applies to Divisions 7.b,c,e–k, Subareas 7.i, IX, and X, and EU waters of CECAF 34.1.1.**

^ Applies to Divisions 7.b–k and Subareas 7.i, IX, and X.

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

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

Table 3.4.2.a. Celtic Sea. Métiers consistent with DCF métier level 5. Mixed-fisheries métiers are further disaggregated into areas: 7.b, 7.c, 7.e, 7.f, 7.g, 7.h, 7.j and 7.k.

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

Table 3.4.2.b. Celtic Sea. Final fleet and métier categories used in the mixed fishery analysis.

		2014		2015	
fleet	metier	Catch	effort	catch	effort
BE_Beam_24<40m	TBB_DEF_7.e	3.10	143.08	23.13	286.03
	TBB_DEF_7.f	376.30	1,091.21	481.22	1,147.76
	TBB_DEF_7.g	44.00	657.78	141.08	674.34
	TBB_DEF_7.h	0.54	20.88	13.95	66.05
EN_Beam_24<40 m	TBB_DEF_7.e	254.00	1,586.71	330.06	1,613.30
EN_Other_all	MIS_MIS_7.e	0.89	212.78	507.76	3,848.90
EN_Otter_10<24m	OTB_CRU_7.e	732.23	1,381.38	503.42	1,413.95
	OTB_CRU_7. g	18.15	62.58	193.66	37.02
	OTB_DEF_7.e	411.55	342.77	794.95	374.38
	OTH	3.18	156.34	15.24	192.92
EN_Static_all	GNS_DEF_7.e	-	-	198.00	497.45
	GTR_DEF_7.e	-	-	8.06	73.91
	LLS_FIF_7.e	-	-	33.30	325.06
FR_Other_10<24m	MIS_MIS_7.e	259.37	1,463.83	1,097.23	2,164.39
	MIS_MIS_7.g	5.79	2.74	17.51	23.60

	MIS_MIS_7.h	23.78	34.98	27.83	65.00
	OTH	11.86	68.17	8.73	29.87
FR_Other_24<40m	MIS_MIS_7.e	194.61	403.06	474.47	481.92
	MIS_MIS_7.h	73.14	89.92	26.36	56.77
	OTH	11.57	98.16	4.89	73.75
FR_Other_all	MIS_MIS_7.e	321.13	10,095.43	386.98	8,442.66
	MIS_MIS_7.f	31.86	74.87	14.40	85.51
	MIS_MIS_7.g	228.05	109.38	249.13	111.51
	MIS_MIS_7.h	247.66	1,508.62	188.15	1,334.14
	MIS_MIS_7.j	31.54	2,321.00	49.74	3,604.30
	OTH	15.58	2,610.88	9.84	1,471.88
FR_Otter_10<24m	OTB_DEF_7.e	1,917.75	2,770.82	3,167.98	2,929.06
	OTB_DEF_7.f	1,008.08	556.69	814.43	389.52
	OTB_DEF_7.g	687.92	355.59	238.96	159.73
	OTB_DEF_7.h	801.13	802.59	1,195.38	1,030.89
	OTH	19.79	139.80	15.70	106.95
FR_Otter_24<40m	OTB_DEF_7.b	246.30	318.45	231.00	270.13
	OTB_DEF_7.c	158.85	413.47	87.05	332.38
	OTB_DEF_7.e	1,705.67	1,828.17	2,124.33	1,770.57
	OTB_DEF_7.f	1,513.16	539.49	585.64	254.81
	OTB_DEF_7.g	1,618.68	587.55	950.69	350.93
	OTB_DEF_7.h	1,679.28	1,409.86	2,389.72	1,467.14
	OTB_DEF_7.j	382.87	830.90	535.25	746.98
	OTH	1.81	37.02	2.67	44.24
FR_Otter_all	OTH	259.76	474.96	56.01	264.91
	OTT_CRU_7.g	145.07	345.33	139.56	313.03
	OTT_DEF_7.e	116.90	172.54	89.02	92.60
	OTT_DEF_7.g	1,245.38	1,036.12	950.46	859.08
	OTT_DEF_7.h	1,388.76	2,393.59	1,869.82	3,015.25
	OTT_DEF_7.j	78.33	488.50	58.84	359.33
	SSC_DEF_7.g	78.90	135.83	99.00	91.73
IE_Beam_10<24m	OTH	2.66	8.62	-	-
	TBB_DEF_7.g	265.25	244.66	259.22	248.96
IE_Beam_24<40m	OTH	1.04	8.14	3.50	8.14

	TBB_DEF_7.g	464.04	763.21	436.12	803.05
IE_Other_24<40m	MIS_MIS_7.g	-	-	200.55	159.59
	OTH	-	-	1.14	510.33
IE_Otter_10<24m	OTB_DEF_7.b	436.20	803.13	194.34	505.80
	OTB_DEF_7.g	3,965.99	2,824.76	5,244.47	3,264.53
	OTB_DEF_7.j	763.44	1,364.96	1,235.62	1,171.00
	OTH	597.58	2,251.30	35.37	1,914.89
	SSC_DEF_7.g	1,745.16	317.55	1,504.71	257.06
	SSC_DEF_7.j	410.49	118.63	385.67	139.38
IE_Otter_24<40m	OTB_DEF_7.b	347.21	466.37	414.59	383.72
	OTB_DEF_7.g	2,001.06	829.85	3,069.09	1,345.72
	OTH	224.45	3,037.83	181.98	2,749.50
	SSC_DEF_7.b	310.53	35.59	359.63	63.82
	SSC_DEF_7.g	854.76	126.43	921.25	100.87
	SSC_DEF_7.j	611.22	183.50	568.44	134.27
IE_Static_all	GNS_DEF_7.g	300.08	246.65	126.73	216.53
	GNS_DEF_7.j	147.67	187.97	83.47	221.95
	OTH	6.88	65.96	1.78	42.75
OTH_OTH	OTH	2,079.03	1,000.00	2,240.48	1,000.00

Table 3.4.2. Proportion of the stocks total landings and discards (from WGCSE) covered by the MIXFISH fleets. A ratio > 1 means that the catch information in MIXFISH is higher than the information used by WGCSE.

YEAR	STOCK	WG.LAND	MIX.LAND	LAND.DIFF	WG.DISC	MIX.DISC	DISC.DIFF	RATIO.LAND	RATIO.DISC
2014	COD-CS	3879	3751	-128	0	0	0	0.97	Inf
2015	COD-CS	4154	4074	-80	0	0	0	0.98	Inf
2014	HAD-CS	9854	9511	-343	3177	3399	222	0.97	0.79
2015	HAD-CS	8545	8398	-147	6694	5823	-870	0.98	1.07
2014	WHG-CS	12847	12898	51	3977	3500	-477	1	0.87
2015	WHG-CS	13174	13061	-113	6101	6650	549	0.99	0.9

Table 3.5.2.1.a. Celtic Sea. Baseline run outputs from the Fcube FLR package.

		COD-CS	HAD-CS	WHG-CS
2016	Fbar	0.73	0.52	0.29
	FmultVsF15	1.39	1	0.77
	Landings	4865	8893	12611
	Ssb	8035	26082	63908
2017	Fbar	0.21	0.4	0.52
	FmultVsF15	0.4	0.77	1.36
	Landings	1447	12444	25125
	Ssb	6200	33560	57746
2018	Ssb	8310	34408	49360

Table 3.5.2.1.b. Comparison between baseline run and ICES advice for finfish. Figures for 2015 compare results from the baseline run to the ICES intermediate year results. The baseline run uses the same assumptions for F in the intermediate year as the forecasts leading to ICES advice.

		COD-CS	HAD-CS	WHG-CS
2016	Landings			
	Baseline	4 865	13 542	16 787
	ICES	4 865	13 542	16 679
	% difference	0.0%	0.0%	0.6%
2017	Total Catches*			
	Baseline	1 447	12 444	25 125
	ICES	1 455	12 444	25 125
	% difference	-0.5%	0.0%	0.0%

***COD-CS landings only**

Table 3.5.2.2.a. Celtic Sea. Results of Final Fcube runs.

	YEAR	SCENARIOS	COD–CS	HAD–CS	WHG–CS
landings	2016	baseline	4865	8893	12611
Fbar	2016	baseline	0.73	0.52	0.29
	2017	baseline	0.21	0.4	0.52
FmultVsF15	2016	baseline	1.39	1	0.77
	2016	sq_E	1.39	1	0.77
	2017	baseline	0.4	0.77	1.36
	2017	cod-cs	0.4	0.4	0.41
	2017	had-cs	0.86	0.77	0.77
	2017	max	1.46	1.45	1.38
	2017	min	0.39	0.39	0.4
	2017	optimQ	0.4	0.77	1.36
	2017	sq_E	1	1	1.01
	2017	whg-cs	1.45	1.45	1.36
landings	2016	sq_E	4865	8893	12611
	2017	baseline	1447	12444	25125
	2017	cod-cs	1447	6968	9020
	2017	had-cs	2826	12444	15829
	2017	max	4236	20505	25393
	2017	min	1420	6743	8861
	2017	optimQ	1447	12444	25125
	2017	sq_E	3187	15415	19842
	2017	whg-cs	4216	20456	25125
Ld_MgtPlan	2017	sq_E	1447	12444	25125
catches	2016	sq_E	4865	13542	16787
	2017	baseline	1447	12444	25125
	2017	cod-cs	1447	6968	9020
	2017	had-cs	2826	12444	15829
	2017	max	4236	20505	25393
	2017	min	1420	6743	8861
	2017	optimQ	1447	12444	25125
	2017	sq_E	3187	15415	19842
	2017	whg-cs	4216	20456	25125
ssb	2016	baseline	8035	26082	63908
	2017	baseline	6200	33560	57746
	2017	sq_E	6200	33560	57746
	2018	cod-cs	8310	39940	63258
	2018	had-cs	6791	34408	57325
	2018	max	5270	26418	49133
	2018	min	8340	40169	63397
	2018	optimQ	8310	34408	49360
	2018	sq_E	6398	31440	53866
	2018	whg-cs	5291	26467	49360
ssb_MgtPlan	2017	sq_E	6200	33560	57746

Table 3.5.2.2.b. Celtic Sea. Catches under the mixed fisheries scenarios relative to the single-stock advice.

	Single–stock catches	Catches per mixed–fisheries scenario 2016 Relative to the single stock advice					
Stock	advice 2017*	"Max"	"Min"	"Cod-cs"	"Had-cs"	"Whg-cs"	"Sq_E"
Cod 7.e-k	1.455	2.91	0.98	0.99	1.94	2.90	2.19
Haddock 7.bc,7.e-k	12.444	1.65	0.54	0.56	1.00	1.64	1.24
Whiting 7.bc,7.e-k	25.125	1.01	0.35	0.04	0.63	1.00	0.79

***Weights in thousand tonnes. Advised catches no more than the indicated value.**

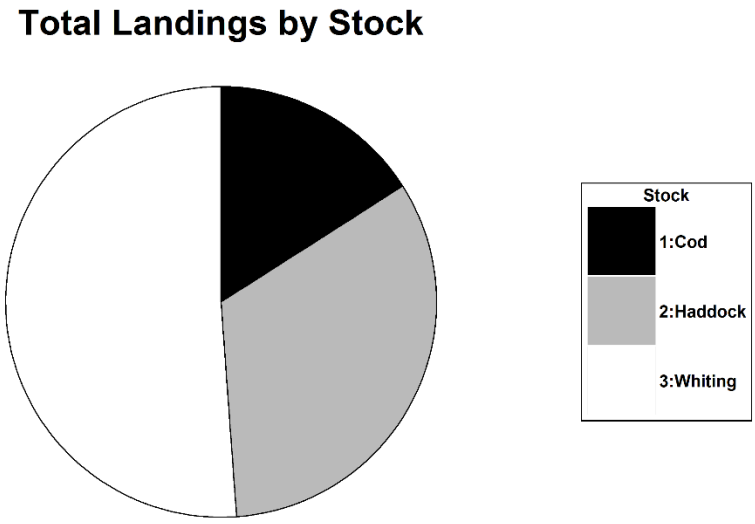


Figure 3.4.1.a. Celtic Sea. Distribution of landings of those stocks included in the mixed fisheries projections.

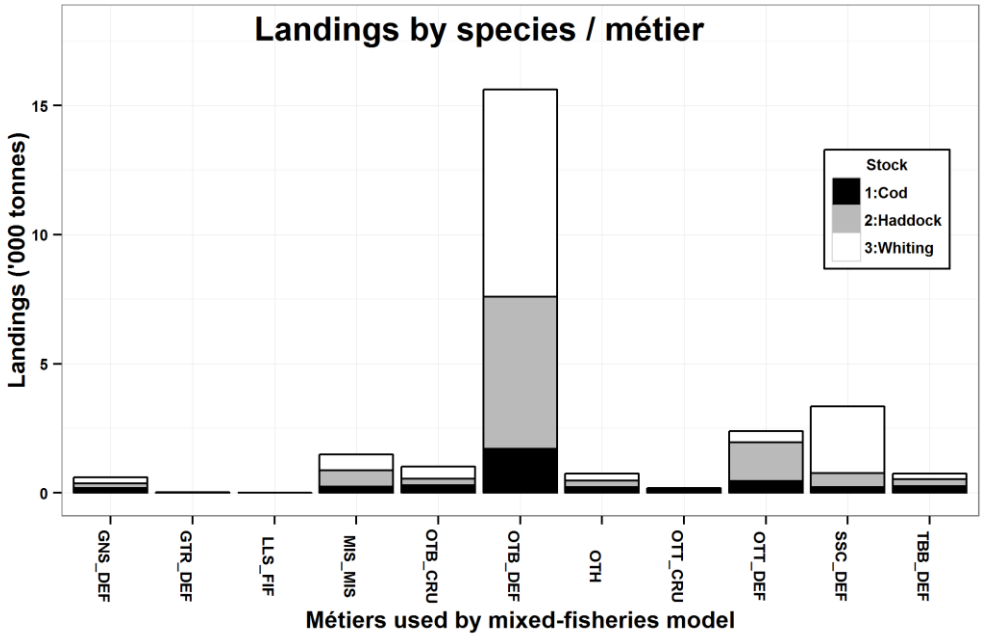


Figure 3.4.1.b. Celtic Sea. Landings distribution of species by métier with landings consisting of ≥ 1% of any of the stocks 1–10 in 2015 Note: The "other" (OTH) displayed here is a mixed category consisting of (i) landings without corresponding effort and (ii) landings of any combination of fleet and métier with landings < 1% of any of the stocks 1–10 in 2015. The "non-allocated" is the differences between total landings used in single-stock advice and mixed-fisheries advice, such as saithe and haddock landings in Subarea VI and VIa respectively.

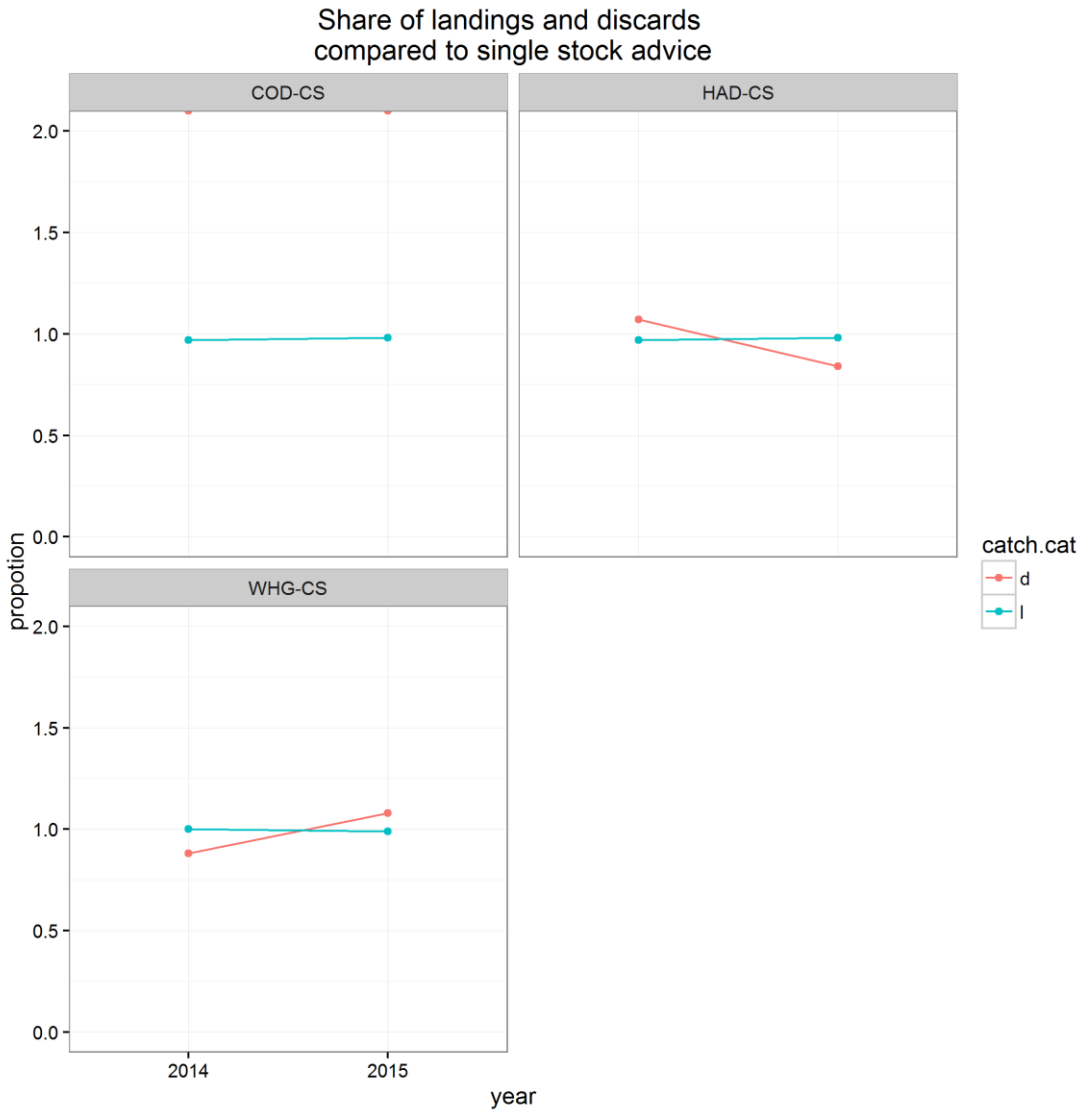


Figure 3.4.2. Celtic Sea. Ratio between the sum of landings (blue, l) and discards (red,d) across fleets used in the MIXFISH analysis and the landings and discards estimated by the WGCSE stock assessments.

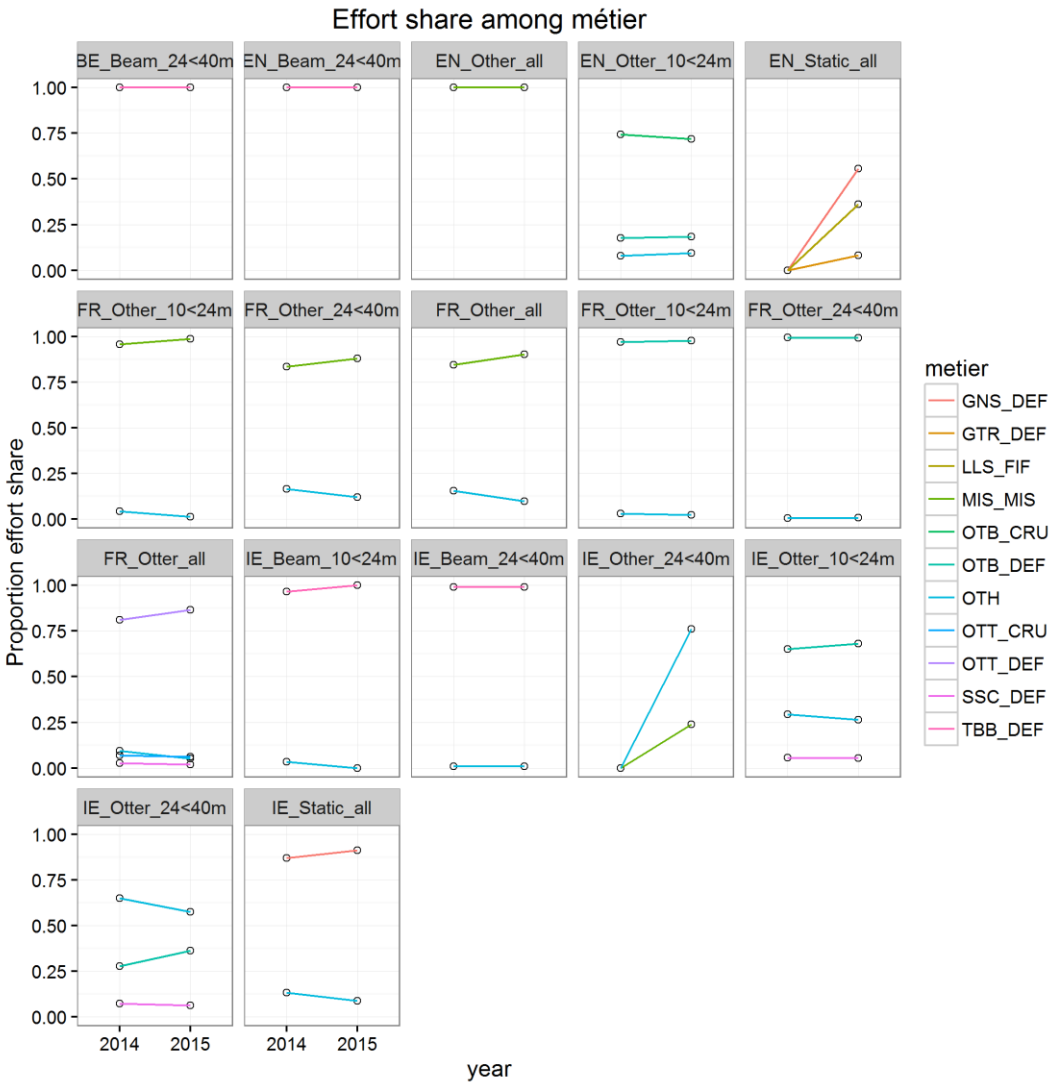


Figure 3.4.3.a. Effort share (in proportion) by métier for each fleet.

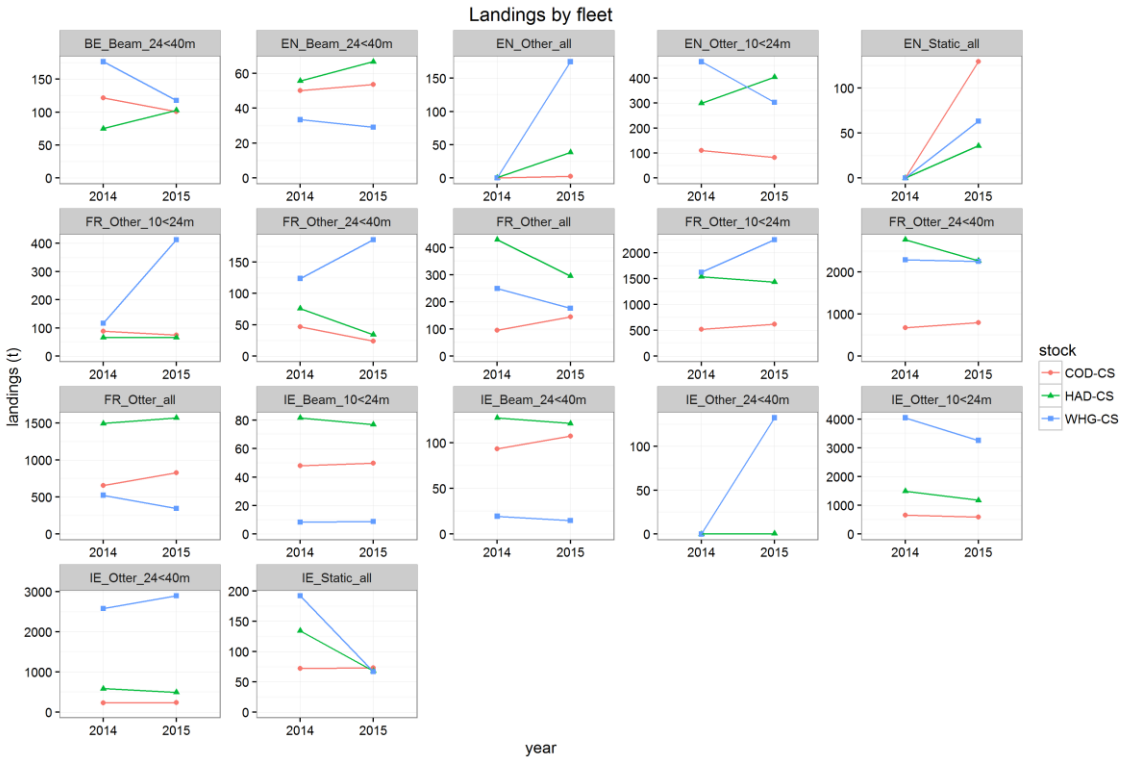


Figure 3.4.3.b. Landings by fleet, stock and year. Note: different scales on the y-axis.

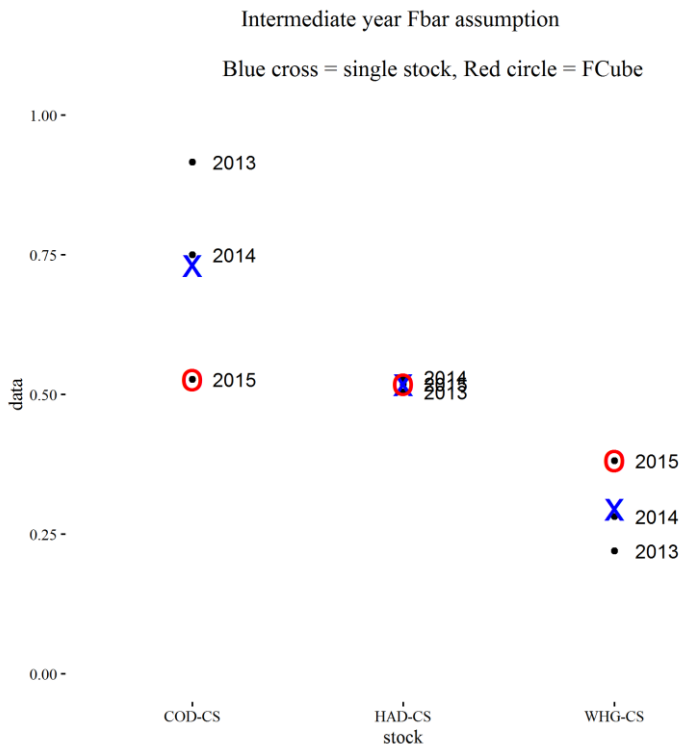


Figure 3.5.1.2.1. Comparison of the intermediate year assumption for the single-stock advice (Blue cross) and an FCube status quo effort (Red circle). Due to the trends in F for some stocks (e.g. cod shows a strong decreasing trend in F, as seen by individual years in black dots) the FCube status quo effort in the intermediate year led to large differences from the single stock assumption – and so a *status quo F* (2013 – 2015) was used in the FCube runs in the intermediate year. This led to more consistency with the single-stock catch advice in 2017.

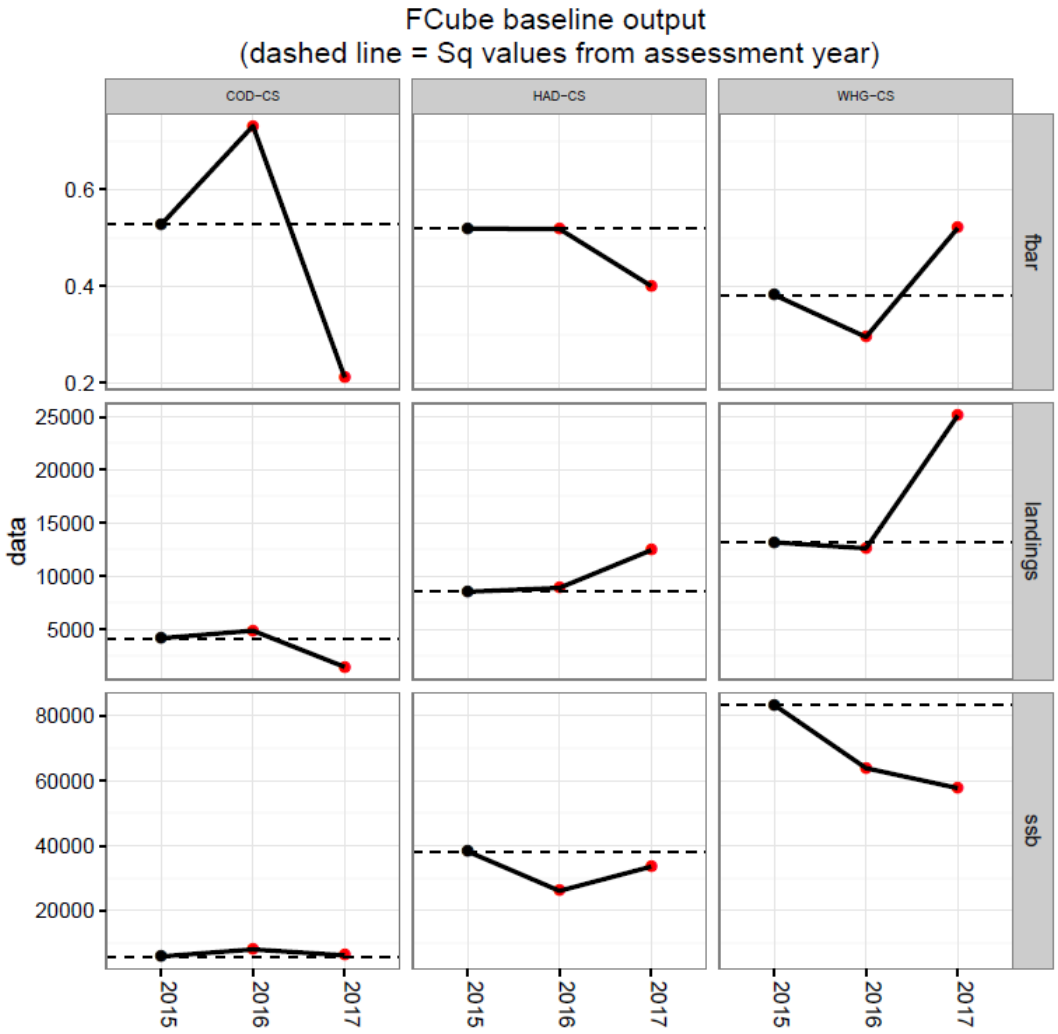


Figure 3.5.2.1.a. Change in Fishing mortality (Fbar), landings (tonnes) and SSB (tonnes) assumed in the intermediate year (2016) and required for the TAC year (2017) under the single stock forecast assumptions consistent with the MSY approach.

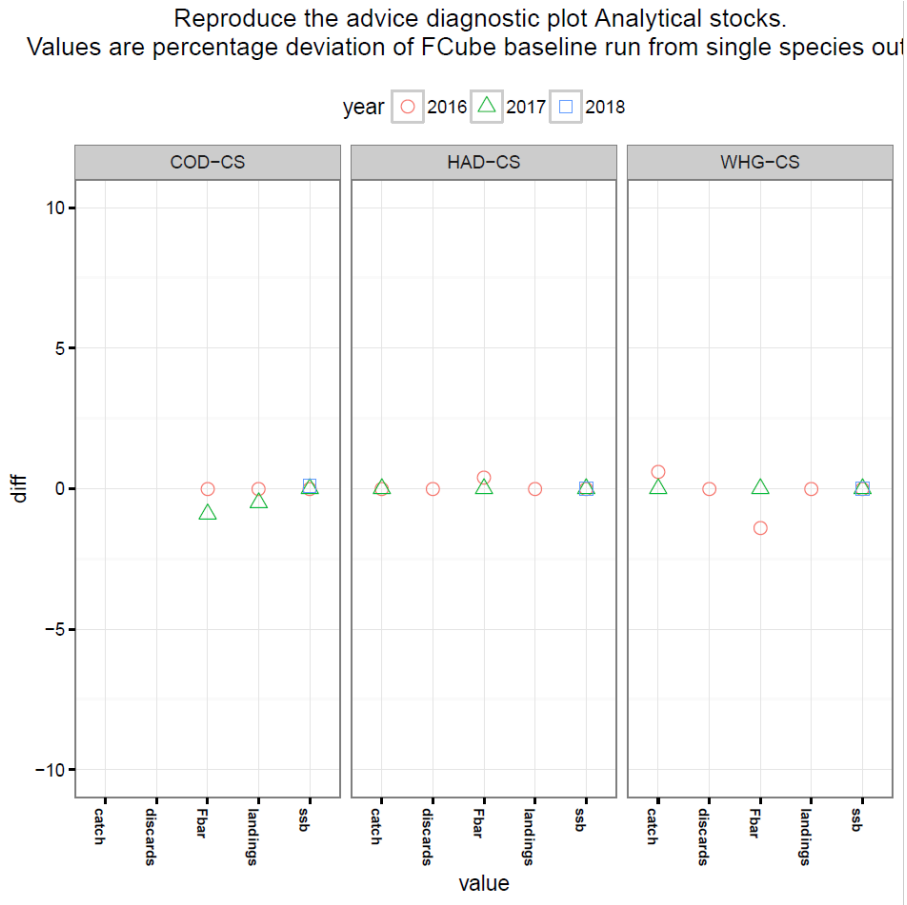


Figure 3.5.2.1.b. Celtic Sea. Difference between Fcube baseline run and Single Species advice for finfish stocks, showing Fbar (2016–2017), catch, discards and landings (2016–2017) and SSB (2017–2018).

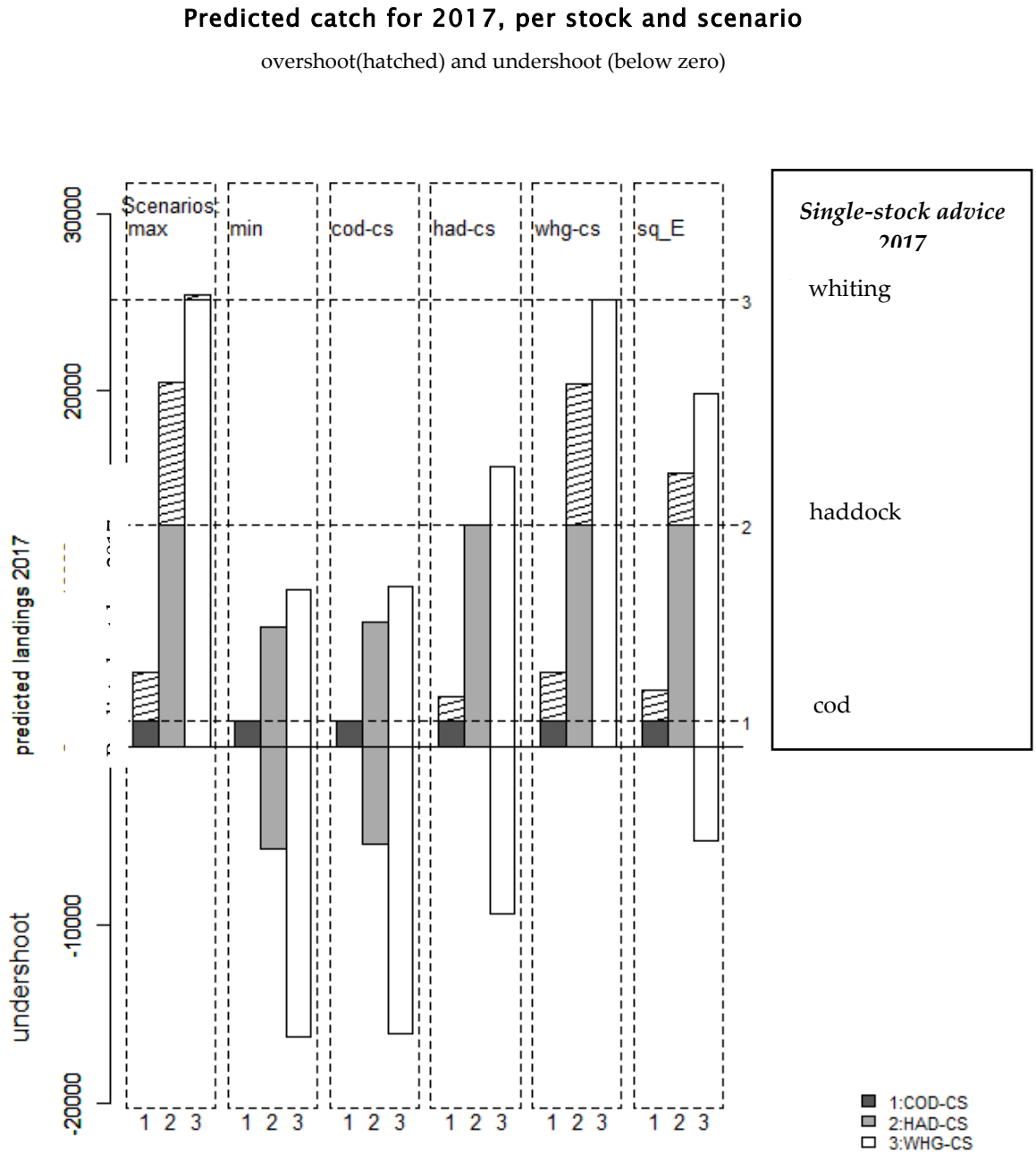


Figure 3.5.2.2.a. Celtic Sea. TAC year results (2017). Fcube estimates of potential landings by stock after applying the *status quo* effort scenario to all stocks in the intermediate year followed by the Fcube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single species TAC) in cases where landings are predicted to be lower when applying the scenario.

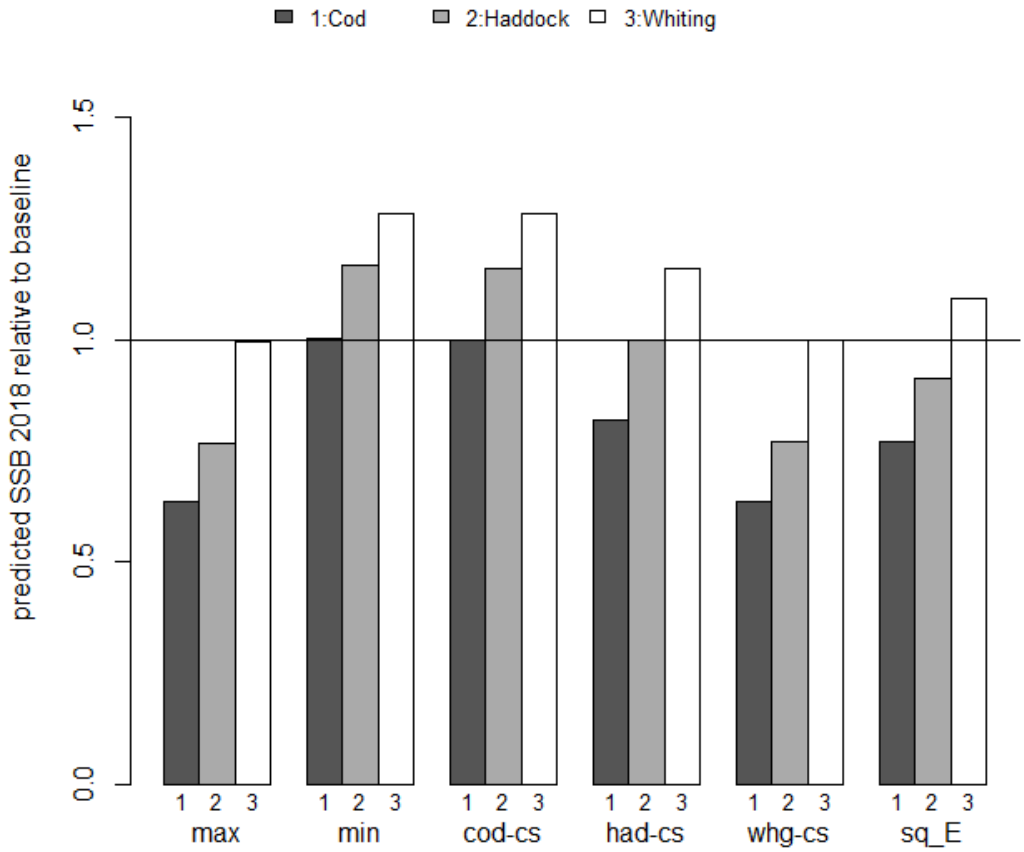


Figure 3.5.2.2.b. Celtic Sea. Estimates of potential SSB at the start of 2018by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2018).

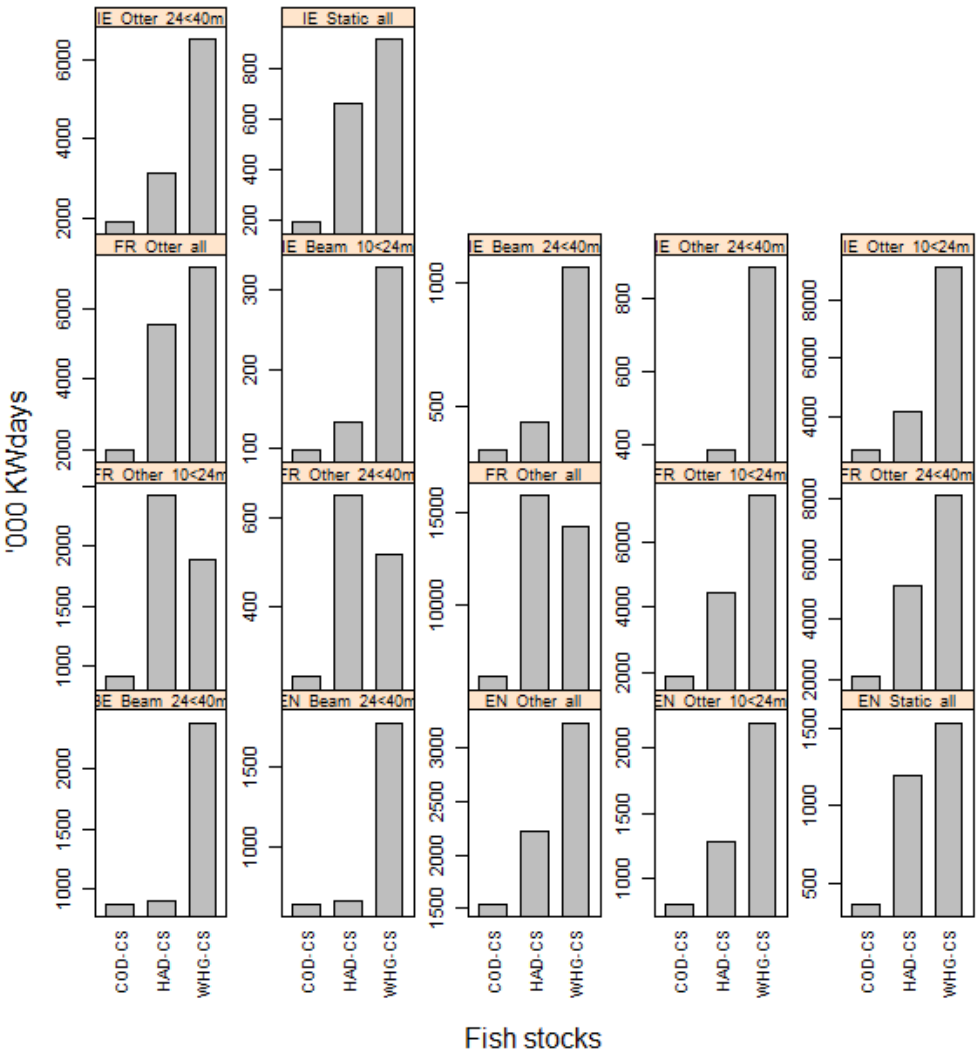


Figure 3.5.2.2.c. Celtic Sea. TAC year results (2016). Fcube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2017(baseline run).

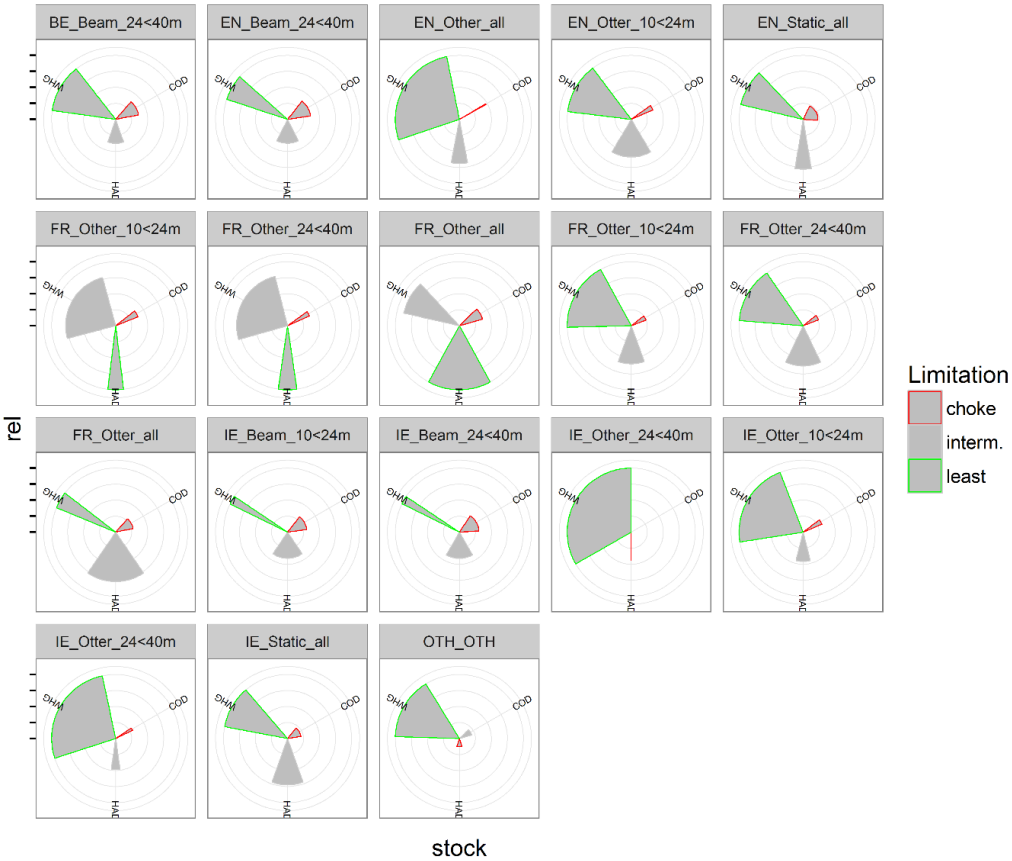
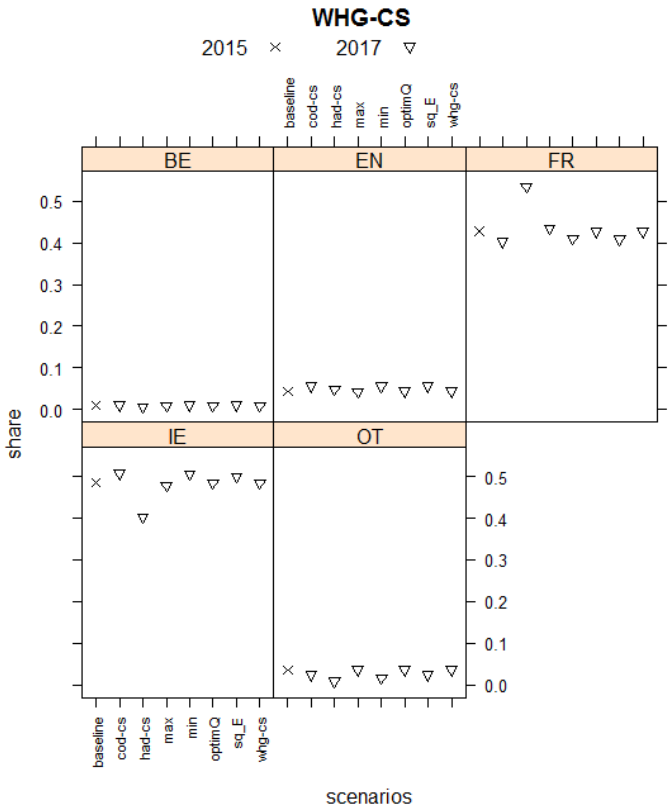


Figure 3.5.2.2.d. Mixed-fisheries advice in the Celtic Sea. Relativefishing effort required to catch each quota by fleet. Each wedge represents the fishing effort required to catch one quota, with the fishing effort to reach the least limiting quota equal to one (outer edge of ring) coloured in green. The most limiting stock is coloured in red. The width of the wedge is proportional to the landings of the stock by the fleet in 2015.


WHG-CS
2015
2017
BE
EN
FR
IE
OT
share
scenarios
baseline
cod-cs
had-cs
max
min
optimQ
sq_E
whg-cs
0.0
0.1
0.2
0.3
0.4
0.5

2011

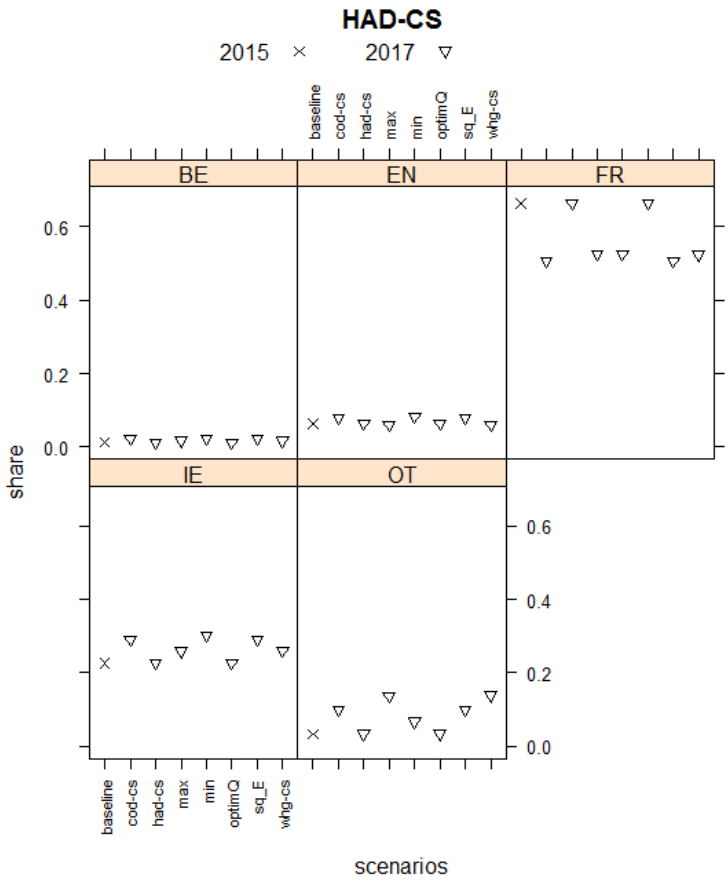


Figure 3.5.2.2.2. Test for relative stability. Changes of relative share of species' landings by country in 2016 and compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

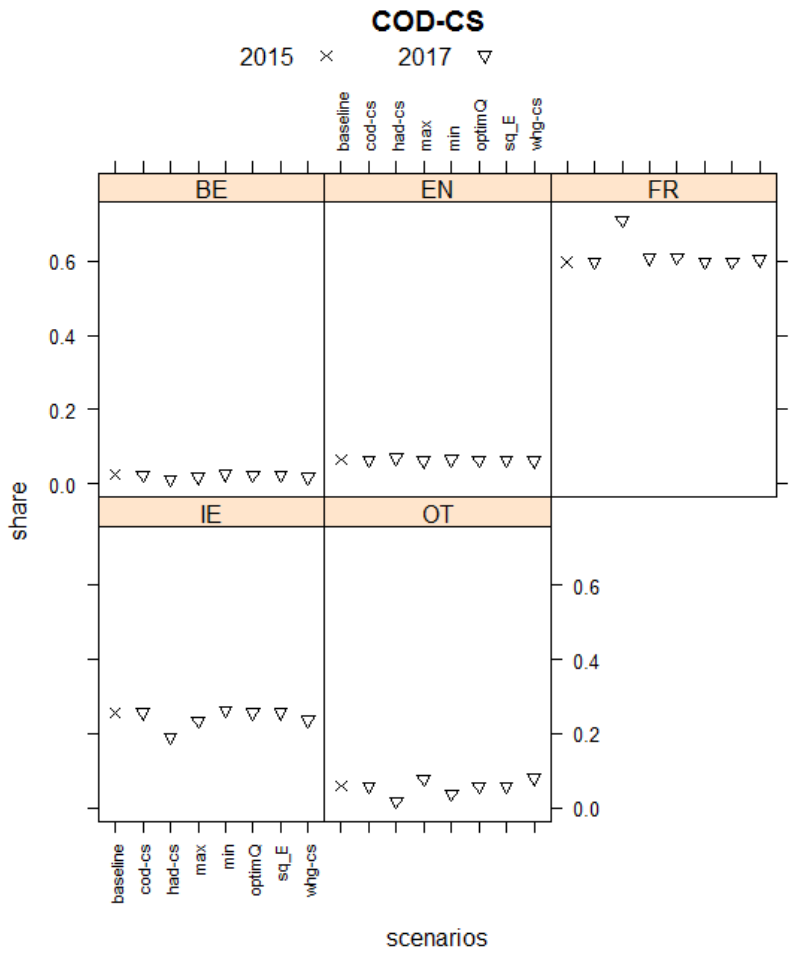


Figure 3.5.2.2.2 (cont). Test for relative stability. Changes of relative share of species' landings by country in 2016 and 2017 compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

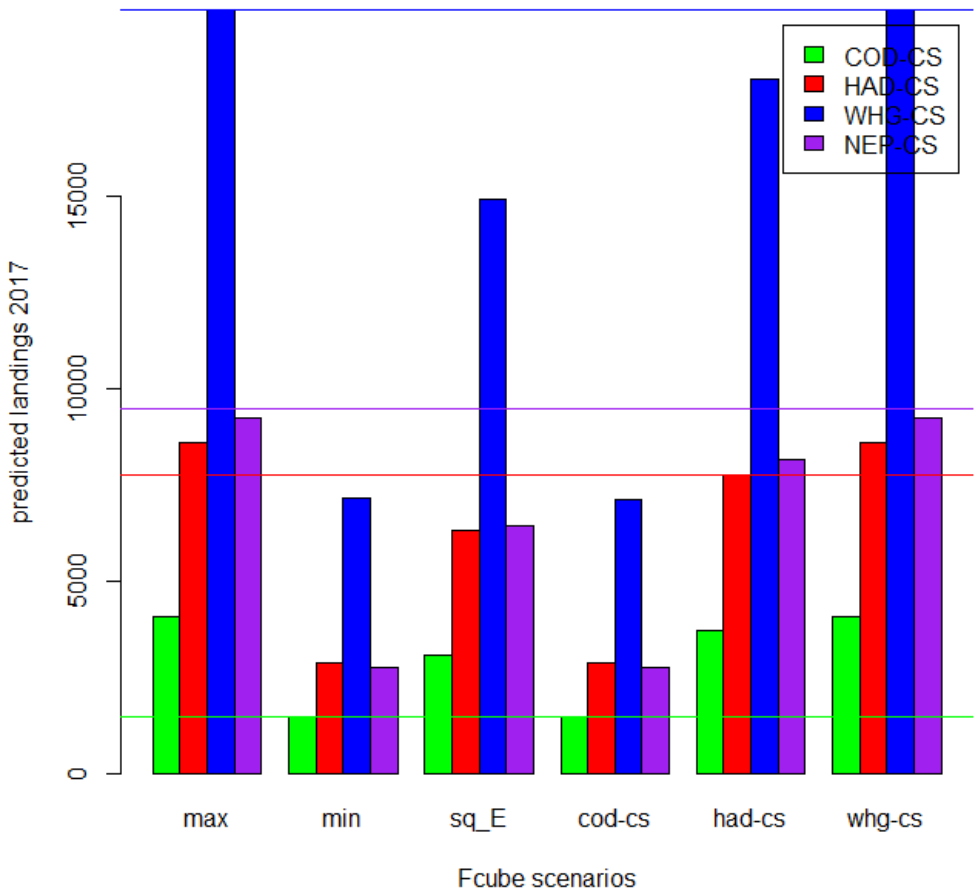


Figure 3.6 Celtic Sea mixed fisheries scenarios for the TAC year (2017) incorporating *Nephrops* stocks from ICES Areas 7 b – k.

4 Iberian waters

4.1 Background

4.1.1 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in Annex IVb of Council Regulation 27/2005 and amended by Council on an annual basis (Annex IIB since then). The objective of this management plan is the recovery of hake and Nephrops of ICES Divisions 8.c and 9.a, and it is applied in both Divisions with the exception of Gulf of Cadiz. The baselines assigned in 2016 (EU Regulation 2016/72) were based on track record per vessel on years 2013 and 2014.

4.1.2 Stock-based management plans

Hake is the only stock considered here as part of the demersal mixed fisheries of the Iberian waters which is subject to multi-annual management plans (Council Regulation (EC) Nº 2166/2005). This plan seeks to rebuild the stock to safe biological limits, set as a spawning-stock biomass above 35 000 tonnes by 2016, and to reduce fishing mortality to 0.27. The main elements of the plan are a 10% annual reduction in F and a 15% constraint on TAC change between years. ICES has not evaluated the southern hake management plan under a single-stock perspective nor under an integrated approach.

4.2 Fcube

4.2.1 Software

All analyses were conducted using the FLR framework (Kell *et al.* (2007); www.flr-project.org; FLCore 2.5.0, FLAssess 2.5.0, Flash 2.5.0) running with R2.15.1 (R Development Core Team, 2011). All forecasts were projected using the same fwd() function in the Flash Package. The Fcube method is developed as a stand-alone script using FLR objects as inputs and outputs.

Software used in the single species assessments and forecasts was as outlined in the text table below.

Species	Assessment	Forecast
HAKE 8.c-9.a	GADGET	GADGET (script: predict.st.sh)
FOUR-SPOT MEGRIM 8.c-9.a	XSA	MFDP
MEGRIM 8.c-9.a	XSA	MFDP
WHITE ANGLERFISH 8.c-9.a	SS3	SS3 (ad hoc R code)

4.2.2 Scenarios

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

In 2016, single-stock ICES advice was given according to MSY approach. Therefore, the same basis was retained in the current mixed-fisheries framework, in which the following six scenarios are considered in the advice:

1) **max**: The underlying assumption was that fishing stops when all quota species are fully utilized with respect to the upper limit corresponding to single-stock exploitation boundary.
2) **min**: The underlying assumption was that fishing stops when the catch for the first quota species meets the upper limit corresponding to single-stock exploitation boundary.
3) **hke**: The underlying assumption was that all fleets set their effort at the level corresponding to their hake quota share, regardless of other stocks.
4) **sq_E**: The effort was set as equal to the effort in the most recently recorded year for which landings and discard data were available.
5) **Ef_Mgt**: The effort in métiers using gear controlled by the EU effort management regime have their effort adjusted according to the regulation (see Council Regulation (EU) 2016/72; Annex IIB).
6) **Hake_MP:** The hake TAC is calculated applying the constraint on inter-annual variation in TAC (15%) established by the current hake management plan (see Council Regulation (EC) Nº 2166/2005, Article 7).

4.3 Stock input data and recent trends

4.3.1 Stocks

4.3.1.1 Data

The assessment data for the different stocks were taken from ICES WGBIE (2016). A number of WGBIE stocks are being assessed using stochastic assessments (GADGET model for southern hake and SS3 for southern white anglerfish). These also make use of stochastic projections, which cannot easily be fully replicated in the deterministic Fcube software. However, Fcube projections are routinely compared to the median projections of the single species stochastic forecasts on which single-stock advice is based. The results show variation over 11% for hake and 5% for white anglerfish, as such WGMIXFISH consider the difference may impact significantly on the mixed fisheries advice.

The final dataset extracted from InterCatch for use by WGBIE includes discards estimates for all stocks and some métiers, and they are included in the assessment of hake and both megrims. InterCatch files also provided non-reported landings besides the official landings. The fleet files specifically required by the WGMIXFISH, needed to split landings by fleet segment and metier, were only provided with official landings, therefore discards and non-reported landings had to be added during the meeting.

4.3.1.2 Trends and Advice

This advice is drafted by the WGBIE-2016 before considerations by ACOM.

Recent trends in SSB, F and recruitment are described on a stock-by-stock basis in ICES (2016), and latest advice by stock is available on the ICES website. In order to give a global overview of all Iberian demersal stocks , this information is summarized below. It should be noted that although there is only one advice, additional management considerations are also listed in the single species advice. Table 4.3.1.2 lists the final advised TACs for 2017 and expected SSBs in 2018.

4.3.1.2.1 Analytical stocks

SPECIES	AREA	STOCK STATUS					SUMMARY	ADVICE 2016
Hake	Divisions 8.c and 9.a	Fishing pressure					The spawning-stock biomass (SSB) has increased since 2004 and is well above Bpa in 2016. The fishing mortality (F) is well above FMSY. Recruitment(R) was high in 2005 to 2009, followed by a period of values closer to the historical mean.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 8049 tonnes.
			2013	2014	2015			
		FMSY	✗	✗	✗	Above		
		Fpa,Flim	✓	✓	✓	Harvested sustainably		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	✓	✓	✓	Above trigger		
		Bpa,Blim	✓	✓	✓	Full reproductive capacity		
		SSBMGT	-	-	-	Not applicable		
Four-spot megrim	Divisions 8.c and 9.a	Fishing pressure					The spawning stock biomass (SSB) decreased from the late 1980s to a minimum in 2001, but since then SSB has increased and is currently above MSY Btrigger. Fishing mortality (F) declined throughout the whole time-series, but has been increasing in the last three years and is currently above FMSY. Recruitment (R) has been around the average	ICES advises on the basis of the MSY approach that catches in 2017 should be no more than 1197 tonnes. If discard rates do not change from the average of the last five years (2011–2015), this implies landings of no more than 861 tonnes.
			2013	2014	2015			
		FMSY	✓	✓	✓	Appropriate		
		Fpa,Flim	✓	✓	✓	Harvested sustainably		
		FMGT	-	-	-	Not applicable		
		Stock size						

SPECIES	AREA	STOCK STATUS	SUMMARY	ADVICE 2016
			since 2000, with the exception of a record high in 2009 and 2012.	
Megrim	Divisions 8.c and 9.a		The spawning stock biomass (SSB) has increased from the minimum observed in 2009, and it is now above MSY Btrigger. Fishing mortality (F) continuously declined until 2010, but it has increased since then and it is now above FMSY. After a period of relatively low recruitment (R), the mean of the last four year classes is close to the long-term average recruitment.	ICES advises on the basis of the MSY approach that catches in 2017should be no more than 214 tonnes. If discard rates do not change from the average of the last five years (2011–2015), this implies landings of no more than 197 tonnes.
White anglerfish	Divisions 8.c and 9.a		The spawning-stock biomass (SSB) has been increasing since 1994 and has been high since 2005. Fishing mortality (F) has been below FMSY since 2008. Recruitment (R) has been low in recent years with no evidence of strong year classes since 2001.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2253 tonnes.All catches are assumed to be landed.

STOCK STATUS

	2013	2014	2015	
MSY Btrigger	✔	✔	✔	Above trigger
Bpa,Blim	✔	✔	✔	Full reproductive capacity
SSBMGT	-	-	-	Not applicable

STOCK STATUS

Fishing pressure				
	2013	2014	2015	
FMSY	✔	✔	✔	Appropriate
Fpa,Flim	✔	✔	✔	Harvested sustainably
FMGT	-	-	-	Not applicable
Stock size				
	2013	2014	2015	
MSY Btrigger	✔	✔	✔	Above trigger

SPECIES	AREA	STOCK STATUS					SUMMARY	ADVICE 2016
		Bpa,Blim	✔	✔	✔	Full reproductive capacity		
		SSBMGT	-	-	-	Not applicable		

4.3.1.2.2 Analytical stocks (not included)

SPECIES	AREA	STOCK STATUS					SUMMARY	ADVICE 2016
Black anglerfish	Divisions 8.c and 9.a	Fishing pressure					Biomass has been increasing since 2000 and is estimated to be above MSY Btrigger over the time-series. Fishing mortality (F) has decreased since 1999 and is estimated to have been below FMSY since 2008.	ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2122 tonnes.All catches are assumed to be landed.
			2013	2014	2015			
		FMSY	✔	✔	✔	Appropriate		
		Fpa,Flim	✔	✔	✔	Harvested sustainably		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	✔	✔	✔	Above trigger		
		Bpa,Blim	✔	✔	✔	Full reproductive capacity		
		SSBMGT	-	-	-	Not applicable		

4.3.1.2.3 Nephrops stocks

SPECIES	AREA	STOCK STATUS					SUMMARY	ADVICE 2016
Nephrops	Division 8.c FU25	Fishing pressure					All information indicates that the stock is at very low abundance level. Landings and lpue have declined continuously. The update of recent data indicates a slight increase in landings and abundance index but remain extremely low.	ICES advises on the basis of the precautionary considerations that there should be no directed fishery and that bycatch should be minimized in both 2017 and 2018. To protect the stock in this functional unit, ICES advises that the management area should be consistent with the assessment area.
			2013	2014	2015			
		FMSY	-	✔	-	Undefined		
		Fpa,Flim	-	✔	-	Undefined		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	✘	✘	✘	Below		
		Bpa,Blim	✘	✘	✘	Below		
		SSBMGT	-	-	-	Not applicable		
Nephrops	Division 9.a FU2627	Fishing pressure					All information indicates that the stock is at a very low abundance level. Landings and lpue have fluctuated along a marked downward trend and are currently very low. Mean sizes have shown an increasing trend over the time-series, which may reflect poor recruitment.	ICES advises that when the precautionary approach is applied, there should be no directed fishery and bycatch should be minimized in both 2017 and 2018. To protect the stock in these functional units, ICES advises that management should be implemented at the functional unit level.
			2013	2014	2015			
		FMSY	-	✔	-	Undefined		
		Fpa,Flim	-	✔	-	Undefined		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	✘	✘	✘	Below		

		Bpa,Blim	✗	✗	✗	Below		
		SSBMGT	-	-	-	Not applicable		
Nephrops	Division 9.a FU2829	Fishing pressure					Standardized commpercial cpue has increased since 2011. Landings and effort had small fluctuations in the period 2011-2015 due to quota limitations resulting from the recovery plan rules, currently in force. Mean sizes have fluctuated along the period with no apparent trend.	ICES advises that when the precautionary approach is applied, should be no more than 260 tonnes in each of the years 2017 and 2018. All catches are assumed to be landed. To protect the stock in these functional units, ICES advises that management should be implemented at the functional unit level.
			2013	2014	2015			
		FMSY	-	✓	-	Undefined		
		Fpa,Flim	-	✓	-	Undefined		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	-	?	-	Undefined		
		Bpa,Blim	?	?	?	Undefined		
		SSBMGT	-	-	-	Not applicable		
Nephrops	Division 9.a FU30	Fishing pressure					Over the time series the abundance index have declined up to 2010 but it increased in the 2011-2013 period. The update of the index indicates that the abundance of the stock has decreased in recent years. The reduction of the size indicator (cpue) in the last two years (2014-2015) was greater than 20% . The effort between 2013 and 2015 remained stable and was 80% lower than observed in the 2008-2012 period due to the penality applied in the period for exceeding the quota in 2012.	ICES advises on the basis of the precautionary approach that catches should be no more than 76 tonnes in each of the years 2017 and 2018. All catches are assumed to be landed. To protect the stock in this functional unit, ICES advises that management should be implemented at the functional unit level.
			2013	2014	2015			
		FMSY	-	✓	-	Undefined		
		Fpa,Flim	-	✓	-	Undefined		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	-	?	-	Unknown		
		Bpa,Blim	-	?	-	Unknown		
		SSBMGT	-	-	-	Not applicable		

Nephrops	Division 8.c FU31	Fishing pressure					All information indicates that the stock is at a very low abundance level. Landings and lpue have declined continuously and are currently extremely low.	ICES advises on the basis of the precautionary considerations, that there should be no directed fishery and bycatch should be minimized in both 2017 and 2018. To protect the stock in this functional unit, ICES advises that the management area should be consistent with the assessment area.
			2013	2014	2015			
		FMSY	-	✔	-	Undefined		
		Fpa,Flim	-	✔	-	Undefined		
		FMGT	-	-	-	Not applicable		
		Stock size						
			2013	2014	2015			
		MSY Btrigger	✘	✘	✘	Below		
		Bpa,Blim	✘	✘	✘	Below		
		SSBMGT	-	-	-	Not applicable		

4.3.1.2.4 Ancillary stocks

SPECIES	AREA	STOCK STATUS	SUMMARY	ADVICE 2016
Seabass	Divisions 8.c and 9.a	Not available yet	Not available yet	Not available yet
Plaice	Subarea 8 and Division 9.a	Not available yet	Not available yet	Not available yet
Pollack	Subarea 8 and Division 9.a	Not available yet	Not available yet	Not available yet
Sole	Divisions 8.c and 9.a	Not available yet	Not available yet	Not available yet
Whiting	Subarea 8 and Division 9.a	Not available yet	Not available yet	Not available yet

4.4 Fleets and métiers

4.4.1 Catch and effort Data

Métier-based landings and effort files requested by the WGMIXFISH data call were provided by the three countries with fleets in Atlantic Iberian waters, *i.e.* Spain, Portugal and France. InterCatch datafiles are also needed to compile discards and non-reported landings which are not provided in the MIXFISH datacall. 2015 data were combined with 2014 data used in last year's WGMIXFISH, in order to carry out a comparison between those two years with the aim of exploring possible trends in effort and catches by country, fleet and métier.

4.4.2 Definitions of fleets and métiers

The fleet and métier disaggregation available was the current DCF structure for the Spanish and French fleets, while the Portuguese data were provided re-aggregated into two groups: polyvalent artisanal fleet and bottom otter trawl. As the French data only provided landings of hake which were not considered in the hake assessment, they were not included in the mixed-fisheries analysis for consistency. The final data provided to the WG contained 11 métiers (Table 4.4.2.a). Regarding fleet segments, size vessels categories were only required for trawl gear: <10m, 10<24m, and 24<40m.

Total catches (in weight) obtained by multiplying the catch-at-age in numbers by the average weight at age used as input in the WGMIXFISH analysis are compared with the total catches (in weight) used by WGBIE in the single species assessments (Table 4.4.2.b). Some discrepancies are observed for hake and anglerfish. Those discrepancies are due to the conversion of catch numbers at length (the assessment models being length based) into numbers at age used in the mixed fishery model.

The original 11 métiers were split by ICES Divisions obtaining a final set with 17 métiers (Figure 4.4.2). Hake provides the highest catches of all metiers except for

DEF_>=100_0_0_8.c, which corresponds with the Spanish gillnet targeting white anglerfish ("*rasco*") in Cantabrian Sea. Megrims are mainly caught by the Spanish bottom otter trawl (OTB_DEF_>=55_0_0): while four-spot megrim appears in both divisions (8.c and 9.a), megrim appears only in Division 8.c.

4.4.3 Trends

Analyses of trends by fleet were carried out on 2014 and 2015 data. A number of overview graphs (using the Lattice package in R) were produced to aid quality checking of the data once compiled into the final fleets object for catches, effort and catchability. In order not to extend the report with repetitive graphics, only the catchability plots by stock, fleet and métier for Spain (Figure 2.4.3.a) and Portugal (Figure 2.4.3.b) are included in this report. Spanish catchabilities do not show particular trends, except a slight decreases for hake and white anglerfish in gillnets "*volanta*" (GNS_DEF_80-99_0_0) and "*rasco*" (GNS_DEF_>100_0_0), respectively, while four-spot megrim catchability show an increase in "*baca*" (OTB_DEF_>=55_0_0). On the other hand, the Portuguese catchabilities show a general decrease for all stocks in the bottom otter trawl métier (OTB_9.a).

4.5 Mixed fisheries forecasts

Discrepancies were found between the FCube baseline runs and the single stock forecasts in hake and white anglerfish similar to those obtained last year (ICES, 2015). These discrepancies are attributed to methodological differences between the length-based assessment models used by WGBIE and the age-based forecast reproduced by WGMIXFISH. As expected, the FCube baseline runs reproduced the megrim and four-spot megrim single-stock forecasts, which are assessed by applying the XSA model.

4.5.1 Description of scenarios

4.5.1.1 Baseline Runs

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

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

The various single-stock forecasts presented by WGBIE are performed using different software and setups (see 4.2.1 above). However, for the purpose of the mixed-fisheries analyses, it is necessary to gather all forecasts into a single unified framework, which builds on the 'fwd()' method in FLR (Flash R add-on package). The same forecast settings as in WGBIE are used for each stock regarding weight-at-age, selectivity and recruitment, as well as assumptions on the F in the intermediate year and basis for advice (LTMP or MSY approach).

4.5.1.2 Mixed fisheries runs

The mixed fishery analysis used a status quo effort assumption for the intermediate year (2016), with the Fcube scenarios used for the TAC year (2017). The status quo effort assumption for the intermediate year is considered a plausible assumption because is in line with the standard single-stock short-term forecasting approach.

This year, the projections were run assuming a full and perfect implementation of a discard ban in 2017 (*i.e.* all quota species caught must be landed, with no exemptions, *de minimis* or inter-species flexibilities).

In summary, the Fcube runs followed the scheme below:

Single stock assessment 2016

MSY approach

sq_E

status quo

2016

↓

Catch in 2016 & SSB at start of 2017

FCUBE 2017

Single-stock ICES advice for 2017	**max**	**min**	**hke**	**sq_E**	***Ef_mgt***	**Hake_MP**
applied to FCUBE (sq_E)	↓	↓	↓	↓	↓	↓

Potential Over / Under catch against single stock advice (Difference between single species advised catch and expected catch)

In addition to this set of scenarios, the same as last year, during this WGMIXFISH meeting other scenarios were explored taken, besides hake, also each of the remaining species as limiting stock: scenarios "ldb" (four-spot megrim as limiting stock), "meg" (megrim), and "mon" (white anglerfish).

4.5.2 Results of Fcube runs

4.5.2.1 Baseline run

The rationale behind the single species baseline runs is given in Section 4.3.1.2. The ICES single-stock advice for these stocks in 2016 (ICES, 2016) is based on the maximum sustainable yield (MSY) approach. The issues and problems encountered in replicating the single species advice for each species are given below. The results from these baseline runs are compared with the results from the corresponding ICES runs in Tables 4.5.2.1.a and 4.5.2.1.b.

Hake

Discrepancies of 11% were obtained for hake. This stock is assessed by the GADGET model (Frøysa *et al.*, 2002; Begley and Howell, 2004), a stochastic assessment model which is difficult to simulate in a mixed-fisheries deterministic forecast. GADGET is a forward simulation model that can be structured in both age and length; therefore requiring direct modelling of growth within the model. In the case of southern stock of hake, the model is length based and F multipliers do not apply linearly. The southern stock of hake was assessed by applying XSA until 2009. However, evidences of substantial growth underestimation provided by tagging results, made evident the age

overestimation by the internationally agreed age estimation method. In 2010, a benchmark (WKROUND) was undertaken in order to solve the consequences of this problem on the assessment, where a GADGET model was introduced (ICES, 2010).

Four-spot megrim

Straightforward, no problems encountered. This stock is assessed by applying the XSA model. In 2014, a benchmark (WKSOUTH) was undertaken in order to include discards on the assessment (ICES, 2014).

Megrim

Straightforward, no problems encountered. This stock is assessed by applying the XSA model. In 2014, a benchmark (WKSOUTH) was undertaken in order to include discards on the assessment (ICES, 2014).

White anglerfish

Discrepancies of 5% were obtained for white anglerfish. The assessment of this stock is performed by applying the SS3 model (Methot, 2000) disaggregated by length. This methodology is applied to this stock since it was accepted in the WKFLAT benchmark in 2012 (ICES, 2012) in order to solve the growth uncertainties detected in the previous age-based model. Assessment outputs disaggregated by age need to be specifically required to the stock coordinator. This transformation may explain the discrepancies obtained.

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

4.5.2.2 Mixed fisheries analyses

The full overview of the Fcube projections to 2017 is presented in Table 4.5.2.2 and Figures 4.5.2.2.a to 4.5.2.2.c. The results for 2017 can be compared to each other as in a single-species option table. For ease of comparison, the landings relative to the single-stock advice are also presented.

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

ICES single-stock advice provides TACs expected to meet single stock FMSY. To be consistent with these objectives a scenario is necessary that delivers the SSB and/or F objectives of the single-stock advice for all stocks considered simultaneously. The "**min**" scenario meets this outcome. Additionally, this scenario assumes that fleets would stop fishing when their first stock share is exhausted, regardless of the actual importance of this stock share for the fleet. While this can be considered an unlikely scenario as long as discarding is allowed, this scenario reflects the constraints that result from a strictly implemented discard ban. Fishing effort should be reduced by 53% of its 2016 level to comply with this scenario, consistent with the reductions in fishing mortality advised for four-spot megrim (very close to the F reduction for hake), and causing reductions of catches in the remaining species higher than those determined by their respective single-stock advice. The "**hke**" scenario gives a result very similar

to the "min" scenario, showing hake as the choke species together four-spot megrim. This scenario reflects the target fishing mortality as set for the hake MSY approach; however the results present loss of fishing opportunities for white anglerfish and, in a lesser extent, for megrim.

Beside the "max" and "min" scenarios, which are shown to bound the results rather than provide realistic levels of catches in 2017, four intermediate, more likely, scenarios were also considered taking into account the current management measures in place. The "**sq_E**" and **"**Ef_Mgt**"** scenarios provide similar over-quota catches for hake and four-spot megrim. For the "**Ef_Mgt**" scenario, the 2016 effort is maintained at the level of 2015 (Council Regulation (EU) 2015/104; Annex IIB). This is different from previous years where an annual 10% effort reduction has been applying since the hake management plan (Council Regulation (EC) Nº 2166/2005) was established. The "**Hake_MP**" scenario gives the expected outcome when the constraint on inter-annual variation in TAC (15%) established by the current hake management plan is applied, while the fleet dynamics is set as in the "hke" scenario. The results of the "Hake_MP" scenario provides lower catches than the "max", "sq_E", and "Ef_Mgt" scenarios for all stocks.

The results of the alternative scenarios explored during this WGMIXFISH meeting, taking each species as limiting stock (Figure 4.5.2.2.d) confirm hake as a choke stock in the Iberian waters mixed-fisheries system. Scenarios with four-spot megrim ("**ldb**"), megrim ("**meg**") and white anglerfish ("**mon**") as limiting stocks produce quota overshooting for hake. This means that although the "min" scenario is determined by the F of four-spot megrim, this restriction only affects metiers catching four-spot megrim in scenario "ldb". These metiers are restricted to bottom otter trawl gear, while hake occurs in the catches of almost all Iberian metiers. However, while scenarios "ldb" and "meg" give levels lower than "sq_E", scenario "mon" produces a picture more similar to the "max" scenario.

4.5.2.2.1 Ancillary stocks

The revised CFP includes a commitment to introduce a landing obligation (excepting some defined exceptions) in EU demersal fisheries in a phased approach from 2016 until 2019. As such, there is increasing interest in the potential other stocks which may limit fishing activity under the new regulatory regime. The impact of mixed fisheries scenarios on stocks without analytical assessment can be explored by using the respective catch per unit effort values. This approach was not carried out this time; however, further mixed-fisheries analyses could include the Iberian Nephrops Functional Units as well as the ancillary Iberian stocks recently considered by WGBIE: seabass, plaice, pollack, sole and whiting.

4.5.2.2.2 Relative stability

Relative stability as such is not directly included as an input to the model. Instead, an assumption that the relative landings share of the fleets are constant is used as a proxy, and in the scenarios above, this input was derived from the landing share by fleet and stock in 2015. The landings by national fleets were summed over nation for each scenario, and the share by country was compared with this initial input. The results did not show deviations across all scenarios (Figures 4.5.2.2.2.a to 4.5.2.2.2.d).

Table 4.3.1.2. Iberian waters: Summary of the 2017 landings and target Fs, resulting from the Advice Approaches considered by ICES. TACs make reference to total catches, as they are used in the assessment model, except for white anglerfish which represent only landings.

Stocks	TAC 2017	F 2017	SSB 2018	Rational
Hake 8.c-9.a	8049 t	0.25	37110 t	MSY approach
Four-spot megrim 8.c-9.a	1197 t	0.19	7507 t	MSY approach
Megrim 8.c-9.a	214 t	0.19	1018 t	MSY approach
White anglerfish 8.c-9.a	2253 t	0.31	7303 t	MSY approach

Table 4.4.2.a. Métier categories used in the Iberian waters mixed-fisheries analysis.

Acronym	DCF definition	Description
GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Spanish set gillnet ("rasco") targeting white anglerfish in ICES Division 8.c with mesh size of 280 mm
GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60–79 mm	Spanish small set gillnet ("beta") targeting a variety of demersal fish in north-western Spanish waters
GNS_DEF_80-99_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 80–99 mm	Spanish set gillnet ("volanta") targeting hake with nets of 90 mm mesh size in north-western Spanish waters
GTR_DEF_60-79_0_0	Trammel net targeting demersal fish with mesh sizes within the range 60–79 mm	Spanish trammel net targeting a variety of demersal species in north-western Spanish waters
LLS_DEF_0_0_0	Set longline targeting demersal fish	Spanish set longline targeting a variety of demersal fish in Spanish Iberian waters
MIS_MIS_0_0_0	Miscelaneous	Portuguese and Spanish artisanal fleet not covered by other metiers
OTB	----	Portuguese bottom otter trawl
OTB_DEF_>=55_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting hake, anglerfish, and megrim using "baca" nets of 70 mm mesh size in Divisions 8.c and 9.a
OTB_ MCD_>=55_0_0	Bottom otter trawl targeting mixed crustaceans and demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting a variety of fish and crustaceans using nets of 55 mm mesh size in south-western Iberian waters (Gulf of Cadiz and Southern Portuguese waters)
OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Spanish bottom otter trawl targeting pelagic (horse mackerel, mackerel…) and demersal fish (hake) by using "jurelera" nets of 55 mm mesh size in north-western Spanish waters
PTB_ MPD _>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Bottom pair trawl targeting pelagic (blue whiting, mackerel…) and demersal fish (hake) by using nets of 55 and 70 mm mesh size in north-western Spanish waters

Table 4.4.2.b. Iberian waters: Proportion of the stocks total catches (from WGBIE) covered by the WGMIXFISH fleets. A ratio >1 means that the catch information in WGMIXFISH is larger than the information used by WGBIE.

YEAR	STOCK	WGBIE	WGMIXFISH	DIFFERENCE	RATIO
2016	HKE	11057	13943	2887	0.8
2016	LDB	1755	1764	9	1.0
2016	MEG	299	297	-3	1.0
2016	MON	1633	1748	115	0.9

Table 4.5.2.1.a. Iberian waters: Baseline run outputs from the Fcube FLR package.

	MANAGEMENT PLAN	HKE	LDB	MEG	MON
2016	Fbar	0.60	0.36	0.28	0.21
	FmultVsF15	1.15	0.89	1.05	0.98
	Landings	13240	2152	310	1541
	SSB	26266	7175	1081	7643
2017	Fbar	0.29	0.19	0.19	0.31
	FmultVsF15	0.55	0.47	0.74	1.46
	Landings	7157	1197	214	2146
	SSB	26813	6923	995	7673
2018	SSB	35162	7483	1014	6990

Table 4.5.2.1.b. Iberian waters: Comparison between baseline run and ICES advice. Figures for 2016 compare results from the baseline run - that use the same assumptions for F in the intermediate year as the forecasts leading to ICES advice – to the ICES intermediate year results.

	MANAGEMENT PLAN	HKE	LDB	MEG	MON
2016	Landings Baseline	13240	2152	310	1541
	Landings ICES	13473	2154	310	1623
	% difference	-2%	0%	0%	-5%
2017	Landings Baseline	7157	1197	214	2146
	Landings ICES	8049	1197	214	2253
	% difference	-11%	0%	0%	-5%

Table 4.5.2.2.: Results of running Fcube scenarios on the TAC year (2017). Comparison of the singe-stock ICES advice and potential landings in the various Fcube scenarios.

	Single–stock catches advice 2017		Catches per mixed–fisheries scenario 2017 relative to the single–stock catch advice					
Stock	WGBIE	WGMIXFISH	"Max"	"Min"	"Hke"	"Sq_E"	"Ef_Mgt"	"Hake_MP"
Hake 8.c-9.a	8049	7157	2.30	1.00	1.02	1.85	1.86	1.53
Four-spot megrim 8.c-9.a	1197	1197	2.35	0.96	0.97	1.85	1.92	1.42
Megrim 8.c-9.a	214	214	1.69	0.68	0.69	1.32	1.37	1.01
White anglerfish 8.c-9.a	2253	2146	0.98	0.37	0.37	0.75	0.76	0.65

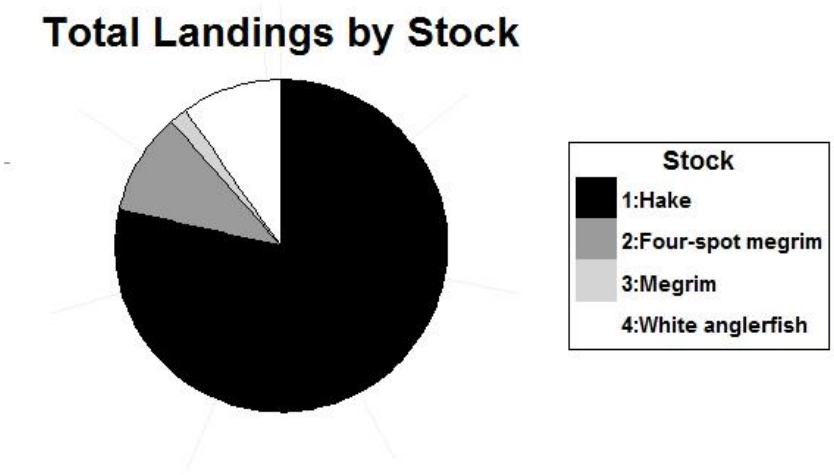


Figure 4.4.1. Iberian waters: Distribution of landings of the stocks included in the mixed fisheries projections.

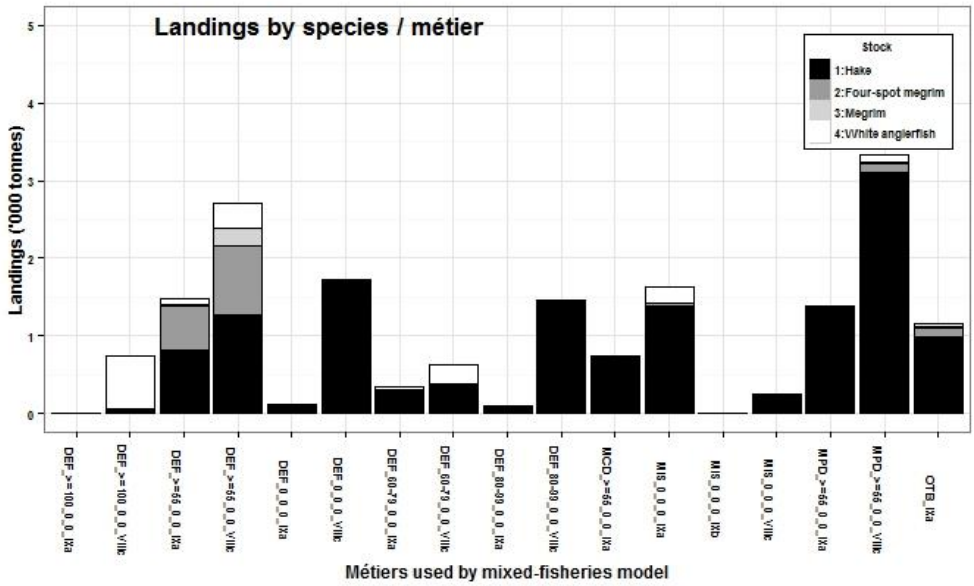


Figure 4.4.2. Iberian waters: Landings distribution of species by métier.

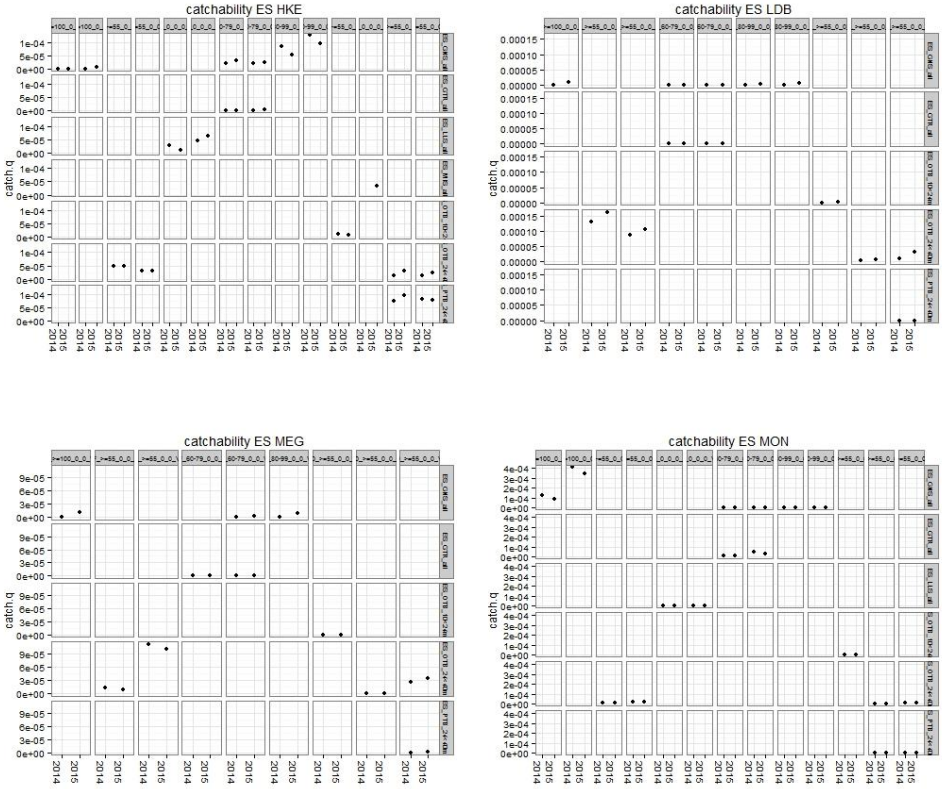


Figure 4.4.3.a. Iberian waters: trends of Spanish catchability by stock, fleet and métier.

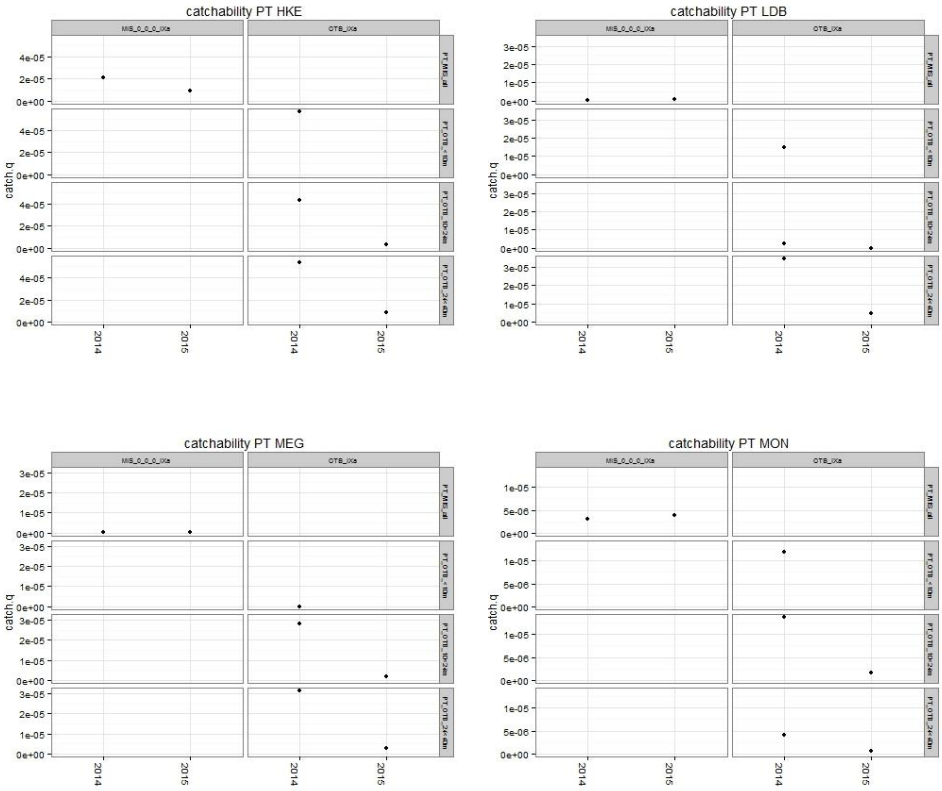


Figure 4.4.3.b. Iberian waters: trends of Portuguese catchability by stock, fleet and métier.

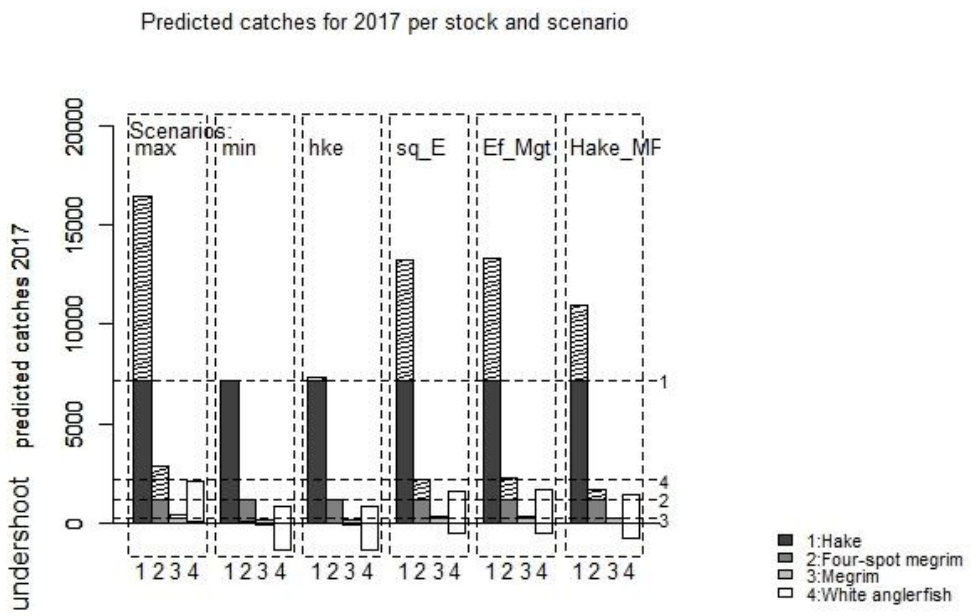


Figure 4.5.2.2.a. Iberian waters mixed-fisheries forecasts: TAC year results (2017). Fcube estimates of potential catches by stock after applying the status quo effort scenario to all stocks in the intermediate year followed by the Fcube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice. Bars below the value of zero show the scale of undershoot (compared to the single species catch advice) in cases where catches are predicted to be lower when applying the scenario.

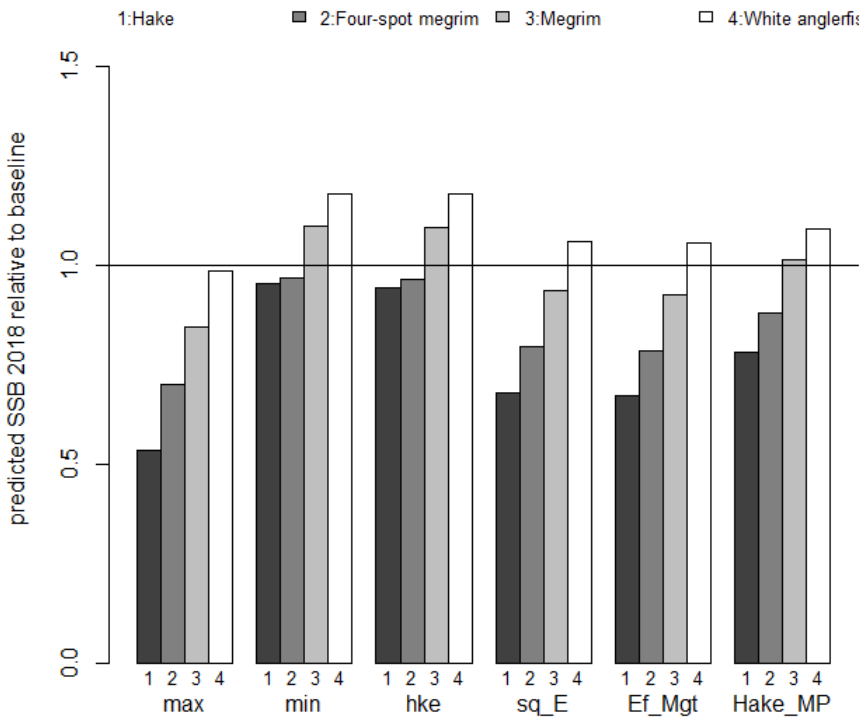


Figure 4.5.2.2.b. Iberian waters mixed-fisheries forecasts: Estimates of potential SSB at the start of 2018 by stock after applying the mixed fisheries scenarios, expressed as a ratio to the single species advice forecast. Horizontal line corresponds to the SSB resulting from the single-stock advice (at the start of 2018).

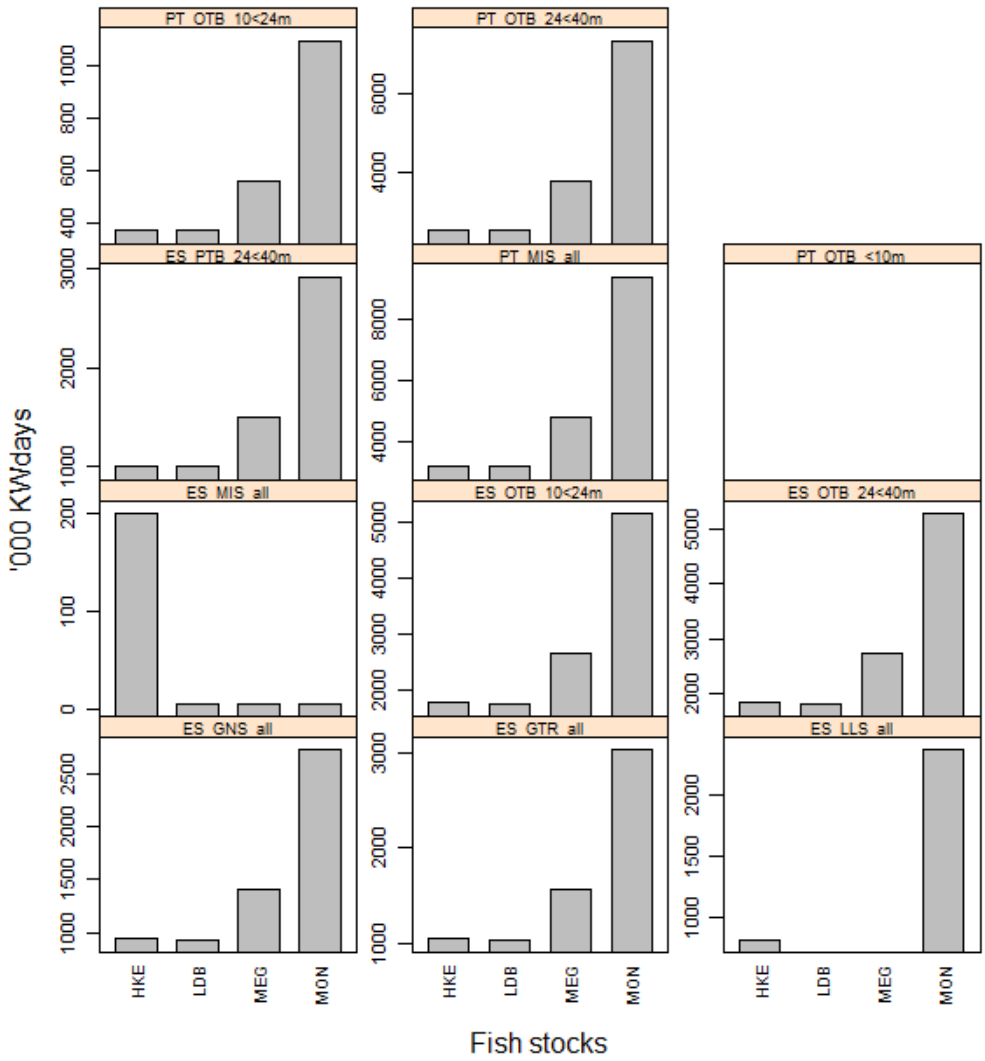


Figure 4.5.2.2.c. Iberian waters mixed-fisheries forecasts: TAC year results (2017). Fcube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2017 (baseline run).

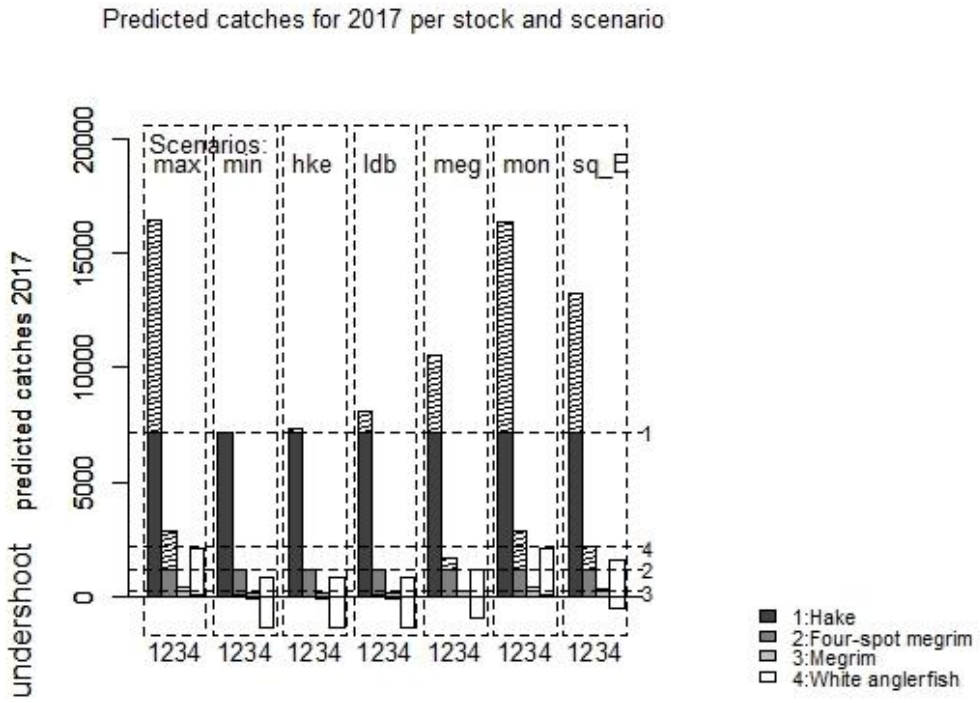


Figure 4.5.2.2.d. Iberian waters mixed-fisheries forecasts for the alternative scenarios taking each species as limiting stock.

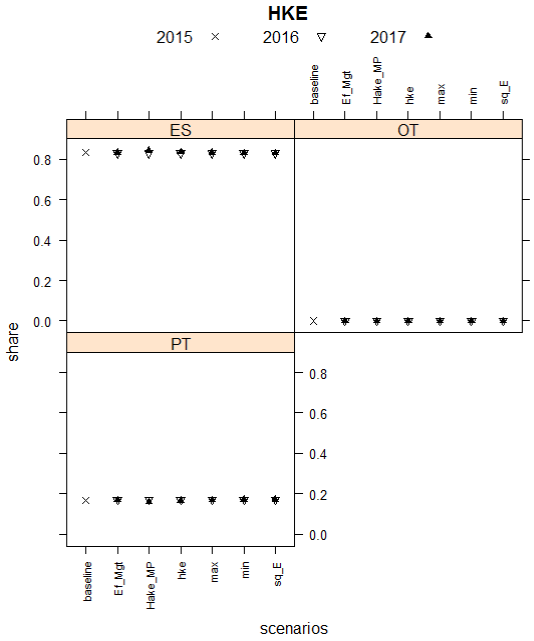


Figure 4.5.2.2.2.a. Iberian waters mixed-fisheries forecasts: Test for relative stability. Changes of relative share of hake' landings by country in 2016 and 2017 compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

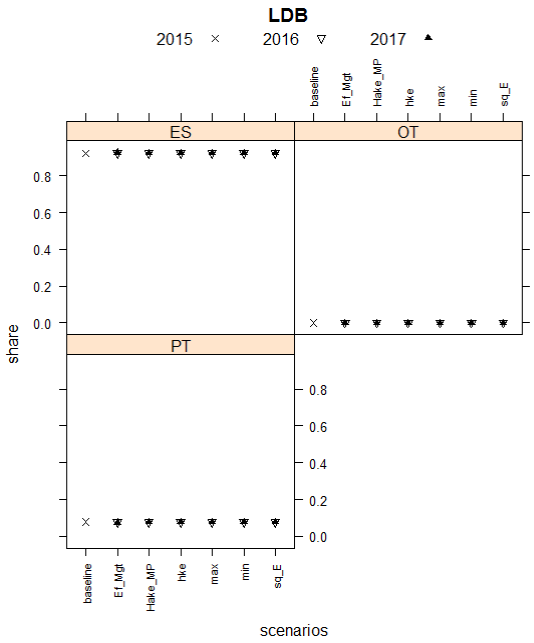


Figure 4.5.2.2.2.b. Iberian waters mixed-fisheries forecasts: Test for relative stability. Changes of relative share of four-spot megrim' landings by country in 2016 and 2017 compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

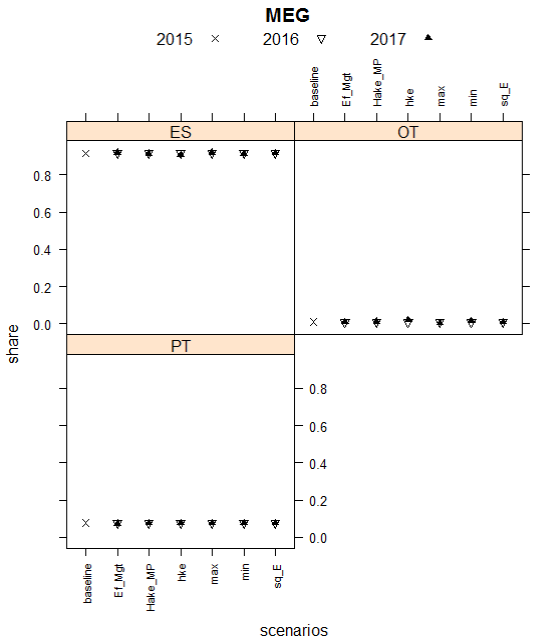


Figure 4.5.2.2.2.c. Iberian waters mixed-fisheries forecasts: Test for relative stability. Changes of relative share of megrim' landings by country in 2016 and 2017 compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

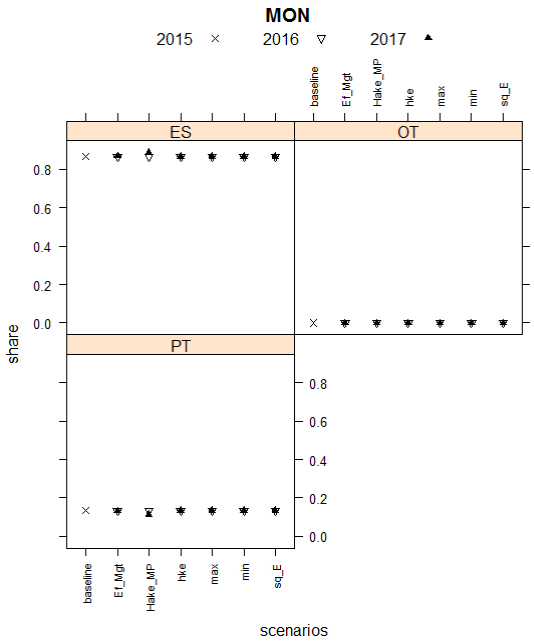


Figure 4.5.2.2.2.d. Iberian waters mixed-fisheries forecasts: Test for relative stability. Changes of relative share of white anglerfish' landings by country in 2016 and 2017 compared to the 2015 share, for the 'baseline' and 6 Fcube scenarios.

5 Additional issues

5.1 Introduction of the EU landings obligation

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

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

To account for this difference, the TACs of the different stocks in the TAC year (i.e. FCube implementation year, 2017) were raised to the total forecast catch from the single stock advice but the fleet stock shares continued to be distributed based on historic landings by the fleets. This change is equivalent to a full and perfect implementation of the discard ban (i.e. all quota species caught must be landed with no exemptions, *de minimis* or inter-species flexibilities) and assumes any uplift in quota is distributed according to past landings shares (consistent with relative stability). While the actual proposed implementation of is yet to be decided, and it is unlikely a full discard ban will be in place from 2017, it was considered basing advice on total catch under a full discard ban would highlight the pinch points in the upcoming implementation of the landings obligation. For example, one of the main consequences of a full implementation would be that some fleets with high discards and low landings of a species in the past would now become 'choked' early on in the fishery limiting their catches of other target stock, as the discard species (of which they have a low quota share) would have a greater mismatch between their catches (which now all count again the fleets stock shares) and their stock shares based on historic landings.

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

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

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

5.2 Haddock assessment

During WGNSSK, the final assessment model and procedure could not be agreed on. An inter-benchmark procedure is expected during summer/autumn 2016. The results presented in this report are then assumed to change when the haddock assessment will be finalized. These updated mixed fisheries options will be done provided in November after WGMIXFISH-METH.

5.3 MIXFISH methodology meeting (WGMIXFISH–METH)

WGMIXFISH-METH – Working Group on Mixed Fisheries Advice Methodology

The Working Group on Mixed Fisheries Advice Methodology (WGMIXFISH-METH), chaired by Youen Vermard, France, will meet in Copenhagen, 10-14 October 2016 to:

a. Review progress on mixed fisheries methodologies, including work under EU projects DISCARDLESS, DrumFish and consider how they might be taken forward and incorporated into the advisory process. In particular, focus should be given to the following priorities:

- Short term catch forecasting methods, including methods to incorporate data-poor stocks taking account of uncertainties;

- Incorporation of advice on protected, endangered and threatened (PET) species into mixed fisheries advice;

- Incorporation of Fmsy ranges into forecasting procedure to provide advice which minimises incompatibility between management advice for multiple stocks exploited in mixed fisheries. A particular attention will be given to the 'optim scenario',

- Application of methodology to other ICES regions, fisheries and stocks.

b. Develop and agree on a work flow to ease the process of MIXFISH-ADVICE for the next years (from data submission by the countries to data exchange with ICES (Stock assessment data, InterCatch data))

c. Write a data call for next year MIXFISH-ADVICE for resubmission of a longer time period with homogeneous fleet and métiers strata.

d. Develop and/or compile a stock annex of the mixed fisheries methodologies

e. Developp a Bay of Biscay mixed fisheries model

WGMIXFISH-METH will report by 16 October 2015 for the attention of ACOM.

Supporting Information

Priority:	The work is essential for ICES to progress in the development of its capacity to provide advice on multi-species fisheries. Such advice is necessary to fulfil the requirements stipulated in the MoUs between ICES and its client commissions.

Scientific justification and relation to action plan:	The issue of providing advice for mixed fisheries remains an important one for ICES. However, in practice all recent advice in this area has resulted from the work and analyses done by sub-groups of STECF rather than ICES. The Aframe project, which started on 1 April 2007 and finished on 31 march 2009 developed further methodologies for mixed fisheries forecasts. The work under this project included the development and testing of the Fcube approach to modelling and forecasts. In 2008, SGMIXMAN produced an outline of a possible advisory format that included mixed fisheries forecasts. Subsequently, WKMIXFISH was tasked with investigating the application of this to North Sea advice for 2010. AGMIXNS further developed the approach when it met in November 2009 and produced a draft template for mixed fisheries advice. WGMIXFISH has continued this work in 2010 to 2012.
Resource requirements:	No specific resource requirements, beyond the need for members to prepare for and participate in the meeting.
Participants:	Experts with qualifications regarding mixed fisheries aspects, fisheries management and modelling based on limited and uncertain data.
Secretariat facilities:	Meeting facilities, production of report.
Financial:	None
Linkages to advisory committee:	ACOM
Linkages to other committees or groups:	SCICOM through the WGMG. Strong link to STECF.
Linkages to other organizations:	This work serves as a mechanism in fulfilment of the MoU with EC and fisheries commissions. It is also linked with STECF work on mixed fisheries.

6 Conclusions and recommendations

WGMIXFISH-ADVICE has produced a draft Celtic Sea Mixed Fisheries advice sheet and a draft for Iberian Waters Mixed Fisheries advice for use by ACOM. The absence of final North Sea haddock assessment and forecast did not allow for finalising the North Sea Mixed fisheries advice. This problem will be resolved later in the year and will allow for finalising a draft advice sheet in November for the North Sea Mixed Fisheries options.

Since 2012, WGMIXFISH-ADVICE is held so that mixed fisheries advice can be available alongside ICES single species advice in June. As in previous years, problems were encountered because of the close proximity of this WG to that of WGNSSK with revisions of single species advice taking place during the North Sea ADG requiring a revised run of the mixed fishery analysis (no such problems were encountered for the Celtic Sea, but it is more likely as further stocks are incorporated). With the increased number of regions consideration should be given to ensure that sufficient time is available to develop and deliver advice for all these regions. This is particularly true for regions where some of the advice is released in the autumn (e.g. *Nephrops* in the Celtic Sea) where it may be more appropriate to release the mixed fisheries advice at that time. ICES Secretariat and ACOM should consider the optimal time to develop and release the advice, given the timing of the various assessment working groups.

No methodological problems were encountered with the FCube package with this year's advice presented in terms of catch rather than landings following some small changes to the FCube code. This change was in order to reflect the implementation of the Landing Obligation in 2017. Further methodological changes are likely to be required in future so that mixed fisheries advice reflects the changing policy and management landscape. The 'value' scenario was reintroduced last year for the North Sea advice as it was considered as appropriate intermediate scenario to reflect potential levels of effort in the fisheries next year given fishing opportunities. The 'effort management' scenario was removed. Further work should continue to identify a 'most plausible' scenario given available fishing opportunities and the management measures in place.

Given the quantity and complexity of data required for the mixed fishery forecasts, the task of checking data is mainly reliant on the availability of expertise from the countries with significant fleet activity in order to identify any issues based on expert knowledge. For this reason active participation from those with a regional interest is the fisheries, and an understanding of the data is vital to ensure data is as accurate as possible and the context of model outputs can be accurately characterised. The working group encourages participation from those countries with significant interests in the regional fisheries at future working groups.

The WGMIXFISH data call requirements are similar to, but separate from, métier-based data submissions to STECF. WGMIXFISH recommends to the RCMs that métier classes be made compatible between the effort, catch and economic datasets requested of nations by STECF as soon as possible to facilitate mixed fishery and bio economic modelling.

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