Stock Annex: Celtic Sea Mixed Fisheries Annex

Mixed Fisheries Annex

Regional specific documentation of standard assessment procedures used by ICES.

Eco-Region:	Celtic Sea
Working Group:	Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE)
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A. General

A.1. Area definition

This mixed fisheries advice considers finfish species ICES area 7.

The species considered are part of the demersal mixed fisheries of the Celtic Sea, and at present are cod, haddock, whiting (Table 1).

It is anticipated that *Nephrops norvegicus* will be incorporated in the advice at some point in future. There are seven *Nephrops* functional units within the Celtic Sea (Table 2), of these all bar FU18 can be assessed through fishery-independent abundance estimates from underwater video surveys. There is evidence that at least some of these *Nephrops* patches are linked in meta-population sense (O'Sullivan *et al*., 2013).

Pelagic (herring, mackerel, horse mackerel) and the industrial fisheries (boar fish) are not considered in a mixed fisheries advice context given the targeted nature of the fisheries for these species.

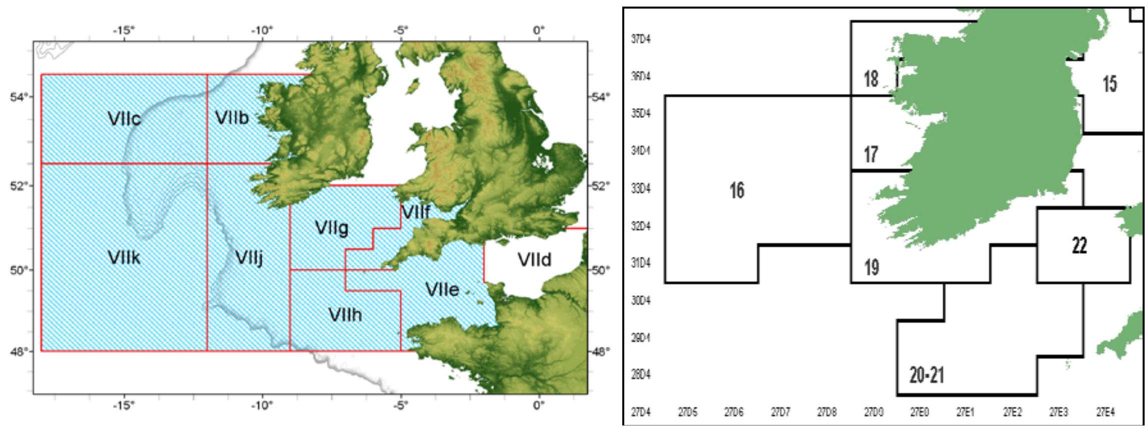

Figure 1 Area description for finfish advice and *Nephrops* Functional Units (FU) in the Celtic Sea region.

Table 1 Finfish stocks

Species	ICES single stock advice area
Cod	Divison 7.e-7.k (Celtic Sea)
Haddock	Division 7.b, 7.c, 7.e-k (Celtic Sea)
Whiting	Division 7.b, 7.c, 7.e-k (Celtic Sea)

Table 2 *Nephrops* Functional Units (FU) in the Celtic Sea.

FU no.	Name	ICES Area	Statistical rectangles
16	Porcupine Bank	7.b, 7.c, 7.j, 7.k	31–35 D5–D6; 32–35 D7–D8
17	Aran Grounds	7.b	34–35 D9–E0
19	Ireland SW and SE coasts	7.a, 7.g, 7.j	31–33 D9–E0; 31 E1; 32 E1–E2; 33 E2–E3
20–21	Celtic Sea – Labadie	7.g, 7.h	28–29 E0, 28–30 E1; 28–31 E2; 29–30 E3
22	Celtic Sea – the Smalls	7.g, 7.f	31–32 E3; 31–32 E4

A.2. Fishery

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, 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, 7.f, and 7.g) 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.h, 7.j, and 7.k).

Fishing effort for the main gears (otter trawlers, beam trawlers) has been relatively stable over the past ten years, though there has been an increase in otter trawl effort since 2009 (STECF, 2014), particularly for the large mesh trawlers (> 100 mm). Unlike other parts of the Celtic Seas (6.a, 7.a) and the North Sea and eastern English channel (4 and 7.d) the Celtic Sea is not subject to effort control measures under the long-term management plan for cod (excepting beam trawlers and gillnetters in 7.e as part of the western channel sole management plan), and so the increase in effort may be due to limiting effort regulation in other areas.

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.

Recent years have seen large but sporadic recruitment for the gadoid stocks and high levels of exploitation resultng in significant fluctuations in the stocks. Incompatibilities between the quota available has resulted in regulatory discarding as well as high-grading in the mixed fisheries, creating significant challenges in managing the exploitation of the stocks and leading to the introduction of a number of technical gear measures designed to reduce discarding of under size and over quota fish. Understanding the strength of technical interactions and likely 'choke' stocks will therefore support design of management measures which provide greater consistency between quotas for the different stocks exploited in the mixed fishery. Industry reports of large incoming cod and haddock recruitments, which appear to be supported by observations in scientific surveys, indicate the need for such measures in the immediate future.

Cod in 7.e–k

The majority of the landings are made by demersal trawls targeting gadoids (i.e. cod, haddock and whiting). In recent years an increasing component has come from gillnets and otter trawls targeting *Nephrops* or benthic species and even a small component from beam trawls. Other commercial species that are caught by these fisheries include haddock, whiting, *Nephrops*, plaice, sole, anglerfish, hake, megrim, and elasmobranchs. Landings are made throughout the year but are generally more abundant during the first quarer. Constraining TAC's set since 2003 and the impact of the Trevose Head Closure since 2005 have reduced landings in Q1 and spread landings throughout the year.

Spatially, the majoriy of cod 7.e-k landings originate from area 7.g (~50%) followed by 7.e and 7.h (~20%). Comparitivly low landings come from 7.f (~10%). The contribution of landings by country had been stable for a number of years. Where French landing account for the greatest proportion (~54%), followed by Ireland (~31%), and lower contributions from the United Kingdom (~12%) and Belgium (~4%).

Haddock in 7.b, 7.c, and 7.e–k

Haddock in divisions 7.b, 7.c, and 7.e–k are taken as a component of catches in mixed trawl fisheries. France takes about 50–80% of the landings, primarily by gadoid trawlers. Trawlers which, prior to 1980 were mainly fishing for hake in the Celtic Sea. Ireland has historically taken the second larges landings, (~25–40%). Fleets from Belgium, Norway, the Netherlands, Spain, and the UK take relatively minor landings.

The vast majority of the landings are taken by otter trawls, most of the remainder of the landings are taken by seines and beam trawls.

Whiting in 7.b, 7.c, 7.e–k

Whiting in divisions 7.b, 7.c and 7.e–k are taken as a component of catches in mixed demersal trawl and seine fisheries. The spatial distribution shows several descrite landings concentrations in western waters and the North Sea. Within this stock area there are two regions with a higher volume of landings i) 7.g and the eastern part of 7.j (Celtic Sea Shelf); ii) 7.e (western Channel). The landings by country show 7.b–k whiting are mostly taken by Ireland and France.

Whiting are caught in directed gadoid trips and as part of mixed fisheries throughout the Celtic Sea, as well as bycatch within *Nephrops* fisheries. Discard rates are high as a consequence of the low market value of the species, particularly at smaller sizes. Highgrading above the MLS to some extent is also prevalent in most fisheries.

[Nephrops – to be included at some point in future

Nephrops is caught in a mixed fishery which takes a catch consisting of haddock, whiting, cod, anglerfish and megrim as well as *Nephrops*. The composition of which can vary with FU. A minor proportion of the landings from Subarea 7 are taken from statistical rectangles outside the defined *Nephrops* FUs. In the Celtic Sea area most are landed from Ireland and France with contributions from the UK and Spain.

Approximatly 60% of the TAC is taken from within the two Irish Sea FUs (FU14 and FU15) not considred within the Celtic Sea mixed fishery.]

A.3. Ecosystem aspects

These are described in the Celtic Seas ecosystem overview in the ICES advisory report.

B. Data

The mixed fisheries assessment is based on catch and effort data that were compiled on the basis of the data collected in annual ICES data calls. The data structured by fleets and métiers were used as inputs, together with single-stock data and advice from the ICES Working Group on the Assessment of Demersal Stocks in the Celtic Seas Ecoregion (WGCES), in the integrated Fcube framework.

The assessment data for the different stocks is taken from the WGCSE, and the forcasting procedures follow those perfomed by this group. The Irish cod, haddock and whiting landings misreporting has been corrected for, consistent with WGCSE. However it was not possible to adjust the associated effort for these corrections.

C. Assessment methodology

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), 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.

Model used:

Fcube

The Fcube model is presented and described in Ulrich *et al.* (2006; 2008; 2009). The basis of the model is to estimate the potential future levels of effort by 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 is in return used to estimate landings and catches by fleet and stock, using standard forecasting procedures.

Partial fishing mortality *F* and catchability *q* by fleet *Fl*, métier *m* and stock *St* from observed landings *LND*, effort *E* and fishing mortality *Fbar* are estimated for year Y:

$$F(Fl,m,St,Y) = Fbar(St,Y) * \frac{LND(Fl,m,St,Y)}{LNDtot(St,Y)} \quad (1)$$

$$q(Fl,m,St,Y) = F(Fl,m,St,Y) / E(Fl,m,Y) \quad (2)$$

To estimate future parameters value $q(Fl,m,St,Y+1)$ at year *Y+1* an average over recent years can be used. Alternatively, the user may choose to vary the value of q, if evidence exists of e.g. significant technical creep, or of a change in selectivity due to a change in mesh size.

The observed distribution of effort by fleet across métiers is estimated:

$$Effshare(Fl,m,Y) = E(Fl,m,Y)/E(Fl,Y) \qquad (3)$$

As with catchability, the simplest approach to the forecast effort distribution $Effshare(Fl,m,Y+1)$ would be to estimate it from an average of past observed effort allocation. Alternatively, a more complex approach such as a behaviour algorithm could be used if available.

These variables are then used for the forecast estimates of catchability by stock for each fleet. This catchability cannot be directly estimated from observed data, as it is linked to the flexibility of the fleet. While catchability by métier is assumed to be measurable as being linked to the type of fishing, the resulting catchability by fleet varies with the time spent in each métier. The catchability of a fleet is thus equal to the average catchability by métier weighted by the proportion of effort spent in each métier for the fleet:

$$q(Fl,St,Y+1) = \sum_m q(Fl,m,St,Y+1) * Effshare(Fl,m,Y+1) \qquad (4)$$

A TAC is usually set in order to achieve a specific fishing mortality. This might be a particular short-term target, such as Fpa, or specific reduction in F as part of a longer-term management plan. This intended F is converted into forecast effort by fleet. This step is rather hypothetical, in that it introduces the concept of "Stock dependent fleet effort". The "stock-dependent fleet effort" is the effort corresponding to a certain partial fishing mortality on a given stock, disregarding all other activities of the fleet. The total intended fishing mortality *Ftarget(St)* is first divided across fleet segments (partial fishing mortalities) through coefficients of relative fishing mortality by fleet. These coefficients are fixed quota shares estimated from observed landings. In principle, these reflect the rigid sharing rules resulting from the principle of relative stability, combined with national processes of quota allocation across fleets. The simplest approach is thus to estimate these from observed mean proportions of landings by fleet. The resultant partial fishing mortalities are subsequently used for estimating the stock-dependent fleet effort:

$$F(Fl,St,Y+1) = Ftarget(St,Y+1) * QuotaShare(Fl,St) \qquad (5)$$

$$E(Fl,St,Y+1) = F(Fl,St,Y+1)/q(Fl,St,Y+1)$$

The final input required is the effort by each fleet during the forecast year. It is unlikely that the effort corresponding to each single-species TAC will be the same across fleets, and it is equally possible that factors other than catching opportunities could influence the amount of effort exerted by a given fleet. Rather than assume a single set of fleet efforts, the approach used in practice with Fcube has been to investigate a number of different scenarios about fleet effort during the forecast period. The user can thus explore the outcomes of a number of options or rules about fleet behaviour (e.g. continue fishing after some quotas are exhausted) or management scenarios (e.g. all fisheries are stopped when the quota of a particular stock is reached).

$$E_{Fl,Y} = rule(E_{Fl,St1,Y}, E_{Fl,St2,Y}, E_{Fl,St3,Y} \ldots)$$

For example, if one assumes that fishermen continue fishing until the last quota is exhausted, effort by fleet will be set at the maximum across stock-dependent effort by fleet ("max" option). Overquota catches of species which quota were exhausted before this last one, are assumed to be discarded.

$$E(Fl, Y+1) = MAX_{St}[E(Fl, St1, Y+1), E(Fl, St2, Y+1), ...] \qquad (6)$$

As a contrast, a more conservative option would be to assume that the fleets would stop fishing when the first quota is exhausted, and thus would set their effort at the minimum across stocks ("min" option). Alternatively, management plans for a particular stock could be explored, with the fleets setting their effort at the level for this stock ("stock_name" option). Different rules could also be applied for the various fleets.

The following options are explored:

1) **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) **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.

3) **'Species specific scenario'**: The underlying assumption is that all fleets set their effort at the level corresponding to their 'species' (i.e. cod or haddock…) quota share, regardless of other stocks.

4) **sq_E**: The effort is set as equal to the effort in the most recently recorded year for which there is landings and discard data.

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 (EC) No 1342/2008).

6) "**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

7) **Range**: described in Ulrich et al. (2017). This scenario searches for the minimum sum of differences between potential catches by stock under the "min" and the "max" scenarios within the F_{MSY} ranges.

All scenarios will be run with two advice approaches, Fmsy transition and management plan. For stocks where a management plan does not exist, the advice according to the latest commission communication on TAC setting is used.

Finally, this resulting effort by fleet is distributed across métiers, and corresponding partial fishing mortality is estimated.

$$E(Fl, m, Y+1) = E(Fl, Y+1) * Effshare(Fl, m, Y+1) \qquad (7)$$

$$F(Fl, m, St, Y+1) = q(Fl, m, St, Y+1) * E(Fl, m, Y+1)$$

Partial fishing mortalities are summed by stock, and then used in standard forecast procedures similar to the ones used in the traditional single-species short-term advice. Corresponding landings are estimated and compared with the single-species TAC.

Software used:

The Fcube model has been coded as a method in R (R Development Core Team, 2008), as part of the FLR framework (Kell *et al.*, 2007, www.flr-project.org). Input data are in the form of FLFleets and FLStocks objects from the FLCore 2.2 package, and two forecast methods were used, stf() from the FLAssess (version 1.99–102) and fwd() from the Flash (version 2.0.0) packages. As such, the input parameterisation as well as the stock projections are made externally using existing methods and packages, while only steps 4 to 6 are internalised in the method, thus keeping full transparency and flexibility in the use of the model.

D. Short-Term Projection methodology

Model used: Overview of software used by WGCSE.

Species	Assessment	Forecast
HADDOCK 7.b, 7.c, 7.e-k	ASAP (Age-Structured Assessment Programme; NOAA toolbox)	MFDP1a
COD 7.e-k	Age-based analytical assessment (FLR 2.x XSA)	FLR STF
WHITING 7.b, 7.c, 7.e-k	Age-based analytical assessment (XSA)	MFDP1a

In the mixed-fisheries runs, all forecasts were done with the same FLR forecasts method (see section C).

For every scenario, the following output is generated per stock:

	Description	Landings	F mult	SSB
Baseline forecast for current year	Applying single species forecast assumptions to last year's data (current year – 1)*	Current yr	Current yr	1st Jan TAC yr
Baseline forecast for TAC year	Applying single species HCRs** to current year results*	TAC yr	TAC yr	1st Jan TAC yr + 1
Current year Fcube results	Applying Fcube to last year's data	Current yr	Current yr	1st Jan TAC yr
Fcube estimate of catches in TAC year	Applying Fcube on current year Fcube results	TAC yr	TAC yr	1st Jan TAC yr + 1
TAC advice results (incl mgt plans)	Applying single species HCRs** to current year Fcube results	TAC yr	TAC yr	1st Jan TAC yr + 1

*** For the Baseline runs, a forecast was run for each stock separately following the same settings as in the ICES single species forecast.**

**** Harvest Control Rules – either from single species management plans or with reference to the F_{MSY} transition approach. Where HCRs according to these approaches were not available values according to the precautionary approach were used.**

The following overview table will be produced to be able to judge the relevance of the different scenarios:

		COD HAD WHG NEPFU16 NEPFU17 NEP19 NEP20-21 NEPFU22 NEPFU18OTH
Current year	Fbar FmultVsF(cur-1) Landings SSB	
Current year+1	Fbar FmultVsF(cur-1) Landings SSB	
Current year+2	SSB	

G. Biological Reference Points

The biological reference points that are used are the same values as referred to in the single stock advisory reports.

H. Other Issues

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I. References

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