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ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The WKMIXFISH met for the first time, in order to 1) compile and review the available fleet and fisheries data for North Sea demersal fisheries, 2) carry out mixed fisheries forecasts taking into account the draft advice that is produced by WGNSSK 2009 and the management measures currently in place for 2009, and 3) develop a draft overview section for the advisory report 2009 that includes a dissemination of the fleet and fisheries data and forecast.

A tremendous amount of work was performed in order to achieve such a requirement in the limited time of the workshop. Catch and effort data were compiled mostly on the basis of the data collected by STECF for the evaluation of the effort regime, and were combined with other STECF economic data of costs and prices. Additional data were directly provided by other nations.

The data structured by fleets and metiers were used as inputs, together with WGNSSK single-stock data and advice, in the integrated Fcube framework. This framework estimates some levels of effort by fleet and corresponding landings and forecast by stock under a number of basic assumptions and simple scenarios about fleet behaviour.

This flexible framework allowed investigating a large panel of issues regarding mixed-fisheries management in the North Sea demersal fisheries. A number of important results were achieved, and in particular:

The single-stock TAC advice for 2010 produced by ICES was found to be fairly robust to different assumptions about quota uptake and fleet behaviour in 2009 for all stocks except cod. This was mostly due to the limited interannual variability in TAC which smoothes out uncertainties. However, a robust TAC advice may not necessarily mean a precautionary TAC advice, since same TACs may correspond to large variability in underlying estimates of SSB and F across scenarios.

For cod, the results showed relatively high sensitivity to the assumptions for 2009. Unless the effort for all fleets is no more than that required to take their cod quota, then the forecasts imply that some degree of over-quota catches of cod are likely to occur. The results further imply that the available effort allocations may not be restrictive for some national fleets.

1 Introduction

1.1 Background

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. In particular, Bannister (2004) identified the mixed-species nature of the fishery, along with its international dimension, as the two main factors contributing to the decline, despite all advice having been consistently intended to reduce *F*. In 2002, the North Sea cod *(Gadus morhua)* stock was in such a bad state that ICES advised a closure of all fisheries for cod as a targeted species or bycatch (ICES, 2002). At the same time, North Sea haddock (*Melanogrammus aeglefinus*) was at its highest level for 30 years, following the recruitment of a very strong 1999 year class. Nonetheless, on the basis that haddock is taken mostly with cod and whiting (*Merlangius merlangus*), ICES advised that "Unless ways to harvest haddock without by-catch or discards of cod can be demonstrated fishing for haddock should not be permitted."

The initial scientific response to this situation came in an approach first implemented for use within a meeting of a subgroup of the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF). What became known as the MTAC approach (after Mixed-species TAC; Vinther *et al.*, 2004) was developed with the intention of making use of quantitative information on the extent to which different species are caught together, and of making the priorities assigned to the different species explicit.

Attempts to use the MTAC approach in an advisory context led to the identification of a number of limitations with the approach (ICES, 2006 – MIXMAN). As a result, ICES established a Workshop (WKMIXMAN, ICES 2006) to "define a framework for simple models of mixed fisheries which can be used to obtain consistency between management (TAC and/or effort) advice for species caught together, given the current availability and accessibility of data". The result of this meeting was the Fcube approach (after Fleet and Fishery Forecast, Ulrich *et al.* 2006; 2008; 2009). This approach was developed further in two further meetings of the MIXMAN group (ICES 2007, 2008) and in the EU-funded research projects EFIMAS (www.efimas.org) initially and then AFRAME (http://ec.europa.eu/research/fp6/ssp/aframe_en.htm). The 2008 MIXMAN report (ICES, 2008) included example sections illustrating how FCUBE data and results might be used to show recent trends in fishing activity and the implications of technical interactions on the possible outcomes of single-species advice in mixed fisheries. In addition, Ulrich *et al.* (2009) summarises the main outcomes obtained for the two other AFRAME Case studies, the Western Waters (Areas VII and VIII) and the Greek Waters in the Mediterranean Sea.

As opposed to the MIXMAN reports, the current WMIXFISH report is intended to produce results which are of practical use, rather than being just illustrative.

In addition to sparking the development of MTAC and Fcube, another side effect of the near-collapse of the North Sea cod stock was the introduction of effort restrictions alongside TACs as a management measure within EU fisheries. There has also been an increasing use of single-species multi-annual management plans, partly in relation to cod recovery, but also more generally. These developments are of key importance for the general approach to mixed-fisheries advice performed here, which must build on the existing legal and management system. Therefore, these management frames are summarised in more detail below.

1.2 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 Regulation 671/2003 of 10 April 2003. The days at sea allowances have been revised by subsequent Council Regulations and the documents listing these days at sea limitations are given in Table 1.2.1

Initially days at sea allowances were defined by calendar month. From 2006 the limit was defined on an annual basis. The maximum number of days a fishing vessel could be absent from port varied according to gear type, mesh size (where applicable) and region. A complex system of 'special conditions' (SPECONs) developed upon request from the Member States, whereby vessels could qualify for extra days at sea if special conditions (specified in the Annexes) were met. The evolution of the number of gear categories and special conditions used in these regulations are given in Table 1.2.2, illustrating the trend towards increasingly detailed micromanagement that has taken place until 2008. A detailed description of these categories as well as the corresponding days at sea can be found in STECF (2008).

In 2008 the system was radically redesigned. For 2009 effort limits were changed to be on the basis of a kWdays effort pot 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. Table 1.2.3 lists the new fleet effort categories and shows how they map to the previous gear groups. The effort allocations available by nation and gear are given in Appendix 1A of Annex IIa of Council Regulation 43/2009. 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 1342/2008. In relation to this, some member states have implemented real-time closure schemes. The closures apply to areas with high cod catch rates with the intention that closing these will lead to an overall reduction in the catchability of cod (Holmes *et al*, 2009).

In addition to the restrictions on effort, a number of other measures have been introduced during 2009 to help ensure that the cod quota is not exceeded. For instance, if a nation's uptake of its cod quota reaches 90% on or before 15 November 2009, this will trigger a requirement for that nation's vessels to use highly selective gears (Regulation 43/2009, Annexe III, para. 5a). This is associated with a ban on high-grading (Regulation 43/2009, Annexe III, para. 5c).

During the WKMIXFISH workshop, some analyses were performed to investigate the consistency of the current effort-based cod plan for 2009 with the Long-Term Management Plan for North Sea Cod (see chapter 4.3)

1.3 Stock-based management plans

The species considered here as part of the demersal mixed fisheries of the North Sea are cod, haddock, whiting, saithe, plaice, sole and *Nephrops norvegicus*. All of these are now subject to multi-annual management plans apart from whiting and *Nephrops*. 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 involved, and as such have never been evaluated in an integrated approach.

The full details and references of these plans are not always easy to find, and therefore we have collected the most important points of these plans below.

1.3.1 Cod in IIIa – IV – VIId (EU management plan – EC 1342/2008)

In December 2008 the European Council agreed on a new cod management plan implementing the new system of effort management and a target fishing mortality of 0.4 (EC 1342/2008) for cod stocks in the North Sea, Skagerrak and Eastern Channel as well as in Kattegat, West of Scotland and the Irish Sea. The main rules for setting TAC for the North Sea cod stock are as follows:

Article 8: Procedure for setting TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel

1) *Each year, the Council shall decide on the TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel. The TACs shall be calculated by applying the reduction rules set out in Article 7 paragraph 1(a) and (b).*

2) *The TACs shall initially be calculated in accordance with paragraphs 3 and 5. From the year where the TACs resulting from the application of paragraphs 3 and 5 would be lower than the TACs resulting from the application of paragraphs 4 and 5, the TACs shall be calculated according to the paragraphs 4 and 5.*

3) *Initially, the TACs shall not exceed a level corresponding to a fishing mortality which is a fraction of the estimate of fishing mortality on appropriate age groups in 2008 as follows: 75 % for the TACs in 2009, 65 % for the TACs in 2010, and applying successive decrements of 10 % for the following years.*

4) *Subsequently, if the size of the stock on 1 January of the year prior to the year of application of the TACs is:*

   a) *above the precautionary spawning biomass level, the TACs shall correspond to a fishing mortality rate of 0,4 on appropriate age groups;*

   b) *between the minimum spawning biomass level and the precautionary spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate on appropriate age groups equal to the following formula: 0,4 – (0,2 * (Precautionary spawning biomass level – spawning biomass) / (Precautionary spawning biomass level – minimum spawning biomass level))*

   c) *at or below the limit spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate of 0,2 on appropriate age groups.*

5) *Notwithstanding paragraphs 3 and 4, the Council shall not set the TACs for 2010 and subsequent years at a level that is more than 20 % below or above the TACs established in the previous year.*

6) *Where the cod stock referred to in paragraph 1 has been exploited at a fishing mortality rate close to 0,4 during three successive years, the Commission shall evaluate the application of this Article and, where appropriate, propose relevant measures to amend it in order to ensure exploitation at maximum sustainable yield.*

1.3.2 Haddock in IIIa – IV (EU and Norway management plan)

"The plan consists of the following elements:

1) *Every effort shall be made to maintain a minimum level of Spawning Stock Biomass greater than 100,000 tonnes (Blim).*

2) *For 2009 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of no more than 0.3 for appropriate age-groups, when the SSB in the end of the year in which the TAC is applied is estimated above 140,000 tonnes (Bpa).*

3) *Where the rule in paragraph 2 would lead to a TAC, which deviates by more than 15 % from the TAC of the preceding year, the Parties shall establish a TAC that is no more than 15 % greater or 15 % less than the TAC of the preceding year.*

4) *Where the SSB referred to in paragraph 2 is estimated to be below Bpa but above Blim the TAC shall not exceed a level which will result in a fishing mortality rate equal to 0.3-0.2*(Bpa-SSB)/(Bpa-Blim). This consideration overrides paragraph 3.*

5) *Where the SSB referred to in paragraph 2 is estimated to be below Blim the TAC shall be set at a level corresponding to a total fishing mortality rate of no more than 0.1. This consideration overrides paragraph 3.*

6) *In the event that ICES advises that changes are required to the precautionary reference points Bpa (140,000t) or Blim, (100,000t) the Parties shall meet to review paragraphs 1-5.*

7) *In order to reduce discarding and to increase the spawning stock biomass and the yield of haddock, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from inter alia ICES.*

8) *No later than 31 December 2010, the parties shall review the arrangements in paragraphs 1 to 7 in order to ensure that they are consistent with the objective of the plan. This review shall be conducted after obtaining inter alia advice from ICES concerning the performance of the plan in relation to its objective.*

9) *This arrangement enters into force on 1 January 2009."*

1.3.3 Saithe in IIIa – IV – VI (EU and Norway management plan)

In 2008 EU and Norway renewed the existing agreement on "*a long-term plan for the saithe stock in the Skagerrak, the North Sea and west of Scotland, which is consistent with a precautionary approach and designed to provide for sustainable fisheries and high yields. The plan shall consist of the following elements:*

1) *Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 106,000 tonnes (Blim).*

2) *Where the SSB is estimated to be above 200,000 tonnes the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of no more than 0.30 for appropriate age groups.*

3) *Where the SSB is estimated to be below 200,000 tonnes but above 106,000 tonnes, the TAC shall not exceed a level which, on the basis of a scientific evaluation by ICES, will result in a fishing mortality rate equal to 0.30-0.20*(200,000-SSB)/94,000.*

4) *Where the SSB is estimated by the ICES to be below the minimum level of SSB of 106,000 tonnes the TAC shall be set at a level corresponding to a fishing mortality rate of no more than 0.1.*

5) *Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15 % from the TAC of the preceding year the Parties shall fix a TAC that is no more than 15 % greater or 15 % less than the TAC of the preceding year.*

6) *Notwithstanding paragraph 5 the Parties may where considered appropriate reduce the TAC by more than 15 % compared to the TAC of the preceding year.*

7) *A review of this arrangement shall take place no later than 31 December 2012.*

8) *This arrangement enters into force on 1 January 2009."*

1.3.4 Plaice in IV (Multiannual plan for sole and plaice in the North Sea EC 676/2007)

Extract from Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea:

Article 7 Procedure for setting the TAC for plaice:

1) *The Council shall adopt the TAC for plaice at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:*

   a) *that TAC the application of which will result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year;*

   b) *that TAC the application of which will result in the level of fishing mortality rate of 0.3 on ages two to six years in its year of application.*

2) *Where application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.*

3) *Where application of paragraph 1 would result in a TAC which is more than 15 % less than the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.*

Under the consideration nr 3 in the "Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea" it is stated:

The Scientific, Technical and Economic Committee for Fisheries (STECF) has advised that the precautionary biomass for the stock of plaice in the North Sea should be 230 000 tonnes.

1.3.5 Sole in IV (Multiannual plan for sole and plaice in the North Sea EC 676/2007)

Extract from Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea:

Article 8 Procedure for setting the TAC for sole:

1) *The Council shall adopt a TAC for sole at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:*

   a) *that TAC the application of which will result in the level of fishing mortality rate of 0,2 on ages two to six years in its year of application;*

   b) *that TAC the application of which will result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.*

2) *Where the application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.*

3) Where the application of paragraph 1 would result in a TAC which is more than 15 % less than the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.

Under the consideration nr 3 in the "Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea" it is stated:

The Scientific, Technical and Economic Committee for Fisheries (STECF) has advised that the precautionary biomass for the stock of sole in the North Sea should be 35 000 tonnes

1.4 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.

2 Software

2.1 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:

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

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:

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

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:

$$F(Fl,St,Y+1) = Ft\arg et(St,Y+1) * QuotaShare(Fl,St) \qquad (5)$$
$$E(Fl,St,Y+1) = F(Fl,St,Y+1)/q(Fl,St,Y+1)$$

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.

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

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.

In the setup used during the workshop, the following options were explored:

1) “**max**”

2) “**min**”

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

4) “**val**”: This represented a very simple proxy computed with regards to revenue. The underlying assumption is that the global effort of each fleet is influenced by the monetary value each fleet can get from its quota share across stocks. The value of the quota share (quota share * mean price by fleet and stock) is used as a weighting factor of the estimated effort necessary to catch each quota share. The final level of effort is set at the level of this weighted mean.

5) “**sq_E**”: The effort is simply set as constant compared to (user-defined) previous years.

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

$$
\begin{aligned}
&E(Fl, m, Y+1) = E(Fl, Y+1) * Effshare(Fl, m, Y+1) \\
&F(Fl, m, St, Y+1) = q(Fl, m, St, Y+1) * E(Fl, m, Y+1)
\end{aligned}
\tag{7}
$$

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.

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.

2.2 FcubEcon

As explained above, the basic principle of Fcube is to predict the future levels of effort by fleet knowing catchability and effort distribution by metier and TAC forecast by stocks (see ICES, 2006). This is also the objective of the EIAA model (Frost *et al.* 2009 and SEC 2006). However, Fcube is actually not calculating future effort based on set TACs and quotas, but applies a number of exogenously fixed efforts with a fixed catch composition to produce catches of different species. These catches are then evaluated against an exogenous TAC vector. This procedure allows for an explicit evaluation of discards that can be positive (overfishing) or negative (underfishing).

The purpose of the FcubEcon is to use economics as the foundation for the values judgement (HCR). One way of doing this is to use constrained maximization of profit. The procedure is not cleaned for value judgements which are embodied in the constraints of the model. However, once the HCR is fixed it should be possible for the model to compute the optimal solutions in terms of number of vessels, sea days, landings and discards.

2.2.1 Software

Fcube works with metiers, defined as gear and landings composition characteristics for each fleet segment. This framework is developed to FcubEcon that is sustained by use of linear/non linear programming (LP/NLP) software that makes it possible to "optimize" the system subject to various constraints.

It was not simple to include that kind of algorithms using R and FLR for the time being. There are two other choices, however: one is to use Excel, and one is to use GAMS (Brooke *et al.* 2005). GAMS is by far the most powerful with respect to the number of (decision) variables and constraints that could be handled. GAMS is, however, not freeware and therefore not available and familiar in all circles. Excel is included in Office standard packages widely used. In the standard package Excel's solver capacity is restricted by the number of variables that can be changed (decision variables) and the number of restrictions that can be included. This is 200 decision variables and 100 explicit restrictions.

The normal excel solver can then handle a model that determines the number of vessels and sea days for 100 fleet segments, or for example 20 fleet segments each fishing on nine metiers (or nine different catch compositions) each equal to 200 decision variables in total.

The model was developed in Excel for the North Sea, using the same data as for Fcube (see chapter 3). The number of decision variables if all number of vessels and sea days per vessel per metier is used is 180.

Together with the optimization models the FcubEcon Excel workbook includes models that reproduce the Fcube scenarios. In total it includes:

1) Models
   a) FcubeOpt uses LP/NLP
   b) FcubeOptCPUE
   c) FcubeMax
   d) FcubeMin
   e) FcubeVal
2) Data input and help sheets in various formats

The FcubeOpt take into account the costs and earnings of the fleets, and maximizing profit it computes the economically optimal allocation of sea days, given a number of restrictions. The FcubeOptCPUE is an alternative to FcubeOpt, where the catches are based on catch per day (CPUE) as opposed to fishing mortalities in FcubeOpt. This is an advantage in fisheries, where stock data are not known. Correctly calibrated FcubeOpt and FcubeOptCPUE will yield the same results.

FcubeOpt may e.g. be used to determine the number of sea days per fleet that maximises profit subject to the *least binding* quota or fishing mortality rates. This solution may not necessarily be equal to FcubeMax seeing that it is possible to re-allocate sea days between metiers in the optimisation scenarios. Likewise this part of the model may maximise profit subject to *most binding* quota or fishing mortality rate which may again not necessarily be equal to the FcubeMin scenario. The value scenario, FcubeVal, where the number of sea days are chosen as the weighted number of sea days according to the catch value of each species also differs from the result of FcubeOpt.

As discussed above, the FcubeOptCPUE component of the model does, in principle, the same as the FcubeOpt component. The difference is that the FcubeOptCPUE uses catch per day (cpue) i.e. catch = cpue*effort, while the FcubeOpt uses catchability rates and fishing mortality rates i.e. catch = catchability * effort *stock size. The former approach simplifies the model.

The Results sheet contains a number of indicators extracted from the model sheets. Most interesting from a biological viewpoint may be fleet landings, quotas and discards. From an economic viewpoint profit, number of vessels, and number of sea days may be of interest.

Results from the model are found in Hoff, Frost, and Ulrich (2009).

2.2.2 General model equations

The economic optimization procedure maximise profit Π as the objective function subject to a number of constraints. For a single species and fleet:

Objective:

$$\max_{U,V} \Pi = \left((p^0 \times h^0 - o^0) \times U^1 + R^0\right) \times V^1)$$

Subject to:

$$h^0 \times U^1 \times V^1 \leq H^1$$

The base period is denoted 0 and future periods 1. The decision (control) variables are the number of sea days per vessel U and the number of vessels V. The catches are the catch per day h multiplied with U and V. These catches must not exceed H (the quota) calculated from stock assessments. The variable costs are denoted o and the fixed costs R. The complete model is shown in Appendix 4.

The constraints are determined exogenously. First of all a distinction could be made between society and the fishermen. *Society's objective* is to maximize profit for the entire fishery, i.e. manage by seeking to allocate the effort on fleet segments to produce maximum profit subject to TAC/quota constraints. This would also entail that vessels which contribute the least to the overall profit are incited to exit the fishery.

Fisherman's objective is to maximise his own (vessel) profit (in the short run) by spending and allocating his sea days best possible on metiers. This implies that changes in number of vessels are not relevant in this case.

As indicated the model setup forms the basis for a range of scenarios of which most of the listed scenarios required that the optimization procedure was implemented.

3 Input data and recent trends

3.1 Stocks

3.1.1 Data

The assessment data for the different stocks are taken from the ICES WGNSSK (2009) report.

For haddock, plaice, saithe, sole and whiting, no modifications were needed to incorporate the assessment and forecast inputs into Fcube. It is, however, to be noted that an issue in the FLXSA software was discovered during the workshop, leading to inconsistencies between the haddock and whiting forecasts presented in WGNSSK and the ones reproduced here, and therefore a full comparison is not possible so far for these stocks (see chapter 4).

The cod assessment was performed with B-Adapt, which assumed "total removals" consisting of an "overall landings" estimate and a "discards estimates". The use of the reported landings data from the different fleets was therefore not consistent with the assessment data used by B-Adapt. The Workshop therefore decided to raise the reported landings data from the different fleets to "overall landings" estimates, using the catch multiplier from B-Adapt. This multiplier was applied to all fleets.

Due to time restrictions at this year's Workshop, the Nephrops stocks were not incorporated in the evaluation. However, it should be noted that the data has been collected and could be taken into account at a later stage. The functional units with separate stock indices from underwater surveys (FU6, FU7, FU8 and FU9) are treated as separate Nephrops identities whereas the four other functional units (FU 5, 10, 32 and 33) are merged together into one data-set. Examples of the inclusion of Nephrops into Fcube estimates are given in ICES SGMIXMAN 2008.

3.1.2 Trends and advice

Recent trends are described on a stock-by-stock basis in ICES WGNSSK (2009), 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 once, this information is collected directly below.

3.1.2.1 Cod in IIIa – IV – VIId

Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as suffering reduced reproductive capacity and as being at risk of being harvested unsustainably. SSB has increased since its historical low in 2006, but remains below Blim. Fishing mortality declined after 2000, but in 2008 increased, predominantly as a consequence of increased discarding and is currently estimated to be between Flim and Fpa. The 2005 year class is estimated to be one of the most abundant amongst the recent below-average year classes. The 2008 year class is estimated to be one of the lowest in the series.

In 2009 ICES advises on the basis of the management plan on an F in 2010 that is 65% of the F in 2008 (F2010=0.51), catches should be less 66 400 t. Assuming discards rates as observed in 2008, this implies landings of less than 40 300 t in 2010. This presumes that the objectives of the management plan are realized which assumes reduction in F and control of catches in 2009 and 2010.

3.1.2.2 Haddock in IIIa – IV

Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and being harvested sustainably. SSB in 2009 is estimated to be above Bpa, although SSB has been declining since 2002. Fishing mortality in 2008 is estimated to be below Fpa, and below the target FHCR (0.3) specified in the EU–Norway management plan. Recruitment is characterized by occasional large year-classes, the last of which was the strong 1999 year class. Apart from the 2005 year class which is about average, recent recruitment has been poor.

In 2009 ICES advises on the basis of the management plan that implies landings in 2010 of 38 000 t, including industrial bycatch.

3.1.2.3 Plaice in IV

Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and as being harvested sustainably. SSB is estimated to have increased above the Bpa. Fishing mortality is estimated to have decreased to below Fpa and Ftarget. Recruitment has been of average strength from 2005 onwards. The recruitment in 2008 is just below the long-term average.

In 2009 ICES advises on the basis of the existing EU management plan. Although the evaluation of the plan has not been conclusive, the fishing mortality in 2010 when applying the management plan is expected to give benefits in terms of long-term yield and low risk to the stock compared to fishing at precautionary levels. ICES therefore advises to limit landings to 63 825 t for the year 2010.

3.1.2.4 Sole in IV

Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and is being harvested sustainably. SSB has fluctuated around the precautionary reference points for the last decade, but has increased since 2008 owing to a large incoming 2005 year-class and reduced fishing mortality. Fishing mortality has shown a declining trend since 1995 and is currently estimated to be below F_{pa}. The assessment suggests that the 2006 year class was below average, and 2007 average.

In 2009 ICES advises on the basis of exploitation boundaries in relation to the agreed management plan that landings should be less that 14 100 t in 2010.

3.1.2.5 Saithe in IIIa – IV – VI

Based on the most recent estimates of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and being harvested sustainably. SSB is estimated to have been above B_{pa} since 2001. From 2001 onwards, F has been at or below the target fishing mortality of 0.3.

ICES advises on the basis of the agreed management plan that the landings should be no more than 118 000 t in 2010.

3.1.2.6 Whiting in IV – VIId

In the absence of defined reference points, the state of the stock cannot be evaluated. An analytical assessment estimates SSB in 2009 as being near the lowest level since the beginning of the time-series in 1990. Fishing mortality has declined from 2000-2004, but increased in recent years. Recruitment has been very low since 2002, with an indication of a modest improvement in the 2007 year-class.

Because no reference points are available, ICES advises on the basis of precautionary considerations that a significant reduction of the TAC is required to remedy the decline in SSB. An immediate TAC reduction of 61% (13 400 t Total catch, 7 400 t human consumption catch) is needed to stabilize the stock, but rebuilding would require a further reduction.

3.1.2.7 Nephrops in Farn Deeps (FU 6)

The UWTV survey, fishery data and length frequency data all point to the stock at the start of the 2008 fishing season continuing to be at a low level. Recruitment signals for Nephrops in 2008 appear to indicate low recruitment.

ICES advises on the basis of exploitation boundaries in relation to high long term yield and low risk of depletion of production potential that the Harvest Rate for Nephrops fisheries should not exceed F2008. This corresponds to landings of no more than 1 210 t for the Farn Deeps stock.

3.1.2.8 Nephrops Fladen Ground (FU 7)

UWTV observations indicate that the stock is fluctuating without obvious trend with estimates for the last 2 years increasing to the highest abundance in the series. Considering the UWTV result alongside the indications of stable or slightly increasing mean sizes in the length compositions of catches (of individuals >35mm carapace length) suggests that the stock is being exploited sustainably. The decline in mean length of smaller individuals in the catch may be indicative of recent good recruitment.

ICES advises on the basis of exploitation boundaries in relation to high long term yield and low risk of depletion of production potential that the Harvest Rate for Nephrops fisheries should not exceed F0.1. This corresponds to landings of no more than 16 419t for the Fladen Ground.

3.1.2.9 Nephrops in Firth of Forth (FU 8)

The evidence from the UWTV survey suggests that the population has been at a relatively high level since 2003. The UWTV survey information, taken together with information showing stable mean sizes, suggests that the stock is being exploited sustainably.

ICES advises on the basis of exploitation boundaries in relation to high long term yield and low risk of depletion of production potential that the Harvest Rate for Nephrops fisheries should not exceed Fmax. This corresponds to landings of no more than 1 567 tonnes for the Firth of Forth stock.

3.1.2.10 Nephrops in Moray Firth (FU 9)

The evidence from the UWTV survey suggests that the population is stable, but at a lower level than that evident from 2003-2005. The UWTV survey information, taken together with information showing stable mean sizes, suggests that the stock is being exploited sustainably.

ICES advises on the basis of exploitation boundaries in relation to high long term yield and low risk of depletion of production potential that the Harvest Rate for Nephrops fisheries should not exceed F2008. This corresponds to landings of no more than 1 372 tonnes for the Moray Firth stock.

3.1.2.11 Summary

A summary of the stock classifications by ICES is given below:

Species	Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to high long-term yield	Fishing mortality in relation to agreed target
Cod IIIa-IV-VIId	Reduced reproductive capacity	Increased risk	Overfished	Above target
Haddock IIIa-IV	Full reproductive capacity	Harvested sustainably	Appropriate	Below target
Plaice IV	Full reproductive capacity	Harvested sustainably	Overfished	Below target
Sole IV	Full reproductive capacity	Harvested sustainably	Appropriate	Above target
Saithe IIIa-IV-VI	Full reproductive capacity	Harvested sustainably	Appropriate	Appropriate
Whiting IV-VIId	Undefined	Undefined	Undefined	NA

3.1.3 Software

One difficulty experienced by the WK group was to use single-species assessment in a consistent way. The collation of WGNSSK data pointed out the great diversity of software and settings, as suggested in the Table below.

Overview of software used by WGNSSK

Species	Assessment	Forecast
HADDOCK IV, IIIa and VIIb	FLR 1.4, FLXSA	MFDP
COD IV, IIIa and VIIb	Stochastic B-ADAPT	Stochastic B-ADAPT
PLAICE IV	FLR 2.x, FLXSA	FLR2.x, FLSTF
WHITING IV and VIId	FLR 2.x, FLXSA	MFDP
SAITHE IV, IIIa and VI	FLR 2.x, FLXSA	FLR 2.x, FLSTF
SOLE IV	FLR 2.x, FLXSA	FLR 2.x, FLSTF

In the mixed-fisheries runs, all forecasts run were done with the same FLR forecasts method (see chapter 2).

3.2 Fleets and métiers

3.2.1 Catch and effort Data

In WKMIXFISH 2009, runs were performed using data based on that collected for STECF SGMOS 09-04 for the evaluation of effort management. Data was received from Belgium, Denmark, France, Germany, the Netherlands, Norway, the UK (without Scotland) and Scotland. Data were recorded by country, gear and mesh size but compared to STECF SGMOS, vessel size categories were added to match fleet segments from the AER (Annual Economic Report) database for the countries where data were available (German, Danish, UK and Scottish fleets). Effort data in Days at Sea were also collected when available (German, Danish, UK and Scottish fleets). Specific data were received from the Netherlands and Norway. The full specification of the data request and points of note regarding data by nation are contained in Appendices 2 and 3. Some discards data were available for some of the segments.

3.2.2 Definitions of fleets and métiers

Fleets and métiers were defined to match with the available economic data and the cod long term management plan (Table 3.2.1).

In order to reduce the number of categories, an aggregation threshold, established through trial and error was used to determine 'small' métiers. A métier failing to catch 300 tonnes per year on average of at least one of the stocks considered was classified as small. All these small métiers were then aggregated by fleet in one "Other" métier (OTH). Further, all small fleets (i.e. containing only the "OTH" métier), were aggregated into one single "OTH" fleet.

The final data used contained 26 national fleets (plus the OTH fleet) from eight countries, from 2003 to 2008. These fleets engaged in one to six different métiers each, resulting in 70 combinations of country*fleet*métier catching cod, haddock, whiting, saithe, plaice, sole and Nephrops (Table 3.2.2).

Catches by these 27 fleets represented only a share of the total catches for the stocks as estimated in single-species analyses. The landings coverage for most stocks was high (over 80%), while it was only 50% for cod, due to the "unallocated removals" estimated by B-Adapt and raised to the landings and discards (Figure 3.2.1). To solve this inconsistency between fleets data and stock data the landings by fleets were raised to the unallocated catches. For the other stocks, the difference between fleet data and stock data were pooled into the "OTH" fleet (both landings and discards).

3.2.3 Trends

A number of overview graphs were produced using the Lattice package in R. These allowed large amounts of information to be summarized into synthetic plots, such as effort by fleet in absolute levels (Figure 3.2.2) and relative trends (Figure 3.2.3), effort share by métier and fleet (Figure 3.2.4) and landings by fleet and stock (Figure 3.2.5). These graphs helped represent trends at the scale of the whole North Sea at once, and point out their relative importance. In addition, these graphs were useful tools to figure out whether the forecast assumptions of e.g. constant effort share by métier and relative stability of the landings share by fleet were plausible hypotheses.

As illustrated by these figures the WK considered that, while these assumptions may not be fully valid for all fleets, especially the smaller ones, in general they were supported by the historical data.

3.2.4 Economic data

To run FcubEcon the same data required for Fcube was used. Further a set of species prices and costs on fleet segment level was needed. The data sources were the Annual Economic report 2005 (AER 2005) as regards the 2002-2004 data and the EIAA model for 2005 data. Average figures for 2003-2005 were used for prices while average figures for 2002-2004 were used for the cost estimates. The latest economic report was published by the Joint Research Centre (JRC) in 2008 (AER 2008) containing information until 2006. However, this information was, as regards prices in particular, less detailed than previous reports, and was therefore not used for our purposes. It was expected that the economic database will be improved in the future.

Cost and price data were extracted for the fleet segments called "Fleet segment base" in Tables 3.2.3 and 3.2.4. For the 2009 model runs the fleet segments used are shown under "Fleet segments 2009" in the tables. The cost data is computed as costs per day per fleet segment, which was assumed to be sufficiently good irrespective of the increase in fuel prices as the model results are presented as comparisons between scenarios rather that the absolute levels. Therefore, the cost structure rather than the cost level is important for the comparisons. The blanks in the tables indicate that either no landings have taken place for the segment or the species, or the information is not available. For model calculations the blanks were substituted by figures from comparable fleet segments.

However, to be able to assess the impact of the increases in fuel prices the development in fuel prices shown in Figure 3.2.6 based on Danish statistics about producer prices, which reflected the global development in fuel prices, were used. National fuel taxes were disregarded. The change in fuel prices played a role for the results from the FcubEcon and Fcube as the share of the fuel costs of the total variable costs differed for the fleet segment, see Table 3.2.3. The fuel costs were adjusted for the price index shown in Figure 3.2.6, and revised variables costs were computed.

4 Mixed-Fisheries forecasts

4.1 Description of scenarios

4.1.1 Baseline Run and Single-stock TAC constraint Run

The objectives of this Single-Stock baseline run were to 1) reproduce as close as possible the single-species advice produced by ICES WGNSSK and ACOM, and 2) act as the reference scenario for subsequent mixed-fisheries analyses.

In this run, a forecast was run for each stock separately following the same settings as in the ICES single species forecast (Table 4.1.1). For example, for cod the assumption was for catches corresponding to a 25% reduction in F in 2009 (F_{09}) compared to F_{08}. For stocks where ICES advice was made according to a long term management plan the rules of the plan were implemented in the baseline script. The resulting TACs for 2010 were expected to equal those advised by ICES. No forecast was conducted for Nephrops stocks.

In addition, an alternative single-species run was conducted, labelled ("TAC-constr2009"), exploring the effect of applying a TAC constraint on landings for the intermediate year instead of the assumptions on F used in the baseline run. TAC levels are often not accounted for in the specification of the intermediate year in single-species forecasts, because it is assumed that TACs do not control sufficiently the level of fishing mortality by stock due to mixed-fisheries interactions. In 2009, only the forecast for haddock used a TAC constraint. The mixed-fisheries approach conducted in this WK relies on the assumption that while single-species TAC may not individually influence the level of fishing mortality, they may still do so when being combined for the whole North Sea demersal fisheries. Therefore, we investigated the influence of this option on single-stock forecasts and advice.

4.1.2 Mixed fisheries runs

4.1.2.1 Fcube analyses of the intermediate year

The single-stock forecasts settings and target F for 2009 from the Baseline Run were used to perform some Fcube scenarios analyses for 2009 (Run "SSF09" – Single-Stock TargetF 2009). The aim of these analyses was to provide alternative sets of plausible levels of F by stock in 2009 accounting for mixed-fisheries interactions. As such, its configuration is similar to the Base Case run described and analysed in ICES SGMixMan (2008).

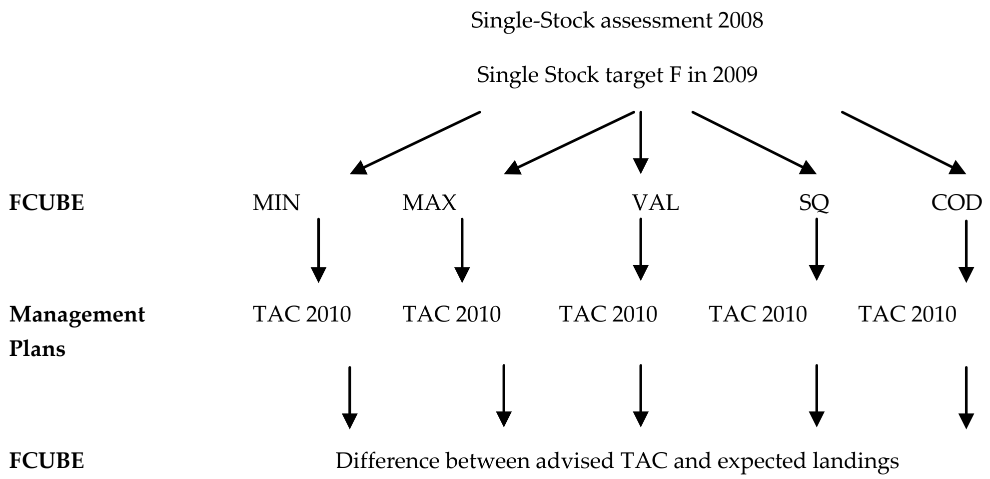
The Fcube scenarios 'max','min','val','Sq_E' and 'cod' were run (see chapter 2.1).

4.1.2.2 Mixed-fisheries advice for 2010 and Fcube analyses for 2010

The new F09 values by stock derived from the Fcube scenarios were used as input for the Intermediate Year in single-species forecasts, instead of the values from WGNSSK. Then the stocks were projected until 2011, using the same settings for 2010 as in the Baseline Run. The aim was to derive single-stock TAC advice for 2010 following single-stock management plans but accounting for mixed-fisheries interactions in 2009.

Finally, the same Fcube scenarios as for 2009 were applied again in 2010. In this way both differences in recommended TACs for 2010 resulting from different scenarios and an estimate of the cumulative difference between TAC and realised catches over two years could be calculated.

In summary, the Fcube runs followed the scheme below:



4.2 Results of Fcube runs

4.2.1 Baseline Run

Reproducing exactly the single-species ICES advice proved to be a difficult task. As pointed out previously, the assessment and forecast software and settings used differ among individual stocks, and no particular focus is given to increase the consistency among these. For the needs of mixed-fisheries analyses it was necessary to integrate all stocks in one common framework using generic forecasting FLR methods. These methods include a number of options which are mostly consistent with the traditional short-term forecast procedures used by WGNSSK, thus allowing some flexibility in the parameterisation of the forecast.

The baseline outputs obtained were as follows (Table 4.2.1)

		COD	HAD	PLE	POK	SOL	WHG
2009	**Fbar**	0.59	0.22	0.25	0.29	0.34	0.47
	FmultVsF08	0.75	0.89	1	0.95	1	1
	landings	41226	44600	59557	110110	15137	21306
	ssb	59591	223879	388131	263377	37670	93845
2010	**Fbar**	0.51	0.32	0.24	0.34	0.3	0.42
	FmultVsF08	0.65	1.29	0.98	1.13	0.9	0.9
	landings	38740	37910	63825	118150	14140	19581
	ssb	64444	195134	442260	234548	37664	92391
2011	**ssb**	73186	166460	488400	212326	39609	93845

This can be compared with the actual single-species ICES advice for landings (Table 4.2.2).

	COD	HAD	PLE	POK	SOL	WHG
2009						
Baseline	41.2	44.6	59.6	110.1	15.1	21.3
ICES Advice	41.9	45.0	59.5	111.0	15.1	19.0
Difference	**-1.6%**	**-0.9%**	**0.1%**	**-0.8%**	**0.0%**	**12.1%**
2010						
Baseline	38.7	37.9	63.8	118.2	14.1	19.6
ICES Advice	40.3	38.0	63.8	118.0	14.1	7.4
Difference	**-3.9%**	**-0.2%**	**0.0%**	**0.1%**	**0.3%**	**164.6%**

For plaice, saithe and sole, it was possible to reproduce exactly the single-species advice (the minor differences arising only from the rounding effect from the ICES advice). This consistency relies mostly on the fact that similar FLR-based software was used both by WGNSSK and WKMIXFISH.

For cod, it was not possible to fully reproduce the ICES advice, although the differences were small. The cod forecast is produced internally in B-Adapt directly on the bootstrapped populations, and the median of the forecasted assessment may be slightly different from the forecast of the median assessment. However, the WKMIXFISH group considered that while this was a source of slight concern which the group tried to solve, the inconsistencies between both were too small to affect significantly the outcomes of the work.

For haddock, small differences appeared in the F baseline (F2010=0.32 here, against 0.37 in ICES advice). But the cap on 15% TAC variation smoothed this out by constraining the 2010 landings in both runs.

The large discrepancies observed for whiting raised extensive discussion during the Workshop, and lead to a thorough check of the input data for both runs. Inconsistencies and software issues have been detected both in some procedures used by WGNSSK and in the forecast used here, for that stock only. This is not detailed here and further work is ongoing about these issues. But in consequence, the baseline scenario for whiting cannot be compared with the ICES advice. Similar issues applied to haddock but to a smaller extent.

4.2.2 – Single-stock TAC constraint Run.

The Results obtained for run 2 were (Table 4.2.3 below):

Table 4.2.3. Results of the "TACconstr2009" run by stock.

		COD	HAD	PLE	POK	SOL	WHG
2009	**Fbar**	0.47	0.22	0.23	0.38	0.31	0.41
	FmultVsF08	0.6	0.89	0.92	1.26	0.91	0.89
	landings	34600	44600	55500	139000	14000	19200
	ssb	59591	223879	388131	263377	37670	93845
2010	**Fbar**	0.49	0.32	0.24	0.38	0.28	0.42
	FmultVsF08	0.62	1.29	0.96	1.26	0.82	0.91
	landings	41520	37910	63825	118150	13375	20288
	ssb	72385	195134	449418	208370	38726	95021
2011	**ssb**	83015	166460	498072	183658	41440	95021

The comparison of both single-stock runs provided an indication on the possible mismatch between actual TAC and predicted landings in 2009. The main noticeable differences were observed for saithe and cod, in opposite directions: A full compliance with the cod TAC in 2009 would result in a decrease in F larger than stipulated by the MP (40% reduction) and consequently higher landings and biomass in following years. On the other hand, the saithe TAC is much larger than the actual recent catches. Then a full TAC uptake, while highly unlikely, would potentially drive the SSB below Bpa by 2011.

One conclusion from this simple comparison at the single stock level was that for four out of the six stocks the short-term forecast is fairly robust to the assumptions on the Intermediate Year. Two reasons for this could be advanced: 1) the TACs in place for 2009 do not imply large changes in effort relative to recent levels and 2) the MPs act as a buffer, i.e. the caps on interannual changes in TAC decrease the impact of the short-term scientific uncertainty.

In consequence, this scenario was not further investigated in a mixed-fishery context, and only the previous baseline single-species scenario was used.

4.2.3 – Mixed-fisheries analyses

4.2.3.1 Fcube analyses of the intermediate year

The Target F by stock for 2009 were set as the landings component of the F used in the Baseline (see table 4.1.1), i.e. a F reduction of 25%, 11% and 5% for cod, haddock and saithe respectively, and no F reduction target for plaice, sole and whiting.

The Fcube scenarios "min", "max", "val", "sq_E" and "cod" were applied to these target Fs.

For each fleet, striking differences occurred with regards to the estimated amount of effort necessary to catch the respective landings share for the various stocks in 2009 (Figure 4.2.1). But these differences differed also from fleet to fleet, indicating that no single pattern could be determined. Whiting and saithe were often the stocks with the highest corresponding effort for most fleets, indicating them to be the species with the least restrictive quota. On the other hand, cod and haddock were those corresponding with the smallest effort, indicating more restrictive quotas. Figure 4.2.1 underlines the relative inconsistencies of the target Fs at the fleet level.

This translated into the resulting effort by fleet (Figure 4.2.2), which could vary dramatically among Fcube scenarios. While the "max" effort was often largely higher than in the other scenarios, it was the closest to the observed effort in 2008 for a number of fleets, including the important Scottish and English trawlers. For many other fleets, the effort estimated in the "val" scenario remained around the range of the observed effort in 2008. Although this scenario was only a very lose proxy for economic incentives (relating to revenue maximisation rather than profit maximisation), hindcasting exercises performed on the years 2004-2006 have shown that this estimate was the closest proxy for observed effort for all fleets but one (Ulrich, unpublished – Chapter 2 in Deliverable D1.2 of EU FP6 AFRAME project - Contract no.: 044168).

For many of the demersal otter trawler fleets, the "val" estimate is also relatively close to the "cod" estimate, pointing out that cod is still a key source of revenue for the fleet in spite of decreasing abundance.

These differences by fleet translate at the stock level when the partial F are summed (Figure 4.2.3 and Table 4.2.4 below).

Table 4.2.4: Results of the "SSF09" Fcube runs.

	COD	HAD	PLE	POK	SOL	WHG
TAC2009	34600	44600	55500	139000	14000	19200
BASELINE	41226	44600	59557	110110	15137	21306
MAX	63936	88549	98060	150011	23760	23174
MIN	38211	43891	47786	69391	11793	11973
VAL	46111	53428	60087	102438	14670	16353
SQ_E	53259	70394	61082	109700	14599	18585
COD	41226	48388	50629	84566	12169	14621

In this run, the cod landings is the "min" scenario are estimated above the TAC 2009 because the F target in 2009 comes from the Management Plan (25% reduction compared to 2008) rather than from the TAC constraint.

The range of landings between the "min" and "max scenarios had somehow narrowed compared to the previous similar exercise performed with 2007 TACs (ICES SG MixMan 2008), indicating that the levels of effort implied by the 2009 TACs are more consistent across stocks.

The "val" scenario was close to the "sq_E" scenario for most stocks, except for haddock and whiting which were underestimated in the "val" scenario, suggesting that these stocks were being targeted more directly than their financial value would indicate.

Finally, the results above provided us with estimates of the potential overquota catches or overshooting of the baseline assumptions. In the "sq_E" scenario, estimated landings of cod and haddock exceed the baseline estimates by 29% and 58% respectively, while whiting landings estimates were 13% below the baseline. In the "val" scenario, the estimated landings in excess of the baseline were 12% and 20% for cod and haddock respectively, while they were 23% below the baseline for whiting.

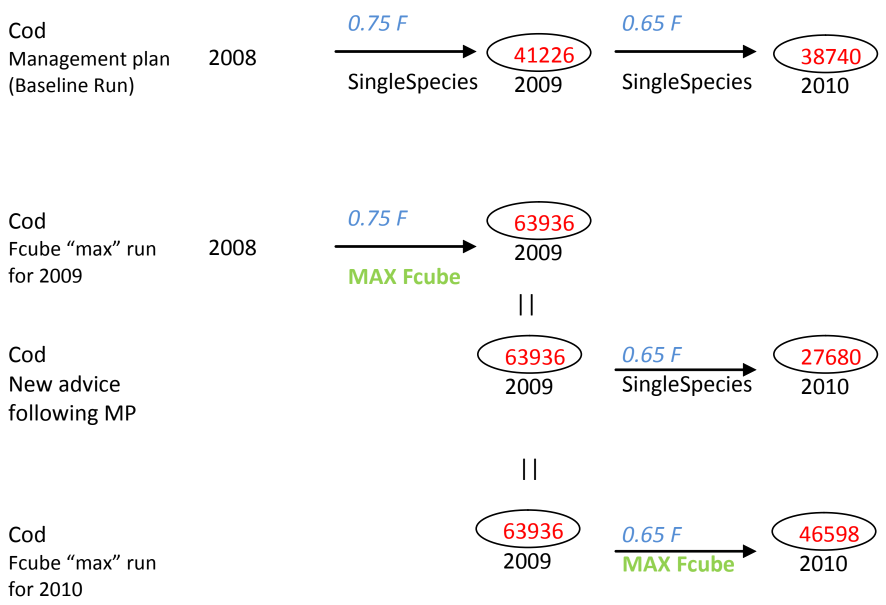
On the contrary, the "cod" scenario, which complies with the 25% reduction in cod F in 2009 assumed by the management plan, implied strong reductions of landings for plaice, sole, saithe and whiting (15%, 20%, 23% and 31% respectively with regards to the baseline; 9%, 13%, 39% and 24% respectively with regards to the TAC 2009).

The relatively lower changes corresponding to haddock suggested that the implications of the haddock and cod management plans were consistent with each other for 2009, while the other management plans were not consistent with these. Although here we have chosen to focus on the cod MP, similar exercises could be conducted for each individual MP separately.

These mixed fisheries analyses indicate that, the 25% reduction in F required for cod also implies that the quotas for other species, notably plaice and sole, would be undershot. As a result, in the absence of further restrictions, it might be anticipated that this scenario might be unlikely to be achieved in practice. However, as detailed in Section 1.2, there has been a substantial change in the way effort is managed in 2009 compared to previous years. In addition, measures such as checks on quota and effort uptake and a ban on high-grading have been introduced which are intended to reduce the possibility of the cod quota being exceeded. These changes mean that the "cod" scenario may be realistic for at least some national fleets.

4.2.3.2 Mixed-fisheries advice for 2010 and Fcube analyses for 2010

The full overview of the runs up to 2010 are presented table 4.2.5. An example of interpretation is given in the scheme below to aid understanding of the advice table. The example follows the landings results for the cod stock in the Fcube "max" scenario:



Green color - Bold: This option is the Fcube run

Blue color - Italic: This option is from the management plan

Red numbers in : Resulting TAC from Table 2.4.5

In this example, the baseline run, which followed the single-stock ICES advice, assumed landings of 41226 tonnes of cod in 2009 (corresponding to the 25% reduction in F from the Management Plan), and 38740 tonnes in 2010 following another 10% reduction. But if we assumed that all fleets will fish to their maximum in 2009, i.e. will catch the full amount of the least restrictive quota (usually saithe or whiting), then 2009 landings were estimated at 63936 tonnes, i.e. 55% more than assumed in the baseline. If this was the case, this would imply lower TAC advice for 2010 of 27680 tonnes in order to comply with the 35% reduction in F in 2010, i.e. a reduction of 29% compared with the single-species advice. If again we assumed that the fleets would fish to their maximum in 2010 also, then the landings would be estimated at 46598 tonnes, i.e. only 20% above the initial single-stock baseline but up to 68% above the landings corresponding to the Management Plan. And while the Single-Stock advice estimated a SSB level around 73000 tonnes by 2011 under full compliance with the MP, the extreme "max" Fcube scenario (maximum fleet catches in 2009 and 2010) estimated SSB in 2011 as low as 19600 tonnes.

These results are further discussed in chapter 5, where they form the basis of the draft final advice.

4.3 Comparison of Fcube outcomes with the current Cod Plan for effort regulation

When all fleet and metier combinations were constrained to produce an overall catch complying with the cod long term management plan ('cod' scenario) the associated estimated effort by fleet calculated by Fcube could be summed and compared to effort allocations under regulation (EC) No. 43/2009. The regulation only applies to EU nations so results for Norway cannot be included in the analysis. Also effort allocations were for the UK so effort totals produced by Fcube for UK (England Wales and NI) and Scotland were combined.

The results obtained were quite striking (Tables not shown). For many countries, the optimum amount of KWdays estimated with Fcube was largely below the national ceilings for 2009. Only for two countries some ratios close to 1 were observed.

It must be kept in mind that the Fcube results are conditioned on various assumptions, including constant catchability and constant effort share by fleet, whereas in practice there may be some variation in these parameters. As a result the Fcube results should be interpreted with caution. With that caveat, the results do imply that the effort allocations available for 2009 may not be restrictive for all fleets.

In addition, Figure 4.2.2 shows how large the effort decrease called for by the "cod" scenario is compared to the status quo (effort in 2008). One can expect that the 2009 effort management plan will still have a significant effect in reducing the effort to a level intermediate between the 2008 level and the "cod scenario" level. However, the implication of these results is that the schemes put in place for some fleets to reduce the catchability of cod must deliver if the intentions of the management plan are to be fulfilled.

The WKMIXFISH group did not have the time to conduct further analyses about this because of the short duration of the meeting. Therefore, the group decided not to include the result tables in this report, considering them as too provisional so far. But this will be further discussed during STECF 2009 meeting on effort management, to be held at the end of September.

4.4 FcubEcon results

The full potentials of the FcuEcon model were not used because of missing or uncertain data for a number of the fleet segments. For the fleet segments for which no economic data was available the information from comparable fleet segments was used.

Two types of calculations were carried out. The first one was a calculation based on table 4.2.4. For each of the five scenarios the landings on species and fleet segments were multiplied with the fish prices, and the effort in terms of kW-days per fleet segments was multiplied with the variable costs per kW-day. Then the profit was calculated by subtracting costs from gross revenue. The variable costs were defined as fuel, provisions, ice, administration, insurance and maintenance. Hence the profit was what was left for remuneration of labour and capital. The result is shown in Table 4.4.1.

Gross revenue is taking into account that over-quota catches are discarded and therefore do not contribute to the revenue, while all the effort forms the basis for the costs. It was noticed from Table 4.4.1 that although the "min" scenario produced the smallest revenue this was the scenario with the highest profit because the applied effort is comparatively smaller. Contrary to that the "max" scenario suffered from over-quota catches of many of the species which was associated with a high effort. The result was a negative profit for the whole fleet.

Only a few of the fleet segments showed a positive profit which was more than counterweighted by the negative profit for the rest of the segments.

Table 4.4.1: Estimated economic results of the "SSF09" Fcube runs. Millions €.

	Revenue	Costs	Profit
max	456	552	-96
min	375	243	132
val	433	338	95
sq_E	440	378	62
cod	396	286	111

The results require that the fishermen comply with the quota restrictions. In the "min" scenario a number of the quotas are not fully used, and it could be expected that the fishermen would continue fishing as long as the value of the remaining shares of the quotas are higher than the cost of fishing them irrespective of the fact that they must discard the over-quota catches of some species. In that case the fishery would continue until the marginal profit is zero. The over-quota catches will be discarded and not counted in the revenue.

The second calculation investigated this problem. Because of the uncertainty as regards the economic data this calculation was only carried out for a few fleet segments for which data was reliable. The calculation showed that for example for the Danish trawlers below 24 meters, the profit could be increased by 7% if the effort was increased 12% assuming that the segments were allowed to catch only the share of the quotas equal to the segment's share of the catches in proportion to the total catches in the "min" scenario. For Danish static gear the increase in profit was 1% for a 2% increase in effort compared to the "min" scenario effort. For the Dutch beam trawl 24-40 meters and 40 meters and above the increase in profit was in both cases 16 % for an increase in effort of 17% compared to the "min" scenario.

These results were indicative but showed that if fishermen's profit maximizing behavior was taken into account the profit would increase and the over-quota catches compared to the "min" scenario would also increase, but not to a level near the "max" effort scenario. The calculations carried out here do not rely on the same assumptions as the "val" scenario and are, therefore, not the same scenario.

5 Overview: Draft Mixed-fisheries Advice for 2010

The ICES single-species advice for 2010 used assumptions about fishing activity during 2009. For instance, for some stocks the advice assumed that fishing mortality during 2009 was constrained by the TAC for that stock. In other cases the amount of fishing mortality during 2009 was assumed to be an average of recent years. In practice the situation is rather more complex, particularly in mixed fisheries where the amount of fishing mortality on a given stock during the year may depend as much on fishing opportunities for other species caught in the same fishery as on the TAC for a particular species. For instance the TAC for North Sea cod has sometimes been less restrictive than intended as vessels continue fishing for other species once their quota for cod is exhausted. As a result, cod is still caught but has to be discarded instead of landed.

The implications of this issue for the outcomes of the stock-based advice depend both on the extent to which the different species are caught together, and on the extent to which there is a mismatch between the fishing opportunities available to each fleet for each stock. Information on recent trends in fishing effort and catches by major demersal fleets in the North Sea is given in Figures 3.2.2 & 3.2.5. This information was used in mixed-fishery forecasts in order to look at the implications of technical interactions and TAC-mismatches for the ICES single species advice for North Sea demersal stocks in 2010. These forecasts investigated a number of different scenarios for fleet activity during 2009-2010.

One possible scenario for fleet effort over 2009-2010 is that all fleets are constrained so that their fishing effort is sufficient just to take their cod quota and no more. The implications of this scenario are shown in Table 4.2.5 as scenario 'cod'. If this scenario held for all fleets, then 2009 quotas for species other than cod would be underutilised. This would also lead to stock abundances at the start of 2010 that are higher than those assumed in the single stock-based advice. In most cases however, this would not change the advised TACs, as these are constrained by the limits on annual changes in TAC specified in the relevant management plans. The underlying stock status would differ from that assumed in the current TAC advice. For instance, the advised plaice TAC for 2010 of 63.8 thousand tonnes was intended to maintain fishing mortality at the current level, whereas if effort was constrained in line with the 'cod' scenario this same TAC would represent a smaller proportion of the overall stock, leading to a 28% reduction in fishing mortality relative to 2008.

Table 4.2.5 presents results in this form for a range of different scenarios of possible fleet effort over 2009 and 2010. In each case the same scenario was assumed for all fleets. In practice different scenarios are likely to apply for each fleet. For instance, some fleets were likely to be constrained by the restricted effort allocations introduced as part of the revised cod recovery plan in 2009, whereas the activity of others might be more in line with the less restricted, 'val' scenario. As a result, no one scenario was considered most representative of what was likely to happen over 2009 and 2010. Overall however, the projections indicated that the ICES TAC advice was robust to different scenarios about fishing activity during 2009 and 2010 for most stocks. This reflected the limits on annual changes in TAC incorporated in the harvest control rules for stocks where management plans were specified.

The main stock where the ICES advice was not robust to scenarios about fishing activity over 2009-2010 was cod. Most of the scenarios investigated implied over-quota catches of cod during 2009, and hence a worse stock state at the start of 2010 than the current advice assumed. The additional measures that were introduced as part of the cod recovery program during 2009 should help to restrict effort on the stock, but there remained a risk that technical interactions may inhibit the rate of recovery of the cod stock.

6 Conclusions and Recommendations

The WKMIXFISH met for the first time in 2009, with the task to deliver the first draft of ICES mixed-fisheries advice. This represented a significant step forward compared to the traditional single-species advice, and a real progress in trying to address one of the most important issues in current fisheries management. Considering the lack of success of the previous initiatives in this direction, the WK group considered that the present report represents a major and positive achievement. Using a simple and process-based approach, with transparent assumptions and widely available data, the group was able to provide advice on a large panel of current issues. Among other, the group could evaluate the consistency among the various single-stock management plans, and between these plans with the overall effort management plan in place in the North Sea. Such analyses have never been performed before. This demonstrated the wide and generic usefulness of the flexible framework developed during 2007-2009. In addition, the WK group worked on a multidisciplinary level, allowing addressing further the major linkages of fisheries management with economic analyses and fleet behaviour. The group and the work done also contributed to bridging an important gap between the work traditionally performed by ICES and the work traditionally performed by STECF.

In conclusion, the WKMIXFISH group was very positive about the results achieved. However, the group wished to underline the tremendous amount of work that has been necessary to achieve these. The workshop was of very short duration (three days). While it may be possible that three days are enough in the future when such mixed-fisheries advice becomes a routine procedure, the time allocated for this first meeting in 2009 was judged too short with regards to the number of questions that arose when such a new procedure was set in form for the first time. It was clear that expectations were different when dealing with research and exploratory work, as was done in previous SGMixMan and project forums, compared to delivering robust and trustworthy advice. As such, the results could only be achieved through major preparatory work ahead of the meeting and extended working hours during the workshop itself.

Compiling the type of effort, catch and economic data required for mixed fisheries forecasts takes considerable resources (not least in person time). The basic requirements for the data were made compatible with those to fulfil the effort and catch assessments of STECF and the annual economic report also compiled by STECF. If the specification of aggregated groups could be made consistent between the two STECF activities (and a 'days at sea' field specified in each case) then no additional data call would be necessary to perform the mixed fisheries forecasts. Currently however, length class specifications are not compatible between data sets forcing an additional data request and (as happened this year) the possibility of incomplete data from nations that have already fully complied with STECF data requirements. The working group recommends that metier classes should be made compatible between the effort, catch and economic datasets requested of nations by STECF as soon as possible.

For haddock, plaice and saithe, we showed that running forward the projections (with and without Fcube) to SSB at the start of 2010 and then applying the harvest control rules of the single species management plans lead to the same recommended TAC for 2010, independently of the assumptions on the intermediate year, because of the effect of the limitations in interannual variability of the TAC. For sole and whiting the resulting TACs were relatively close in value. The working group therefore considers that the single-stock management plans (or HCR rule in the case of whiting) for these stocks are robust to uncertainties in stock assessment and the behaviour of fishing fleets in terms of TAC advice. However, the same levels of TAC in 2010 can correspond to large differences in terms of underlying SSB and levels of F.

For cod, the results showed relatively high sensitivity to the assumptions for 2009. Unless the effort for all fleets is no more than that required to take their cod quota, then the forecasts imply that some degree of over-quota catches of cod are likely to occur. The results further imply that the available effort allocations may not be restrictive for some national fleets.

It must also be kept in mind that Nephrops stocks could not be included in the current analyses, because of time shortage and of the difficulty to make forecasts in a similar manner as for demersal fish stocks. But these stocks should be accounted for in future mixed-fisheries advice.

Finally, it is important to keep in mind that all the results presented above are based on deterministic projections with transparent but strong assumptions on a number of constant patterns. In addition, the results here are obtained based on rather rough metiers definitions, using only gear and mesh size information and aggregated at the year level. This may mask the fact that some of these metiers may catch the various stocks sequentially rather than simultaneously, thus affecting the patterns of technical interactions. The partial economic analyses presented in this report show that other levels of effort would be expected with other underlying assumptions. Therefore, all results above must be interpreted with caution, as for any other projection model. Further work should continue, in order to i) improve the robustness of these underlying assumptions and ii) include such short-term mixed-fisheries analyses in longer-term management plans prospective, in order to define robust integrated and fleet-based management plans for the whole demersal fisheries in the North Sea.

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8 Tables

Table 1.2.1, Council regulations introducing and modifying fishing effort (days at sea) allowances in EU fisheries.

Year of application	Regulation
2003	(EC) No 2341/2002–Annex XVII
2004	(EC) No 2287/2003–Annex V
2005	(EC) No 27/2005–Annex IVa
2006	(EC) No 51/2006–Annex IIa
2007	(EC) No 41/2007–Annex IIa
2008	(EC) No 40/2008–Annex IIa
2009	(EC) No 43/2009–Annex IIa

Table 1.2.2. Overview over the number of regulated gear categories and corresponding special conditions by year.

Gear type	Cat./Specon	2003	2004	2005	2006	2007	2008	2009
Demersal Traws, seines, towed gears	Categories	3	3	3	5	5	5	3
	Special Con.	-	2	4	15	17	17	-
Beam trawl	Categories	1	1	1	4	4	4	2
	Special Con.	-	-	1	5	5	5	-
Static demersal nets	Categories	1	1	1	-	-	-	-
	Special Con.	-	2	2	-	-	-	-
Gillnets	Categories	-	-	-	2	4	4	1
	Special Con.	-	-	-	1	1	1	-
Trammel	Categories	-	-	-	1	1	1	1
	Special Con.	-	-	-	1	1	1	-
Longlines	Categories	1	1	1	1	1	1	1
	Special Con.	-	-	-	-	-	-	-
Total		6	10	13	35	39	39	8

Table 1.2.3; Gear categories used in effort management in 2009 (regulations 1342/2008 and 43/2009)

Mesh size ranges used in Gillnet categories changed in 2007. The most recent categorisation is given here.

GEAR GROUP (2006-2008)	CODE	GEAR GROUP 2009
Demersal trawls, seines or similar towed gears of mesh size ≥120 mm except beam trawls;	4av	TR1
Demersal trawls, seines or similar towed gears of mesh size 100 mm to 119 mm except beam trawls;	4aiv	TR1
Demersal trawls, seines or similar towed gears of mesh size between 90 mm to 99 mm except beam trawls;	4aiii	TR2
Demersal trawls, seines or similar towed gears of mesh size between 70 mm to 89 mm except beam trawls;	4aii	TR2
Demersal trawls, seines or similar towed gears of mesh size between 16 mm to 31 mm except beam trawls.	4ai	TR3
Beam trawls with mesh sizes equal to or larger than 120mm	4biv	BT1
Beam trawls with mesh sizes equal to or larger than 80 mm and less than 90mm	4bi	BT2
Beam trawls with mesh sizes equal to or larger than 90 mm and less than 100mm	4bii	BT2
Beam trawls with mesh sizes equal to or larger than 100 mm and less than 120mm	4biii	BT2
Gillnets & entangling nets with mesh size less than 110mm	4ci	GN
Gillnets & entangling nets with mesh size greater than or equal to 110mm and less than 150mm	4cii	GN
Gillnets & entangling nets with mesh size greater than or equal to 150mm and less than 220mm	4ciii	GN
Gillnets & entangling nets with mesh size greater than or equal to 220mm	4civ	GN
Trammel Nets	4d	GT
Longlines	4e	LL

Table 3.2.1: 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 3.2.2: Final fleet and métier categories used in the mixed fishery analysis. 4, 3AN and 7D refer to the area.

Fleet	Métier
Be_Beam	BT1.4 BT2.4 OTH
DK_Beam	BT1.4 OTH
DK_Dseine	TR1.4 OTH
DK_Otter <24	TR1.3AN TR1.4 TR2.3AN TR2.4 OTH
DK_Otter >24	TR1.3AN TR1.4 TR2.3AN TR2.4 OTH
DK_Otter 40+	TR3.4 OTH
DK_Static <24	GN1.3AN GN1.4 GT1.4 OTH
EN_Beam >24	BT1.4 BT2.4 OTH
EN_Otter <24	TR1.4 TR2.4 OTH
EN_Otter >24	TR1.4 OTH
EN_Static	GN1.4 OTH
FR_Static	GT1.4 OTH

Fleet	Métier
FR_Otter	TR1.4 TR2.4 TR2.7D OTH
GE_Beam	BT2.4 OTH
GE_DSeine	TR1.4 OTH
GE_Otter	TR1.4 TR1.3AN TR2.4
NL_Beam <24	BT2.4 OTH
NL_Beam 24-40	BT2.4 OTH
NL_Beam 40+	BT1.4 BT2.4 OTH
NL_Otter	TR1.4 TR2.4
NO_Beam	BT1.4 BT2.4
NO_Otter	TR1.4 OTH
SC_Beam >24	BT1.4 BT2.4
SC_Dseine	TR1.4
SC_Otter <12	TR1.4 TR2.4 OTH
SC_Otter 12-24	TR1.4 TR2.4 OTH
SC_Otter >24	TR1.4 TR2.4

Table 3.2.3. Cost estimates for base fleet segments compared to segments used for the 2009 MIX-FISH runs.

Fleet segments base	Variable cost per day[1)]	Variable cost per kW-day	Fuel cost share	Fleet segments 2009
	1000 €	1000 €	Per cent	
BEL_BEAM	2.07	0.0033	43%	BE_Beam
DEN_BEAM		0.0025		DK_Beam
DEN_DEM_SEINE	0.63	0.0037	13%	DK_DSeine
DEN_DEM_TRAWL_<24	0.63	0.0028	29%	DK_Otter<24
DEN_DEM_TRAWL24_40	1.66	0.0027	32%	DK_Otter>24
		0.0027		DK_Otter40+
DEN_GILLNET	0.35	0.0035	14%	DK_Static<24
ENG_BEAM	2.70	0.0037	34%	EN_Beam>24
ENG_DEM_TRAWL		0.0027		EN_Otter<24
		0.0027		EN_Otter>24
ENG_STATIC		0.0035		EN_Static
		0.0027		FR_Otter
		0.0035		FR_Static
		0.0055		GE_Beam
		0.0037		GE_DSeine
		0.0028		GE_Otter
NLD_BEAM_<24	1.21	0.0055	31%	NL_Beam<24
NLD_BEAM_>=24	4.04	0.0025	50%	NL_Beam24-40
		0.0025		NL_Beam40+
		0.0028		NL_Otter
NOR_BEAM		0.0025		NO_Beam
NOR_ROUNDFISH		0.0027		NO_Otter
OTH_OTH		0.0035		OTH_OTH
SCO_BEAM	0.77	0.0051	35%	SC_Beam>24
SCO_DEM_SEINE	1.75	0.0042	21%	SC_DSeine
		0.0027		SC_Otter<12
SCO_DEM_TRAWL_>=24	1.20	0.0037	25%	SC_Otter>24
SCO_DEM_TRAWL_<24	3.08	0.0043	25%	SC_Otter1224

Source: AER 2005. Data average 2002-2004

1) Indicates the fleet segments for which costs are available

Table 3.2.4. Price estimates for base fleet segments compared to segments used for the 2009 MIX-FISH runs.

Fleet segments base	Prices (€ per kg)											Fleet segments 2009
	COD	HAD	NEP6	NEP7	NEP8	NEP9	NEPoth	PLE	POK	SOL	WHG	
BEL_BEAM	2.10	1.06					4.28	1.89	1.00	9.01	0.94	BE_Beam
DEN_BEAM	1.88	1.02		7.26			7.26	1.84	0.61	9.46	0.61	DK_Beam
DEN_DEM_SEINE	1.88	1.02						1.84	0.61	9.46	0.61	DK_DSeine
DEN_DEM_TRAWL_<24	1.88	1.02		7.26			7.26	1.84	0.61	9.46	0.61	DK_Otter<24
DEN_DEM_TRAWL24_40	1.88	1.02		7.26			7.26	1.84	0.61	9.46	0.61	DK_Otter>24
												DK_Otter40+
DEN_GILLNET	1.88	1.02		7.26			7.26	1.84	0.61	9.46	0.61	DK_Static<24
ENG_BEAM	2.21	1.29	3.81				3.81	2.01	0.71	10.28	1.04	EN_Beam>24
ENG_DEM_TRAWL	2.21	1.29	3.81				3.81	2.01	0.71	10.28	1.04	EN_Otter<24
												EN_Otter>24
ENG_STATIC	2.21	1.29	3.81				3.81	2.01	0.71	10.28	1.04	EN_Static
												FR_Otter
												FR_Static
												GE_Beam
												GE_DSeine
												GE_Otter
NLD_BEAM_<24	2.10	1.06					4.28	1.89		9.01	0.94	NL_Beam<24
NLD_BEAM_>=24	2.10	1.06					4.28	1.89	1.00	9.01	0.94	NL_Beam24-40
												NL_Beam40+
												NL_Otter
NOR_BEAM	1.53	0.94					7.26	1.84	0.53	9.46	0.61	NO_Beam
NOR_ROUNDFISH	1.53	0.94					7.26	1.84	0.53	9.46	0.61	NO_Otter
OTH_OTH	2.21	1.29		3.81			3.81	1.89	0.71	9.01	1.04	OTH_OTH
SCO_BEAM	2.21	1.29	3.81	3.81	3.81	3.81	3.81	2.01	0.71	10.28	1.04	SC_Beam>24
SCO_DEM_SEINE	2.21	1.29	3.81	3.81	3.81	3.81	3.81	2.01	0.71	10.28	1.04	SC_DSeine
												SC_Otter<12
SCO_DEM_TRAWL_<24	2.21	1.29	3.81	3.81	3.81	3.81	3.81	2.01	0.71	10.28	1.04	SC_Otter1224
SCO_DEM_TRAWL_>=24	2.21	1.29	0.00	3.81				2.01	0.71	10.28	1.04	SC_Otter>24

Source: AER 2005 and the EIAA model for 2005. Data average 2002-2005

Table 4.1.1. Overview of target F, settings used for the intermediate year and the rules (harvest control rules from management plans except for whiting) applied to single-stock ICES advice. All 2010 TAC values were agreed by STECF (2009) and also the obtained values applying annex II of the EU com 2009/224 on Fishing opportunities for 2010 except for whiting (opt A is the advice and opt B is the value according EU com 2009/224).

SPECIES	TARGET F	FORECAST AND HCR SETTINGS	EXPECTED LANDINGS 2009	TAC 2010
COD IV, IIIa and VIIb	0.4	25% reduction in 2009 F08 ref man plan, and then, in 2010,a further 10 % reduction: 0.65*F09	41900	40300 (incl. all catches)
HADDOCK IV, IIIa and VIIb	0.3	TAC constraint in 2009, then 15% TAC constraint applies	44700	38000
PLAICE IV	0.3	3 yr average, scaled to 2008. Man.plan 10% reduction in F, then 15% TAC constraint applies	59500	63800
SOLE IV	0.2	3 yr average, scaled to 2008. Man.plan 10% reduction in F, with 15 % TAC constraint which does not apply	15140	14100
SAITHE IV, IIIa and VI	0.3	3 yr average, not scaled, 15 % TAC constraint applies	110000	118000
WHITING IV and VIId		No decline in SSB, 3 yr average, scaled to 2008, 15% reduction according to EU com 2009/224 Final.	19000	7400 opt A 12920 opt B

Table 4.2.5. Results of Final Fcube runs.

Landings		Cod	Haddock	Plaice	Saithe	Sole	Whiting
Applying Advice on 2008 data (eg Management Plan or advice)							
2009	Baseline run	41226	44600	59557	110110	15137	21306
Applying Fcube on 2008 data							
2009	cod	41226	48388	50629	84566	12169	14621
	max	63936	88549	98060	150011	23760	23174
	min	38211	43891	47786	69391	11793	11973
	sq_E	53259	70394	61082	109700	14599	18585
	val	46111	53428	60087	102438	14670	16353
Applying Fcube on 2009 Fcube results							
2010	cod	38740	25403	50595	76094	11758	14882
	max	46598	50656	104952	126357	23636	27074
	min	40369	25724	50308	71465	11366	12969
	sq_E	44762	37559	66391	101553	15078	19373
	val	44837	34257	62290	104637	13981	18552
Applying Advice on 2009 Fcube results (eg Management Plan or advice)							
2010	cod	38740	37910	63825	118150	12046	19335
	max	27680	37910	63825	118150	16100	18144
	min	40637	37910	63825	119034	11900	18786
	sq_E	31187	37910	63825	118150	13784	20160
	val	35670	37910	63825	118150	13831	19695
	Baseline run	38740	37910	63825	118150	14140	19581

Fmult Vs F08		Cod	Haddock	Plaice	Saithe	Sole	Whiting
Applying Advice on 2008 data (eg Management Plan or advice)							
2009	Baseline run	0.75	0.89	1	0.95	1	1
Applying Fcube on 2008 data							
2009	cod	0.75	0.97	0.84	0.7	0.78	0.65
	max	1.45	2.05	1.78	1.39	1.76	1.11
	min	0.68	0.87	0.78	0.56	0.75	0.52
	sq_E	1.08	1.52	1.03	0.94	0.96	0.85
	val	0.87	1.09	1.01	0.87	0.96	0.74
Applying Fcube on 2009 Fcube results							
2010	cod	0.65	0.85	0.72	0.62	0.68	0.6
	max	1.76	2.55	2.19	1.44	2.24	1.38
	min	0.64	0.83	0.71	0.55	0.65	0.49
	sq_E	1.08	1.52	1.03	0.94	0.96	0.85
	val	0.89	1.22	0.95	0.95	0.88	0.78
	Baseline run	0.65	1.29	0.98	1.13	0.9	0.9

SSB		Cod	Haddock	Plaice	Saithe	Sole	Whiting
Applying Advice on 2008 data (eg Management Plan or advice)							
2009	Baseline run	59591	223879	388131	263377	37670	93845
2010	Baseline run	64444	195134	442260	234548	37664	92391
2011	Baseline run	73186	166460	488400	212326	39609	93845
Applying Fcube on 2009 SSB							
2010	cod	64444	190968	458032	258002	40439	100794
	max	37844	147057	375160	198501	29650	90072
	min	68049	195913	463069	272060	40791	104166
	sq_E	50209	166844	439575	234922	38166	95792
	val	58634	185431	441326	241563	38100	98602
Applying Fcube on 2010 Fcube results							
2011	cod	73186	176162	531899	276327	44764	106516
	max	19591	103623	330067	165939	22358	82651
	min	77187	180784	539193	296467	45505	111673
	sq_E	41893	138260	480486	227459	39232	96793
	val	55796	160723	489707	232079	40212	100061

9 Figures

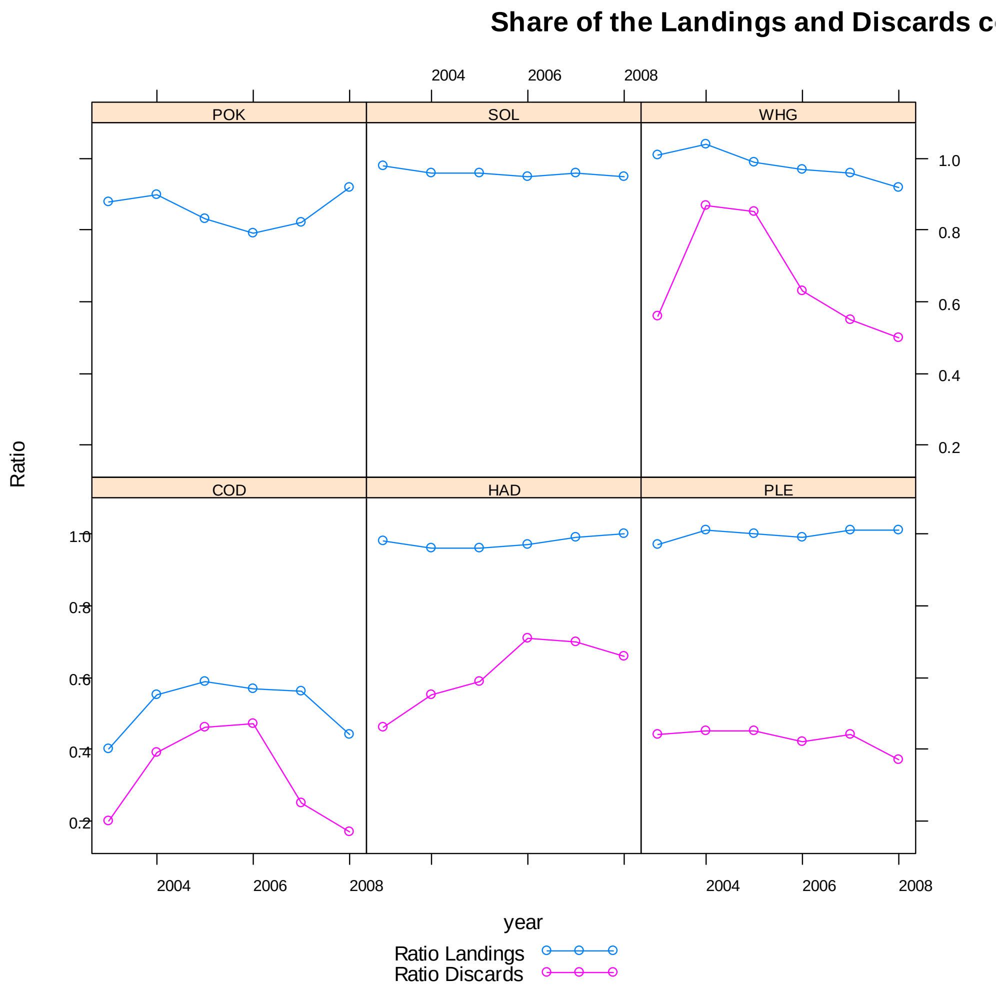
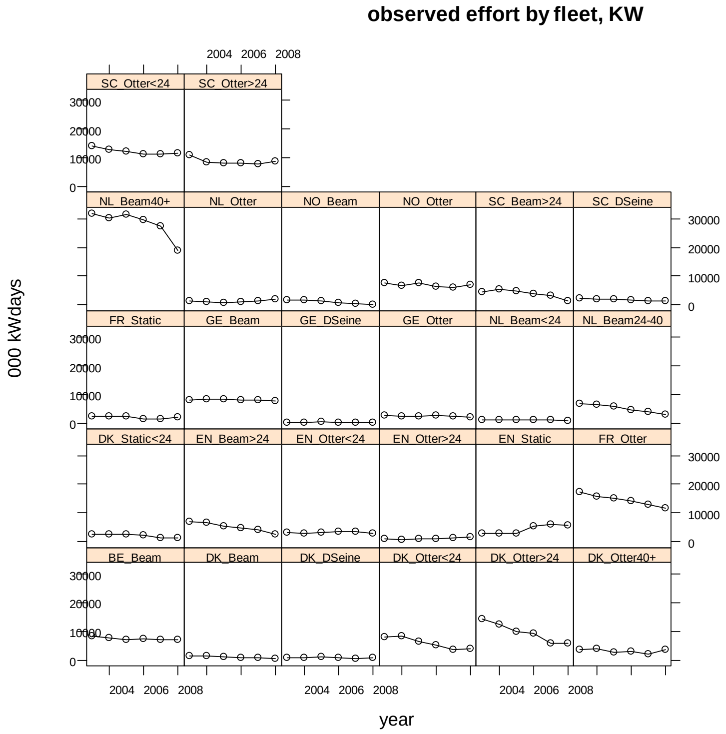


Figure 3.2.1. Ratio between the sum of landings and discards by fleet and the landings and discards used in WGNSSK stock assessment, before raising of cod data.



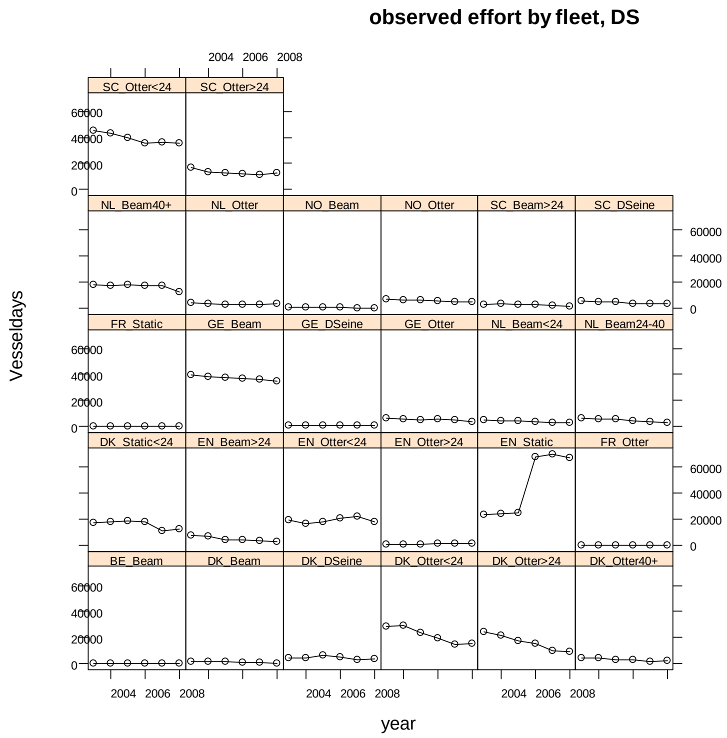


Figure 3.2.2 – Effort by fleet and year for the North Sea demersal fleets, in '000 KWdays (up) and Days at Sea (Bottom)

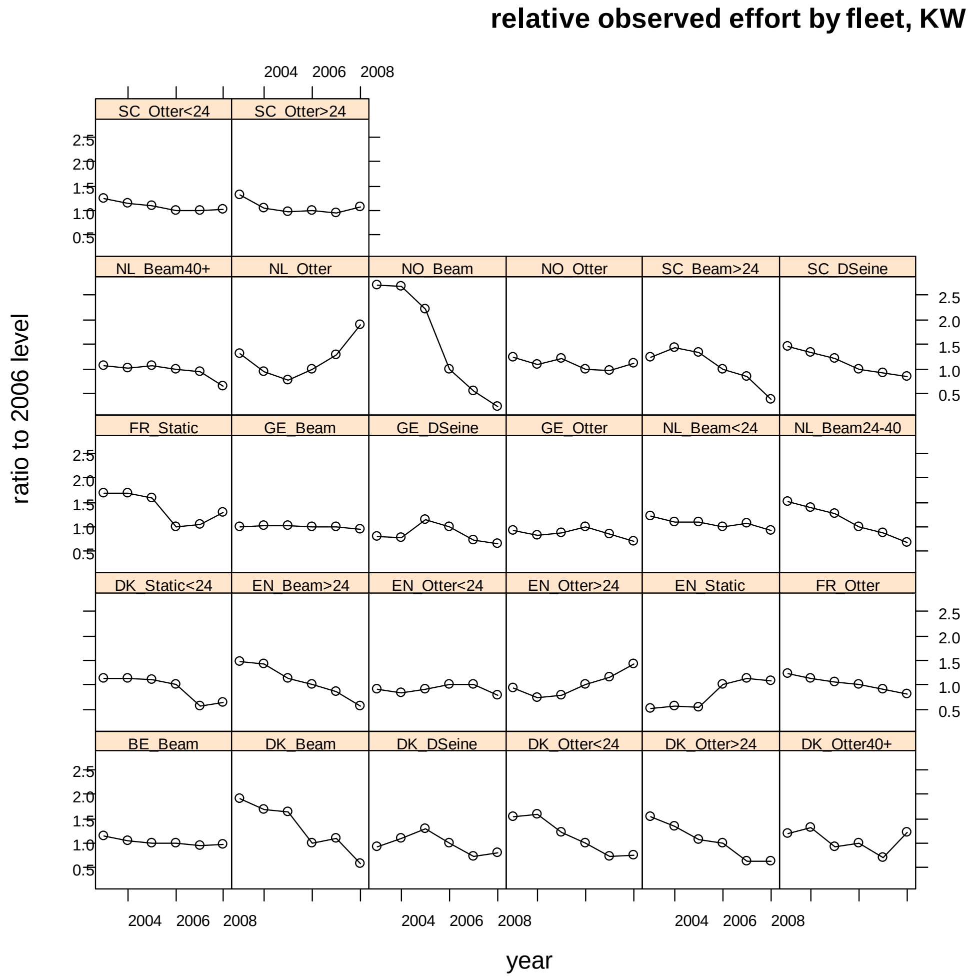


Figure 3.2.3 – Relative trends in effort (KW Days) by fleet and year for the North Sea demersal fleets

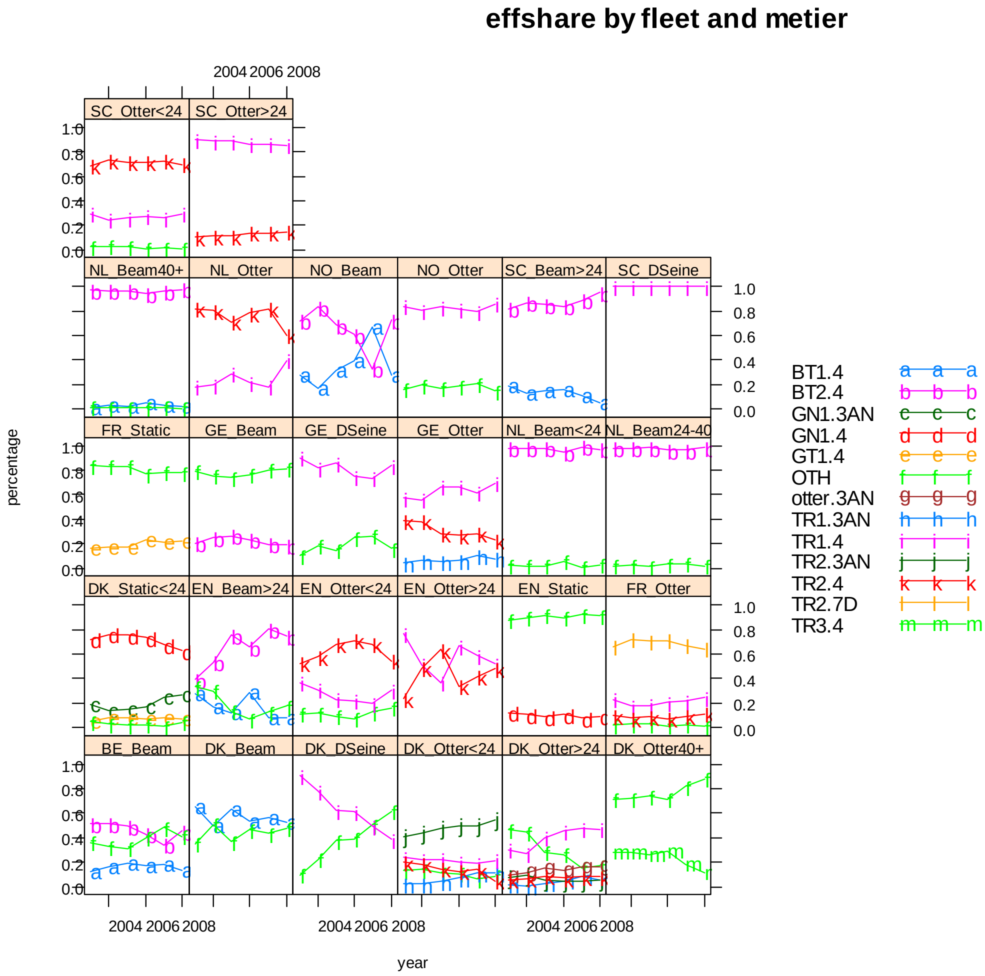


Figure 3.2.4 – Effort share (in proportion) by métier for each fleet

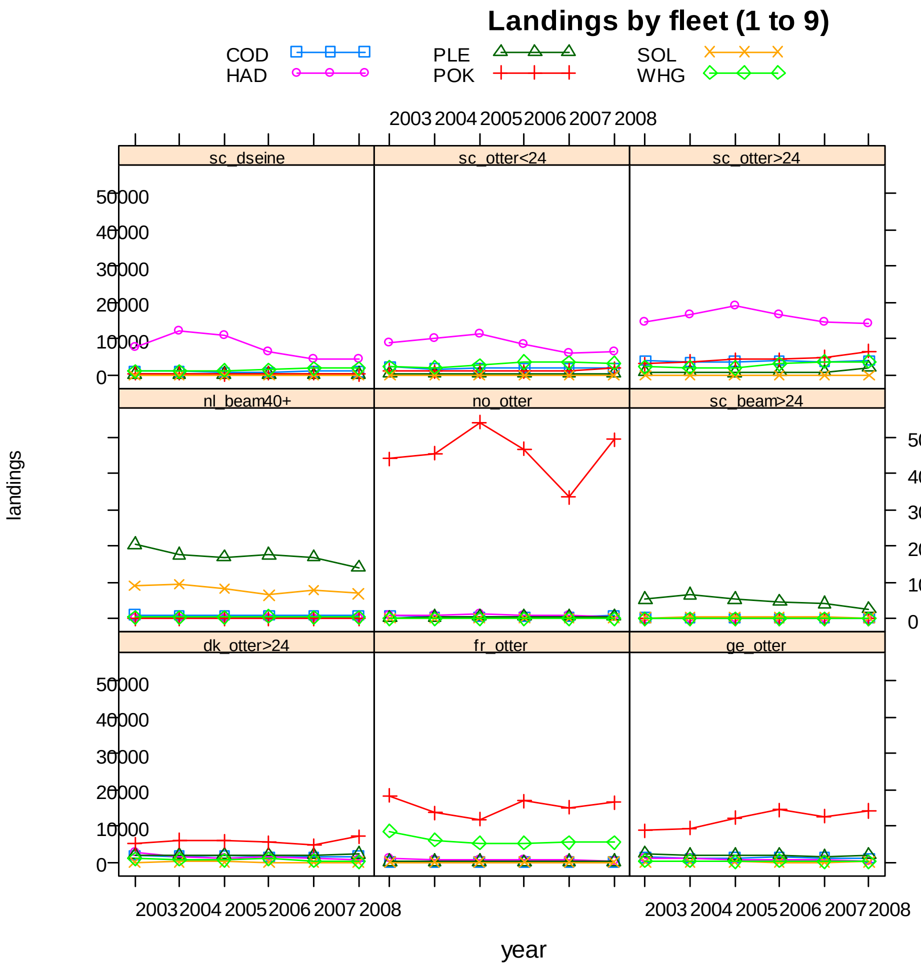


Figure 3.2.5. Landings by fleet, stock and year. Fleets are shown in decreasing groups of total landings and with different scales, 1 to 9 first, then 10 to 18, then 19 to 26.

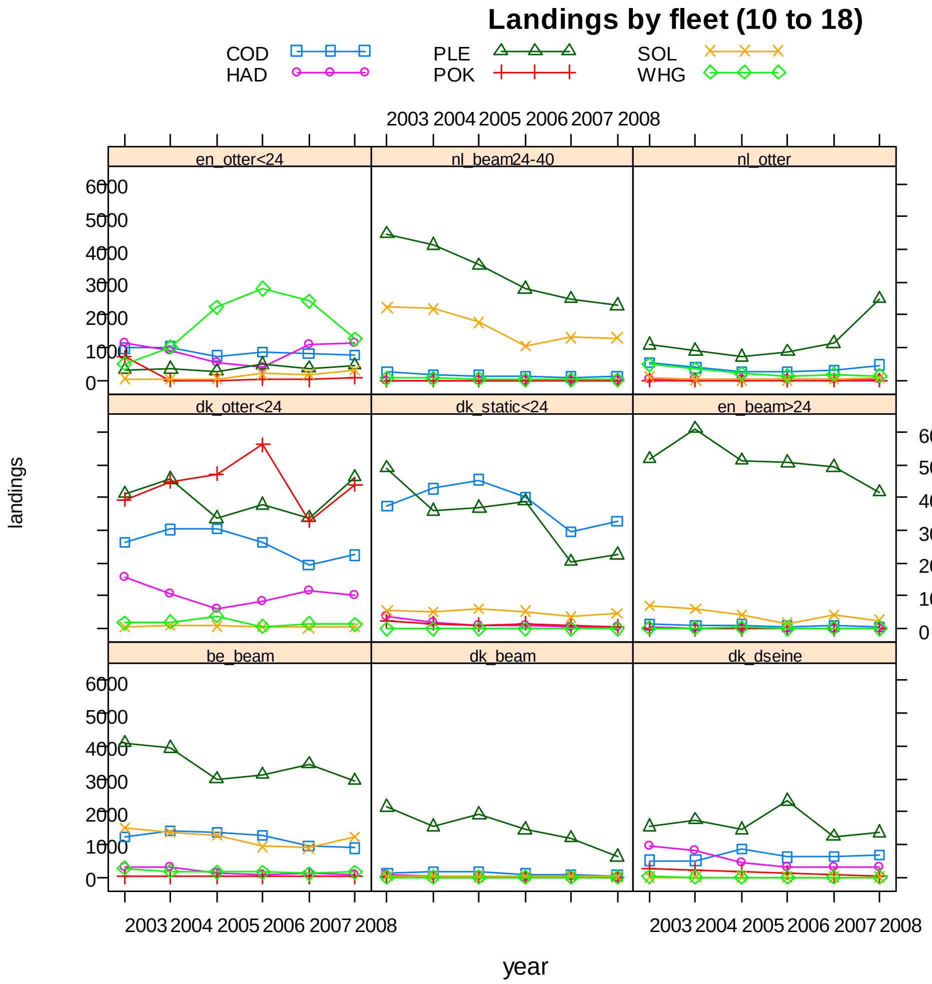


Figure 3.2.5. (Ctd)

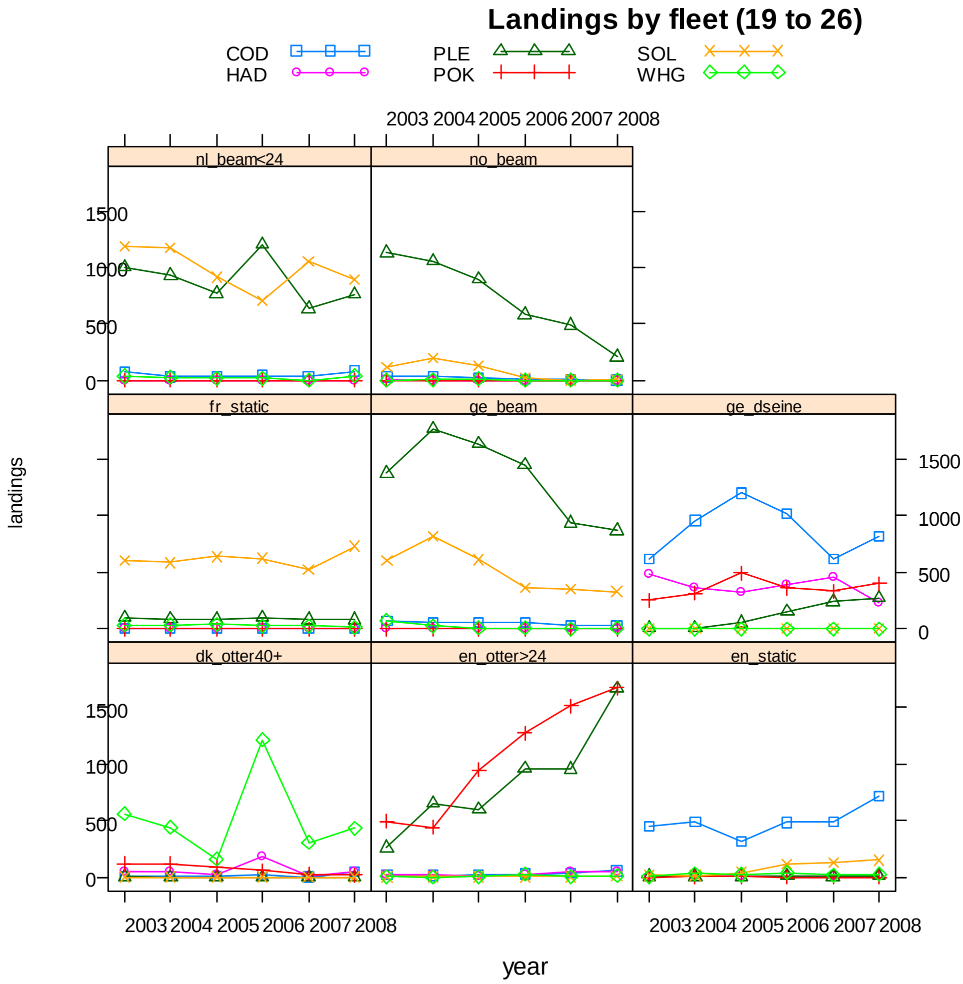
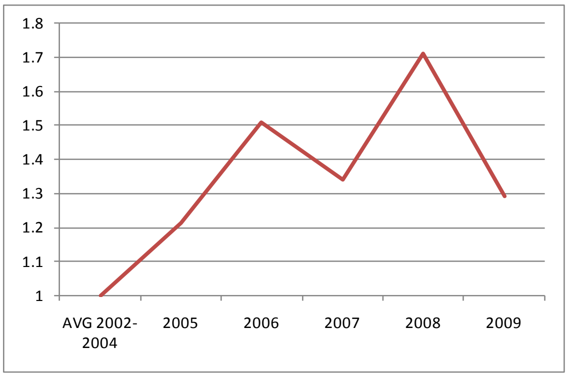


Figure 3.2.5. (Ctd)

Figure 3.2.6. Index for the fuel price development.



Source: The Danish oil industry association (www.oliebranchen.dk)

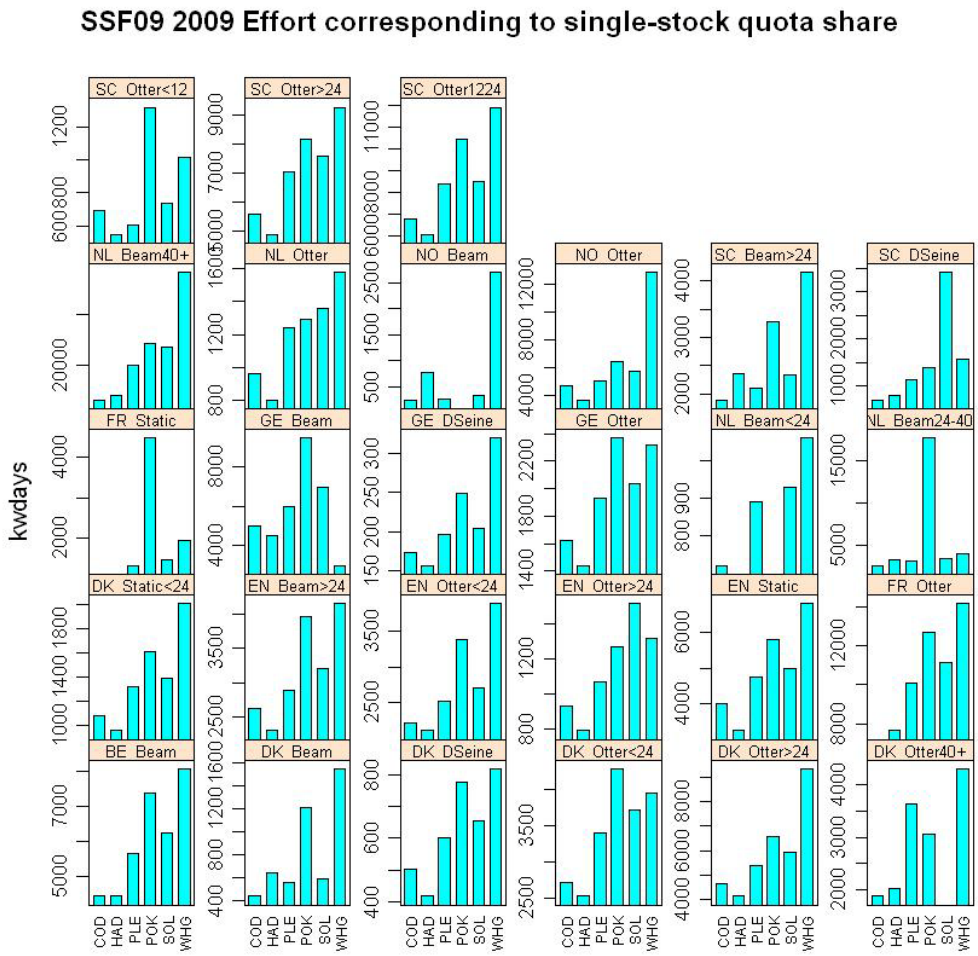


Figure 4.2.1. Run "SSF09" (Single-Stock Target F in 2009). Fcube estimates of effort by fleet corresponding to the individual "quota share" (or partial target F) by stock in 2009, in '000 kWdays.

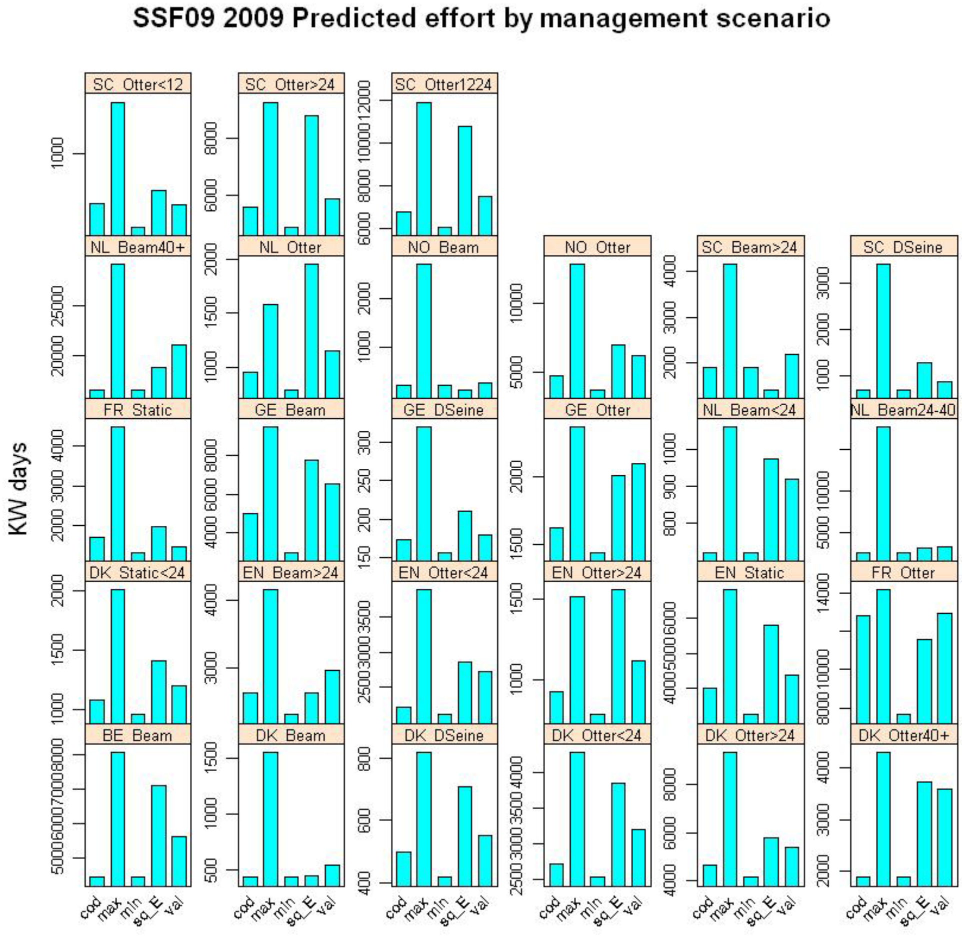


Figure 4.2.2. Run "SSF09". Fcube estimates of effort by fleet for the various scenarios in 2009, in '000 KWdays.

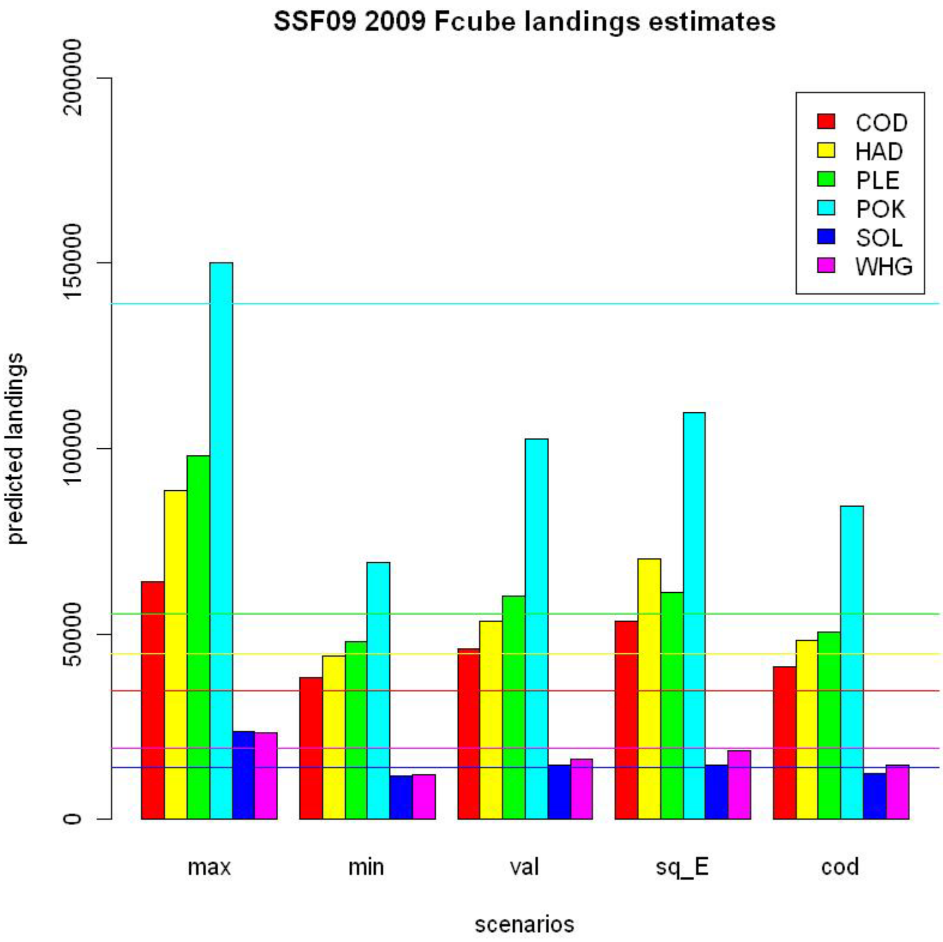


Figure 4.2.3. Run "SSF09". Fcube estimates of landings by stock for the various scenarios in 2009. Straight lines are the current 2009 TAC by stock.

Annex 1: List of participants

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Annex 2: Specification of the data call

The specification of the data call was kept as close as possible to that issued by STECF for use in STECF effort review meetings. The main differences were a specification of vessel length categories (for effort and catch) that match those specified by the commission for use in the annual economic report (AER) and the specification of effort in terms of days at sea as well as in terms of kWdays (as specified by STECF).

Fields in the effort data file were specified as follows:-

COUNTRY: Given according to the code in Table 1.

YEAR: Years 2003 to 2008, given in four digits.

QUARTER: Given as a single digit.

VESSEL_LENGTH_CATEGORY: Given according to the code in Table 2.

GEAR: Given according to the code in Table 3.

MESH_SIZE: Given according to the code in Table 4.

NOMINAL EFFORT: Given in kWdays, i.e. engine power in kW times days at sea.

EFFORT_DAYS_AT_SEA: Given in days at sea.

Fields in the catch data file were specified as follows:-

COUNTRY: Given according to the code in Table 1.

YEAR: Years 2003 to 2008, given in four digits.

QUARTER: Given as a single digit.

VESSEL_LENGTH_CATEGORY: Given according to the code in Table 2.

GEAR: Given according to the code in Table 3.

MESH_SIZE: Given according to the code in Table 4.

SPECIES: Given according to the code in Table 5.

LANDINGS: Given in units of tonnes.

DISCARDS: Given in units of tonnes.

Table 1: Country coding

Country	Code
Belgium	BE
Denmark	DK
France	FR
Germany	GE
The Netherlands	NL
Norway	NO
UK(not Scotland)	EN
UK(Scotland)	SC

Table 2: Vessel Length Categories

Vessel length	Code
Under 12 m	u12m
≥ 12m < 24m	o12t24m
≥ 24m < 40m	o24t40m
≥ 40m	o40m

Table 3: Gear coding

<table>
<tr><th colspan="3">Types of Fishing Techniques</th><th>Code</th></tr>
<tr><td rowspan="6">Mobile Gears</td><td colspan="2">Beam trawls</td><td>BEAM</td></tr>
<tr><td rowspan="2">Bottom trawls and demersal seines</td><td>Bottom otter trawls, multi-rig otter trawls or bottom pair trawls</td><td>OTTER</td></tr>
<tr><td>Fly shooting seines, anchored seines or pair seines</td><td>DEM_SEINE</td></tr>
<tr><td rowspan="2">Pelagic trawls and pelagic seines</td><td>Midwater otter trawls or midwater pair trawls</td><td>PEL_TRAWL</td></tr>
<tr><td>Purse seines, fly shooting seines or anchored seines</td><td>PEL_SEINE</td></tr>
<tr><td colspan="2">Dredges</td><td>DREDGE</td></tr>
<tr><td rowspan="4">Passive Gears</td><td colspan="2">Drifting longlines or set longlines</td><td>LONGLINE</td></tr>
<tr><td colspan="2">Driftnets or set gill nets (except trammel nets)</td><td>GILL</td></tr>
<tr><td colspan="2">Trammel nets</td><td>TRAMMEL</td></tr>
<tr><td colspan="2">Pots and traps</td><td>POTS</td></tr>
</table>

Table 4: Mesh size coding

GEAR TYPE	MESH SIZE RANGE
Mobile Gears	<16
	16-31
	32-54
	55-69
	70-79
	80-89
	90-99
	100-119
	≥ 120
Passive gears	10-30
	31-49
	50-59
	60-69
	70-79
	80-89
	90-99
	100-109
	110-149
	150-219
	≥ 220

Table 5: Species codes

COMMON NAME	ALPHA-3 CODE	SCIENTIFIC NAME
Cod	COD	Gadus morhua
Haddock	HAD	Melanogrammus aeglefinus
Norway lobster (Nephrops)	NEP	Nephrops norvegicus
Plaice	PLE	Pleuronectes platessa
Saithe	POK	Pollachius virens
Sole (Common sole)	SOL	Solea solea
Whiting	WHG	Merlangius merlangus

Annex 3: Data issues for specific nations

Belgium

The Belgium date used for this Workshop is the dataset submitted to the STECF effort review meeting which implies that effort is expressed in Kwdays and not in days at sea. The vessel categories are less than 10 m, 10 m to 15 m and over 15 m instead of the vessel categories that match those used by economist for the EIAA model.

Denmark

Landings and effort data were compiled according to the specification of the data request. It was only possible to attach discard information to some metiers.

France

The France date used for this Workshop is the dataset submitted to the STECF effort review meeting which implies that effort is expressed in Kwdays and not in days at sea. The vessel categories are less than 10 m, 10 m to 15 m and over 15 m instead of the vessel categories that match those used by economist for the EIAA model.

Germany

The German date used for this Workshop is the dataset submitted to the STECF effort review meeting, except that effort is in days at sea. The vessel categories are therefore less than 10 m, 10 m to 15 m and over 15 m instead of the vessel categories that match those used by economist for the EIAA model

The Netherlands

The Dutch data used for this workshop were not those submitted to STECF, but were provided directly by IMARES. No discards data were included, but some discards estimates for the Dutch Beam trawlers were roughly added by raising the discards estimates from ICES WGNSSK to the corresponding landings share of these fleets.

Norway

The Norwegian data used for this workshop were provided directly by IMR, without discards estimates.

UK (England, Wales and Northern Ireland)

Data were provided for England, Wales and Northern Ireland for the period 2003-2008. Landings and effort data were retrieved from databases held at Cefas on a year, quarter, species, area, gear, mesh, special condition basis. Length compositions for the landings and discards came from the discard sampling. ALKs for landings were created on a year, quarter, species, area basis from the market sampling data. The same strata were used for discard ALKs but the data came from the discard sampling programme. Annual versions of the ALK (i.e. year, species, area) were created for filling in missing values.

Missing values in the retained portion of the ALK (i.e. lengths observed for which no age data exist) were filled first using the annual retained ALK, then the quarterly discard ALK then the annual discard ALK. Missing values in the discarded portion of the ALK were filled using the annual discard ALK, then the annual retained ALK. Strata were only considered to have sufficient age data if more than 80% of the fish measured had associated ages. Those strata with less than 80% aged result in the provision of landings and discards biomass only. In those strata considered well aged, lengths for which there was no associated age were ignored. Numbers retained and discarded at age were raised up such that the retained biomass equalled the landings recorded in FAD (the official system for recording landings information in England and Wales. Discard data were also ignored if the retained biomass of a strata was less than 0.02% of the total landings – these strata are presented with landings biomass only. For simplicity, discard estimates were applied to all vessel length classes, irrespective of the length-class from which they were originally sampled.

Scotland

Landings and effort data were compiled according to the specification of the data request. It was only possible to attach discard information to some metiers. The Scottish discard observer scheme is designed to achieve a reasonable coverage of vessels in each of the following categories

- MTR: Motor trawl (bottom trawls, boat length >= 27.432m, targeting demersal species)
- LTR: Light trawl (bottom trawls, boat length < 27.432m, targeting demersal species)
- PTR: Pair trawl (all pair trawls targeting demersal species)
- SEN: Seine nets (single and pair)
- NTR: Nephrops trawls (all trawls targeting Nephrops)

Where the gear categories for records in the landings dataset could be mapped to one of the above categories a discard value was assigned according to the discard ratio of that category. Therefore records mapped to these categories always receive the same ratio of discards to landings.

Vessels with OTTER and PEL_TRAWL gear and in the length categories o24t40m and o40m were mapped to the MTR category. However, as for STECF effort calculations all records with OTTER gear and with mesh between 70 and 100mm are mapped to NTR.

The sampling of vessels <10m is very limited and it is considered unreasonable to assume they have the same discarding patterns as larger boats. Scotland does not provide discard estimates for vessels < 10m to STECF. Discard estimates are therefore not estimated for vessels in the u12m category.

Annex 4. Equations in FcubEcon

1. Data from base line

1.1. Observed (estimated) stock in number on age groups ($S_{i,c}$)

1.2. Observed average weight per fish on age groups ($w_{i,c}$)

1.3. Observed (estimated fishing mortality rates $f_i^0 = avg \sum_c f_{i,c}^0$

1.4. Observed fishing mortality rate for species on age groups ($m_{i,c}$)

1.5. Number of vessels per fleet segment (V_v)

1.6. Number of sea days per vessel per fleet segment per metier ($U_{v,u}$)

1.7. Observed landings per species, fleet and metier ($H_{i,v,u}$)

1.8. Observed prices per species, fleet and metier ($p_{i,v,u}$)

1.9. Observed variable costs on fleet segment O_v

1.10. Observed fixed cost on fleet segment R_v

2. Calculation (estimation) of catchability q

(1) $f_{i,v,u}^0 = f_i^0 \frac{H_{i,v,u}^0}{H_i^0}$

(2) $q_{i,v,u}^0 = \frac{f_{i,v,u}^0}{V_v^0 \times U_{v,u}^0}$

If landings (*H*) is available on metier *f* could be calculated on metier.

3. Harvest (quota) in projection year (1)

If *f* is fixed then:

(3) $H_i^1 = \sum_c w_{i,c} \times S_{i,c}^0 (1 - e^{-(m_{i,c} + f_{i,c}^1)}) \times \frac{f_{i,c}^1}{m_{i,c} + f_{i,c}^1}$

We fix a target $\widetilde{f_{i,c}^1}$ for the projection year by scaling $f_{i,c}^1$ with a multiplier g. Tilde is used to show that targets are set:

(4) $\widetilde{f_i^1} = avg \sum_c g_i^1 * f_{i,c}^1$

If $\widetilde{H^1}$ is fixed find $\widetilde{f^1}$ by using “solver” to estimate g for $\widetilde{f_{i,c}^1} = g_i \times f_{i,c}^1$

Fcube approach does not solve by constrained optimisation but by solving equations

(5) $q_{i,v}^0 = \sum_u q_{i,v,u}^0 \times \frac{U_{v,u}^0 \times V_v^0}{\sum_u U_{v,u}^0 \times V_v^0}$

(6) $E_{i,v}^1 = \frac{\widetilde{f_i^1}}{q_{i,v}^0} \times \frac{H_{i,v}^0}{\sum_v H_{i,v}^0}$

(7) $E_{i,v,u}^1 = \frac{U_{v,u}^0 \times V_v^0}{\sum_u U_{v,u}^0 \times V_v^0} \times E_{i,v}^1$

(8) $E_{i,v,u}^1 = U_{i,v,u}^1 \times V_{i,v}^1$

(9) $f_{i,v,u}^1 = \{minE_{i,v}^1; maxE_{i,v}^1\} q_{i,v,u}^0 \times E_{i,v,u}^1$

Harvest can then be calculated by use of (3) or shortcut where $\widetilde{H_i^1}$ is the target TAC and f_i^1 is the target fishing mortality.

(10) $H_{i,v,u}^1 = \frac{f_{i,v,u}^1}{f_i^1} \times \widetilde{H_{i,v,u}^1}$

4. Economic optimization

Fcube uses harvest and quotas (projected harvest), initial fishing mortality rates and projected fishing mortality rates (based on an F multiplier called Fmult), catchability rates and fishing effort in terms of sea days. It is assumed that fishing mortality is linear in the number of sea days (effort). Fcube requires all this information but as there is an unambiguous relationship between harvest and fishing mortality and between fishing mortality and effort, basically, there is no need to use fishing mortality in the calculations as there is a fixed relationship between harvest and effort. However, to get as close as possible to the original Fcube setup, FcubEcon still uses *f* and equation (3) to calculate harvest.

FcubeEcon Opt

The economic optimization procedure of FcubeEcon *Opt* is:

(11) $\max_{U,V} \Pi = \sum_{i,v,u}(p^0_{i,v,u} \times H^1_{i,v,u} - (o^0_{v,u} \times U^1_{v,u} + R^0_v) \times V^1_v)$

Where (11.a) $H^1_{i,v,u} = \sum_c w_{i,c} \times S^0_{i,c}(1 - e^{-(m_{i,c}+f^1_{i,c,v,u})}) \times \frac{f^1_{i,c,v,u}}{m_{i,c}+f^1_{i,c,v,u}}$

And (11.b) $f^1_{i,c,v,u} = f^0_{i,c} \times \frac{q^0_{i,v,u} \times U^1_{v,u} \times V^1_v}{f^0_i}$

If fixed costs are omitted the gross cash flow is maximized (short term adjustment) else net profit is maximised (long term adjustment)

The optimal solution is found subject to a number of possible restrictions:

(12) $\sum_v \sum_u q^0_{i,v,u} \times U^1_{v,u} \times V^1_v \leq \sum_{u,v} \widetilde{f^1_{i,v,u}}$

(13) $H^1_i \leq \widetilde{H^1_i}$ (target harvest) or

(14) $\sum_i(\widetilde{H^1_i} - H^1_i) \times p^0_i = 0$

(15) $V_v = constant$ or

(16) $V_v \leq \widetilde{V_v}$ (target fleet)

(17) $U_{v,u} = constant$ or

(18) $U_{v,u} \leq \widetilde{U_{v,u}}$ (target sea days per vessel)

It may be appropriate to expand the cost part to take into account that fuel costs (sometimes also other types of costs) are subtracted before the crew share is calculated:

(19)

$$\max_{U,V} \Pi = \sum_{i,v,u}(p^0_{i,v,u} \times H^1_{i,v,u} \times (1 - r^0_v) + ((d^0_{v,u} \times r^0_v - (d^0_{v,u} + a^0_{v,u} + b^0_{v,u})) \times U^1_{v,u} + R^0_v) \times V^1_v)$$

Where *r* is the crew share in proportion to landing value, *d* is fuel cost per effort unit, *a* is fishing costs and *b* is semi-fixed costs. The element $d^0_{v,u} \times r^0_v$ is added if the fuel costs are deducted from the landing value before the crew share is calculated.

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Finally, the approach with no target fishing mortality rate (f) but a target harvest $\widetilde{H^1_i}$

(20) $\max_{U,V} \Pi = \sum_{i,v,u}((p^0_{i,v,u} \times h^0_{i,v,u} - o^0_{v,u}) \times U^1_{v,u} + R^0_v) \times V^0_v$

Where h is the catch per unit effort

(21) $h^0_{i,v,u} = \frac{H^0_{i,v,u}}{V^0_v \times U^0_{i,v,u}}$

If (20) is amended in the same way as (19) we have

(22)

$$\max_{U,V} \Pi = \sum_{i,v,u} (p^0_{i,v,u} \times h^0_{i,v,u} \times (1 - r^0_v) + (d^0_{v,u} \times r^0_v - (d^0_{v,u} + a^0_{v,u} + b^0_{v,u})) \times U^1_{v,u} + R^0_v) \times V^1_v$$

Subject to (12)-(18)

Annex 5: Recommendations

Recommendation	For follow up by:
1. The working group recommends that metier classes be made compatible between the effort, catch and economic datasets requested of nations by STECF as soon as possible.	Commission through STECF