Bioeconomic Modelling Applied to Fisheries
with R/FLR/FLBEIA

Ernesto Jardim1, Agurtzane Urtizberea2, Arina Motova1, Chato Osio1, Clara Ulrich3,
Colin Millar4, Iago Mosqueira1, Jan Jaap Poos4, Jarno Virtanen1, Katell Hamon4,
Natacha Carvalho1, Raul Prellezo2, and Steve Holmes5

1JRC, Fishreg - Maritime Affairs Unit. European Commission
2AZTI Foundation, Marine Research Division. Spain
3Technical University of Denmark, National Institute of Aquatic Resources. Denmark
4Wageningen University and Research Centre. The Netherlands
5Marine Scotland Science, Marine Laboratory. UK

January 15, 2013

Abstract

The main objectives of the study presented in this report were to test the FLBEIA API, condition an operating model for the North Sea mixed fisheries and provide feedback on bioeconomic modelling limitations. Additionally, Fishrent and Fcube were also tested. FLR, FLBEIA, Fishrent and Fcube are software packages implemented by the scientific community studying fisheries to run bioeconomic models. A large test was carried out on FLBEIA by both running existing examples and trying to implement a bioeconomic model for the North Sea. In general the group felt FLBEIA is on the correct path to provide a bioeconomic modelling framework, although some work is still required. FLBEIA is not ready yet for production. A list of bugs and improvements was assembled. Conditioning a bioeconomic operating model for the North Sea showed the difficulties of merging economic and biological information. Inconsistencies on the effort definition seem to create additional problems when relating both sources of information. This subject must be further explored. The exercise was successful but data problems prevented the performance of a full economic analysis, although trend analysis on economic indicators for each scenario tested was possible. Nevertheless, these results must be taken carefully.
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1 Introduction

In the scientific community working on fisheries advice, there’s a long standing claim, from biologists that economic models don’t take into account the full complexity of the stocks’ dynamics, and from economists that biological models don’t take into account the economic effects of management and the fleet’s adaptive strategies. The final outcome is the lack of an integrated bioeconomic modelling platform that takes into account the full complexity and dynamics of stocks and fisheries, as well as the interaction between the availability of resources and their exploitation.

The STECF Expert Working Group (EWG) 12-02, dealing with Baltic and Cod multi-annual management plans (STECF, 2012b) requested JRC to assess the possibility of extending Fcube (Ulrich et al., 2011), a multi-species multi-fleet projection algorithm for scenario testing of TAC and effort management options, and merging it with Fishrent (Salz et al., 2010, 2011), a bioeconomic model that aims at optimizing the long term rent from fisheries.

After assessing the workload required and its objectives, JRC replied: Extending Fcube and making the software ready for production in the short term (2 to 3 month) is not possible due to other commitments. However, JRC is interested in developing a mixed fishery bioeconomic model based on Fishrent and Fcube algorithms in FLR.

To progress along these lines, JRC organized a workshop on bioeconomic modelling using FLR, FLBEIA, Fishrent and Fcube (WKBEM) in Ispra, Italy, on the 19th-23rd of November of 2012, with the following ToR:

- Test FLBEIA API
- Condition a model based on North Sea mixed fisheries
- Provide feedback on software limitations and further work

FLBEIA is an FLR1 package that implements a framework for bioeconomic modelling. The package is being developed by AZTI Fundazioa (Spain) and it was considered as a promising platform to merge Fishrent and Fcube ideas. One of the tasks of WKBEM was to test FLBEIA, in particular with regards to its capacity of delivering bioeconomic analysis in a production environment, like the one found in STECF EWG meetings.

Parallel to testing FLBEIA, WKBEM explored the possibility of building a dataset containing both biological and economic information. Such dataset would allow the inclusion of economic dynamics in an operating model, a major step forward to integrated bioeconomic MSEs. On the other hand, it would expose shortfalls and limitations of the data and methodologies.

To carry out this exercise the group used two datasets:

- the STECF economic dataset published in the Annual Economic Report (STECF, 2012a);
- the ICES WGMIXFISH dataset with stock assessment results for the major demersal stocks in the North Sea and Fcube projections for distinct management scenarios (Anon., 2012).

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1http://flr-project.org
The AER dataset is available online\(^2\) to be used for scientific analysis. The WGMIXFISH dataset is the only known attempt to aggregate biomasses, catches, fishing mortality, fishing effort and prices using fleet segments similar to those defined for economic variables under the DCF\(^3\). The dataset was requested from ICES, which replied positively.

## 2 Testing the FLBEIA framework

Two different procedures were used to test FLBEIA:

- running a set of examples provided by AZTI researchers,
- parameterizing FLBEIA to simulate the Scottish fleets operating in the North Sea.

### 2.1 Compiling, profiling and parallelization

A number of issues were identified in the package that will require further work. This should be considered as a normal part of the development cycle, as further testing and application of the package will help pushing it towards maturity.

The structure of the package, based around a single function that connects the various elements being simulated, is well thought out, although a detailed review should identify elements ready for improvement.

Some thought needs to be given to the ability of the structure chosen to accommodate the use of the multiple options for parallelization currently available in R. Although the package has already been successfully used in an HPC environment, a grid system, other systems could provide different users with the ability to run complex models efficiently, and FLBEIA should ideally work with them too. For example, the ability to run on multiple cores, using the `multicore` package, might be limited by the use of input and output files, that might be accessed and written simultaneously by processes running in parallel.

Some of the operations carried out by the `BEIA` function could benefit from speed improvements. An initial exercise of speed profiling was carried out. There is no single operation greatly slowing down the `BEIA` method, but some functions and methods being called repeatedly were identified. Small improvements in their execution speed could have a significant impact on overall running times.

For analyses of limited complexity, like the ones done during the meeting, memory did not seem to be a limiting factor, but this is likely to become more important once larger and more complex fisheries are modelled. FLBEIA could benefit from some of the developments taking place in `FLR` that allow storage of large objects on disk, and an initial test is being carried out on using those facilities with an FLBEIA example.

### 2.2 Running examples

Two examples were put together by AZTI scientists to show how to make use of FLBEIA’s flexibility regarding modelling processes and testing alternative management procedures. The

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\(^2\)http://stecf.jrc.ec.europa.eu/data-reports

\(^3\)Data collection framework (Reg. EC/199/2008; Reg. EC/949/2008)
simplest example, using two stocks and two fleets, was a good starting point for the work to be carried out in the following days. The second example, which was more complex, took too long to run and was not explored any further. In both cases the examples were based around external data and code files.

2.3 Parameterizing FLBEIA to simulate the Scottish fleets operating in the North Sea

FLBEIA was applied on a subset of the WGMIXFISH dataset with 2 Scottish fleets (SC_Otter>=24 and SC_Otter<24) and one species, haddock (HAD).

The following problems were found while parameterizing the model:

- The stock recruitment relationship must be defined with internal functions of FLBEIA and using the FLSR class is not straightforward. A code fix was developed during the meeting.
- The names of objects could be inconsistent between different steps because they are currently redefined at several times.
- It was hard to know if all objects had to be used and even when obviously not used, they still had to be created (example BD).
- The 2 fleets used didn’t have all haddock catches, a third fleet should have been created to include the fishing mortality missing.
- Only 1 stock was used which meant that only part of the revenue was taken into account.

The group has a few suggestions which would make it easier to run the model and make our simulation better:

- A GUI or a suite of scripts would be useful. This has been partially addressed.
- Objects should be defined only once (names of stocks, fleets, metiers, years used for simulation/prediction, age of the stocks)
- For objects and controls that are not necessary, default values should be created in the BEIA call (so that the user doesn’t have to make the objects).
- It would be good to create a fleet with the rest of the catch (based on the FLStock and FLFleets objects)
- The fishing revenue from other species should also be included per fleet (per metier?) so that the profit and other economic indicators are calculated from the whole revenue rather than a subset.

2.4 Comparing FLBEIA with Fishrent and Fcube

Fishrent (Salz et al., 2011) and FLBEIA (Garcia et al., 2012) are two bioeconomic models created to conduct bioeconomic analysis for fisheries. Although both have the same aim the packages differ on the structure, implementation and objectives.

Fishrent is a simulation model but it can also optimize a fishery over a number of years for a set of variables (e.g. profit, employment, wages, and landings). This is useful to investigate
the potential of the system and has been used to estimate the resource rent of fisheries systems (Salz et al., 2010). This type of optimization is not generally used for impact assessments which are based on forward simulations of the fishery under a set of objectives and constraints.

**FLBEIA** is a simulation model where the MSE (management strategy evaluation) framework is followed. That is, it assesses the consequences of a range of management strategies or options. It does not seek to prescribe an optimal strategy or decision. Instead, it seeks to provide the decision maker with the information on which to base a rational decision, given their own objectives, preferences, and attitudes to risk.

In terms of the simulation of the fleet tactical behavior, both are able to simulate different pre-defined behavior (i.e, Max TAC, Min effort, etc). In the case of **Fishrent** it is done on a fleet basis and in **FLBEIA** on a metier basis. The optimization of the fishing decision of a fleet (optimal allocation of the fishing effort of a fleet to the different metiers) is available in **FLBEIA**.

**FLBEIA** has directly taken the capital dynamics model developed and used in **Fishrent**.

Price dynamics are different in both models but both allow simulations based on fixed or dynamic prices.

To account for all the mortality on a stock, **Fishrent** uses catch shares of the fleets included and if the sum of the catch shares for those fleets is lower than one, the rest of the catch is taken by a non-explicit fleet for which no economic dynamics are included. In **FLBEIA** an additional fleet needs to be defined. It has to be decided if this fleet should be excluded from the economic analysis or if it has to mimic the behavior of some other fleet.

In **Fishrent**, the value of other species is accounted for as a percentage of the value of the included species. It is important to account for this extra revenue because the long term fleet dynamics investigate past profits to project investment and disinvestment in fisheries. In **FLBEIA** is open to the user to decide how to deal with unaccounted revenue.

Stock assessment in **Fishrent** is currently restricted to biomass dynamics model while **FLBEIA** allows the user to choose age structured or biomass dynamics models. The age structured population dynamics are being added to **Fishrent** in FP7 project VECTORS.

Uncertainty is a key issue in impact assessment. **FLBEIA**, following the MSE approach, provides results in terms of risk levels, accounting for the uncertainty derived from the operating model (biologic and economic sub-models) and the management procedure model. **Fishrent** is a deterministic model.

### Conditioning an operating model for the North Sea mixed demersal fisheries

The aim of this task was to build an operating model for the north sea mixed demersal fishery that includes economic information, which required merging the information contained in the AER dataset (economic) and the WGMIXFISH dataset (stock assessment). Such operating model would allow economic drivers to be taken into account when modelling the dynamics of the fleet, as well as simulating decision making processes that consider the economic outcome of the fleets.

One of the biggest challenges in merging the two datasets is reconciling the mis-match between the different fleet definitions and spatial aggregation used by each group.
This section describes the exercise carried out to build the operating model, that should include:
(i) the population dynamics of the major demersal stocks caught in the North Sea, (ii) fishing
effort, fishing mortality and costs for the most important fleets operating in the North Sea, and
(iii) sales prices of commercial species.

The exercise was split into two tasks:

1. conditioning the populations dynamics, by using stock assessment results to fit stock-
recruitment models for each stock and add uncertainty both to fishing mortality and
recruitment;

2. computing economic indicators, by linking the AER and WGMIXFISH datasets so that
economic information from the AER could be applied to the WGMIXFISH.

Additionally, the analysis performed by the WGMIXFISH can be extended to include some
economic indicators. Such analysis is a complex scaling of costs and revenues and would not
constitute an integrated bioeconomic analysis, but may help the scenario analysis done for Fcube
results.

3.1 Conditioning the populations dynamics

In conditioning the biological components of the model we were chiefly interested in how easy
was it to develop operating models in FLBEIA. In fact the first task was to simplify the code to
make it easier to see where and how conditioning could be implemented. In the end it was a
relatively easy task. All the FLBEIA requires is a list of FLBiol objects and a list of FLSR like
objects.

The FLBiol objects were created from a FLStock object. To introduce variability in the history
of the stock, correlated log-normal error was added to the historical F at age (estimated from
the current assessment of the stock, in this example NS haddock) and independent log-normal
error to the historical recruitment. Predefined values in the following code are the CVs used in
the log-normal errors (i.e. CV.harvest), the number of realisations to generate (niter) and
the final year in the FLBEIA projection (finaly).

```r
stock.prop <- propagate(stock, niter)
harvest(stock.prop) <- genFLQuant(harvest(stock), method = "ac",
    cv = CV.harvest, n = niter)
stock.n(stock.prop) <- genFLQuant(stock.n(stock), method = "ac",
    cv = CV.stockn, n = niter)
```

Then the numbers at age implied by recruitment and F was calculated and the object converted
to a list of FLBiols

```r
bio <- as.FLBiol( fwdWindow(stock.prop, FLBRP(stock.prop), end = finaly) )
biols <- FLBiols(bio)
```

We chose to use newly developed methods to add uncertainty to stock histories genFLQuant
and a combination of fwdWindow with FLBRP found in Flash and FLAssess respectively, to
deal with the forecast assumptions. These methods are available in a package FLDData being

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4 See FLR for more information on classes
developed by the JRC as part of the a4a initiative\(^5\). In short they model the correlation in the data matrix and use this to add noise around the data. Currently two methods are available, one to add multivariate gaussian error (on the log scale) and the other models the trajectories by age as random walks.

To complete the conditioning it is necessary to estimate the stock recruitment relationship implied by each simulation to be used in the operating model projections. Predefined values are the stock recruitment model (srmodel).

```r
# set up stock recruitment object
SRsim <- FLSRsim(model=srmodel, rec = rec(bio, rec.age=1), ssb = ssb(bio))
SRsim@params[] <- sr(as.FLSR(bio, model=srmodel))@params
SRsim@timelag[] <- c(1,2) # c(timelag.year,timelag.season)

# uncertainty in SR
# projection uncertainty - multiplicative error CV = 20%
SRsim@uncertainty[] <- rlnorm(dim(SRsim@uncertainty[])[2], 0, 0.2)

# historical uncertainty... not clear what to do...
SRsim@uncertainty[, dimnames(catch.n(stock))$year] <- 1
# or should it be exp(sr.pars @ residuals)[,dimnames(catch.n(stock))$year]
SRs <- list(SRsim)
names(SRs) <- bio@name
```

The objects `biols` and `SRs` were then ready to be passed to the FLBEIA function.

### 3.2 Computing economic indicators

The cornerstone of merging both datasets was linking the different fleet definitions.

In both datasets the fleet definition includes information about the fishing technique and vessel length. However, both data sets are using different definitions and aggregation levels for fishing techniques.

Fleet length classes differ in both data sets. Nevertheless, the length categories used in the WGMIXFISH dataset are aggregations of the ones used by the AER, e.g. the $<24m$ used by the WGMIXFISH covers the $<10m$, 10-12m, 12-18m and 18-24m used in the AER.

Regarding Member States, the AER dataset has information for the UK, while the WGMIXFISH dataset has England and Scottish fleets separated. Additionally, the WGMIXFISH dataset includes Norway which is not included in the AER dataset.

Table 1 shows the links between the WGMIXFISH and the AER fleet definitions.

\(^5\)https://fishreg.jrc.ec.europa.eu/web/a4a
Table 1: Link between the AER and the WGMIXFISH fleet definitions

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*Continued on next page*
The method used to compute economic costs for the North Sea demersal fishery was based on modelling economic variables by unit as a function of the fleet’s components, which are shared between the two datasets, and use the North Sea information to scale the variables and estimate absolute economic indicators. The full analysis is presented in Annex 01.

Our approach was:

1. use the AER dataset to compute economic variables by unit: fixed costs by vessel, crew costs by revenue and variable costs by effort;

2. use the AER dataset to model the economic variables mention above as functions of the fleets’ components: member state, gear and vessel length;
3. compute the economic variables by unit for the fleets defined in the WGMIXFISH dataset using the common components of the fleet definition;

4. compute the economic indicators for the North Sea: fixed costs, crew costs and variable costs, by scaling the economic variables by unit with the relevant information, capacity, revenue or effort.

For this analysis variable costs were split into variable costs depending on revenue, e.g. labour costs, and those depending on effort, e.g. energy costs. With regards to revenue the value of landings was computed using average prices estimated from the AER information and multiplied by the weight landed by species in the WGMIXFISH dataset. Furthermore, it was necessary to compute the revenue due to other species than those included in the WGMIXFISH dataset, since the fleets considered also landed other commercial species forming part of the revenue. Finally, all economic variables were adjusted for inflation to 2010 values. For details see Annex 01.

The major challenge of this analysis was to use information at distinct aggregation levels to compute all necessary indicators, the AER data is aggregated at the FAO region 27, while the WGMIXFISH dataset is aggregated to the North Sea. The rescaling mechanism adopted overcomes this problem but assumes that the costs per operational unit are constant for all area 27. This assumption is clearly sensitive to the relation between steaming and fishing each fleet segment has when fishing in the North Sea or outside the North Sea. In any case there was no information to inspect this assumption.

Several data problems were found during the exercise. The WGMIXFISH dataset information about prices is not coherent and some member states submitted data in different units for the same time series. With regards to the capacity information some member states did not provide information. As expected, the AER dataset is more consistent with regards to the economic information. However, there are several cases of incomplete information, e.g. providing fixed costs but not capacity. In both cases the expert’s reports are valuable resources and both are available on STECF and ICES websites, respectively.

The definition of effort can be a major source of error when merging the datasets. Both the criteria used for allocation of fishing activity to segments/metiers and the unit of effort can be potentially problematic.

In the case of the allocation criteria there is a fundamental difference between the economic and the biological analysis. For economics the boat is the unit of analysis, and the fact that more fishing mortality may be executed by having more than one gear is not relevant. It simply reflects a different relationship between costs and income, when compared with a vessel using a single gear. However, for conservation purposes it’s extremely important to know which gears a fleet can use and their selectivity. The dynamics associated with multi-gear fishing have a huge impact on the stocks’ conservation and can not be ignored when forecasting. In this perspective, the AER criteria of allocating each vessel’s effort to the dominant gear (used >50% of the time) may result in an underestimation of effort for multi-gear fleets, once that the effort of the non-dominant gears is not accounted. The WGMIXFISH data call does not state effort allocation criteria explicitly and seems to rely on the definition of metier.

With regards to the effort unit, neither data call states it explicitly, leaving the definition for the relevant regulations, and ultimately to the Members States’ interpretation. One potential problem with the loose definitions of units for measuring fishing effort is the usage of ”days-at-sea” and ”days-fishing” interchangeably. If days-at-sea are recorded and supplied, then the
steaming time of the vessel between the harbour and the fishing grounds is included. If days-
fishing is supplied, then the steaming time is generally excluded from the data. For coastal fleets
this shouldn’t be too problematic but for fleets that go to faraway fishing grounds it may have
some impact.

Potentially, there are discrepancies in the methods for effort allocation and the effort unit def-
inition, which make it difficult to understand if both series are comparable. As a matter of
fact, even within each data set the internal consistency of effort values between countries is not
guaranteed.

Comparing CPUEs computed from each dataset for the same fleet reflect the problem of different
effort definitions. Figure 1 shows an example for cod, where it is clear that differences between
both datasets exist. The impact of this inconsistency was not further explored, but there is
potential to change the relation between costs and revenues.

The results presented from the approach above have to be interpreted with care once there are
still doubts about the data consistency. However, there are some improvements that can be
done in future analysis:

- revise data
- get complete information from all countries and all variables;
- improve modelling
  - deal with high residuals through outliers analysis or alternative error models to deal
    with over-dispersion;
  - explore alternatives to GLM;
- explore the results at the fleet level to better identify data problems and improvements on
  modelling;
- explore methods to define how uncertainty on models can be included in the economic
  indicators;

4 Feedback

FLBEIA seems a well thought out framework for developing management strategy framework
evaluations combining both economic and biological data.

Being developed within the FLR architecture, FLBEIA can rely on the full FLR machinery in terms
of data structuring and parameter estimation for the fishery component.

However, as a stand-alone approach, FLBEIA combines functions embedded in the package and
some specific scripts that need to be called and used in the right order to run the analysis.

Clearly it requires significant expertise on the R language and the FLBEIA framework in general.
A new user will have to invest some time, even if already familiar with FLR, to apprehend the
complexity of FLBEIA and feel confident with the results.

The examples prepared for the workshop run, which is an important achievement considering
distinct platforms were used and each person had to make some tweaking of the code. The
modular design worked moderately well, although some bugs prevented the group to go further
in testing. It appears that simple assumptions about the economic behavior of fishing fleets in multi-species fisheries can be modelled.

Overall FLBEIA seems very promising but there needs to be a fair amount of code streamlining and testing by multiple different users to assess flexibility of use under different situations.

- Design

FLBEIA design in levels seems appropriate. However, the implementation is not complete and it should be revisited to simplify/clear the procedures to make changes of input functions or options. As it stands now it’s confusing.
With regards to the user interface some debate is still required. Using files to run analysis is not the best approach (see below).

Memory and speed performance should be evaluated and improved when possible.

- **FLR standard**

  *FLBEIA* does not use the *FLR* objects appropriately. The code needs to be reviewed to more closely merge with *FLR*. *FLR* methods could be extended or modified if required, rather than implementing alternative versions.

  This situation makes the implementation of case studies cumbersome. A code review combined with the implementation of more flexible use of standard *FLR* objects would improve the usability for a wide group of people. For example, during the workshop the biological conditioning was reduced to ten lines of code by taking advantage of *FLR* functionality.

- **Flexibility**

  The flexibility of *FLBEIA* to allow freedom to the user to adapt, update or change some of the dynamics in the model following their own needs is still to be demonstrated. By design it seems promising but the group was unable to test it thoroughly. These features are not ready for production.

  Considering the combination of flexibility and transparency that are strengths of *FLR* it sounds promising and worthwhile to develop this package in a truly integrated and multidisciplinary way.

  Once more national labs try to use *FLBEIA*, it will become apparent if it indeed has sufficiently flexibility to accommodate the wide range of case-studies that are available in Europe.

- **Documentation**

  The documentation provided by *FLBEIA* is quite extensive when compared to other software packages.

  An extensive API documentation is required as it relates to the functions that can be provided at each level.

  In addition, providing examples on the *FLR* wiki would greatly facilitate the use of *FLBEIA* for the national labs in the EU.

- **Code cleaning**

  *FLBEIA*’s code requires cleaning and naming standardization to make it possible for others to develop, check or contribute.

  Running examples showed some implementation problems which seem to be possible to overcome with a bit of work to modularize the code and organize the model building into distinct functions.

- **Diagnostics**

  Testing and contrasting for complex models such as MSEs is a general problem, which is reflected in *FLBEIA*’s analysis. It’s an open question that will require the involvement of the scientific community. Definitely it must be sorted out if *FLBEIA* is to be used in impact assessments.
• Conditioning
It its current form it is not strait forward to tune a new case study.
Conditioning is dependent on the state of the data, nevertheless this is something that has
been made more user-friendly for non FLR users.
As expected, conditioning requires some ad hoc coding for adapting the model to the data.
Coding requires quite a lot of work specially for cleaning up.
Data preparations of the different objects is currently a bit confusing.

• Long term optimization
Ideally a long term management evaluation tool would provide optimal economic man-
agement advice. However, in such a complex environment it may be not be possible (nor
necessary) to carry out such analysis. A discussion has to be made about the interest and
relevance of optimizing the rent of multi-fleet mixed fisheries and in which scope it may
happen.

• Analysis based on external files
The mechanism applied to the FLBEIA examples makes review and adaptation of code more
difficult, and limits the ability to apply certain mechanisms for High Performance Com-
puting, like multicore. From the various experiences, a standard guideline for structuring
files and folders could be developed.
The architecture of the files is not optimal since there are many redundant objects and
several read/write operations that can be streamlined to make it more efficient

• Other
Avoid use of @ slot accessors.

4.1 Lessons learned for FLR

• Need to fully review FLFleet class and methods. Initial proposal is along these lines:
  – Possible improvements to class design, ensuring back compatibility
    * Class to move to DB (SQLite) implementation, and methods into SQL queries
    * Review needs for accessors and merging methods, draw a full map

5 Future work
The participants acknowledged the progress made during the workshop and showed interest in
participating in a follow up.

5.1 FLBEIA
All participants considered FLBEIA a good framework for bioeconomic analysis to support impact
assessments.
The participants showed interest in being involved in future developments and to contribute if
possible/necessary.
To make it widely available and used it still requires some work, mainly tidying up examples and documentation, cleaning the code and integrating it better in FLR.

It is clear that more standard FLR objects should be used in FLBEIA, which will require some recoding of FLBEIA and FLR.

More documentation should be made available for FLBEIA on public accessible websites.

The user interface can be improved with some concerted effort involving FLBEIA core developers/users and FLR core developers and experienced R programmers. This would lead to the improvement of the economic classes and methods within FLR itself.

5.2 Link with STECF/Effort

The JRC effort database is considered a valuable resource as the data was requested specifically to be compatible with fleet definitions specified for recovery and long term management plans:

- the cod long term management plan [R(EC) No 1342/2008],
- the recovery plan for Southern hake and Norway lobster stocks in the Iberian peninsula [R(EC) No 2166/2005],
- the multi-annual plan for the North Sea plaice and sole stocks [R(EC) No 676/2007],
- the multi-annual plan of Western Channel sole stock [R(EC) No 509/2007],
- the multi-annual plan for the cod stocks in the Baltic Sea [R(EC) No 1098/2007],
- the multi-annual plan for the sustainable exploitation of the stock of sole in the Bay of Biscay [R(EC) No 388/2006],
- R(EC) No 2347/2002 establishing specific access requirements and associated conditions applicable to fishing for deep sea stocks, and
- R(EC) No 1954/2003 on the management of the fishing effort relating to certain Community fishing areas and resources - so called Western Waters regime.

The database contains effort statistics (kWdays, GTdays) and number of vessels by fleet and sub-fleet categories, and catch information (tonnes landed and, where data exists, discarded) for nearly all species caught by EU member states. To date it has not been considered possible to merge this data set with the AER economic data. The biggest difficulty is the different vessel length categories used.

For the Kattegat, Skagerrak, North Sea and the Western Waters the effort database uses three vessel length-over-all categories: less than 10m (‘u10m’), between 10m and 15m (‘o10t15m’) and more than 15m (‘o15m’). The first length category is consistent with the AER. The upper bound of the second category, 15m, falls part way between the bounds of the 12m to 18m category of the AER data (‘VL1218’). The effort database split at 15m relates to the fact that only vessels greater than 15m were required to carry VMS. VMS is now required for vessels $\geq 12m$. There is nothing in R(EC) No 1342/2008 requiring the ‘o10t15m’ vessel length category. For the Baltic region there is not a problem. The length categories less than 8m (‘u8m’) and between 8m and 10m (‘o8t10m’) can be merged. All other length categories are as for the AER.

Table 2 shows a possible link between gear definitions used in each dataset. Gear codes are mostly compatible.
<table>
<thead>
<tr>
<th>Active/Passive Gear</th>
<th>Description</th>
<th>AER Code</th>
<th>Effort Meeting Code</th>
<th>Associated Gear Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Gear</td>
<td>Beam Trawlers</td>
<td>TBB</td>
<td>BEAM</td>
<td>TBB</td>
<td>Beam Trawls</td>
</tr>
<tr>
<td></td>
<td>Demersal Trawlers</td>
<td>DTS</td>
<td>OTTER</td>
<td>OTB, OTT, PTB</td>
<td>Bottom otter trawls, multi-rig otter trawls or bottom pair trawls</td>
</tr>
<tr>
<td></td>
<td>and/or demersal seiners</td>
<td>DEM_SEINE</td>
<td>SSC, SDN, SPR</td>
<td></td>
<td>Fly shooting seines, anchored seines or pair seines</td>
</tr>
<tr>
<td></td>
<td>Pelagic Trawlers</td>
<td>TM</td>
<td>PEL_TRAWL</td>
<td>OTM, PTM</td>
<td>Midwater otter trawls, midwater pair trawls</td>
</tr>
<tr>
<td></td>
<td>Purse Seiners</td>
<td>PS</td>
<td>PEL_SEINE</td>
<td>PS</td>
<td>Purse seines, fly shooting seines, anchored seines</td>
</tr>
<tr>
<td></td>
<td>Dredges</td>
<td>DRB</td>
<td>DREDGE</td>
<td>DRB, HMD</td>
<td>Dredges</td>
</tr>
<tr>
<td></td>
<td>Vessels using other active gears</td>
<td>MGO</td>
<td>No equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vessels using polyvalent active gears only</td>
<td>MGP</td>
<td>No equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Gear</td>
<td>Vessels using hooks</td>
<td>HOK</td>
<td>LONGLINE</td>
<td>LHP, LHM, LTL, LL, LLS</td>
<td>Drifting longlines, set longlines</td>
</tr>
<tr>
<td></td>
<td>Drift and/or fixed nets</td>
<td>DFN</td>
<td>GILL</td>
<td>GNS, GND</td>
<td>Driftnets, set gillnets (except trammel nets)</td>
</tr>
<tr>
<td></td>
<td>Vessels using pots and/or traps</td>
<td>FPO</td>
<td>TRAMMEL</td>
<td>GTR</td>
<td>Trammel nets</td>
</tr>
<tr>
<td></td>
<td>Vessels using other passive gears</td>
<td>PGO</td>
<td>POTS</td>
<td>FPO</td>
<td>Pots &amp; traps</td>
</tr>
<tr>
<td></td>
<td>Vessels using polyvalent passive gears only</td>
<td>PGP</td>
<td>No equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyvalent Gears</td>
<td>Vessels using active and passive gears</td>
<td>PMP</td>
<td>No equivalent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
One additional difficulty in matching the AER to the effort database is the different criteria used for the allocation of effort in the case of multi-gear vessels. The AER approach is to allocate effort deployed by each vessel to the dominant gear, defined by the gear used more than 50% of the time. While the effort database uses the criteria defined in the relevant regulation.

The effort database currently makes no distinction between Nephrops functional units. The WGMIXFISH showed effort and total landed weight data can be successfully supplied by specific Nephrops FU.

5.3 Link with ICES/WGMIXFISH

The ICES WGMIXFISH will continue meeting twice a year, and this is certainly a good framework for continuing the work, as it insures regular milestones, work planning from one time to the next, and embedding results in an operational advice context.

The work done to merge economic information from the AER to the WGMIXFISH dataset identified some problems with the data that WGMIXFISH will have to overcome if they want to pursue the objective of extending the $F_{\text{cube}}$ analysis to integrate economic indicators.

The progress on getting economic indicators for $F_{\text{cube}}$ should result in a true feedback loop so that it can serve as a operating model for Management Strategy Evaluation algorithms.

References


Annex #01

Building a bioeconomic dataset
Merging STECF economic indicators with ICES WGMIXFISH fisheries indicators under distinct Fcube scenario testing

January 15, 2013

Abstract

A methodology was developed to compute economic costs for the North Sea demersal fishery based on modelling economic indices as a function of the fleet’s components and use the North Sea information to scale the indices and estimate crew costs, variable costs and fixed costs. The basis for this exercise were STECF’s economic dataset published in the Annual Economic Report (AER) and the "biological" dataset with the results of the application of Fcube to the North Sea demersal fisheries, carried out by ICES WGMIXFISH. Revenue was computed by multiplying average prices estimated from the AER information by the weight landed by species in the North Sea. Furthermore, it was necessary to compute the revenue due to other species than those included in the WGMIXFISH dataset, once that the fleets considered also catch other commercial species from which a part of the revenue is made of. All economic variables were adjusted for inflation to 2010 values. Several data problems were found during the exercise. The WGMIXFISH dataset information about prices is not coherent and some member states submitted data in distinct units for the same time series. With regards to the capacity information, also some member states did not provide information. As expected, the AER dataset is more consistent with regards to the economic information. However, there are several cases of incomplete information, e.g. providing fixed costs but not capacity, which may bias the analysis of aggregated data. In both cases the expert’s reports are valuable resources and both are available on STECF and ICES websites, respectively. The biggest problem however is the effort information, which in both cases does not seem to be the same, generating very different CPUE values for each dataset. The impact of this issue was not further explored, but clearly there is potential to change the relation between costs and revenues. In particular due to data problems the results were not sufficiently robust to allow the computation of fleet performance indicators. However, it is possible to evaluate relative differences for each scenario and add to the WGMIXFISH analysis a layer of rational based on economics.
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1 Introduction

One of the biggest challenges to perform bioeconomic analysis in Europe is the mis-match between economic and stock assessment datasets. The different fleet definitions and spatial aggregation used for each group of variables, make it very hard to link the information from both sources.

During the Workshop on Bioeconomic Modelling (WKBEM) an exercise was carried out to explore the possibility of building a dataset containing both biological and economic information. Such dataset would allow the inclusion of economic dynamics in an operating model, a major step forward to integrated bioeconomic MSEs. On the other hand, it would expose shortfalls of the data and methodologies.

To carry out this exercise the group used two datasets:

- the STECF economic dataset published in the Annual Economic Report (REF) - this dataset was stored in a postgresql database;
- the ICES WGMIXFISH dataset with stock assessment results for the major demersal stocks in the North Sea and Fcube projections for distinct management scenarios (REF) - this dataset was stored in FLR objects.

The objective of this exercise was to compute economic indicators for the North Sea demersal fishery, using statistical modelling to estimate how economic indicators for FAO area 27 (from the AER) related with the fleet’s components, which are shared between the two datasets, and apply these to the North Sea information (from WGMIXFISH) to compute economic indicators for the North Sea demersal fisheries.

As a secondary objective, the analysis performed by WGMIXFISH can be extended to include economic indicators. Such analysis is a complex scaling of costs and revenues and would not constitute an integrated bioeconomic analysis, but may help the scenario analysis done for Fcube results.

2 Data

In detail, the economic variables taken form the AER were:

- Income
  - value of landings (euros),
- Variable costs
  - energy costs (euros),
  - crew wage (euros),
  - unpaid labour (euros),
  - repair costs (euros),
  - other variable costs (euros)
- Fixed costs
  - depreciation costs (euros),
  - opportunity costs (euros),
  - other non-variable costs (euros)
- Fisheries
  - weight of landings (kg),
  - fishing effort (kwdays),
  - capacity (number of vessels),

while from the WGMIXFISH dataset were:
• Income
  – prices (euros/ton),
• Fisheries
  – weight of landings (kg),
  – fishing effort (kwdays),
  – capacity (number of vessels),

3 Methods

The methodology applied rescales economic indicators using a set of relationships with the components of the fleet definition, member state, gear and vessel length. These components are used by both datasets but aggregated and coded differently. Coding and aggregation are shown in Table 1.

Table 1: Link between the AER and the WGMIXFISH fleet definitions

<table>
<thead>
<tr>
<th>WGMIXFISH fleet code</th>
<th>country</th>
<th>AER gear</th>
<th>vessel length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE_Beam&lt;24</td>
<td>BEL</td>
<td>TBB</td>
<td>VL1824</td>
<td></td>
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<tr>
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<td>BEL</td>
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<td>BEL</td>
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<td>VL2440</td>
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<td>TBB</td>
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<td>DK_FDF</td>
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<td>FDF</td>
<td>NA</td>
<td>Fully Documented Fishery</td>
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<td>DNK</td>
<td>OTH</td>
<td>NA</td>
<td>Other metier</td>
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<td>DNK</td>
<td>DTS</td>
<td>VL0010</td>
<td></td>
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<td>DTS</td>
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<td>NA</td>
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<td>DK_Static</td>
<td>DNK</td>
<td>PGP</td>
<td>VL0010</td>
<td>polyvalent passive gears only</td>
</tr>
<tr>
<td>DK_Static</td>
<td>DNK</td>
<td>PGP</td>
<td>VL1012</td>
<td>polyvalent passive gears only</td>
</tr>
<tr>
<td>DK_Static</td>
<td>DNK</td>
<td>PGP</td>
<td>VL1218</td>
<td>polyvalent passive gears only</td>
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<tr>
<td>EN_Beam</td>
<td>GBR</td>
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<td>DTS</td>
<td>VL1012</td>
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</tr>
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<td>GBR</td>
<td>DTS</td>
<td>VL1218</td>
<td>SC_Otter&lt;24 + EN_Otter&lt;24</td>
</tr>
<tr>
<td>UK_Otter&lt;24</td>
<td>GBR</td>
<td>DTS</td>
<td>VL1824</td>
<td>SC_Otter&lt;24 + EN_Otter&lt;24</td>
</tr>
<tr>
<td>UK_Beam&lt;24</td>
<td>GBR</td>
<td>DTS</td>
<td>VL0010</td>
<td>SC_U10_OTB + EN_U10</td>
</tr>
<tr>
<td>UK_Otter24-40</td>
<td>GBR</td>
<td>DTS</td>
<td>VL2440</td>
<td>EN_Otter24-40 + SC_Otter&gt;=24</td>
</tr>
<tr>
<td>EN_Otter&gt;=24</td>
<td>GBR</td>
<td>DTS</td>
<td>VL40XX</td>
<td></td>
</tr>
<tr>
<td>SC_Static</td>
<td>GBR</td>
<td>DFN</td>
<td>VL0010</td>
<td></td>
</tr>
<tr>
<td>SC_Static</td>
<td>GBR</td>
<td>DFN</td>
<td>VL1012</td>
<td></td>
</tr>
<tr>
<td>SC_Static</td>
<td>GBR</td>
<td>DFN</td>
<td>VL1218</td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
The method models economic variables by unit as a function of the fleet’s components, which are shared between the two datasets, and use the North Sea information to scale the variables and estimate absolute economic indicators. The relationships are considered linear between the economic variables by unit and the fleet’s components. A set of GLMs with log link functions and Gamma errors were fit, with the exception of crew share for which a logit link was used.

In summary, our approach focused on:

1. use the AER dataset to compute economic variables by unit: fixed costs by vessel, crew costs by revenue and variable costs by effort;

2. use the AER dataset to model the economic variables mention above as functions of the fleets’ components: member state, gear and vessel length;
3. compute the economic variables by unit for the fleets defined in the WGMIXFISH dataset using the common components of the fleet definition;

4. compute the economic indicators for the North Sea: fixed costs, crew costs and variable costs, by scaling the economic variables by unit with the relevant information, capacity, revenue or effort.

For this analysis variable costs were split into variable costs depending on revenue, labour costs, and those depending on effort, energy and repair costs.

With regards to revenue a simple computation of value of landings was done using average prices estimated from the AER information and applied to the weight landed by species in the WGMIXFISH dataset. Furthermore, it was necessary to compute the revenue due to other species than those included in the WGMIXFISH dataset, once that the fleets considered also landed other commercial species from which a part of the revenue is made of.

Finally, all economic variables were adjusted for inflation to 2010 values.
# INIT

```r
library(FLCore)

## Loading required package: grid
## Loading required package: lattice
## Loading required package: MASS
## FLCore 2.5.0 development version
##
## Attaching package: 'FLCore'
## The following object(s) are masked from 'package:base':
##
## cbind, rbind

source("../analysis/funs.R")

yrs <- 2008:2010

sessionInfo()

## R version 2.15.1 (2012-06-22)
## Platform: x86_64-pc-linux-gnu (64-bit)
##
## locale:
## [1] LC_CTYPE=en_US.UTF-8   LC_NUMERIC=C
## [3] LC_TIME=en_US.UTF-8    LC_COLLATE=en_US.UTF-8
## [5] LC_MONETARY=en_US.UTF-8 LC_MESSAGES=en_US.UTF-8
## [7] LC_PAPER=C             LC_NAME=C
## [9] LC_ADDRESS=C           LC_TELEPHONE=C
##[11] LC_MEASUREMENT=en_US.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] grid     stats    graphics grDevices utils     datasets  methods
## [8] base
##
## other attached packages:
## [1] FLCore_2.5.0 MASS_7.3-22 lattice_0.20-6 knitr_0.8
##
## loaded via a namespace (and not attached):
## [1] digest_0.5.2   evaluate_0.4.2 formatR_0.6   plyr_1.7.1
## [5] stats4_2.15.1  stringr_0.6   tools_2.15.1
```

3.1 Read data

```r

#

## WGMIXFISH
##
## fleet object

attach("../data/fleets/03_OneYearFcube v1_2_FcubeAllObjects.Rdata")

fltscn <- res.fleets
detach()
```
# stocks (only works in linux due to the usage of 'ls')
stks <- system("ls ../data/stocks/", inter = TRUE)
stks <- split(stks, stks)

for (i in stks) {
    load(paste("../data/stocks/", i, sep = ""))
stks[[i]] <- stock
}

names(stks) <- unlist(lapply(strsplit(names(stks), "\\."), ",", 1))
stks <- FLStocks(stks)

# economic

eco.orig <- read.csv("../data/economic/WGMIXFISH_data.csv", stringsAsFactors = FALSE)
eco <- eco.orig[, c("country_code", "fishing_tech", "vessel_length", "variable_code", "species_code", "year", "value", "sub_reg", "wgmix_code")]

NSdiv <- c("27.3.A", "27.7.D", unique(eco.orig$sub_reg)[grep("27.4", unique(eco.orig$sub_reg))])

# !NOTE: will remove VL24XX not sure about VL40XX
eco <- subset(eco, year %in% yrs & vessel_length != "VL24XX" & country_code != "NOR")
wg2eco <- read.csv("../data/economic/WGMIXFISH_segments.csv", stringsAsFactors = FALSE)
inflation <- read.csv("../data/economic/WGMIXFISH_ratio.csv", stringsAsFactors = FALSE)

3.2 Pre-process data

3.2.1 Correction by inflation

infIndex <- subset(inflation[, -4], year < 2011)
# correct up to 2010
infIndex[infIndex$year == 2010, "inflation"] <- 0
# compute the multiplicative index
infIndex[order(infIndex$year), ]
infIndex <- lapply(split(infIndex, infIndex$country), function(x) {
    x[, "inflation"] <- cumprod(x[, "inflation"]/100 + 1)
    x
})
infIndex <- do.call("rbind", infIndex)

# merge and correct the relevant variables
ecoFix <- merge(eco, infIndex, by.x = c("country_code", "year"), by.y = c("country", "year"), all.x = TRUE)
vars2fix <- c("totenercost", "totvarcost", "totdepcost", "totnovarcost", "OPR", "totrepcost", "totcrewwage", "totunpaidlab", "totvallandg")
df0 <- subset(ecoFix, variable_code %in% vars2fix)
df0 <- transform(df0, value = value * inflation)
ecoFix <- rbind(df0, subset(ecoFix, !(variable_code %in% vars2fix)))

3.2.2 Average prices

Prices by species and year were computed from the AER information and allocated to the WGMIXFISH landings information, so that revenue from landings could be estimated. For years without price
information the average prices for years with information were used. The information from the AER was aggregated at the sub-region level (Areas 27.4a,b,c + 27.3a 27.7d were used), Member State, fleet segment, fishing gear, vessel length, species and year.

Average fish price by species was computed by $\bar{AvP} = \frac{\sum_{t=2008}^{2010} (vL)_t}{\sum_{t=2008}^{2010} (wL)_t}$, while for years without information a weighted average between 2008 and 2010 was used, $\bar{AvP} = \frac{\sum_{t=2008}^{2010} (vL)_t}{\sum_{t=2008}^{2010} (wL)_t}$. Where $AvP$ is average price, $vL$ is value of landings and $wL$ is volume of landings.

```r
nms <- names(fltscn[[1]])
fltscn <- lapply(fltscn, function(x) {
  cat("\n")
  for (i in nms) {
    cat(i, " ")
    flt <- x[[i]]
    metiers(flt) <- lapply(metiers(flt), function(y) {
      flc <- catches(y)
      # stk <- grep("NEP", names(flc)) if(length(stk)>0){ flc[stk] <-
      # lapply(flc[stk], function(z){
      flc <- lapply(flc, function(z) {
        cat("."
        stk <- z@name
        fl <- flt@name
        if (fl %in% c("SC_Otter<24", "EN_Otter<24"))
          fl <- "UK_Otter<24"
        if (fl %in% c("SC_U10_OTB", "EN_U10"))
          fl <- "UK_Beam<10"
        if (fl %in% c("EN_Otter24-40", "SC_Otter>=24"))
          fl <- "UK_Otter24-40"
        cc <- subset(wg2eco, wgmix_code == fl)
        gr <- cc$gear_code[1]
        ms <- cc$country_code[1]
        if (!(ms == "NOR" | fl %in% c("NL_Static", "FR_Nets", "OTH_OTH", "unalloc"))) {
          if (!is.na(pmatch("NEP", stk)))
            stk <- "NEP"
          if (gr %in% c("FDF", "OTH", "PEL"))
            gr <- "DTS"
        } # value of landings
        val <- subset(ecoFix, variable_code == "totvallandg" & country_code ==
          ms & fishing_tech == gr & species_code == stk)[, c("vessel_length",
          "year", "value")]
        # weight of landings
        wgt <- subset(ecoFix, variable_code == "totwghtlandg" & country_code ==
          cc$country_code[1] & fishing_tech == gr & species_code ==
          stk)[, c("vessel_length", "year", "value")]
        # compute prices
        val <- transform(val, id = paste(vessel_length, year, paste = ""))
        wgt <- transform(wgt, id = paste(vessel_length, year, paste = ""))
        id <- unique(val$id)
        df0 <- data.frame(id = id, pr = NA)
        for (i in id) df0[df0$id == i, "pr"] <- sum(subset(val, id ==
          i)$value)/sum(subset(wgt, id == i)$value)
        pr <- tapply(df0$pr, unlist(lapply(strsplit(as.character(df0$id),
          " "))), "mean", na.rm = T)
        # prices in euros per tonne
        price(z)[] <- mean(df0$pr, na.rm = T) * 1000
        price(z)[, names(pr)] <- pr * 1000
      }
    }
  }
})
```
Visualize prices for one scenario (should be the same for all).

```r
x <- fltscn[[i]]
pr <- lapply(x, function(y) {
  pr <- lapply(metiers(y), function(z) {
    data.frame(metier = name(z), expand.grid(stk = rownames(pr), year = z@range["minyear"] : z@range["maxyear"], price = c(pr))
  })
  pr <- do.call("rbind", pr)
  pr$flt <- name(y)
  pr
})
pr <- do.call("rbind", pr)
```
Figure 1: Prices by species
4 Stocks

The stocks included in the WGMIXFISH dataset are presented below. With the exception of some Nephrops stocks all of these have analytical assessments, estimates of biomass and fishing mortality.

```r
names(stks)
## [1] "COD"  "HAD"  "NEP10" "NEP32" "NEP33" "NEP34" "NEP5"
## [8] "NEP6"  "NEP7"  "NEP8"  "NEP9"  "NEPOTH" "PLE"  "POK"
## [15] "SOL"   "WHG"
```

![Figure 2: Stock summary](image)

**Haddock in the North Sea and Skagerrak: index**

![Figure 3: Stock summary](image)
Figure 4: Stock summary

Figure 5: Stock summary

Figure 6: Stock summary
Figure 7: Stock summary

Figure 8: Stock summary

Figure 9: Stock summary
Figure 10: Stock summary

Figure 11: Stock summary

Figure 12: Stock summary
Figure 13: Stock summary

Figure 14: Stock summary

Figure 15: Stock summary
Figure 16: Stock summary

Figure 17: Stock summary
5 Fleets

The fleets include in the WGMIXFISH dataset are presented below. This information was provided as FLFleet objects, which are very complex and difficult to parse. The structure of the economic data within the FLFleet class is the following:

1. fleet level
   - effort
   - fcost
   - capacity
   - crewshare

(a) metier level
   - effshare
   - vcost
   i. catch level
   - price

# using the projection in status quo, the historical data is the same
flts <- names(fltscn[["sq_E"]])
flts

## [1] "BE_Beam<24"  "BE_Beam>=24"  "BE_Otter"  "BE_Pelagic"
## [5] "BE_U10"      "BE_U24"      "BE_Static"  "BE_U40"
## [9] "DK_Beam"     "DK_Beam24-40" "DK_Otter<=24" "DK_Otter>24"
## [13] "DK_Pelagic"  "DK_Pelagic24-40" "DK_Pelagic>40" "DK_Pelagic10-40"
## [17] "DK_Pelagic<24" "DK_Pelagic<40" "DK_Pelagic40-24" "DK_Pelagic40-40"
## [21] "DK_Pelagic<24" "DK_Pelagic<40" "DK_Pelagic40-24" "DK_Pelagic40-40"
## [25] "DK_Pelagic<24" "DK_Pelagic<40" "DK_Pelagic40-24" "DK_Pelagic40-40"
## [29] "NL_Beam"     "NL_Beam24-40" "NL_Beam>40" "NL_Beam10-40"
## [33] "NL_Pelagic"  "NL_Pelagic24-40" "NL_Pelagic40-24" "NL_Pelagic40-40"
## [37] "NL_Pelagic"  "NL_Pelagic24-40" "NL_Pelagic40-24" "NL_Pelagic40-40"
## [41] "unalloc"

for (i in flts) {
  message("----------------------------------------------------------------")
  summary(fltscn[["sq_E"]][i])
}

## ----------------------------------------------------------------
## An object of class "FLFleet"
##
## Name: BE_Beam<24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort   : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost    : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare: [ 1 10 1 1 1 1 ], units = NA
## Metiers:
## BT2.4 :
## COD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## OTH :
## COD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"
##
## Name: BE_Beam>=24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## BT1.4 :
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## BT2.4 :
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## OTH :
## COD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
An object of class "FLFleet"

Name: BE_Otter
Description:
Range: min max minyear maxyear
NA NA 2003 2012
Quant: quant

effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
fcost : [ 1 10 1 1 1 1 ], units = number of vessels
capacity : [ 1 10 1 1 1 1 ], units = number of vessels
crewshare : [ 1 10 1 1 1 1 ], units = NA

Metiers:
OTH :
CDD : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
POK : [ 1 10 1 1 1 1 ]
HAD : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
NEPOTH : [ 1 10 1 1 1 1 ]

TR2.4 :
PLE : [ 1 10 1 1 1 1 ]
CDD : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
POK : [ 1 10 1 1 1 1 ]
HAD : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
NEPOTH : [ 1 10 1 1 1 1 ]
NEP5 : [ 1 10 1 1 1 1 ]

An object of class "FLFleet"

Name: DK_Beam
Description:
Range: min max minyear maxyear
NA NA 2003 2012
Quant: quant

effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
fcost : [ 1 10 1 1 1 1 ], units = number of vessels
capacity : [ 1 10 1 1 1 1 ], units = number of vessels
crewshare : [ 1 10 1 1 1 1 ], units = NA

Metiers:
BT1.4 :
CDD : [ 1 10 1 1 1 1 ]
HAD : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
POK : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
NEP32 : [ 1 10 1 1 1 1 ]
## OTH :
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]

# An object of class "FLFleet"
#
## Name: DK_FDF
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

Metiers:
## OTH :
## PLE : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## TR1.3AN :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## TR1.4 :
## CDD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]

# An object of class "FLFleet"
##
## Name: DK_OTH
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
An object of class "FLFleet"

Name: DK_Otter<24

Range: min max minyear maxyear

NA NA 2003 2012

Quant: quant

# effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
# fcost : [ 1 10 1 1 1 1 ], units = number of vessels
# capacity : [ 1 10 1 1 1 1 ], units = number of vessels
# crewshare : [ 1 10 1 1 1 1 ], units = NA

# Metiers:
# OTH :
# SOL : [ 1 10 1 1 1 1 ]
# WHG : [ 1 10 1 1 1 1 ]
# HAD : [ 1 10 1 1 1 1 ]
# CDD : [ 1 10 1 1 1 1 ]
# POK : [ 1 10 1 1 1 1 ]
# PLE : [ 1 10 1 1 1 1 ]
# NEP32 : [ 1 10 1 1 1 1 ]
# NEP33 : [ 1 10 1 1 1 1 ]
# TR1.4 :
# CDD : [ 1 10 1 1 1 1 ]
# HAD : [ 1 10 1 1 1 1 ]
# SOL : [ 1 10 1 1 1 1 ]
# WHG : [ 1 10 1 1 1 1 ]
# PLE : [ 1 10 1 1 1 1 ]
# POK : [ 1 10 1 1 1 1 ]
# NEP7 : [ 1 10 1 1 1 1 ]
# NEPOTH : [ 1 10 1 1 1 1 ]
# TR2.3AN :
# CDD : [ 1 10 1 1 1 1 ]
# HAD : [ 1 10 1 1 1 1 ]
# POK : [ 1 10 1 1 1 1 ]
An object of class "FLFleet"

Name: DK_Otter24-40
Description:
Range: min max minyear maxyear
NA NA 2003 2012
Quant: quant

effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
fcost : [ 1 10 1 1 1 1 ], units = number of vessels
capacity : [ 1 10 1 1 1 1 ], units = number of vessels
crewshare : [ 1 10 1 1 1 1 ], units = NA

Metiers:
OTH :
COD : [ 1 10 1 1 1 1 ]
HAD : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
NEP32 : [ 1 10 1 1 1 1 ]
NEP7 : [ 1 10 1 1 1 1 ]
NEPOTH : [ 1 10 1 1 1 1 ]
NEP33 : [ 1 10 1 1 1 1 ]
NEP5 : [ 1 10 1 1 1 1 ]
TR1.4 :
WHG : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
COD : [ 1 10 1 1 1 1 ]
POK : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
HAD : [ 1 10 1 1 1 1 ]
NEP7 : [ 1 10 1 1 1 1 ]
NEPOTH : [ 1 10 1 1 1 1 ]
NEP33 : [ 1 10 1 1 1 1 ]
NEP32 : [ 1 10 1 1 1 1 ]
NEP5 : [ 1 10 1 1 1 1 ]
TR2.4 :
WHG : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
## An object of class "FLFleet"

## Name: DK_Pelagic
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## OTH :
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"

## Name: DK_Seine
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## OTH :
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## pelagic.4 :
## SDL : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## An object of class "FLFleet"

### Name: DK_Static
### Description:
### Range: min max minyear maxyear
### NA NA 2003 2012
### Quant: quant

## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## GN1.3AN :
## CDD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## GN1.4 :
## CDD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## An object of class "FLFleet"

## Name: EN_Beam
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort       : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost        : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity     : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare    : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## BT2.4 :
## COD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"

## Name: EN_FDF
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort       : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost        : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity     : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare    : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## OTH :
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
An object of class "FLFleet"

Name: EN_Otter<24
Description:
Range: min year max year
NA NA 2003 2012
Quant: quant
effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
fcost : [ 1 10 1 1 1 1 ], units = number of vessels
capacity : [ 1 10 1 1 1 1 ], units = number of vessels
crewshare : [ 1 10 1 1 1 1 ], units = NA

Metiers:
OTH :
COD : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
TR1.4 :
HAD : [ 1 10 1 1 1 1 ]
CDD : [ 1 10 1 1 1 1 ]
SOL : [ 1 10 1 1 1 1 ]
WHG : [ 1 10 1 1 1 1 ]
POK : [ 1 10 1 1 1 1 ]
PLE : [ 1 10 1 1 1 1 ]
NEP32 : [ 1 10 1 1 1 1 ]
NEPOTH : [ 1 10 1 1 1 1 ]
NEP5 : [ 1 10 1 1 1 1 ]
NEP6 : [ 1 10 1 1 1 1 ]
NEP7 : [ 1 10 1 1 1 1 ]
NEP8 : [ 1 10 1 1 1 1 ]
NEP9 : [ 1 10 1 1 1 1 ]
NEP10 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]

# An object of class "FLFleet"
## Name: EN_Otter>=40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## OTH :
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
## Name: EN_Otter24-40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
## Metiers:
## TR1.4 :
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## TR2.4 :
## SOL : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"
## Name: EN_U10
## Description:
## Range:  min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## GN1.4 :
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
### HAD : [ 1 10 1 1 1 1 ]
### POK : [ 1 10 1 1 1 1 ]
### SOL : [ 1 10 1 1 1 1 ]
### WHG : [ 1 10 1 1 1 1 ]
### NEP6 : [ 1 10 1 1 1 1 ]
### NEP8 : [ 1 10 1 1 1 1 ]
### NEPOTH : [ 1 10 1 1 1 1 ]
### TR2.4 :
### CDD : [ 1 10 1 1 1 1 ]
### HAD : [ 1 10 1 1 1 1 ]
### PLE : [ 1 10 1 1 1 1 ]
### POK : [ 1 10 1 1 1 1 ]
### SOL : [ 1 10 1 1 1 1 ]
### WHG : [ 1 10 1 1 1 1 ]
### NEP6 : [ 1 10 1 1 1 1 ]
### NEP8 : [ 1 10 1 1 1 1 ]
### NEP9 : [ 1 10 1 1 1 1 ]
### NEP7 : [ 1 10 1 1 1 1 ]
### demhc.4 :
### PLE : [ 1 10 1 1 1 1 ]
### POK : [ 1 10 1 1 1 1 ]
### WHG : [ 1 10 1 1 1 1 ]
### HAD : [ 1 10 1 1 1 1 ]
### COD : [ 1 10 1 1 1 1 ]
### NEP6 : [ 1 10 1 1 1 1 ]
### NEP8 : [ 1 10 1 1 1 1 ]

---

#### An object of class "FLFleet"
####
#### # Name: FR_Nets
#### # Description:
#### # Range: min max minyear maxyear
#### # NA NA 2003 2012
#### # Quant: quant
####
#### # effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
#### # fcost : [ 1 10 1 1 1 1 ], units = number of vessels
#### # capacity : [ 1 10 1 1 1 1 ], units = number of vessels
#### # crewshare : [ 1 10 1 1 1 1 ], units = NA
####
#### # Metiers:
#### # GT1.4 :
#### # CDD : [ 1 10 1 1 1 1 ]
#### # PLE : [ 1 10 1 1 1 1 ]
#### # WHG : [ 1 10 1 1 1 1 ]
#### # SOL : [ 1 10 1 1 1 1 ]
#### # POK : [ 1 10 1 1 1 1 ]
#### # HAD : [ 1 10 1 1 1 1 ]
#### # OTH :
#### # CDD : [ 1 10 1 1 1 1 ]
#### # WHG : [ 1 10 1 1 1 1 ]

---
## An object of class "FLFleet"

## Name: FR_Otter>=40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## TR1.4 :
## PLE : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"

## Name: FR_Otter10-40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA

## Metiers:
## TR2.4 :
## CDD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## TR2.7D :
## CDD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"

## Name: GE_Beam>=24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## BT2.4 :
##
## OTH :
##
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"

## Name: GE_Otter<24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## OTH :
##
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
##
## TR2.4 :
##
## COD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
##
## NEP33 : [ 1 10 1 1 1 1 ]

## -----------------------------------------------

50
## An object of class "FLFleet"
##
## Name: GE_Otter>=40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## OTH :
##
## CDD : [ 1 10 1 1 1 1 ]
##
## HAD : [ 1 10 1 1 1 1 ]
##
## TR1.4 :
##
## HAD : [ 1 10 1 1 1 1 ]
##
## CDD : [ 1 10 1 1 1 1 ]
##
## POK : [ 1 10 1 1 1 1 ]
##
## PLE : [ 1 10 1 1 1 1 ]
##
## WHG : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"
##
## Name: GE_Otter24-40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## OTH :
##
## CDD : [ 1 10 1 1 1 1 ]
##
## HAD : [ 1 10 1 1 1 1 ]
##
## TR1.4 :
##
## HAD : [ 1 10 1 1 1 1 ]
##
## COD : [ 1 10 1 1 1 1 ]
##
## POK : [ 1 10 1 1 1 1 ]
##
## PLE : [ 1 10 1 1 1 1 ]
##
## WHG : [ 1 10 1 1 1 1 ]
##
## NEPOTH : [ 1 10 1 1 1 1 ]
##
## NEP33 : [ 1 10 1 1 1 1 ]
##
## NEP5 : [ 1 10 1 1 1 1 ]
##
## NEP32 : [ 1 10 1 1 1 1 ]
##
## TR2.4 :
##
## CDD : [ 1 10 1 1 1 1 ]
## GE_Static

### Description:
- **Range:** min max minyear maxyear
- **NA NA 2003 2012**
- **Quant:** quant

### Effort:
- effort : [ 1 10 1 1 1 1 ], units = 000 kWdays

### Cost:
- fcost : [ 1 10 1 1 1 1 ], units = number of vessels

### Capacity:
- capacity : [ 1 10 1 1 1 1 ], units = number of vessels

### Crew Share:
- crewshare : [ 1 10 1 1 1 1 ], units = NA

### Metiers:
- **GN1.4**:
  - COD : [ 1 10 1 1 1 1 ]
  - HAD : [ 1 10 1 1 1 1 ]
  - POK : [ 1 10 1 1 1 1 ]
  - SOL : [ 1 10 1 1 1 1 ]
  - PLE : [ 1 10 1 1 1 1 ]
  - WHG : [ 1 10 1 1 1 1 ]
  - NEPOTH : [ 1 10 1 1 1 1 ]
  - NEP33 : [ 1 10 1 1 1 1 ]
  - NEP32 : [ 1 10 1 1 1 1 ]

## NL_Beam<24

### Description:
- **Range:** min max minyear maxyear
- **NA NA 2003 2012**
- **Quant:** quant

### Effort:
- effort : [ 1 10 1 1 1 1 ], units = 000 kWdays

### Cost:
- fcost : [ 1 10 1 1 1 1 ], units = number of vessels

### Capacity:
- capacity : [ 1 10 1 1 1 1 ], units = number of vessels

### Crew Share:
- crewshare : [ 1 10 1 1 1 1 ], units = NA

### Metiers:
- **BT2.4**:
  - COD : [ 1 10 1 1 1 1 ]
  - HAD : [ 1 10 1 1 1 1 ]
  - PLE : [ 1 10 1 1 1 1 ]
  - SOL : [ 1 10 1 1 1 1 ]
  - WHG : [ 1 10 1 1 1 1 ]
### NEP33 : [ 1 1 1 1 1 1 ]
### NEPOTH : [ 1 1 1 1 1 1 ]
### NEP5 : [ 1 1 1 1 1 1 ]
### NEP32 : [ 1 1 1 1 1 1 ]
### OTH :
### CDD : [ 1 1 1 1 1 1 ]
### PLE : [ 1 1 1 1 1 1 ]
### SOL : [ 1 1 1 1 1 1 ]
### WHG : [ 1 1 1 1 1 1 ]
### HAD : [ 1 1 1 1 1 1 ]
### NEPOTH : [ 1 1 1 1 1 1 ]
### NEP33 : [ 1 1 1 1 1 1 ]

### An object of class "FLFleet"

### Name: NL_Beam>=40
### Description:
### Range: min max minyear maxyear
### NA NA 2003 2012
### Quant: quant
###
### effort : [ 1 1 1 1 1 1 ], units = 000 kWdays
### fcost : [ 1 1 1 1 1 1 ], units = number of vessels
### capacity : [ 1 1 1 1 1 1 ], units = number of vessels
### crewshare : [ 1 1 1 1 1 1 ], units = NA
###
### Metiers:
### BT2.4 :
### POK : [ 1 1 1 1 1 1 ]
### WHG : [ 1 1 1 1 1 1 ]
### PLE : [ 1 1 1 1 1 1 ]
### CDD : [ 1 1 1 1 1 1 ]
### HAD : [ 1 1 1 1 1 1 ]
### SOL : [ 1 1 1 1 1 1 ]
### NEPOTH : [ 1 1 1 1 1 1 ]
### NEP33 : [ 1 1 1 1 1 1 ]
### NEP5 : [ 1 1 1 1 1 1 ]
### NEP32 : [ 1 1 1 1 1 1 ]
### NEP6 : [ 1 1 1 1 1 1 ]
### OTH :
### POK : [ 1 1 1 1 1 1 ]
### PLE : [ 1 1 1 1 1 1 ]
### HAD : [ 1 1 1 1 1 1 ]
### CDD : [ 1 1 1 1 1 1 ]
### SOL : [ 1 1 1 1 1 1 ]
### WHG : [ 1 1 1 1 1 1 ]
### NEPOTH : [ 1 1 1 1 1 1 ]
### NEP5 : [ 1 1 1 1 1 1 ]
### NEP33 : [ 1 1 1 1 1 1 ]

### An object of class "FLFleet"

### Name: NL_Beam24-40
### Description:
# Range: min max minyear maxyear
# NA NA 2003 2012
## Quant: quant
##
## effort : [1 10 1 1 1 1], units = 000 kWdays
## fcost : [1 10 1 1 1 1], units = number of vessels
## capacity : [1 10 1 1 1 1], units = number of vessels
## crewshare : [1 10 1 1 1 1], units = NA
##
## Metiers:
## BT2.4:
## PLE : [1 10 1 1 1 1]
## SOL : [1 10 1 1 1 1]
## WHG : [1 10 1 1 1 1]
## CDD : [1 10 1 1 1 1]
## HAD : [1 10 1 1 1 1]
## NEPOTH : [1 10 1 1 1 1]
## NEP33 : [1 10 1 1 1 1]
## NEP5 : [1 10 1 1 1 1]
## NEP32 : [1 10 1 1 1 1]
##
## OTH:
## PLE : [1 10 1 1 1 1]
## SOL : [1 10 1 1 1 1]
## WHG : [1 10 1 1 1 1]
## CDD : [1 10 1 1 1 1]
## HAD : [1 10 1 1 1 1]
## POK : [1 10 1 1 1 1]
## NEP5 : [1 10 1 1 1 1]
## NEPOTH : [1 10 1 1 1 1]
## NEP33 : [1 10 1 1 1 1]

# An object of class "FLFleet"
#
## Name: NL_Otter
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [1 10 1 1 1 1], units = 000 kWdays
## fcost : [1 10 1 1 1 1], units = number of vessels
## capacity : [1 10 1 1 1 1], units = number of vessels
## crewshare : [1 10 1 1 1 1], units = NA
##
## Metiers:
## OTH:
## SOL : [1 10 1 1 1 1]
## CDD : [1 10 1 1 1 1]
## WHG : [1 10 1 1 1 1]
## HAD : [1 10 1 1 1 1]
## POK : [1 10 1 1 1 1]
## PLE : [1 10 1 1 1 1]
## NEP5 : [1 10 1 1 1 1]
## NEPOTH : [1 10 1 1 1 1]
## NEP33 : [1 10 1 1 1 1]
##
## TR1.4:
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## TR2.4 :
## WHG : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## TR2.7D :
## WHG : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## TR2.7D :
## WHG : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## TR2.7D :
## WHG : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"
##
## Name: NL_Static
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## GN1.4 :
## COD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
##
## OTH :
## SOL : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
## Name: NO_Otter<40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## OTH :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## otter.4 :
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
##
## Name: NO_Otter>=40
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## otter.4 :
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
##
## Name: NO_Pelagic
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## pelagic.4 :
## POK : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## COD : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
##
## Name: NO_Static
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## GN1.4 :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## LL1.4 :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
##
## Name: SC_FDF
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
## TR1.4 :
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## An object of class "FLFleet"
##
## Name: SC_Otter<24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 ], units = NA
##
## Metiers:
## TR1.4 :
##  WHG : [ 1 10 1 1 1 1 ]
##  CDD : [ 1 10 1 1 1 1 ]
##  SOL : [ 1 10 1 1 1 1 ]
##  PLE : [ 1 10 1 1 1 1 ]
##  PGK : [ 1 10 1 1 1 1 ]
##  HAD : [ 1 10 1 1 1 1 ]
##   NEP32 : [ 1 10 1 1 1 1 ]
##   NEP6 : [ 1 10 1 1 1 1 ]
##   NEP9 : [ 1 10 1 1 1 1 ]
##  NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP31 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]
## TR2.4 :
##  PLE : [ 1 10 1 1 1 1 ]
##  CDD : [ 1 10 1 1 1 1 ]
##  SOL : [ 1 10 1 1 1 1 ]
##  PLE : [ 1 10 1 1 1 1 ]
##  PGK : [ 1 10 1 1 1 1 ]
##  HAD : [ 1 10 1 1 1 1 ]
##  WHG : [ 1 10 1 1 1 1 ]
##  NEP9 : [ 1 10 1 1 1 1 ]
##  NEPOTH : [ 1 10 1 1 1 1 ]
##  NEP10 : [ 1 10 1 1 1 1 ]
##  NEP8 : [ 1 10 1 1 1 1 ]
##  NEP7 : [ 1 10 1 1 1 1 ]
##  NEP6 : [ 1 10 1 1 1 1 ]
##  NEP5 : [ 1 10 1 1 1 1 ]
##  NEP32 : [ 1 10 1 1 1 1 ]
##  NEP33 : [ 1 10 1 1 1 1 ]
##  NEP34 : [ 1 10 1 1 1 1 ]
##
## Metiers:
## TR1.4 :
##  WHG : [ 1 10 1 1 1 1 ]
##  CDD : [ 1 10 1 1 1 1 ]
##  SOL : [ 1 10 1 1 1 1 ]
##  PLE : [ 1 10 1 1 1 1 ]
##  PGK : [ 1 10 1 1 1 1 ]
##  HAD : [ 1 10 1 1 1 1 ]
##   NEP32 : [ 1 10 1 1 1 1 ]
##   NEP6 : [ 1 10 1 1 1 1 ]
##   NEP9 : [ 1 10 1 1 1 1 ]
##  NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP31 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]
## TR2.4 :
##  PLE : [ 1 10 1 1 1 1 ]
##  CDD : [ 1 10 1 1 1 1 ]
##  SOL : [ 1 10 1 1 1 1 ]
##  PLE : [ 1 10 1 1 1 1 ]
##  PGK : [ 1 10 1 1 1 1 ]
##  HAD : [ 1 10 1 1 1 1 ]
##  WHG : [ 1 10 1 1 1 1 ]
##  NEP9 : [ 1 10 1 1 1 1 ]
##  NEPOTH : [ 1 10 1 1 1 1 ]
##  NEP10 : [ 1 10 1 1 1 1 ]
##  NEP8 : [ 1 10 1 1 1 1 ]
##  NEP7 : [ 1 10 1 1 1 1 ]
##  NEP6 : [ 1 10 1 1 1 1 ]
##  NEP5 : [ 1 10 1 1 1 1 ]
##  NEP32 : [ 1 10 1 1 1 1 ]
##  NEP33 : [ 1 10 1 1 1 1 ]
##  NEP34 : [ 1 10 1 1 1 1 ]
##
## Metiers:
## TR1.4 :
##  WHG : [ 1 10 1 1 1 1 ]
##  CDD : [ 1 10 1 1 1 1 ]
##  SOL : [ 1 10 1 1 1 1 ]
##  PLE : [ 1 10 1 1 1 1 ]
##  PGK : [ 1 10 1 1 1 1 ]
##  HAD : [ 1 10 1 1 1 1 ]
##   NEP32 : [ 1 10 1 1 1 1 ]
##   NEP6 : [ 1 10 1 1 1 1 ]
##   NEP9 : [ 1 10 1 1 1 1 ]
##  NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP31 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]
## An object of class "FLFleet"
##
## Name: SC_Otter>=24
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## OTH :
##
## COD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## TR1.4 :
##
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]
##
## TR2.4 :
##
## SOL : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEP34 : [ 1 10 1 1 1 1 ]

## An object of class "FLFleet"
##
## Name: SC_Static
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## OTH :
##
## WHG : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## PK : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
##
## ptt.4 :
##
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
##
## An object of class "FLFleet"
##
## Name: SC_U10_OTB
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = 000 kWdays
## fcost : [ 1 10 1 1 1 1 ], units = number of vessels
## capacity : [ 1 10 1 1 1 1 ], units = number of vessels
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## TR1.4 :
##
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PK : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]
## TR2.4 :
## PLE : [ 1 10 1 1 1 1 ]
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]

---

## An object of class "FLFleet"

##
## Name: OTH_OTH
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
## Quant: quant
##
## effort : [ 1 10 1 1 1 1 ], units = NA
## fcost : [ 1 10 1 1 1 1 ], units = NA
## capacity : [ 1 10 1 1 1 1 ], units = NA
## crewshare : [ 1 10 1 1 1 1 ], units = NA
##
## Metiers:
##
## OTH :
##
## CDD : [ 1 10 1 1 1 1 ]
## HAD : [ 1 10 1 1 1 1 ]
## PLE : [ 1 10 1 1 1 1 ]
## POK : [ 1 10 1 1 1 1 ]
## SOL : [ 1 10 1 1 1 1 ]
## WHG : [ 1 10 1 1 1 1 ]
## NEP33 : [ 1 10 1 1 1 1 ]
## NEP6 : [ 1 10 1 1 1 1 ]
## NEP32 : [ 1 10 1 1 1 1 ]
## NEP9 : [ 1 10 1 1 1 1 ]
## NEP7 : [ 1 10 1 1 1 1 ]
## NEP8 : [ 1 10 1 1 1 1 ]
## NEP5 : [ 1 10 1 1 1 1 ]
## NEPOTH : [ 1 10 1 1 1 1 ]
## NEP10 : [ 1 10 1 1 1 1 ]

---

## An object of class "FLFleet"

##
## Name: unalloc
## Description:
## Range: min max minyear maxyear
## NA NA 2003 2012
# AER Economic Indicators by Year

This section presents the economic indicators computed for area 27 based on the information of the AER, fixed costs ("fixCost"), variable costs depending on effort ("effCost"), crew costs ("crewCost"), revenue from the North Sea ("nsval") and revenue from area 27 ("value"). These will be used for comparison with the same indicators computed for the North Sea after merging the two datasets. Due to the distinct space scales used, the comparison will have to be carried out in relative terms, e.g. the percentage of revenues allocated to costs.

```r
eco4tests <- transform(eco.orig, id = paste(country_code, fishing_tech, vessel_length), 
                      ns = sub_reg %in% NSdiv)

lst <- lapply(split(eco4tests, eco4tests$id), function(x) {
  mat <- tapply(x$value, list(var = x$variable_code, y = x$year, ns = x$ns),
                 sum, na.rm = T)
  data.frame(expand.grid(dimnames(mat)), value = c(mat), flt = unique(x$id))
})
eco4tests <- do.call("rbind", lst)

nsval <- with(subset(eco4tests, var == "totvallandg" & ns == TRUE), tapply(value, 
                     list(flt, y), sum, na.rm = T))
nsval <- apply(nsval, 2, sum, na.rm = T)/1e+06

fixCost <- with(subset(eco4tests, var %in% c("totdepcost", "totnovarcost", "OPR")), 
                 tapply(value, list(flt, y), sum, na.rm = T))
fixCost <- apply(fixCost, 2, sum, na.rm = T)/1e+06

nves <- with(subset(eco4tests, var == "totves"), tapply(value, 
               list(flt, y), sum, na.rm = T))
nves <- apply(nves, 2, sum, na.rm = T)

effCost <- with(subset(eco4tests, var %in% c("totenercost", "totrepcost")), 
                 tapply(value, list(flt, y), sum, na.rm = T))
effCost <- apply(effCost, 2, sum, na.rm = T)/1e+06

crewCost <- with(subset(eco4tests, var %in% c("totcrewwage", "totunpaidlab")), 
                 tapply(value, list(flt, y), sum, na.rm = T))
crewCost <- apply(crewCost, 2, sum, na.rm = T)/1e+06

val <- with(subset(eco4tests, var == "totvallandg"), tapply(value, 
                 list(flt, y), sum, na.rm = T))
val <- apply(val, 2, sum, na.rm = T)/1e+06

nms <- list(year = 2008:2012, indicator = c("nsval", "value", "fixCost", "effCost",
               "crewCost", "totCost"), type = c("absolute", "rel2value"))
```
Computing economic variables by unit based on the AER information

At the first step the economic indicators were standardized by unit and estimated by fleet segment and year.

Part of variable costs is more dependent on fleet effort (e.g. energy costs), while labour costs are more dependent on value of landings. For this exercise variable costs been distinguished to effort and income related.

Additionally, to have the full revenue on the North Sea it was necessary to model the extra income coming from species not included in the WGMIXFISH dataset.

The indices used in this exercise are: costs of effort by effort unit (euro/kwday), fixed costs by vessel (euro/vessel) and crew share\(^1\) (%).

### 7.1 Other revenue

To estimate the full revenue for each fleet, the ratio between value of landings of species considered in the WG dataset \((vI)\) and not considered in the WG dataset \((vO)\) was modelled. This procedure allows scaling partial income to total income from the North Sea.

```r
# subset
df0 <- subset(ecoFix, variable_code == "totvallandg" & sub_reg %in% NSdiv)
# id species in fleet
df0$wgspp <- FALSE
nms <- lapply(fltscn[[1]], function(x) {
  nms <- catchNames(x)
  nms[nchar(nms) > 3] <- substring(nms[nchar(nms) > 3], 1, 3)
  unique(nms)
})
for (i in names(nms)) df0[df0$wgmix_code == i & df0$species_code %in% nms[[i]], "wgspp"] <- TRUE
```

\(^1\)could be referred to as crew costs by unit of income (euro/euro)
# compute income of other species

```r
df1 <- subset(df0, !wgspp)
vO <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)
```

# compute income of WG species

```r
df1 <- subset(df0, wgspp)
vI <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)
```

# check all levels of factors match

```r
all.equal(dimnames(vI), dimnames(vO))
```

## [1] TRUE

# compute variable costs by unit effort

```r
vR <- vI/vO
```

# build data.frame for glm and rename factors to make it easier ...

```r
vR.df <- data.frame(expand.grid(dimnames(vR)), vI = c(vI), vO = c(vO), vR = c(vR))
vR.df <- subset(vR.df, !is.na(vR) & vR > 0)
pairs(vR.df)
```
names(vR.df)[1:4] <- c("ms", "gr", "loa", "y")
vR.df <- transform(vR.df, metier = paste(ms, gr, loa, sep = ":"))

# summaries

```r
table(vR.df$loa)
```

```r
##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 22 23 34 27 33 11
```

```r
tapply(vR.df$vR, vR.df$loa, mean, na.rm = T)
```

```r
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 1.367 1.572 5.199 1.784 1.928 11.122
```
Figure 18: by fleet

```r
bwplot(vR ~ loa, data = vR.df)
```

```
# Figure 18: by fleet

table(vR.df$y)
```

```
##
## 2008 2009 2010
## 46 52 52
```

```
tapply(vR.df$vR, vR.df$y, mean, na.rm = T)
```

```
## 2008 2009 2010
## 2.978 3.221 3.320
```
Figure 19: by year

table(vR.df$ms)
##
## BEL DEU DNK FRA GBR NLD
## 15 22 29 18 45 21
tapply(vR.df$vR, vR.df$ms, mean, na.rm = T)
##
## BEL DEU DNK FRA GBR NLD
## 1.995 10.391 1.892 2.740 1.873 1.434
bwplot(vR ~ ms, data = vR.df)

Figure 20: by member state

table(vR.df$gr)

##
## DFN DTS FPO HOK PGP TBB
## 26 56 9 7 9 43

tapply(vR.df$vR, vR.df$gr, mean, na.rm = T)

##
## DFN DTS FPO HOK PGP TBB
## 6.08561 4.22343 0.01851 0.19774 2.02857 1.45470

68
Figure 21: by gear

7.1.1 GLM

# GLM for metier components! NOTE: shall observations 22,111 need to be removed because had leverage 1 ??
vR.glm <- glm(vR ~ (loa + gr + ms + y)^2, family = Gamma("log"), data = vR.df, maxit = 200)
anova(vR.glm, test = "F")

## Analysis of Deviance Table

## Model: Gamma, link: log
## Response: vR
##
## Terms added sequentially (first to last)
##
##
## Df Deviance Resid. Df Resid. Dev  F Pr(>F)
## NULL 149 451
## loa 5  72.9  144 378 30.51 6.2e-16 ***
## gr 5 109.0  139 269 45.58 < 2e-16 ***
## ms 5  29.2  134 240 12.23 2.1e-08 ***
## y 2  0.3  132 239 0.27 0.76
## loa:gr 15  84.7  117 155 11.82 2.2e-13 ***
## loa:ms 17  45.4  100 109  5.57 1.7e-11 ***
## loa:y 10  1.4  90 108  0.29 0.76
## gr:ms 5  44.2  85  64 18.50 1.9e-11 ***
## gr:y 10  1.6  75  62  0.33 0.97
## ms:y 9  4.8  66  57  1.12 0.36
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

# year is not significantative

vR.glm <- glm(vR ~ (loa + gr + ms)^2, family = Gamma("log"), data = vR.df, maxit = 500)
anova(vR.glm, test = "F")

## Analysis of Deviance Table
##
## Model: Gamma, link: log
##
## Response: vR
##
## Terms added sequentially (first to last)
##
##
## Df Deviance Resid. Df Resid. Dev  F Pr(>F)
## NULL 149 451
## loa 5  72.9  144 378 38.2 < 2e-16 ***
## gr 5 109.0  139 269 57.1 < 2e-16 ***
## ms 5  29.2  134 240 15.3 4.4e-11 ***
## loa:gr 15  84.9  119 155 14.8 < 2e-16 ***
## loa:ms 17  45.4  102 109  5.07 1.1e-10 ***
## loa:y 10  1.4  90 108  0.29 0.76
## gr:ms 5  44.2  85  64 18.50 1.9e-11 ***
## gr:y 10  1.6  75  62  0.33 0.97
## ms:y 9  4.8  66  57  1.12 0.36
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

par(mfrow = c(2, 2))
plot(vR.glm)
Figure 22: GLM diagnostics

```r
xyplot(residuals(vR.glm) ~ predict(vR.glm) | vR.df$gr, type = c("smooth", "p"),
  xlab = "", ylab = "")
```
Figure 23: GLM residuals VS predicted by MS

```
xyplot(residuals(vR.glm) ~ predict(vR.glm) | vR.df$gr, type = c("smooth", "p"),
       xlab = "", ylab = "")
```

Figure 24: GLM residuals VS predicted by gear

```
xyplot(residuals(vR.glm) ~ predict(vR.glm) | vR.df$loa, type = c("smooth", "p"),
       xlab = "", ylab = "")
```
7.1.2 Predictions

```r
cRnew.df <- do.call("rbind", sapply(unique(with(wg2eco, paste(country_code, gear_code, vessel_length_code, sep = ":"))), ":"))
cRnew.df <- data.frame(cRnew.df)
names(cRnew.df) <- c("ms", "gr", "loa")
cRnew.df <- cRnew.df[cRnew.df$loa != "NA" & cRnew.df$loa != "VL24XX" & cRnew.df$ms != "NOR",]
cRnew.df <- transform(cRnew.df, metier = paste(ms, gr, loa, sep = ":"))
cRnew.df$cRpred <- predict(cR.glm, newdata = cRnew.df, type = "response")

dotplot(reorder(metier, cRpred) ~ cRpred, type = c("p", "h"), data = cRnew.df, xlab = "ratio")
```

Figure 25: GLM residuals VS predicted by vessel length category
Figure 26: Estimates of value of landings ratio for all metiers

7.2 Variable costs by effort

The information from the AER was aggregated at the region level (Area 27), Member State, fleet segment, fishing gear, vessel length and year.
Effort costs by unit of effort were computed by year as $e_C = (r_C + n_C + v_C) \cdot eff^{-1}$, while for years without information a weighted average between 2008 and 2010 was used, $e_C = \sum_{t=2008}^{2010} (r_C + n_C + v_C)_t \cdot (\sum_{t=2008}^{2010} (eff)_t)^{-1}$, where $e_C$ is effort costs, $r_C$ is repair and maintenance costs, $n_C$ is energy costs, $v_C$ is other variable costs and $eff$ is fishing effort in kw/day.

```r
# subset
df0 <- subset(ecoFix, variable_code %in% c("totenercost", "totvarcost", "totrepcost", "totkwfishdays"))
df0 <- transform(df0, id = paste(country_code, fishing_tech, vessel_length, year, sep = "::"))
# remove cases that don't have energy or effort
errvec <- unique(subset(df0, variable_code %in% c("totenercost", "totkwfishdays") & value <= 0)$id)
df0 <- subset(df0, !(id %in% errvec))
# remove cases that don't have totvar and repair at the same time
errvec <- unique(subset(df0, (variable_code == "totvarcost" & value <= 0) & (variable_code == "totrepcost" & value <= 0))$id)
df0 <- subset(df0, !(id %in% errvec))

# compute costs
dfi <- subset(df0, variable_code != "totkwfishdays")
eC <- tapply(dfi$value, dfi[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)

# compute associated effort
df1 <- subset(df0, variable_code == "totkwfishdays")
eCEff <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)

# check all levels of factors match
all.equal(dimnames(eC), dimnames(eCEff))

## [1] TRUE

# compute variable costs by unit effort
eCBar <- eC/eCEff

# build data.frame for glm and rename factors to make it easier ...
eC.df <- data.frame(expand.grid(dimnames(eC)), eC = c(eC), eCEff = c(eCEff), eCbar = c(eCBar))
eC.df <- subset(eC.df, !is.na(eCbar))
pairs(eC.df)
```
names(eC.df)[1:4] <- c("ms", "gr", "loa", "y")
eC.df <- transform(eC.df, metier = paste(ms, gr, loa, sep = ":"))

# summaries
table(eC.df$loa)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 23 28 35 30 35 11

tapply(eC.df$eCbar, eC.df$loa, median, na.rm = T)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 2.627 3.079 4.186 5.231 4.589 4.561
Figure 27: by fleet

table(eC.df$y)

##
## 2008 2009 2010
## 48 57 57
tapply(eC.df$eCbar, eC.df$y, mean, na.rm = T)

## 2008 2009 2010
## 4.800 4.397 4.456
\texttt{bwplot(eCbar \sim y, data = eC.df)}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure28}
\caption{by year}
\end{figure}

\texttt{table(eC.df$ms)}

\begin{verbatim}
##
## BEL DEU DNK FRA GBR NLD
## 14 18 29 18 63 20
\end{verbatim}

\texttt{tapply(eC.df$eCbar, eC.df$ms, mean, na.rm = T)}

\begin{verbatim}
##
## BEL DEU DNK FRA GBR NLD
## 7.074 4.083 3.790 4.768 4.106 5.403
\end{verbatim}

78
bwplot(eCbar ~ ms, data = eC.df)

Figure 29: by member state

table(eC.df$gr)

##
## DFN DTS FPO HOK PGP TBB
## 20 69 9 9 10 45

tapply(eC.df$eCbar, eC.df$gr, mean, na.rm = T)

##
## DFN DTS FPO HOK PGP TBB

79
bwplot(eCbar ~ gr, data = eC.df)

Figure 30: by gear

7.2.1 GLM

# GLM for metier components
eC.df <- eC.df[rownames(eC.df) != "225", ]
eC.glm <- glm(eCbar ~ (loa + gr + ms + y)^2, family = Gamma("log"), data = eC.df)
anova(eC.glm, test = "F")

## Analysis of Deviance Table
##
## Model: Gamma, link: log
##
## Response: eCbar
## Terms added sequentially (first to last)

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Deviance</th>
<th>Resid. Df</th>
<th>Resid. Dev</th>
<th>F</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>160</td>
<td>32.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loa</td>
<td>5</td>
<td>4.39</td>
<td>155</td>
<td>28.0</td>
<td>24.88</td>
<td>1.1e-14 ***</td>
</tr>
<tr>
<td>gr</td>
<td>5</td>
<td>1.43</td>
<td>150</td>
<td>26.5</td>
<td>8.09</td>
<td>3.8e-06 ***</td>
</tr>
<tr>
<td>ms</td>
<td>5</td>
<td>3.40</td>
<td>145</td>
<td>23.1</td>
<td>19.30</td>
<td>2.7e-12 ***</td>
</tr>
<tr>
<td>y</td>
<td>2</td>
<td>0.28</td>
<td>143</td>
<td>22.9</td>
<td>3.92</td>
<td>0.02398 *</td>
</tr>
<tr>
<td>loa:gr</td>
<td>15</td>
<td>5.84</td>
<td>128</td>
<td>17.0</td>
<td>11.04</td>
<td>1.7e-13 ***</td>
</tr>
<tr>
<td>loa:ms</td>
<td>18</td>
<td>8.66</td>
<td>110</td>
<td>8.4</td>
<td>13.64</td>
<td>&lt; 2e-16 ***</td>
</tr>
<tr>
<td>loa:y</td>
<td>10</td>
<td>1.34</td>
<td>100</td>
<td>7.0</td>
<td>3.80</td>
<td>0.00035 ***</td>
</tr>
<tr>
<td>gr:ms</td>
<td>6</td>
<td>2.54</td>
<td>94</td>
<td>4.5</td>
<td>12.01</td>
<td>2.1e-09 ***</td>
</tr>
<tr>
<td>gr:y</td>
<td>10</td>
<td>1.19</td>
<td>84</td>
<td>3.3</td>
<td>3.38</td>
<td>0.00111 **</td>
</tr>
<tr>
<td>ms:y</td>
<td>9</td>
<td>0.59</td>
<td>75</td>
<td>2.7</td>
<td>1.85</td>
<td>0.07387 .</td>
</tr>
</tbody>
</table>

---

Signif. codes: 0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

par(mfrow = c(2, 2))
plot(eC.glm)
Figure 31: GLM diagnostics

```r
xyplot(residuals(eC.glm) ~ predict(eC.glm) | eC.df$y, type = c("smooth", "p"),
layout = c(3, 1), ylab = "", xlab = "")
```
Figure 32: GLM residuals VS predicted by year

```
xyplot(residuals(eC.glm) ~ predict(eC.glm) | eC.df$ms, type = c("smooth", "p"),
ylab = "", xlab = "")
```

Figure 33: GLM residuals VS predicted by MS

```
xyplot(residuals(eC.glm) ~ predict(eC.glm) | eC.df$gr, type = c("smooth", "p"),
ylab = "", xlab = "")
```
7.2.2 Predictions

```r
xyplot(residuals(eC.glm) ~ predict(eC.glm) | eC.df$loa, type = c("smooth", "p"), ylab = "", xlab = "")
```

Figure 34: GLM residuals VS predicted by gear

Figure 35: GLM residuals VS predicted by vessel length category
eCnew.df <- do.call("rbind", strsplit(unique(with(wg2eco, paste(country_code, gear_code, vessel_length_code, sep = ":"))), ":"))
eCnew.df <- data.frame(eCnew.df, factor(rep(yrs, rep(nrow(eCnew.df), 3))))
names(eCnew.df) <- c("ms", "gr", "loa", "y")
eCnew.df <- eCnew.df[eCnew.df$loa != "NA" & eCnew.df$loa != "VL24XX" & eCnew.df$ms != "NOR",]
eCnew.df <- transform(eCnew.df, metier = paste(ms, gr, loa, sep = ":"))
eCnew.df$eCpred <- predict(eC.glm, newdata = eCnew.df, type = "response")

dotplot(reorder(metier, eCpred) ~ eCpred | y, type = c("p", "h"), layout = c(3, 1), data = eCnew.df, xlab = "cost (euro/kwday)")
7.3 Fixed costs by vessel

The information from the AER was aggregated at the region level (Area 27), Member State, fleet segment, fishing gear, vessel length and year.
Fixed costs by vessel were computed by year as \( f_C = (nvC + dC + OPR).cap^{-1} \), while for years without information a weighted average between 2008 and 2010 was used, \( f_C = \sum_{t=2008}^{2010} (nvC + dC + OPR).t \). 

\( \bar{f}_C \) is fixed costs, \( OPR \) is opportunity costs of capital, \( dC \) is depreciation costs, \( nvC \) is other non-variable costs and \( cap \) is capacity in number of vessels.

df0 <- subset(ecoFix, variable_code %in% c("totdepcost", "totnovarcost", "OPR", "totves") & year %in% yrs)
df0 <- transform(df0, id = paste(country_code, fishing_tech, vessel_length, year, sep = ":"))
# remove cases that don't have all the information required
errvec <- unique(subset(df0, value <= 0)$id)
df0 <- subset(df0, !id %in% errvec))

# compute fixed costs
df1 <- subset(df0, variable_code != "totves")
fC <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)

# compute associated capacity
df1 <- subset(df0, variable_code == "totves")
fCCap <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)

# check all levels of factors match
all.equal(dimnames(fC), dimnames(fCCap))

## [1] TRUE

# compute fixed costs by unit capacity
fCbar <- fC/fCCap

# build data.frame for glm and rename factors to make it easier ...
fC.df <- data.frame(expand.grid(dimnames(fC)), fC = c(fC), fCCap = c(fCCap), fCbar = c(fCbar))
fC.df <- subset(fC.df, !is.na(fCbar))
fC.df <- subset(fC.df, fCbar > 0)
pairs(fC.df)
names(fC.df)[1:4] <- c("ms", "gr", "loa", "y")
fC.df <- transform(fC.df, metier = paste(ms, gr, loa, sep = ":"))

# summaries
table(fC.df$loa)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 23 28 37 29 36 9

tapply(fC.df$fCbar, fC.df$loa, mean, na.rm = T)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 9239 30071 60053 148331 245987 736565
bwplot(fCbar ~ loa, data = fC.df)

Figure 37: by fleet

table(fC.df$y)

##
## 2008 2009 2010
## 55 49 58
tapply(fC.df$fCbar, fC.df$y, mean, na.rm = T)

##
## 2008 2009 2010
## 153115 132170 140775

89
bwplot(fCbar ~ y, data = fC.df)

Figure 38: by year

table(fC.df$ms)
##
## BEL DEU DNK FRA GBR NLD
## 11 24 29 16 62 20

tapply(fC.df$fCbar, fC.df$ms, mean, na.rm = T)
##
## BEL DEU DNK FRA GBR NLD
## 210503 303686 99120 136765 86612 151300
bwplot(fCbar ~ ms, data = fC.df)

table(fC.df$gr)
##
## DFN DTS FPO HOK PGP TBB
## 26 67 9 8 10 42
tapply(fC.df$fCbar, fC.df$gr, mean, na.rm = T)
## DFN DTS FPO HOK PGP TBB
## 88318 215931 31924 55804 34906 124196

Figure 39: by member state

table(fC.df$gr)
##
## DFN DTS FPO HOK PGP TBB
## 26 67 9 8 10 42
tapply(fC.df$fCbar, fC.df$gr, mean, na.rm = T)
## DFN DTS FPO HOK PGP TBB
## 88318 215931 31924 55804 34906 124196
7.3.1 GLM

# GLM for metier components
fC.glm <- glm(fCbar ~ (loa + gr + ms + y)^2, family = Gamma("log"), data = fC.df)
anova(fC.glm, test = "F")

## Analysis of Deviance Table
## Model: Gamma, link: log
## Response: fCbar

Figure 40: by gear

bwplot(fCbar ~ gr, data = fC.df)
## Terms added sequentially (first to last)

<table>
<thead>
<tr>
<th>Df</th>
<th>Deviance</th>
<th>Resid. Df</th>
<th>Resid. Dev</th>
<th>F</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>161</td>
<td>251.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loa</td>
<td>5</td>
<td>205.4</td>
<td>156</td>
<td>45.6</td>
<td>521.82</td>
</tr>
<tr>
<td>gr</td>
<td>5</td>
<td>2.8</td>
<td>151</td>
<td>42.8</td>
<td>7.18</td>
</tr>
<tr>
<td>ms</td>
<td>5</td>
<td>10.1</td>
<td>146</td>
<td>32.7</td>
<td>25.56</td>
</tr>
<tr>
<td>y</td>
<td>2</td>
<td>0.1</td>
<td>144</td>
<td>32.6</td>
<td>0.56</td>
</tr>
<tr>
<td>loa:gr</td>
<td>15</td>
<td>5.7</td>
<td>129</td>
<td>27.0</td>
<td>4.81</td>
</tr>
<tr>
<td>loa:ms</td>
<td>17</td>
<td>11.6</td>
<td>112</td>
<td>15.3</td>
<td>8.68</td>
</tr>
<tr>
<td>loa:y</td>
<td>10</td>
<td>1.8</td>
<td>102</td>
<td>13.6</td>
<td>2.22</td>
</tr>
<tr>
<td>gr:ms</td>
<td>7</td>
<td>4.9</td>
<td>95</td>
<td>8.6</td>
<td>8.96</td>
</tr>
<tr>
<td>gr:y</td>
<td>10</td>
<td>0.7</td>
<td>85</td>
<td>7.9</td>
<td>0.94</td>
</tr>
<tr>
<td>ms:y</td>
<td>9</td>
<td>1.8</td>
<td>76</td>
<td>6.1</td>
<td>2.50</td>
</tr>
</tbody>
</table>

---

## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

# year is not significant

```r
fC.glm <- glm(fCbar ~ (loa + gr + ms)^2, family = Gamma("log"), data = fC.df)
anova(fC.glm, test = "F")
```

## Analysis of Deviance Table

## Model: Gamma, link: log
## Response: fCbar
## Terms added sequentially (first to last)

<table>
<thead>
<tr>
<th>Df</th>
<th>Deviance</th>
<th>Resid. Df</th>
<th>Resid. Dev</th>
<th>F</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>161</td>
<td>251.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loa</td>
<td>5</td>
<td>205.4</td>
<td>156</td>
<td>45.6</td>
<td>426.20</td>
</tr>
<tr>
<td>gr</td>
<td>5</td>
<td>2.8</td>
<td>151</td>
<td>42.8</td>
<td>5.86</td>
</tr>
<tr>
<td>ms</td>
<td>5</td>
<td>10.1</td>
<td>146</td>
<td>32.7</td>
<td>8.68</td>
</tr>
<tr>
<td>loa:gr</td>
<td>15</td>
<td>5.7</td>
<td>131</td>
<td>27.0</td>
<td>3.95</td>
</tr>
<tr>
<td>loa:ms</td>
<td>17</td>
<td>11.6</td>
<td>114</td>
<td>15.4</td>
<td>7.10</td>
</tr>
<tr>
<td>gr:ms</td>
<td>7</td>
<td>4.9</td>
<td>98</td>
<td>8.6</td>
<td>8.96</td>
</tr>
<tr>
<td>gr:y</td>
<td>10</td>
<td>0.7</td>
<td>85</td>
<td>7.9</td>
<td>0.94</td>
</tr>
<tr>
<td>ms:y</td>
<td>9</td>
<td>1.8</td>
<td>76</td>
<td>6.1</td>
<td>2.50</td>
</tr>
</tbody>
</table>

---

## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```r
par(mfrow = c(2, 2))
plot(fC.glm)
```
Figure 41: GLM diagnostics

```r
xyplot(residuals(fC.glm) ~ predict(fC.glm) | fC.df$ms, type = c("smooth", "p"),
ylab = "", xlab = "")
```
Figure 42: GLM residuals VS predicted by MS

```r
xyplot(residuals(fC.glm) ~ predict(fC.glm) | fC.df$gr, type = c("smooth", "p"), ylab = "", xlab = "")
```

Figure 43: GLM residuals VS predicted by gear

```r
xyplot(residuals(fC.glm) ~ predict(fC.glm) | fC.df$loa, type = c("smooth", "p"), ylab = "", xlab = "")
```
7.3.2 Predictions

```r
fCnew.df <- do.call("rbind", strsplit(unique(with(wg2eco, paste(country_code, gear_code, vessel_length_code, sep = "::"))), "::"))
fCnew.df <- data.frame(fCnew.df)
names(fCnew.df) <- c("ms", "gr", "loa")
fCnew.df <- fCnew.df[fCnew.df$loa != "NA" & fCnew.df$loa != "VL24XX" & fCnew.df$ms != "NOR",]
fCnew.df <- transform(fCnew.df, metier = paste(ms, gr, loa, sep = "::"))
fCnew.df$fCpred <- predict(fC.glm, newdata = fCnew.df, type = "response")

dotplot(reorder(metier, fCpred) ~ fCpred, type = c("p", "h"), data = fCnew.df, xlab = "cost (euro/vessel)")
```
Figure 45: Estimates of fixed costs by vessel for all metiers

7.4 Crewshare by landing income

The information from the AER was aggregated at the region level (Area 27), Member State, fleet segment, fishing gear, vessel length and year.
Crew share by income were computed by year as $c_S = (c_C + uL) i_L^{-1}$, while for years without information a weighted average between 2008 and 2010 was used, $c_S = \frac{\sum_{t=2008}^{2010} (c_C + uL)_t}{\sum_{t=2008}^{2010} (i_L)_t}$, where $c_S$ is crew share, $c_C$ is crew costs, $uL$ is unpaid labour costs and $i_L$ is value of landings in euros.

```r
# subset
df0 <- subset(ecoFix, variable_code %in% c("totcrewwage", "totunpaidlab", "totvallandg") & year %in% yrs)
df0 <- transform(df0, id = paste(country_code, fishing_tech, vessel_length, year, sep = "::"))
# remove cases that don't have all the information required
errvec <- unique(subset(df0, variable_code %in% c("totcrewwage", "totvallandg") & value <= 0)$id)
df0 <- subset(df0, !(id %in% errvec))

# compute total costs
df1 <- subset(df0, variable_code != "totvallandg")
cC <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)
# compute total income from landings
df1 <- subset(df0, variable_code == "totvallandg")
iL <- tapply(df1$value, df1[, c("country_code", "fishing_tech", "vessel_length", "year")], sum, na.rm = T)

# check all levels of factors match
all.equal(dimnames(cC), dimnames(iL))

## [1] TRUE

# compute fixed costs by unit capacity
cS <- cC/iL

# build data.frame for glm and rename factors to make it easier ...
cS.df <- data.frame(expand.grid(dimnames(cS)), cS = c(cS), cC = c(cC), iL = c(iL))
cS.df <- subset(cS.df, !is.na(cS))
cS.df <- subset(cS.df, cS > 0)
pairs(cS.df)
```
names(cS.df)[1:4] <- c("ms", "gr", "loa", "y")
cS.df <- transform(cS.df, metier = paste(ms, gr, loa, sep = "::"))

# summaries
table(cS.df$loa)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 20 21 30 22 28 7

tapply(cS.df$cS, cS.df$loa, mean, na.rm = T)

##
## VL0010 VL1012 VL1218 VL1824 VL2440 VL40XX
## 0.4995 0.4247 0.3456 0.3458 0.2856 0.3091

99
bwplot(cS ~ loa, data = cS.df)

Figure 46: by fleet

table(cS.df$y)
##
## 2008 2009 2010
## 34 43 51
tapply(cS.df$cS, cS.df$y, mean, na.rm = T)
## 2008 2009 2010
## 0.3534 0.3717 0.3735
bwplot(cS ~ y, data = cS.df)

```
## BEL DEU DNK FRA GBR NLD
## 6 10 16 18 63 15
```

tapply(cS.df$cS, cS.df$ms, mean, na.rm = T)

```
## BEL DEU DNK FRA GBR NLD
## 0.3834 0.2691 0.4778 0.4230 0.3473 0.3277
```

table(cS.df$ms)

```
## BEL DEU DNK FRA GBR NLD
## 6 10 16 18 63 15
```

tapply(cS.df$cS, cS.df$ms, mean, na.rm = T)

```
## BEL DEU DNK FRA GBR NLD
## 0.3834 0.2691 0.4778 0.4230 0.3473 0.3277
```
Figure 48: by member state

```r
table(cS.df$gr)
#>
#>   DFN DTS FPO HOK PGP TBB
#>  24  45   9   9   7  34

tapply(cS.df$cS, cS.df$gr, mean, na.rm = T)
#>
#>   DFN  DTS  FPO  HOK  PGP  TBB
#> 0.3811 0.3205 0.3276 0.5963 0.5719 0.3282
```

102
bwplot(cS ~ gr, data = cS.df)

Figure 49: by gear

7.4.1 GLM

# GLM for metier components
cS.df <- subset(cS.df, cS <= 1 & cS >= 0)
cS.glm <- glm(cS ~ (loa + gr + ms + y)^2, family = Gamma("logit"), data = cS.df)
anova(cS.glm, test = "F")

## Analysis of Deviance Table
## Model: Gamma, link: logit
## Response: cS

103
## Terms added sequentially (first to last)

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Deviance</th>
<th>Resid. Df</th>
<th>Resid. Dev</th>
<th>F</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>126</td>
<td>18.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loa</td>
<td>5</td>
<td>4.12</td>
<td>121</td>
<td>14.48</td>
<td>11.93</td>
<td>2.2e-07 ***</td>
</tr>
<tr>
<td>gr</td>
<td>5</td>
<td>3.07</td>
<td>116</td>
<td>11.42</td>
<td>8.88</td>
<td>6.3e-06 ***</td>
</tr>
<tr>
<td>ms</td>
<td>5</td>
<td>2.76</td>
<td>111</td>
<td>8.66</td>
<td>7.99</td>
<td>1.9e-05 ***</td>
</tr>
<tr>
<td>y</td>
<td>2</td>
<td>0.20</td>
<td>109</td>
<td>8.46</td>
<td>1.45</td>
<td>0.245</td>
</tr>
<tr>
<td>loa:gr</td>
<td>15</td>
<td>1.29</td>
<td>94</td>
<td>7.17</td>
<td>1.24</td>
<td>0.278</td>
</tr>
<tr>
<td>loa:ms</td>
<td>14</td>
<td>2.16</td>
<td>80</td>
<td>5.02</td>
<td>2.23</td>
<td>0.021 *</td>
</tr>
<tr>
<td>loa:y</td>
<td>10</td>
<td>0.19</td>
<td>70</td>
<td>4.83</td>
<td>0.27</td>
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<tr>
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<td>0.40</td>
<td>64</td>
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<td>0.460</td>
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<tr>
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<td>54</td>
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</tr>
<tr>
<td>ms:y</td>
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<td>45</td>
<td>3.27</td>
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</table>

---

**Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**

# year and some interactions not significative

cS.glm <- glm(cS ~ loa + gr + ms + loa:ms, family = Gamma("logit"), data = cS.df)
anova(cS.glm, test = "F")

### Analysis of Deviance Table

#### Model: Gamma, link: logit

#### Response: cS

### Terms added sequentially (first to last)

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<th>Resid. Dev</th>
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<td>6.28</td>
<td>2.29</td>
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</tbody>
</table>

---

**Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**

par(mfrow = c(2, 2))
plot(cS.glm)
Figure 50: GLM diagnostics

```r
xyplot(residuals(cS.glm) ~ predict(cS.glm) | cS.df$ms, type = c("smooth", "p"), ylab = "", xlab = "")
```
Figure 51: GLM residuals VS predicted by MS

```r
xyplot(residuals(cS.glm) ~ predict(cS.glm) | cS.df$gr, type = c("smooth", "p"), ylab = "", xlab = "")
```

Figure 52: GLM residuals VS predicted by gear

```r
xyplot(residuals(cS.glm) ~ predict(cS.glm) | cS.df$loa, type = c("smooth", "p"), ylab = "", xlab = "")
```
7.4.2 Predictions

cSnew.df <- do.call("rbind", strsplit(unique(with(wg2eco, paste(country_code, gear_code, vessel_length_code, sep = ":"))), ":"))
cSnew.df <- data.frame(cSnew.df)
names(cSnew.df) <- c("ms", "gr", "loa")
cSnew.df <- cSnew.df[cSnew.df$loa != "NA" & cSnew.df$loa != "VL24XX" & cSnew.df$ms != "NOR", ]
cSnew.df <- transform(cSnew.df, metier = paste(ms, gr, loa, sep = ":"))
cSnew.df$cSpred <- predict(cS.glm, newdata = cSnew.df, type = "response")

dotplot(reorder(metier, cSpred) ~ cSpred, type = c("p", "h"), data = cSnew.df, xlab = "%")
8 Computing Economic Indicators for the WGMIXFISH dataset

Economic indicators for the demersal fisheries in the North Sea were estimated by scaling the indices obtained in the previous section with the WGMIXFISH information.
8.1 Putting it all together

```r
# merging
ecoPred.df <- merge(cS.df, cSnew.df, all = T)
ecoPred.df <- merge(ecoPred.df, fC.df, all = T)
ecoPred.df <- merge(ecoPred.df, fCnew.df, all = T)
ecoPred.df <- merge(ecoPred.df, eC.df, all = T)
ecoPred.df <- merge(ecoPred.df, eCnew.df, all = T)
ecoPred.df <- merge(ecoPred.df, vR.df, all = T)
ecoPred.df <- merge(ecoPred.df, vRnew.df, all = T)
ecoPred.df <- merge(ecoPred.df, wg2eco, by.x = c(1, 2, 3), by.y = c(2, 3, 4),
all = TRUE)
```

```r
# computing
ecoPredBar <- lapply(split(ecoPred.df, ecoPred.df$wgmix_code), function(x) {
  df0 <- x[, c("wgmix_code", "cS", "cC", "iL", "cSpred", "fC", "fCCap", "fCbar",
  "fCpred", "eC", "eCEff", "eCbar", "eCpred", "vI", "vO", "vR", "vRpred")]
  df0[, c("cC", "iL", "fC", "fCCap", "eC", "eCEff", "vI", "vO")]
  <- apply(x[, c("cC", "iL", "fC", "fCCap", "eC", "eCEff", "vI", "vO")], 2, sum)
  df0["cS"] <- weighted.mean(x$cS, x$iL)
  df0["cSpred"] <- median(x$cSpred, na.rm = T)
  df0["fCbar"] <- weighted.mean(x$fCbar, x$fCCap)
  df0["fCpred"] <- median(x$fCpred, na.rm = T)
  df0["eCbar"] <- weighted.mean(x$eCbar, x$eCEff)
  df0["eCpred"] <- median(x$eCpred, na.rm = T)
  df0["vR"] <- df0[, "vI"]/df0[, "vO"]
  df0["vRpred"] <- median(x$vRpred, na.rm = T)
  df0})
ecoPredBar <- do.call("rbind", ecoPredBar)
ecoPredBar <- merge(data.frame(wgmix_code = names(fltscn[[1]])), ecoPredBar, all = T)
```

8.2 Allocating estimates to WGMIXFISH fleets

```r
df0 <- ecoPredBar[, c("wgmix_code", "fCpred", "cSpred", "eCpred", "vRpred")]
# UK must be allocated to SC & EN.
ecoPredBar[ecoPredBar$wgmix_code == "SC_Otter<24", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Otter<24"), -1]
ecoPredBar[ecoPredBar$wgmix_code == "EN_Otter<24", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Otter<24"), -1]
ecoPredBar[ecoPredBar$wgmix_code == "SC_U10_OTB", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Beam<10"), -1]
ecoPredBar[ecoPredBar$wgmix_code == "EN_U10", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Beam<10"), -1]
ecoPredBar[ecoPredBar$wgmix_code == "EN_Otter24-40", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Otter24-40"), -1]
ecoPredBar[ecoPredBar$wgmix_code == "SC_Otter>=24", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- subset(df0, wgmix_code == "UK_Otter24-40"), -1]
# FDF can have the same cost structure as similar non-FDF Otters to be
# allocated to FDF (DK mean)
ecoPredBar[ecoPredBar$wgmix_code == "DK_FDF", c("fCpred", "cSpred", "eCpred",
  "vRpred")]
  <- apply(subset(df0, wgmix_code \%in\% c("DK_Otter<24", "DK_Otter24-40")),
  2, weighted.mean)
```
ecPredBar[ecPredBar$wgmix_code == "EN_FDF", c("fCpred", "cSpred", "eCpred",
"vRpred")][, -1] <- subset(df0, wgmix_code == "UK_Otter<24")[, -1]
ecPredBar[ecPredBar$wgmix_code == "SC_FDF", c("fCpred", "cSpred", "eCpred",
"vRpred")][, -1] <- subset(df0, wgmix_code == "UK_Otter<24")[, -1]

# NOR data allocated matching gear and loa as much as possible
ecPredBar[ecPredBar$wgmix_code == "NO_Otter>=40", c("fCpred", "cSpred", "eCpred",
"vRpred")][, -1] <- apply(subset(df0, wgmix_code %in% ecoPredBar$wgmix_code[grep("Otter>=40",
ecoPredBar$wgmix_code)])[, -1], 2, mean, na.rm = T)

v <- ecoPredBar$wgmix_code[grep("Otter", ecoPredBar$wgmix_code)]
ecPredBar[ecPredBar$wgmix_code == "NO_Otter<40", c("fCpred", "cSpred", "eCpred",
"vRpred")][, -1] <- apply(subset(df0, wgmix_code %in% v[-grep(">=40", v)])[, -1],
2, mean, na.rm = T)

# overall mean for unknown (alloc and OTH and ...)
ecoPredBar[ecPredBar$wgmix_code %in% c("DK_OTH", "DK_Pelagic", "NO_Pelagic",
"NO_Static", "OTH_OTH", "unalloc", "NO_OTH"), "eCpred"] <- mean(df0$eCpred,
na.rm = TRUE)
ecoPredBar[ecPredBar$wgmix_code %in% c("DK_OTH", "DK_Pelagic", "NO_Pelagic",
"NO_Static", "OTH_OTH", "unalloc", "NO_OTH"), "fCpred"] <- mean(df0$fCpred,
na.rm = TRUE)
ecoPredBar[ecPredBar$wgmix_code %in% c("DK_OTH", "DK_Pelagic", "NO_Pelagic",
"NO_Static", "OTH_OTH", "unalloc", "NO_OTH"), "cSpred"] <- mean(df0$cSpred,
na.rm = TRUE)
ecoPredBar[ecPredBar$wgmix_code %in% c("DK_OTH", "DK_Pelagic", "NO_Pelagic",
"NO_Static", "OTH_OTH", "unalloc", "NO_OTH"), "vRpred"] <- mean(df0$vRpred,
na.rm = TRUE)

dotplot(reorder(wgmix_code, vRpred) ~ vRpred, type = c("p", "h"), data = ecoPredBar,
xlab = "ratio")
Figure 55: Ratio of the value of landings between species included in WGMIXFISH and other species

```
dotplot(reorder(wgmix_code, eCpred) ~ eCpred, type = c("p", "h"), data = ecoPredBar, 
   xlab = "cost (euro/kwday)")
```
Figure 56: Effort costs

dotplot(reorder(wgmix_code, fCpred) ~ fCpred, type = c("p", "h"), data = ecoPredBar, xlab = "cost (euro/vessel)")
null
8.3 Estimate economic indicators for WGMIXFISH

```r
fltscn <- lapply(fltscn, function(flt) {
  # remove unalloc, it's not working
})
```
flt <- flt[names(flt) != "unalloc"]
lapply(flt, function(x) {
  cat(name(x), "\n")
  v <- subset(ecoPredBar, wgmix_code == name(x))
  attr(x, "fCostpves") <- v$fCpred
  # (math mambo jambo because I computed vIn/vOut instead of vAll/vIn)
  attr(x, "incomeRatio") <- 1/v$vRpred + 1
  cap <- c(capacity(x))
  if (sum(cap < 1 | is.na(cap)) > 0) {
    fcost(x)[] <- NA
  } else {
    fcost(x) <- capacity(x) * v$fCpred
  }
  crewshare(x) <- v$cSpred
  metiers(x) <- lapply(metiers(x), function(y) {
    # effort costs
    attr(y, "eCostpue") <- v$eCpred
    attr(y, "eCost") <- effshare(y) * effort(x) * 1000 * v$eCpred
    # crew costs
    attr(y, "cCost") <- revenue(y) * v$cSpred
    # variable cost
    vcost(y) <- attr(y, "eCost") + attr(y, "cCost")
    y
  })
  x
})

9 Results

The economic indicators were aggregated by scenario.

nms <- list(year = 2008:2012, indicator = c("wgval", "nsval", "fixCost", "effCost", "crewCost", "totCost"),
type = c("absolute", "rel2value"), scn = names(fltscn))
eco.wg <- array(NA, dimnames = nms, dim = unlist(lapply(nms, length)))
for (i in names(fltscn)) {
  # AER REVENUES (after using AER average prices for WGMIX dataset)
  lst <- lapply(fltscn[[i]][-41], revenue, na.rm = T)
i0 <- apply(do.call("rbind", lst), 2, sum, na.rm = T)/1e+06

  # REVENUES SCALED BY RATIO (using AER average prices for WGMIX dataset)
  lst <- lapply(fltscn[[i]][-41], fixedRevenue, na.rm = T)
i1 <- apply(do.call("rbind", lst), 2, sum, na.rm = T)/1e+06

  # CREW COSTS SCALED BY RATIO (using AER average prices for WGMIX dataset)
  lst <- lapply(fltscn[[i]][-41], fixedcCost, na.rm = T)
c1 <- apply(do.call("rbind", lst), 2, sum, na.rm = T)/1e+06

  # FIXED COSTS (using AER average prices for WGMIX dataset)
  lst <- lapply(fltscn[[i]][-41], fcost)
c2 <- apply(do.call("rbind", lst), 2, sum, na.rm = T)/1e+06

  # EFFORT COSTS (using AER average prices for WGMIX dataset)
  lst <- lapply(fltscn[[i]][-41], ecost)
9.1 Comparing economic indicators between AER and WGMIXFISH

The following tables show the value of landings on the North Sea computed from the AER dataset and the WGMIXFISH dataset. The values estimated are higher in the WGMIXFISH estimates by about 6% to 9%. These may have an impact on the estimation of crew costs, which are a percentage of revenue.

```r
# # AER # # eco.aer[as.character(2008:2010), "nsval", "absolute"]
## 2008 2009 2010
## 770.2 759.0 828.1

# # Estimated # # eco.wg[as.character(2008:2010), "nsval", "absolute", "sq_E"]
## 2008 2009 2010
## 842.5 804.9 906.9
```

The absolute values of economic indicators are not comparable between the two datasets because the areas covered by both datasets are different. The AER costs refer to area 27 while the estimates for the WGMIXFISH refer to the North Sea. The analysis were made using the percentage of income each cost category represent, which could be seen as a standardized cost structure.

```r
# # AER # # eco.aer[as.character(2008:2010), , "rel2value"]
## indicator
## year nsval value fixCost effCost crewCost totCost
## 2008 0.6782 1 0.3756 0.5094 0.4665 1.3515
## 2009 0.5298 1 0.2189 0.3190 0.3505 0.8884
## 2010 0.5363 1 0.2341 0.3189 0.3231 0.8761

# # Estimated # # eco.wg[as.character(2008:2010), , "rel2value", "sq_E"]
```
### Economic Indicators’ Trends

The major differences between the two sets of economic indicators are the higher values of effort related costs and lower values of crew costs the North Sea indicators present. These constitute the variable costs of exploitation, which being a ratio with revenue also reflects the higher revenue estimated by the modelling approach.

Overall, the results show about 20% losses on the estimated values while the AER show about 12% gains in 2009 and 2010.

#### Fcube-based Economic Indicators’ Trends

Although the relative values shows different results, a comparison between scenarios in terms of relative changes can be informative.

#### Fixed costs

Fixed costs dynamics are not well represented because Fcube does not include in/out strategies from the fleet, so it simply reflects the lower income by vessel, which is mostly driven by effort in the short term. Fixed costs relative to income will decrease in a "max" strategy while the "min" strategy showed the largest increase.

#### Crew costs

Crew costs depend on the distribution of landings in value by fleet, once that each fleet has a different crew share, landings composition and each species has a distinct price. If one scenario results in an increase of landings of the most expensive species, the income for the fleets landing these species will be higher, and crew costs will increase accordingly. The results obtained are not too different, between 6% and 8% increase in 2012 with regards to 2010. Meaning that a largest share of income will have to be allocated to labour costs in 2012 when compared to 2010.

#### Effort costs

Effort costs
Effort costs reflect directly the changes in effort between scenarios. As expected the "min" scenario shows the lowest increase, in fact a decrease. The "Ef_Mgt" scenario shows the highest increase in the percentage of income allocated to effort costs.

With regards to income, as value of landings, only scenarios with high effort will increase their income, "max" and "sq_E". The other scenarios show a decrease in income, with "min" showing the highest decrease, about 30%.

Finally, the share of income allocated to total costs, which reflects changes in the gross profit of each scenario, shows that in all cases the situation will get worst, with the best scenario being "max".

10 Final comments

The approach followed is promising but the results presented have to be taken with care. There are still some issues that require improvement:

- revise data
- complete information from all countries and all variables;
- improve modelling
  - deal with high residuals through outlier analysis or alternative error models to deal with overdispersion;
  - explore alternatives to GLM;
- explore the results at the fleet level to better identify data problems and improvements on modelling;
- explore methods to define how uncertainty on models can be included in the economic indicators;

The major challenge of this analysis was to use information at distinct aggregation levels to compute all necessary indicators, the AER data is aggregated at the FAO region 27, while the WGMIXFISH dataset is aggregated to the North Sea. The rescaling mechanism adopted overcomes this problem but assumes
that the costs per operational unit are constant for all area 27. This assumption is clearly sensitive to the relation between steaming and fishing each fleet segment has when fishing in the North Sea or outside the North Sea. In any case there was no information to inspect this assumption.

Several data problems were found during the exercise. The WGMIXFISH dataset information about prices is not coherent and some member states submitted data in different units for the same time series. With regards to the capacity information some member states did not provide information. As expected, the AER dataset is more consistent with regards to the economic information. However, there are several cases of incomplete information, e.g. providing fixed costs but not capacity. In both cases the expert’s reports are valuable resources and both are available on STECF and ICES websites, respectively.

The definition of effort can be a major source of error when merging the datasets. Both the criteria used for allocation of fishing activity to segments/metiers and the unit of effort can be potentially problematic.

In the case of the allocation criteria there is a fundamental difference between the economic and the biological analysis. For economics the boat is the unit of analysis, and the fact that more fishing mortality may be executed by having more than one gear is not relevant. It simply reflects a different relationship between costs and income, when compared with a vessel using a single gear. However, for conservation purposes it’s extremely important to know which gears a fleet can use and their selectivity. The dynamics associated with multi-gear fishing have a huge impact on the stocks’ conservation and can not be ignored when forecasting. In this perspective, the AER criteria of allocating each vessel’s effort to the dominant gear (used >50% of the time) may result in an underestimation of effort for multi-gear fleets, once that the effort of the non-dominant gears is not accounted. The WGMIXFISH data call does not state effort allocation criteria explicitly and seems to rely on the definition of metier.

With regards to the effort unit, neither data call states it explicitly, leaving the definition for the relevant regulations, and ultimately to the Members States’ interpretation. One potential problem with the loose definitions of units for measuring fishing effort is the usage of “days-at-sea” and “days-fishing” interchangeably. If days-at-sea are recorded and supplied, then the steaming time of the vessel between the harbour and the fishing grounds is included. If days-fishing is supplied, then the steaming time is generally excluded from the data. For coastal fleets this shouldn’t be too problematic but for fleets that go to faraway fishing grounds it may have some impact.

Potentially, there are discrepancies in the methods for effort allocation and the effort unit definition, which make it difficult to understand if both series are comparable. As a matter of fact, even within each data set the internal consistency of effort values between countries is not guaranteed.

Comparing CPUEs computed from each dataset for the same fleet reflect the problem of different effort definitions. Figure 59 shows an example for cod, where it is clear that differences between both datasets exist. The impact of this inconsistency was not further explored, but there is potential to change the relation between costs and revenues.
Figure 59: Log CPUE ratios. AER CPUE over WGMIXFISH CPUE
Abstract

The main objectives of the study presented in this report were to test the FLBEIA API, condition an operating model for the North Sea mixed fisheries and provide feedback on bioeconomic modelling limitations. Additionally, Fishrent and Fcube were also tested. FLR, FLBEIA, Fishrent and Fcube are software packages implemented by the scientific community studying fisheries to run bioeconomic models. A large test was carried out on FLBEIA by both running existing examples and trying to implement a bioeconomic model for the North Sea. In general the group felt FLBEIA is on the correct path to provide a bioeconomic modeling framework, although some work is still required. FLBEIA is not ready yet for production. A list of bugs and improvements was assembled. Conditioning a bioeconomic operating model for the North Sea showed the difficulties of merging economic and biological information. Inconsistencies on the effort definition seem to create additional problems when relating both sources of information. This subject must be further explored. The exercise was successful but data problems prevented the performance of a full economic analysis, although trend analysis on economic indicators for each scenario tested was possible. Nevertheless, these results must be taken carefully.
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