WORKING GROUP ON MIXED FISHERIES ADVICE METHODOLOGY (WGMIXFISH-METHODS)

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editor

Claire Moore

Authors

Mikel Aristegui Ezquibela • Paul Bouch • Thomas Brunel • Harriet Cole • Paul Dolder • Dorleta Garcia Olga Kalinina • Mathieu Lundy • Colin Millar • Lionel Pawlowski • Marianne Robert • Paz Sampedro Shawna Sanfey • Cristina Silva • Klass Sys • Marc Taylor • Vanessa Trijoulet • Clara Ulrich • Youen Vermard

ICES International Council for the Exploration of the Sea
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i Executive summary

The ICES Working Group on Mixed Fisheries Methodology (WGMIXFISH-METHODS) annual meeting centred on the improvement of the mixed fisheries advice production process, through increasing quality, transparency and reproducibility. Two ecoregions (Celtic Sea and North Sea) have begun the move to the Transparent Assessment Framework (TAF). Gaps in documentation were identified and are now listed for improvement over the coming year. Data call changes have been proposed to ensure WGMIXFISH have the tools required to meet the growing demand for information on biological and technical interactions.

Additionally, working group identified, discussed and tested new techniques in the field of mixed fisheries assessment (VAST, spatial targeting index). The number of areas assessed by the working group increased with the addition of an Irish Sea (27.7.a) FCube model. Collaboration continued with other groups, which was driven by the groups growing need for quality economic information (WGECON), and tools for visualization and exploration of mixed fisheries trends (WKTarget, Infomatics). Finally, major concerns have been raised about the suitability and completeness of extracts from the Regional Database (RDB). These finding will be shared with the Regional Database and Estimation System (RDBES) development group

ii Expert group information

Expert group name	Working Group on Mixed Fisheries Methodology (WGMIXFISH-METHODS)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	Claire Moore, Ireland
Meeting venue and dates	10-14 June 2019, Nantes, France (18 participants)

1 Introduction

The Working Group on Mixed Fisheries Methodology (WGMIXFISH-METHODS) was formed in response to the need to further develop how ICES provides mixed fisheries advice and to progress application of methods, independent of the annual advisory meeting (WGMIXFISH-NS; ICES, 2015). Annually this meeting focuses on the development and improvement of mixed fisheries analysis.

2 Terms of Reference

2018/2/FRSG43 The Working Group on Mixed Fisheries Advice Methodology (WGMIXFISH-METHODS), chaired by Claire Moore, Ireland, will meet in Nantes, France 10–14 June, 2019 to:

a) Document the complete workflow of WGMIXFISH-ADVICE, from data submission to advice production, in order to improve the workflow and increase understanding of the process, both within and outside the working group.
b) Update and develop datacall for WGMIXFISH-ADVICE, identifying possible areas of improvements, expansion, and cohesion across ecoregions.
c) Future direction and development of WGMIXFISH advice.
d) Continue to explore the impacts of including additional species in the Celtic Sea FCube model.
e) Investigate and where possible improve the fleet/métier definition in Bay of Biscay.
f) Develop the Irish Sea FCube.
g) Continue development of the combined implementation of FCube and FLBEIA in conjugation with economists.
h) Present work from ProByFish group and explore future collaborations with WGMIXFISH. (https://wwz.ifremer.fr/emh/content/download/118221/file/Probyfish-Pres.pdf).

WGMIXFISH-METHODS will report by 16 August 2019 for the attention of ACOM.

3 ToR A - Document the complete workflow of WGMIXFISH-ADVICE, from data submission to advice production, in order to improve the workflow and increase understanding of the process, both within and outside the working group

3.1 Background

The primary objective of WGMIXFISH is to provide management advice and options, which take into, account the consequences of technical interactions in multistock, multigear fisheries for three ecoregions (Celtic Seas, North Sea, and Iberian Waters). The production of this advice is a complex process, which transforms data from various sources. In light of ICES move towards a quality assurance framework (QAF), the group felt that it was time to document the advice production process, from data submission to advice publication. The documentation of this process will have a number of benefits:

1. It will provide WGMIXFISH members with a formalized framework/roadmap, which clearly identifies procedures and responsibilities for the production of a consistently high quality advice product in an effective and efficient manner;
2. It will allow WGMIXFISH members to identify knowledge gaps and possible areas for improvement;
3. It will increase the group's transparency, making the work of WGMIXFISH more accessible, therefore allowing other ICES groups to effectively engage and collaborate with the group;
4. It will also provide a transparent guide for non-group members (ADG, stakeholders).

3.2 Process flow

The process flow in Figure 3.1 illustrates the overview of mixed fisheries advice production for the Celtic Seas ecoregion, from data submission to the final advice products. This process flow identifies the main stages of advice production and classifies its current state of documentation in relation to their processes and procedures. These five main stages are future discussed below in relation to their current limitations, this year's improvements and possible future progress:

Data Sources

Mixed fisheries advice for the Celtic Seas ecoregion is produced using four data sources:

1. Single species reference points which are outlined in the advice sheet;
2. FLR stock assessment objects of catch numbers;
3. Accessions (data call);
4. InterCatch (extraction).

A disproportionate amount of time is spent by the members of WGMIXFISH collecting all available data sources due to issues with completeness and compatibility. In previous years, our ability to produce advice was hindered by receiving incomplete data from SC, which was mostly driven by miscommunication and unclear requests from WGMIXFISH. After some collaboration with single species SC a formalized request form was developed (Annex 1) to send to the SC annually. This form clearly outlined the data (and format) required by WGMIXFISH, and proved to be very effective in improving the quality and consistency in the data received by WGMIXFISH.

The Accessions data requested by ICES in the annual data call varies greatly between ecoregions, resulting in inconsistencies in widely spread stocks such as Hake. This year it was decided to improve this data call, expanding the data call, while also clarifying the language and bringing consistency between all regions assessed by WGMIXFISH (addressed in section 4.1 of this report).

Data Processing

Since 2017, WGMIXFISH have produced advice using a private repository on GitLab (https://gitlab.com). The aim of moving to GitLab was to streamline and document the process of advice production. Despite making huge leaps in this area, some aspects of the Celtic Sea data processing has remind manual and time consuming. In particular, the data processing is not currently fully documented on GitLab. Therefore, it is the aim of both the Celtic Seas and the North Seas to move the advice production to the ICES Transparent Assessment Framework (TAF). TAF is currently in development and provides a structured and open approach to organize and document ICES stock assessments. TAF uses a standard sequence of R scripts to document and execute the entire stock assessment process and make the results available online. The key benefits of this new framework are the streamlining of workflows and improved understanding of stock assessment methods. Additionally, this new approach improves the quality assurance and peer review of ICES stock assessments, see http://taf.ices.dk for more information.

Progress was made during the WGMIXFISH-METH 2019 meeting to move the mixed fisheries assessments into TAF. The compilation of the catch and effort data submitted to Accessions has been fully scripted and added to TAF (https://github.com/ices-taf/wgmixfish_accessions). This compiles the latest submissions to accessions with previous submissions to provide a single input file for catch and effort data. It became clear during WGMIXFISH-METHODS 2019 that a quality control procedure would be a useful tool to develop with respect to streamlining workflows and so a draft report template was created. This process would identify obvious data issues in the accessions submission, which would then be dealt with before starting the data processing in the main workflow for each ecoregion. Data submitters could have access to the code that produces the QC report so that they can identify and rectify obvious data errors (i.e. missing species codes) before submission. In addition to reducing common data errors, the QC process will also aim to increase consistency between the catch and effort files submitted to accessions and consistency with data from InterCatch. Further development needs to be done to decide when the number of inconsistencies between datasets is high enough that the submission will be rejected and returned to the data submitter for correction.

Model implementation

As stated above, since 2017, the model implementation has been documented and executed in GitLab. Although this aspect of the code is well documented and maintained on the repository, this repository is currently limited to WGMIXFISH members and is not laid out in a way that is intuitive to follow for outsiders. Therefore, a move to TAF would provide a structure that the ICES community is becoming progressively more comfortable with. The North Sea (https://github.com/ices-taf/2019_NorthSea_MixedFisheriesAdvice) and the Celtic Sea (https://github.com/ices-taf/2018_CelticSea_MixedFisheriesAdvice) mixed fisheries assessment has been partially moved to TAF So far, progress has been made to incorporate the sourcing of input data and adding data scripts to process the fleet data. Work is underway to complete the inclusion of data processing (fleet objects, stock objects, reproduce the advice) and model analysis (Fcube) scripts to the repository by WGMIXFISH-ADVICE 2019.

Over the next year, improvements will be made to essential documentation such as:

- Stock annexes – which provide the standard assessment procedures the advice produced;
- Audits – An audit system will be introduced to ensure the continued high standard of the final advice process;
- Reports – due to increased workload of this group reporting was difficult in previous years, but now thanks to increased membership and a change in meeting dates reporting will be made a priority.

Products

WGMIXFISH produces a number of products and services annually. Aside from the advice sheets for three ecoregions, the group also contributes to the fisheries overview, supports the single species stock assessment working groups and special request. Annually the members of this group dedicate substantial amounts of time to the development of new methods to tackle the growing number of mixed fisheries challenges being faced by fisheries in Europe. These products need to be documented annually in the final reports of this working group. Without correct documentation it impossible to ensure that sufficient resources are allocated to this group.

3.3 Conclusions

This overview provides a useful tool for understanding and engaging with the mixed fisheries advice production process. The process flow outlined in Figure 3.1 highlights the current lack of up-to-date documentation available. A major goal for WGMIXFISH is to improve the efficiency, quality and transparency of this process over the coming year.

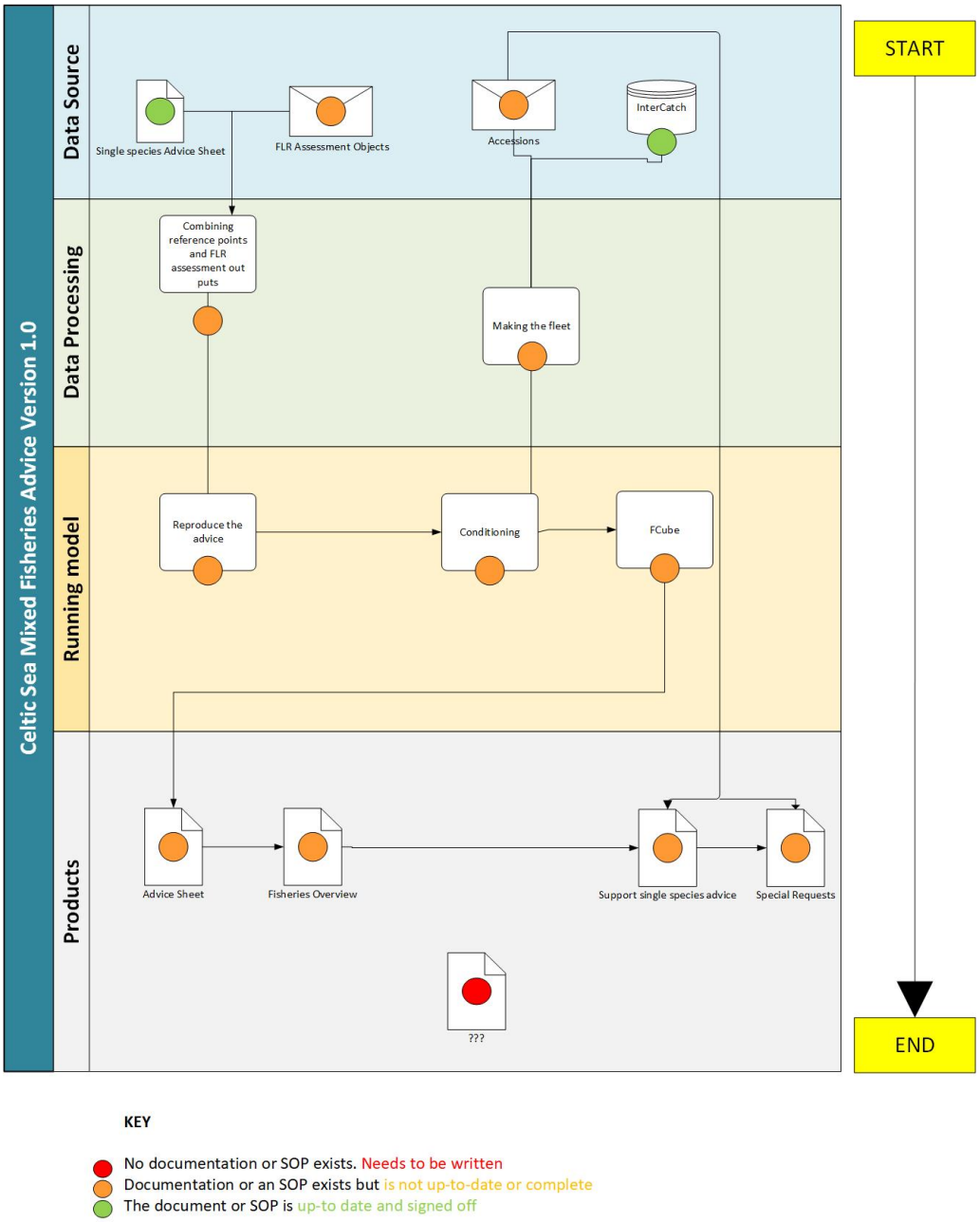


Figure 3.1. Process flow diagram depicting the current system used to produce Celtic Sea mixed fisheries advice.

4 ToR B - Update and develop data call for WGMIXFISH-ADVICE, identifying possible areas of improvements, expansion, and cohesion across ecoregions.

4.1 Background

The WGMIXIFISH data call currently requests catch and effort data for three ecoregions: Bay of Biscay and Iberian Coast, Greater North Sea, and Celtic Seas. However, the data requested varies significantly by ecoregion, with one ecoregion requests all stocks (WGNSSK), another a list of specific stocks (WGBIE), and final one requesting a long list of assessed and unassessed species (WGCSE). The inconsistencies between the three ecoregions has resulted in limitations in how WGMIXFISH can utilize the data, explore new techniques, or identify new technical and biological interactions. These limitations, along with possible solutions are discussed below:

4.2 Addition of new species

The structure of the current ICES WGMIXFISH data call, is restricted to the list of species and stocks given in Annex 4. This list includes 296 stocks from 87 species. The stocks are those for which ICES will provide advice and are all associated to a given single-stock assessment working group. However, in the recent years a number of initiatives within and outside ICES have focused on other species of lesser commercial importance, but which are caught as bycatches in mixed-fisheries and are thus also affected by fishing. However, catch information on these species are scarce and the MIXFISH group discussed the needs and added value to collect additional information for these species, not least knowledge of which fisheries are the main contributors of the impact. Some of the initiatives dealing with these species are among others:

WGECO

ICES WGECO, the ICES Working Group on the Ecosystem Effects of fishing, and ICES WGBYC, the ICES Working Group on Bycatch, which have investigated the sensitiveness of a number of bycatch species. In WGECO 2019 (ICES, 2019b) report, TOR e) compared different methods and sources of information and returned a list of species occurring in DATRAS and identified as sensitive or vulnerable/endangered/critically endangered by IUCN (Table 7.1). Out of these species, WGECO highlighted a few species of relevance for MIXFISH, including Halibut (*Hippoglossus hippoglossus*), considered vulnerable and sensitive (in Table 7.2). Additionally, WGECO highlighted a list of species that either do not appear in the COMMISSION IMPLEMENTING DECISION (EU) 2016/1251 or appear in the list only for a very limited area that does not cover their distribution (Table 7.3). These are:

Table 7.3. Species that either do not appear in the COMMISSION IMPLEMENTING DECISION (EU) 2016/1251 or appear in the list only for a very limited area that does not cover their distribution. Gislason *et al.*, 2019 (in prep.), Greenstreet *et al.*, 2012.

Species	Identified as sensitive, vulnerable (VU), near threatened (NT) or data deficient (DD) by:
Balistes capriscus	IUCN (VU)
Myliobatis aquila	IUCN (VU)
Anarhichas lupus	Gislason *et al.*, Greenstreet *et al.*, (IUCN DD)
Anarhichas minor	Gislason *et al.*, Greenstreet *et al.*, IUCN (NT)
Dipturus oxyrinchus	Gislason *et al.*, IUCN (NT)
Leucoraja naevus	Gislason *et al.*, Greenstreet *et al.*
Raja brachyura	Gislason *et al.*, Greenstreet *et al.*, IUCN (NT)
Raja microocellata	Gislason *et al.*, IUCN (NT)
Rajella bathyphila	Gislason *et al.*
Rajella lintea	Gislason *et al.*
Scyliorhinus stellaris	Gislason *et al.*, Greenstreet *et al.*, IUCN (NT)

PROBYFISH

Another initiative of importance is the European Commission tender on the identification of measures to protect bycatch species in mixed-fisheries management plans, EASME/EMFF/2017/022. This tender, financed under the project called PROBYFISH, aims to develop a modelling framework and a support tool to assist fisheries managers and stakeholders in managing bycatch stocks at the fleet or métier level within the different geographical areas covered by the new generation of MAPs. This should be used to assess whether proposals for regionalised management measures under mixed-fisheries plans are in accordance with the objectives of the CFP.

PROBYFISH aims in particular to develop agreed and robust methods to define target and bycatch species, to identify the species for which TAC management of target species would be sufficient to ensure sustainable exploitation without additional safeguards, and to identify measures that will lead to the sustainable development of the bycatch stocks which are not sufficiently protected by target species TACs. To achieve these objectives and provide relevant results across a range of regions and fisheries, ProByFish has worked in collaboration with ICES, organising the ICES WKTARGET workshop and liaising with ICES WGMIXFISH. Based on a combination of species sensitivity (building further on the list above) and on the feasibility assessment for the potential inclusion of the bycatches species in the mixed-fisheries models, ProByFish selected a number of target and bycatch species of interest for the various regions.

Conclusions

Of these species, a few are not currently on the stock list in the data call. These have been outlined table 4.1, 4.2 and 4.3. A first step would be to include these stocks in the MIXFISH accessions data call, allowing the estimation of landings by fleet and métier. This would not require substantial additional work for data providers. A second step would be to include these stocks in InterCatch, allowing for discards estimation. At present, there are no stock coordinators in charge of these stocks, so estimating discards and age or length distribution would require some work additional work from ICES. The group concluded to explore the possibility of requesting InterCatch data for the following three species: conger, halibut, and wolfish.

Table 4.1. Suggested species for addition to Bay of Biscay data call.

Scientific name	Common name	IUCN*	Probyfish**	Greenstreet *et al.***	ICES assessment	TAC
Scyliorhinus canicula	Dogfish	LC	S	S	3. DLM?	YES
Squalus acanthias	Spurdog	EN	S	S	1	YES
Raja clavata	Thornback ray	NT	S	S	3. Evaluate fleet data, probably not reliable landings/catch data	YES
Lophius bude-gassa	Black-bellied angler	LC	S	S	3. DLM?	YES
Nephrops norvegicus	*Nephrops*	LC	-	-	1 (not dynamic)	YES
Dicentrarchus labrax	Bass	LC	N	-	1	NO
Mullus surmuletus	Red mullet	DD	N	N	5. SPICT?	NO
Conger conger	Conger eel	LC	S	S	Evaluate fleet data and possibility of assessment	NO

Table 4.2. Suggested species for addition to Celtic Sea data call.

Scientific name	Common name	IUCN*	Probyfish**	Greenstreet *et al.***	ICES	TAC
Pleuronectes platessa	Plaice	LC	N	N	1 In progress	YES
Nephrops norvegicus	*Nephrops*	LC	-	-	1 SPICT in progress	YES
	Red gurnard				To be considered	
Squalus acanthias	Spurdog	EN			To be considered	YES
Scyliorhynus canicula	Dogfish				To be considered	
	Black Scabbard fish				To be considered	
Conger conger					To be considered	
RIB					To be considered	

Table 4.3 Suggested species for addition to North Sea data call.

Scientific name	Common name	IUCN**	Proby-fish***	Greenstreet *et al.****	ICES data category	TAC
Platichthys flesus	Flounder	LC	N	N	3	NO
Scophthalmus rhombus	Brill	LC	N	N	3	YES
Limanda limanda	Dab	LC	N	N	3	NO
Lophius budegassa, Lophius piscatorius	An-glerfish	LC	S	S	3	YES
Molva molva	Ling	LC	S	S	3	YES
Squalus acanthias	Spurdog	EN	S	S	1? Evaluate fleet data	YES
Raja clavata	Thorn-back ray	NT	S	S	3? Evaluate fleet data	YES
Leucoraja naevus	Cuckoo ray	LC	S	S	3? Evaluate fleet data	YES
Raja montagui	Spotted ray	LC	S	S	3? Evaluate fleet data	YES
Anarhicas lupus	Wolffish	DD	S	S	Evaluate fleet data and possibility of assessment	NO
Hippoglossus hippoglossus	Halibut	VU	S	S	Evaluate fleet data and possibility of assessment	NO

4.3 Value information

Value information is becoming increasing more important for the development of bioeconomic mixed-fisheries modelling. Ongoing work is being conducted in conjunction with WGECON to attain this required information. A summary of this work and discussion can be found in section 9 of this report.

4.4 Spatial information

There is a clear and present need for high-resolution spatial data to tackle the challenges presented in mixed fisheries management; this is addressed further in section 5 of this report. As the current WGMIXFISH data call is at the resolution of ICES division, it does not fit our present or future data-requirements.

It is envisaged that these spatial requirements will be met by the regional database and estimation system (RDBES), which will include disaggregated biological and census data at the level of statistical rectangle. However, the timeline of the RDBES does not match with our current requirements. Therefore, we discussed the development of an interim data call, the structure of which would provide us with a step towards the data that we need and a format which is more consistent with the RDBES, therefore ensuring that any scripts developed can be used again in future.

The ICES VMS and logbook data call was suggested as an interim solution as it is an established data call which would allow us to get effort data at the level of statistical rectangle. Although this data call does have total landings in weight and value, per DCF métier level 6, it does not provide species-specific information. Perhaps there is scope the future to combine these to data calls. However, it is important to note that there could be some possible downsides to this. The operations declared in the VMS are the daily estimates of the landings, reported by stat rectangle. Declarations are the legal declaration of landings at the end of the trip, reported by subdivision. The operations are allowed to be an estimate so can show differences compared to the final, legal declarations. This can of course be scaled to the declarations values, however this would need to be checked as it might not be biologically meaningful.

The RDB was ruled out as a possible interim solution due to data issues, which are further outline in section 10 of this report.

4.5 Conclusion

There is a pressing need to update the WGMIXFISH data call to meet the groups growing data requirements. This update should provide consistency between the ecoregions, while also expanding the list of stocks/species requested. The proposed text for the updated data call can be found in Annex 5. The group also recommends that this updated data call be accompanied by data call workshop for submitters, which would provide invaluable clarity and reduce data submission errors.

5 ToR C - Future direction and development of mixed fisheries advice

5.1 Informatics team and the future for WGMIXFISH

Informatics in Support of Ecosystem Based Fisheries Management Project

- The strategic vision of the Informatics project is to put in place the infrastructure (human and structural), competence and political vision to efficiently integrate and utilize the ever increasing sources of fisheries related data (including fishery/ecosystem interaction data) to improve decision-making, governance, enforcement, conservation, sustainability, profitability, transparency and public perception of the marine fishing sector.

This project is funded by the European Maritime and Fisheries Fund (EMFF) and the team consists of two R developers with statistical and biological/environmental backgrounds (Shawna Sanfey and Olga Kalinina), a SQL developer, a project manager and two MI team leaders who help steer and define the project (Colm Lordan and David Currie). This team is based at the Marine Institute (MI), Galway, Ireland.

Data are a key input into the advice, which drives fisheries management, but access to it is often restricted to scientists. This project provides tools for a number of different audiences to discover and explore the fisheries data that is collected within Ireland. Data can be difficult to interpret if you are not familiar with its context so rather than just providing the data itself this project has developed graphical data-driven tools and applications that will make its interpretation easier. Some fisheries data are confidential so all project work has been performed with security in mind with the aim being to make datasets as accessible as possible while respecting existing data protection and data sensitivity requirements. Knowledge-sharing and capacity building is embedded within the project – this has taken the form of presentations by the project personnel at the Marine Institute, to local user groups, and to the wider public at events such as SeaFest. The computer code outputs from the project will also be shared in an open-manner so that the wider community can have access to them.

Project Objectives:

- To establish an inter-departmental and agency steering group to develop a strategic work plan for the project;
- To review existing data holdings and to anticipate future data collection and integration requirements based on Common Fisheries Policy (CFP) priorities and policy drivers which potentially affect the CFP;
- To establish a properly resourced cross departmental and agency data integration team that will develop and maintain data integration infrastructure and solutions;
- To make integrated fisheries datasets as accessible as possible while respecting existing data protection and data sensitivity requirements;
- To build capacity within organizations to work with and evolve integrated data;
- To develop software systems and tools to generate useful insights and knowledge from integrated data;
- To use integrated data to inform and monitor discard reduction plans, mixed fisheries management plans, MSY targets, habitat and species conservation plans etc.

MI based project aims:

- To visualize existing fisheries data;
- To increase its usage/utility and
- To make it more easily accessible.

These aims are very much compatible with those of the mixed fisheries working group so a natural working relationship was developed to apply the stills in R development of the Informatics team to the mixed fisheries data, tools etc.

The Mixed Fisheries shiny app is still in development. Initial work has focused on digitizing the annual report produced by the group to allow more interaction between the user/reader and the data and visualizations produced by the group. The data management and exploration tools, which were previously created by the WGMIXFISH group, were recreated and integrated into the app with the aim to create a 'one-stop shop' for mixed fisheries data exploration and analysis. Elements of the Celtic Seas ecoregion fisheries overview were incorporated into the app as they provided important contextual information, which placed the mixed fish the relevant environment, and framework.

An interactive tool was developed for the mixed fisheries app, which allows the user to examine:

- Submitted Landings data in terms of species mixing in the Celtic Seas ecoregion which allows to identify if the stock data are sufficient to include in mixed fisheries forecast.
- Total fishing effort used by different countries grouped by vessels length, fishing gear for a target species during selected year;
- TAC areas along with the stock assessment areas, highlighting areas of overlap etc. There are plans to integrate other spatial output of the WGMIXFISH group into this interactive mapping tool in future, for example this could include outputs of species distribution overlap mapping;
- Overview of historical species stock status with more functionality to the objective of reproducing single species advice by ability to compare all biological reference points to FCube baseline runs at once;
- FCube Catch forecast which allows user to choose different scenarios and exploring visualization strategies for potential overshoot and undershoot compare to the single species advice;
- Detailed breakdown of changes by relative share of species landings by countries compare to the baseline;
- Level of effort required by each fleet to catch their quota share of the single species TAC advice for each stock with added value providing instant information on chocked and unchocked stock.

Currently the output of the informatics team is accessible only through the WGMIXFISH SharePoint site. The previous outputs of this team are, however, open access and freely available online. The code used to produce these outputs is available on the Marine institute Github page (https://github.com/IrishMarineInstitute) and the data are also freely available from the Marine Institute either as downloads through the individual shiny apps or directly from the Marine Institute.

Outputs:

1. Species Dashboard; Provides the annual review of fish stocks and the latest scientific advice that informs fishing opportunities for the following year. Makes this advice available online in an interactive way – for example it includes a forecasting tool that allows users to see the projected impact of different fishing scenarios. https://shiny.marine.ie/speciesdash/;
2. Digital Stockbook; Web application that makes biological fisheries data more available. This App allows people to explore the length, weight, and age data of commercial species that are caught around Ireland and allows the effects of factors such as year, sex, area, and gear on the fish to be investigated. https://shiny.marine.ie/stockbook/ ;
3. IGFS data explorer; The IGFS is part of an internationally coordinated series of demersal trawl surveys that provides data on fish stocks. This app allows users to explore the results of the survey using a number of tools. https://shiny.marine.ie/igfs/ ;
4. Cod tagging data portal; The Marine Institute, in partnership with AFBI and Cefas, are conducting a cod-tagging project in the Irish Sea. This graphical, data-driven tool allows users to look at the data collected including recaptures, tagging events and gear of tagging vessel. https://shiny.marine.ie/tagging/ .

5.2 VAST

There was discussion of a potential scoping workshop taking place next year on the future needs for mixed fisheries advice. It was considered that in addition to the forecasting methods currently used to provide mixed fisheries short-term advice, other forms of advice could be developed and presented to managers and stakeholders at that workshop. Advice could take many forms, which complement each other. For example, development of descriptive indicators of spatial overlaps of species caught together in mixed fisheries, modelling approaches to understand gear catchability effects, further developing forecasting methods or bioeconomic modelling approaches for evaluation of medium-term mixed fishery management frameworks and data visualization approaches to make accessible the different levels of information provided by the group. Some of these ideas were presented and briefly discussed.

Species co-occurrence

An approach, which uses a geostatistical model to identify co-occurrence of species caught together in mixed fisheries was outlined. The approach, known as a Vector Autoregressive Spatio-temporal model (VAST; Thorson, 2019), includes three main components:

- A Spatial Dynamic Factor Analysis (SDFA) able to take account of latent (unobserved) drivers which affect species distribution (encounter probability) and positive density (catch rates on encounter) for one or more species;
- Gaussian Markov Random Fields (GMRFs) to model the variation in probability of encounter and positive density (and account for autocorrelation);
- Use of a Generalised Linear Mixed Modelling (GLMM) framework to estimate effects of the contribution of different gears or other covariates on encounter probability and density.

VAST is available as an R package (https://github.com/James-Thorson-NOAA/VAST) and was principallly developed for index standardization, but has been applied to investigate species interactions for nine different fish stocks in the Celtic Sea (Dolder *et al.*, 2018). The species considered in the study were cod, haddock, whiting, hake, plaice, sole, white-bellied anglerfish, black-bellied anglerfish and megrim and the data were from seven fisheries-independent survey time-

series. Each of the species were treated separated as adult and juvenile components and the spatio-temporal overlap of the different species groups analysed. It was found that:

- There were clear common patterns in the spatial factors describing the species distributions. The first three factors describing 83.7% of the patterns in encounter probability and 69% of the patterns in density, with onshore-offshore and north–south patterns identified (Figure 5.1). Further, the species loaded on to these spatial patterns differently. For example, taking the first factor for average positive density (top-right of Figure 5.1) plaice, sole, whiting, haddock and juvenile cod are positively associated this first factor while Monkfish, hake and megrims negatively associated with the factor.

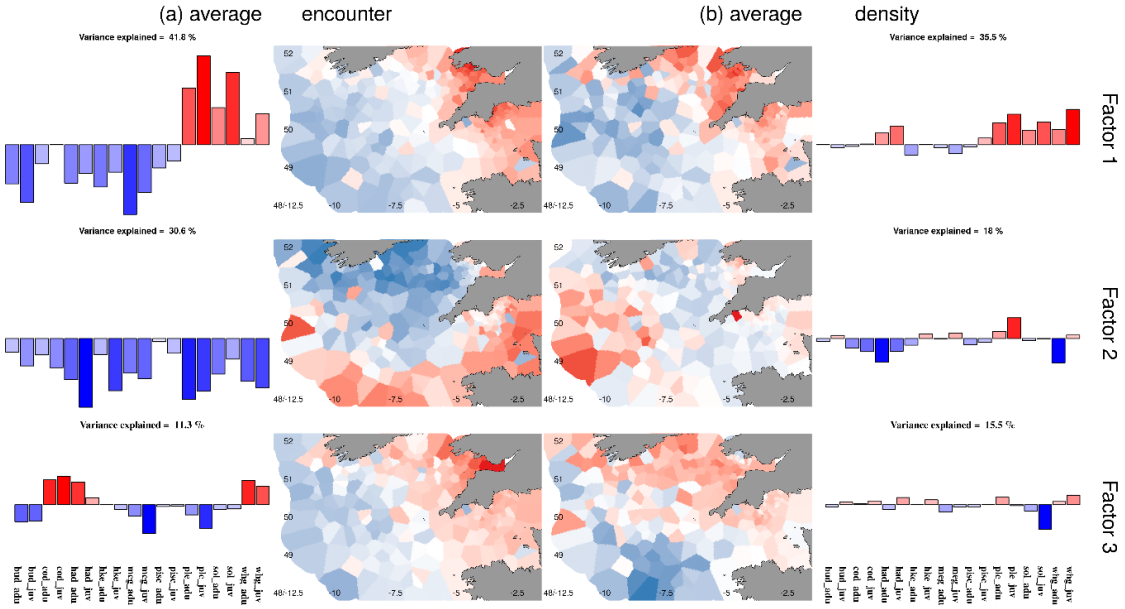


Figure 5.1. Factor values for the first three factors for (A) Average encounter probability and (B) Average positive density for the species (outer figures) and spatially (inner figures). Red: positive association to the factor, Blue: negative association.

- There were clear species groups that emerged when looking at the variation in spatio-temporal dynamics of the species. Figure 5.2 presents a Principal Components Analysis rotation of the factor loadings and there are separate species groups emerging for encounter probability (Monkfish, megrims and hake are separate from the other species), and for the positive density on encounter (cod, haddock and whiting separate from the other species). This is confirmed by a correlation plot, which shows clear species groups as defined by hierarchal clustering (Figure 5.3).

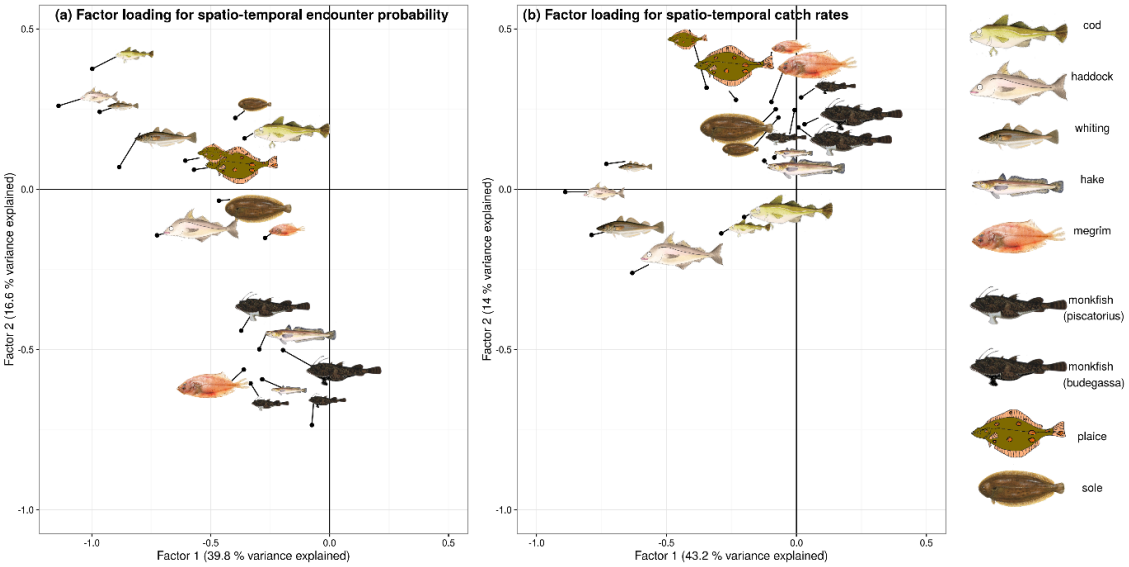


Figure 5.2. Position of each species on the first two axes from the factor analysis for (a) spatio-temporal encounter probability and (b) spatio-temporal positive density. Fish images from The Fisherman/Shutterstock.com and Richard Griffin/Shutterstock.com.

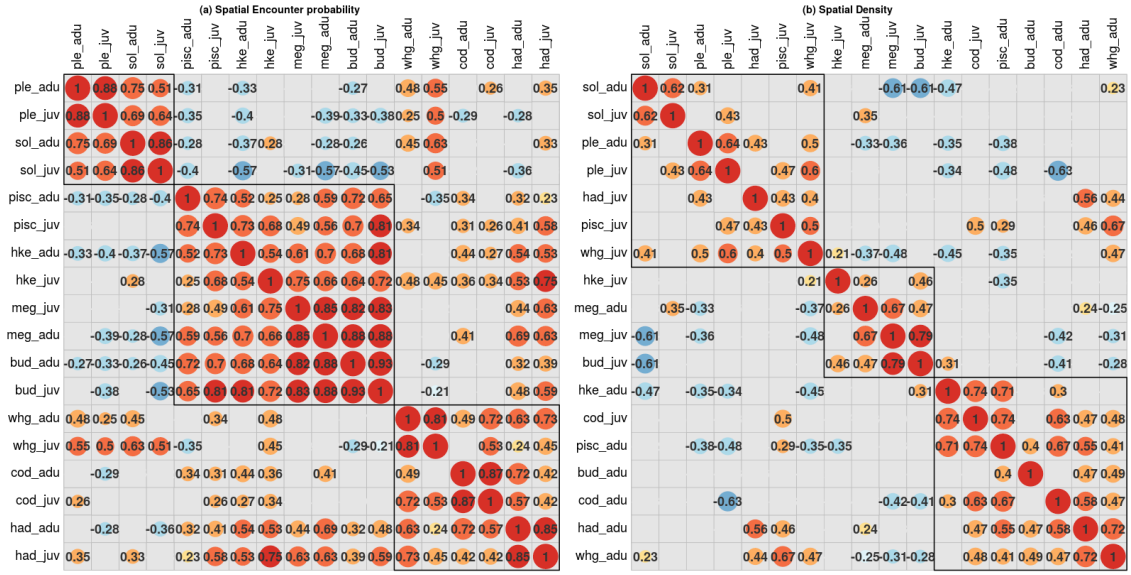


Figure 5.3. Interspecies correlations for (a) spatial encounter probability over all years and (b) spatial positive density. Species are clustered into three groups based on a hierarchical clustering method with non-significant correlations (the Confidence Interval [±1.96 * SEs] spanned zero) left blank.

- Only more subtle differences in species distributions were found within species groups (Figure 5.4). However, the model could be used to predict catch composition at a given location when a certain gear type was used, showing the differences in fishing opportunities available at the time and the relative effect of location fished and gear used.

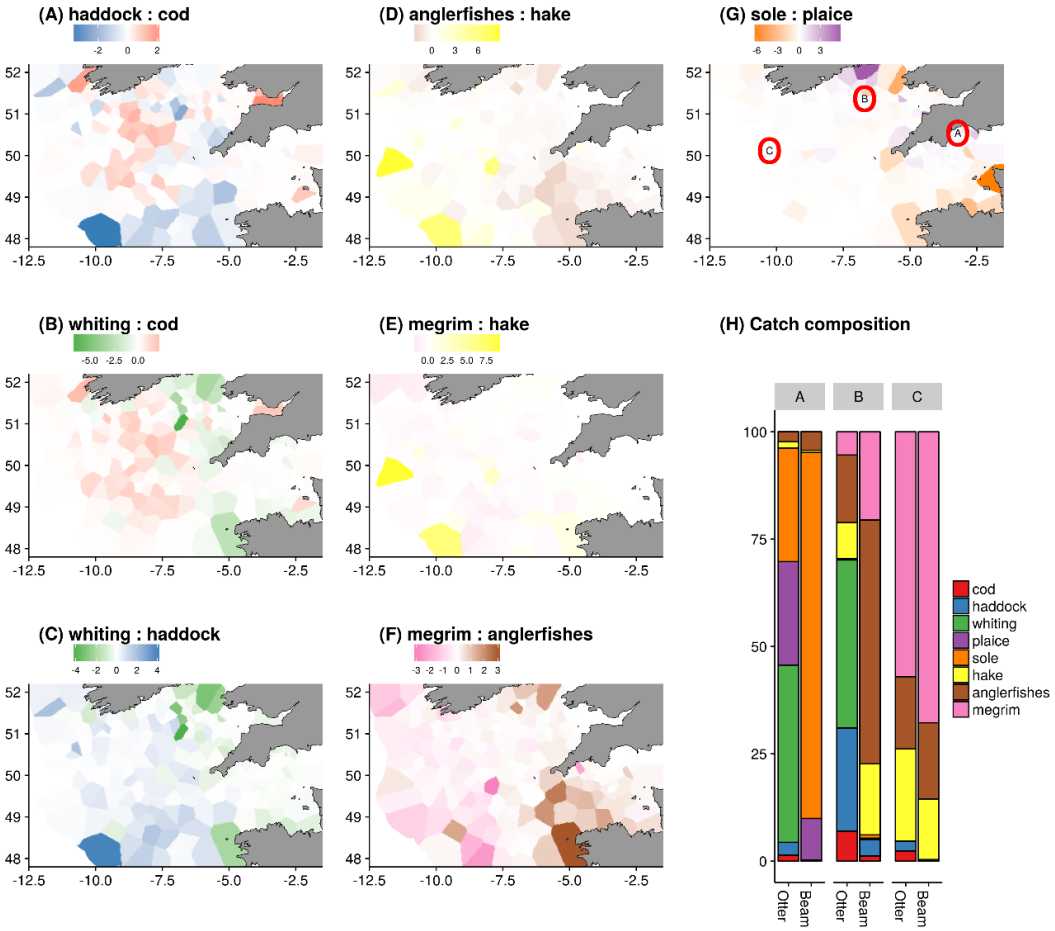


Figure 5.4. Differences in the standardized spatial density for pairs of species and expected catch rates for two different gears at three different locations in 2015. A, B and C in subfigure (H) correspond to the spatial locations illustrated in subfigure (G).

It was concluded that the approach has potential for exploring spatial co-occurrence across different ecoregions and species, as a way of describing some of the spatial dynamics in the fisheries. Further details on the methods can be found in Dolder *et al.*, 2018.

5.3 Spatial targeting index

A simple metric of spatial targeting was shown as a way of identifying changing spatial patterns in the fisheries. The approach was based on work presented by Quirijns *et al.*, 2008 (after Gulland, 1955) where an indicator was developed to relate the catch rates observed in the fisheries to catch rate that would be expected were fishing to be random in relation to the resource. The indicator is:

$$I = \frac{\widehat{LPUE}}{\sum LPUE_{ij}/N_{ij}}$$

Where the nominator represents the average landings rate per unit effort (LPUE, used as a proxy for catch rate) for the fishery and the denominator the landings rate were the fishery to fish at random across the spatial domain, with N the number of spatial units and i and j representing a spatial unit and time respectively. Here, if the fishery fishes at random in relation to the resource the indicator is 1, while if the fishery targets the species you would expect an indicator of >1, and avoidance shown by <1.

A conceptual challenge in the approach is to ensure that where a fishery exclusively targets a species it does not appear to be fishing at random. To illustrate, if we have a species with biomass distributed as follows:

Biomass			
12	6	2	8
6	24	56	4
2	43	78	9
8	23	53	6
0	3	1	12

And four different types of fisheries with effort distributed as follows:

Fishery	Fishing effort distribution				Landings				LPUE			
Fleet 1 - Targeted, but other fisheries	10	10	10	10	120	60	20	80	12	6	2	8
	10	15	15	10	60	360	840	40	6	24	56	4
	10	15	15	10	20	645	1170	90	2	43	78	9
	10	15	15	10	80	345	795	60	8	23	53	6
	10	10	10	10	0	30	10	120	0	3	1	12
Fleet 2 - Single focus targeted	0	0	0	0	0	0	0	0	NA	NA	NA	NA
	0	40	40	0	0	960	2240	0	NA	24	56	NA
	0	40	40	0	0	1720	3120	0	NA	43	78	NA
	0	35	35	0	0	805	1855	0	NA	23	53	NA
	0	0	0	0	0	0	0	0	NA	NA	NA	NA
Fleet 3 - random	11.5	11.5	11.5	11.5	138	69	23	92	12	6	2	8
	11.5	11.5	11.5	11.5	69	276	644	46	6	24	56	4
	11.5	11.5	11.5	11.5	23	494.5	897	103.5	2	43	78	9
	11.5	11.5	11.5	11.5	92	264.5	609.5	69	8	23	53	6
	11.5	11.5	11.5	11.5	0	34.5	11.5	138	0	3	1	12
Fleet 4 - other fisheries	22	10	10	22	264	60	20	176	12	6	2	8
	15	2	2	15	90	48	112	60	6	24	56	4
	15	2	2	15	30	86	156	135	2	43	78	9
	15	2	2	15	120	46	106	90	8	23	53	6
	22	10	10	22	0	30	10	264	0	3	1	12

The targeting index for each of the fisheries would be calculated as follows:

Table 5.1. Example calculation of targeting index based on two different methods.

		Method 1			Method 2		
	$\widehat{LPUE}$	N	$\sum LPUE_{ij}/N_{ij}$	TI	N	$\sum LPUE_{ij}/N_{ij}$	TI
Fleet 1 - Targeted, but other fisheries	21.5	20	17.8	1.21	20	17.8	1.21
Fleet 2 - Single focus targeted	46.5	6	46.2	1.01	20	17.8	2.61
Fleet 3 - random	17.8	20	17.8	1.00	20	17.8	1.00
Fleet 4 - other fisheries	8.3	20	17.8	0.46	20	17.8	0.46

Thus, Fleet 2 would *appear* as randomly distributed to the resource because of the limited spatial extend of the fishery under method 1. A more appropriate method would be to ensure that the denominator represented the LPUE across the entire spatial domain (method 2). Thus, while the nominator should be based on data on the fishery of interest, the denominator should be based on all fisheries using the gear in the area. This way targeted fisheries are correctly identified:

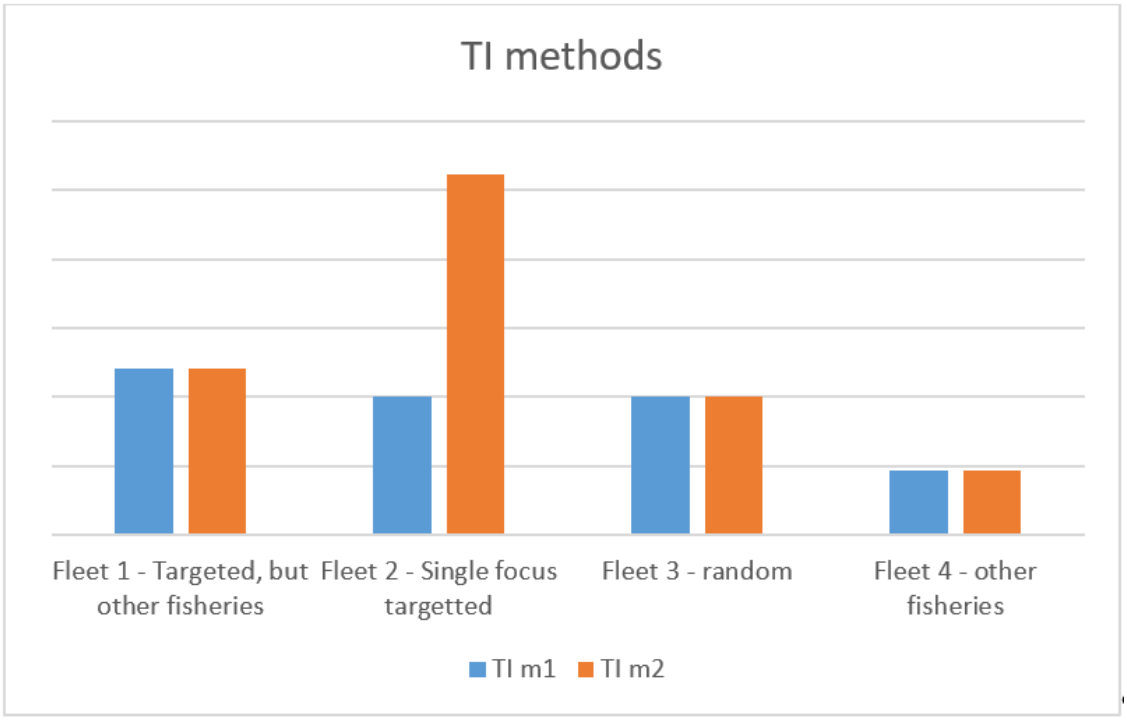


Figure 5.5. Example of conceptual targeting index based on four different fishery types in relation to a fishery resource.

An attempt was made to systematically apply the targeting index approach to the fisheries data within the Regional Database (RBD) based on the ICES statistical rectangle records of landings and effort. However, it quickly became apparent that the spatial information (landings by species by rectangle) was incomplete or too irregular for the method to be applied. In many cases, only some years were submitted, or landings were available but with missing effort information for the combination of identifiers (Figure 5.6). This was not unexpected as countries were not required to submit all data going back in time, and so only recent data has been submitted by most countries.

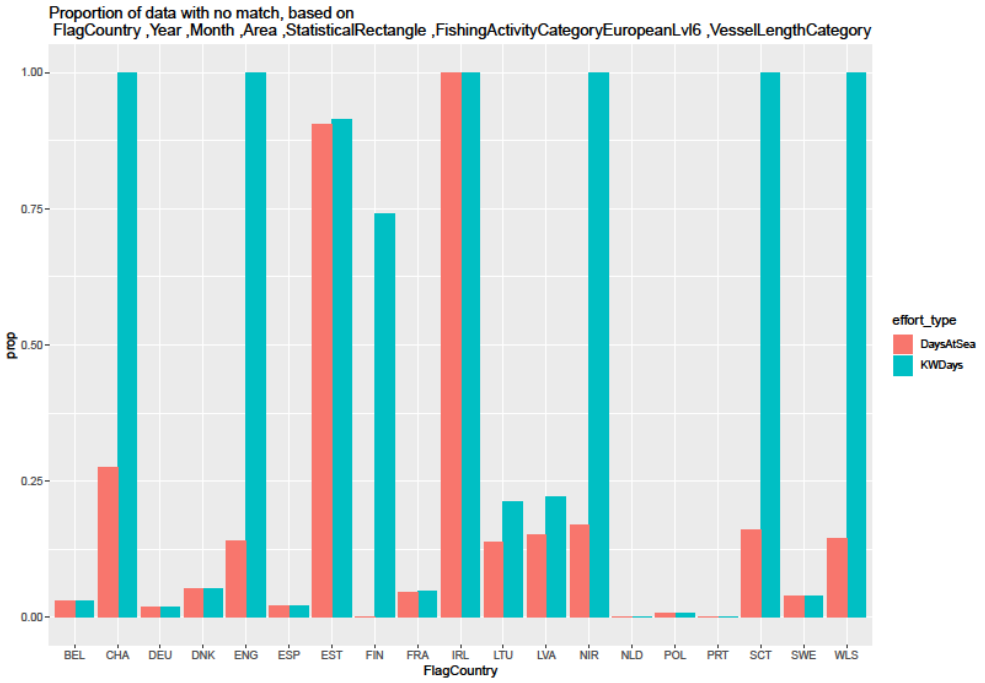


Figure 5.6. Proportion of the spatial landings' records without an associated effort record.

An example of the type of produce that could be produced given the data availability is given at Figure 5.7, showing the top ten species by landings total for French Otter trawlers >100 mm mesh size in the North Sea. The indicator identifies saithe as the main target species, though the precise values and trends should not be considered final due to the incomplete data in the RDB.

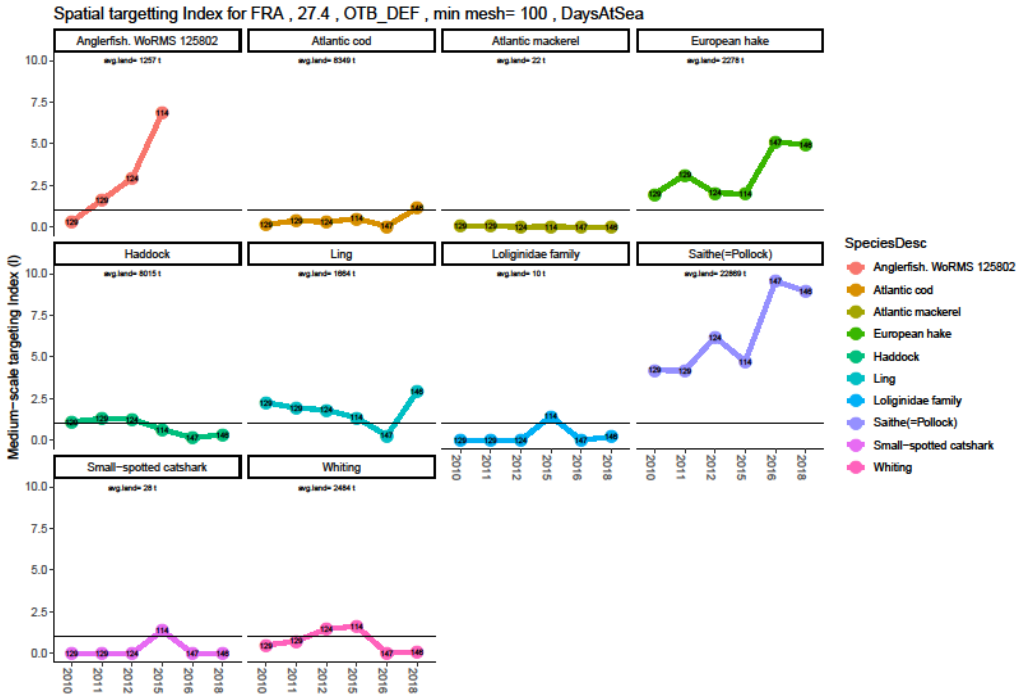


Figure 5.7. An example [Not operative] targeting index for the top ten species for a fishery. The numbers in the circles represent the number of ICES rectangles in which there were catch and effort records for a given year. Note that several years are missing in the series due to incomplete data.

A recommendation required for any development of such a tool in future would be for a more complete time-series of spatial data to be provided or uploaded to the RDB or its successor.

6 ToR D - Continue to explore the impacts of including additional species in the Celtic Sea FCube model

6.1 Background

During the 2019 Celtic Sea mixed fisheries assessment, it is hoped to incorporate the following *Nephrops* stock: FU16, 17, 19, 2021, 22 and 7OTH. However before this can be done we need to consider two issues. First, how to take account of live and dead discards in the forecast. Second, the separation of TAC uptake by FU.

6.2 Incorporating live and dead discards

Nephrops discard survival rate is defined within the legal framework of the landings obligation (Figure 6.1). The basis for this survival rate is outline in the stock annex of each single species stock annex, i.e. FU 17 (ICES 2015):

> *"Given the trip durations (5–7 days typically) and behaviour of this fleet means the majority of discards are returned to the sea over suitable sediment. The proportion scavenged by birds is probably quite low. Tow durations, volume of catches, prolonged sorting on deck and moderate density of Nephrops on the seabed probably results in relatively low discard survival. This is assumed to be around 25% in line with other Nephrops stocks in the Celtic Sea."*

With the incorporation of *Nephrops* into Celtic Seas WGMIXFISH advice, we need to understand the procedure for how survival rates are accounted for in the single species forecast, and determine the best procedure for accounting for them in mixed fisheries.

Procedure in single species assessment:
In the single species assessments for *Nephrops* in the Celtic Sea, a survival rate of 25% is applied to the outputs of the forecast, from which the dead discard rate is calculated (Figure 6.2).

Proposed procedure for mixed fisheries assessment:
Although incorporation of survival rates is quite a simple procedure for the single species assessment, this will not be the case for the mixed fisheries forecast. In the mixed fisheries procedure the dead discards will need to be counted against the quota, and will need to be present in the stock and fleet objects as they could choke the fishery. Some intersessional work will be done before the 2019 WGMIXFISH-Advice meeting on how to best implement this.

Survivability exemption for Norway lobster

1. The survivability exemption provided for in Article 15(4)(b) of Regulation (EU) No 1380/2013 shall apply to:

(a) Norway lobster (*Nephrops norvegicus*) caught in pots, traps or creels (gear codes: (1) FPO and FIX), in ICES subareas 6 and 7;

(b) Norway lobster (*Nephrops norvegicus*) caught with bottom trawls with a mesh size equal to or larger than 100 mm in ICES subarea 7;

(c) Norway lobster (*Nephrops norvegicus*) caught with bottom trawls with a mesh size of 70-99 mm in combination with highly selective gear options, as set out in Articles 9(2) and 10(2) of this Regulation, in ICES subarea 7;

(d) Norway lobster (*Nephrops norvegicus*) caught with otter trawls with a mesh size of 80-110 mm in combination with highly selective gear options, as set out in Articles 9(2) and 10(2) of this Regulation, in ICES division 6a within twelve nautical miles of the coast.

2. When discarding Norway lobster caught in cases referred to in paragraph 1, the Norway lobster shall be released whole, immediately and in the area where it has been caught.

(1) Gear codes used in this Regulation refer to those codes in Annex XI to Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy (OJ L 112, 30.4.2011, p. 1). For the vessels whose LOA is less than 10 metres gear codes used in this table refer to the codes from the FAO gear classification.

(10) The new joint recommendation suggests a survivability exemption for Norway lobster caught using bottom trawls with a mesh size equal to or larger than 100 mm and for Norway lobster caught with bottom trawls with a mesh size of 70-99 mm in combination with selective gear options (TRI and TR2 fisheries) in ICES subarea 7. Member States provided scientific evidence in order to demonstrate discard survival rates for Norway lobster in that fishery. The evidence was submitted to STECF which concluded that the survival study made with Seltra trawl provided a sufficient data, however the overall effect on the extensive fishery of Norway lobster with other fishing gears remains difficult to assess. STECF noted that assuming that a relatively high survival rate applies to all gears, a relatively low discard rate is implied in that fishery. That exemption should therefore be included in the new discard plan for the years 2019-2021.

Figure 6.1. Legislation defining survival rates for *Nephrops* in the Celtic Sea (European Commission, 2014).

```
Mean weight in landings - 1986:- Current WG Year
Mean weight in discards - 1986: - Current WG Year
Discard rate:Average (proportion by number) 2013-Current WG Year. Calculated as discards/(landings + discards)
Dead discard rate:Average 2014 - Current WG Year(proportion by number). Calculated as dead discards divided by
dead removals (landings + dead discards). Only applies in scenarios where discarding is allowed

```{r Inputs to Catch option table}

land.wt.yrs <- seq(2016,2018,1)
disc.wt.yrs <- seq(2016,2018,1)
discard.rate.yrs <- seq(2016,2018,1)
dead.discard.rate.yrs <- seq(2016,2018,1)
prop.removal.ret.yrs <-seq(2016,2018,1)

wgcse.yr <- FU16$year[length(FU16$year)]
stock.abundance <- FU16$abund[length(FU16$abund)]

land.mean.wt <- round(mean(FU16$mean.wt.lan[FU16$year %in% land.wt.yrs],na.rm=T),1)
disc.mean.wt <- round(mean(FU16$mean.wt.dis[FU16$year %in% land.wt.yrs],na.rm=T),1)

discard.rate <- round((mean(FU16$discard.rate[FU16$year%in% discard.rate.yrs],na.rm=T)*100),1)

dead.discard.rate <- mean(FU16$dead.discard.rate.n[FU16$year %in% dead.discard.rate.yrs]  ,na.rm=T)
prop.removal.ret.n <-round((mean(FU16$prop.removal.ret[FU16$year %in% prop.removal.ret.yrs],na.rm=T)*100),1)
disc.survival <- 0

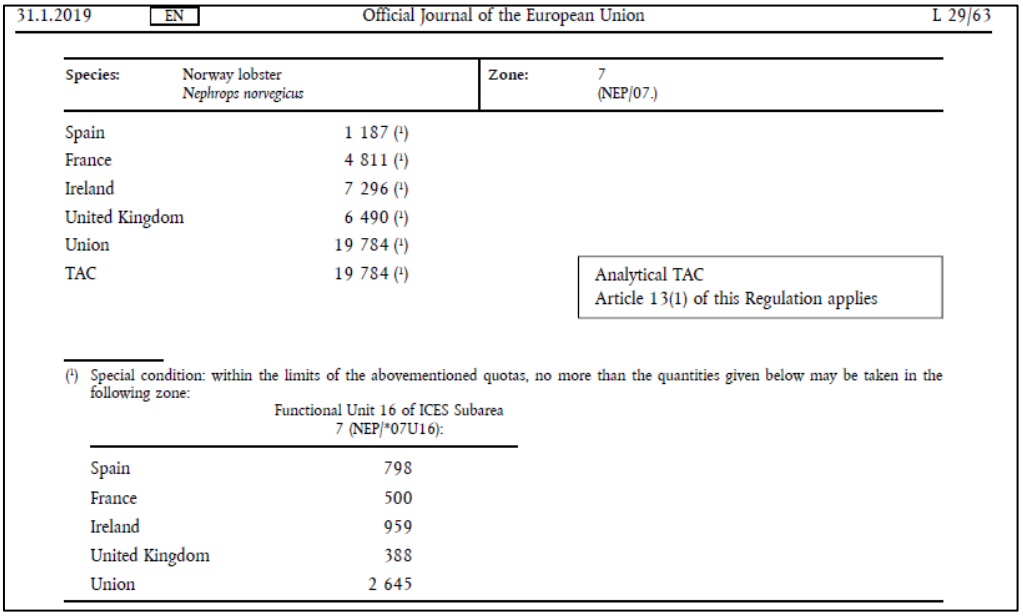

fu16.catch.inputs<- data.frame(wgcse.yr, stock.abundance, land.mean.wt,
disc.mean.wt,discard.rate,dead.discard.rate,disc.survival)
```

Figure 6.2: Example of the calculations used to produce the dead discard rates for *Nephrops* in FU16.
```

6.3 TAC uptake

Nephrops management occurs at the level of Subarea 27.7.

Nephrops is assessed at the spatial resolution of Functional Unit (FU), and are based on ICES Statistical Rectangle boundaries. However, *Nephrops* management, specifically TAC allocation, is at the level of ICES area, with a TAC being provided for all of area 7 (except FU16) (Figure 6.3). Therefore, we need to determine how best to divide the TAC up between the FU's so that it can be used in the forecast. To achieve this we looked at TAC uptake trends over time (Table 6.1) and calculated the average TAC uptake per FU (Table 6.2) to determine how the split should be applied.



31.1.2019 EN Official Journal of the European Union L 29/63

Species:	Norway lobster *Nephrops norvegicus*	Zone:	7 (NEP/07.)
Spain	1 187 (1)		
France	4 811 (1)		
Ireland	7 296 (1)		
United Kingdom	6 490 (1)		
Union	19 784 (1)		
TAC	19 784 (1)		

Analytical TAC
Article 13(1) of this Regulation applies

(1) Special condition: within the limits of the abovementioned quotas, no more than the quantities given below may be taken in the following zone:

	Functional Unit 16 of ICES Subarea 7 (NEP/*07U16):
Spain	798
France	500
Ireland	959
United Kingdom	388
Union	2 645

Figure 6.3. 2019 TAC allocation for *Nephrops*.

Table 6.1. TAC uptake by FU for the period 2000–2018.

Year	FU 14	FU 15	FU 16	FU 17	FU 18	FU 19	FU 20-21	FU 22	OutFU	Total Landings	TAC for 7
2000	567	8370	910	880	9	696	1778	2890	243	16 344	21 000
2001	532	7441	1222	913	2	815	1833	2938	368	16 064	18 900
2002	577	6793	1327	1155	14	1318	2674	1993	243	16 093	17 790
2003	376	7052	1064	935	16	1239	2953	2065	186	15 884	17 790
2004	472	7266	1406	525	22	1074	2443	1828	161	15 197	17 450
2005	570	6529	2197	780	15	711	2469	2533	180	15 982	19 544
2006	628	7535	2185	637	14	741	2523	1761	270	16 294	21 498
2007	959	8424	2074	913	3	957	2419	2950	206	18 905	25 153
2008	726	10482	1000	1057	1	851	2980	3090	111	20 288	25 153

Year	FU 14	FU 15	FU 16	FU 17	FU 18	FU 19	FU 20-21	FU 22	OutFU	Total Landings	TAC for 7
2009	693	9166	879	626	10	868	3145	2185	322	17 860	24 650
2010	583	8929	922	939	7	687	1793	2714	316	16 925	22 432
2011	561	10159	1278	659	13	643	1237	1636	359	16 510	21 759
2012	531	10527	1258	1246	28	849	1189	2618	110	18 276	21 759
2013	495	8672	1141	1295	0	794	1387	2257	325	16 354	23 605
2014	679	8613	1189	766	0	468	1,836	2526	194	16 271	20 989
2015	378	8632	1394	370	0	507	2,116	2350	174	15 921	21 619
2016	237	7327	2154	641	0	591	2,453	3329	80	16 812	23 348
2017	265	6149	2632	295	0	420	1,849	3560	137	15 307	25 356
2018	263	5756	2751	537	0	219	1803	1975	158	13 462	29 091

Table 6.2. Average TAC uptake of each FU (2000–2018)

	FU 14	FU 15	FU 16	FU 17	FU 18	FU 19	FU 20-21	FU 22	OutFU
Mean	3	49	9	5	0	5	13	15	1
Max	5	62	20	8	0	8	19	23	2
Min	1	40	5	2	0	2	7	10	0
StDev	0.9	5.9	4.3	1.6	0.1	1.7	3.4	3.2	0.5

7 ToR E - Investigate and where possible improve the fleet/métier definition in Bay of Biscay

Not possible within the time frame of the working group as person responsible had to attend an ADG. This ToR will be addressed during the 2020 WGMIXFISH-METHODS meeting.

8 ToR F - Develop the Irish Sea FCube

8.1 Irish Sea Mixed Fishery Considerations

ICES Division 27.7.a, the Irish Sea, is relativity enclosed sea basin situated between Ireland and Great Britain. It is connected to the Celtic sea at its southern extreme by the St George's Channel and in north is linked to sea region West of Scotland by the Northern Channel. Within the Irish Sea there are distinct habitat patches formed from a combination of bathymetry, topographical features, and hydrography. The average depth is 50 m but the area is contrasted between a deeper channel, in the west, and shallower bays in the east. The channel has a maximum depth exceeding 275 m while the eastern bays have depths less than 50 m. The seabed of the eastern Irish Sea is dominated by fine sediment plains with some small areas of areas of mud habitat, the fine sediments graduate to more coarse material in central areas. A large well-defined deep-water mud basin is located in the north-western region in close to the Northern Irish and Irish coast. There is another distinct mud habitat in the east of the division. These two patches are identified as two separate *Nephrops* functional units (FU14 and FU15). Although these areas support spatially disaggregated fisheries with markedly different target assemblages there is an opportunity mixed fishery interactions (Figure 8.1).

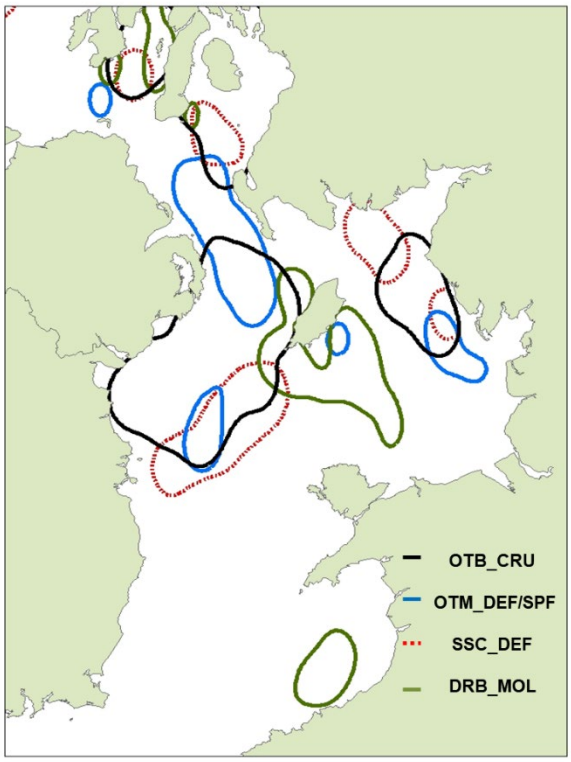


Figure 8.1. Spatial distribution of UK fishery activity 2007–2016 by primary métiers in the Irish Sea.

8.2 Fishery description

Seven species are managed by TACs in the division namely *Nephrops* (FU14 and FU15), haddock, plaice, sole, whiting, cod, and herring. The herring fishery is not considered to have mixed fishery interactions. Four nations dominate the fishing effort namely Northern Ireland, Republic of Ireland, and Belgium.

8.3 Landings

The regional database (RDB) data were used to explore the landings reported by different métiers within the Irish Sea (2016–2018). *Nephrops* is the main demersal species landed within the Irish Sea mixed fisheries. The species is targeted using otter trawls (OTB) with mesh size in the range 70–99 mm with 98.3% of landings made by this gear. Although landings of other species in the *Nephrops* fishery constitute a small proportion of the overall landings there is evidence of significant discarding in these fisheries, including whiting (ICES, 2019a).

At present haddock account for the second highest landings and are mainly caught in otter trawls (59.7%) and mid-water otter trawl (OTM; 23.3%). Plaice accounts for the third highest landings in the Irish Sea, mainly targeted by beam trawls (TBB) which also accounts for the primary gear landing sole. TBB gears account for 53.6% of plaice landings and 61.7% of sole landings. At present landings of whiting in the Irish Sea area at a historically low level with TAC of 80 t set annually during 2014–2018. The majority of landings and discards of whiting arise from otter trawls (ICES, 2019a). Landings of cod are observed in otter trawls (79.3%) and mid-water trawls (10%). There is some variation in the landings profiles of each métier at the EU Member State level, reflecting different fishing patterns, practice, and quota shares (ICES 2018).

The exploration of the landings identifies that their mixed fishery interactions are most likely to arise in otter trawl fisheries targeting *Nephrops*. Further exploration of the of targeted métier landings shows the primary a high degree of overlap in the catch characteristics of the main métiers. Figure 8.2 shows the density histograms of landings, by haul, from the RDB. The predominant landed species in OTB_CRU is *Nephrops* but others species are encountered at similar magnitudes. Within OTB_DEF and OTM_DEF there remains to be mixed fishery interactions across all TAC managed species although skewed toward demersal gadoid species and similarly in TBB_DEF with a bias toward demersal flatfish. The landings data in the RDB and extracted from ICES InterCatch were compared to support the use of the RDB to accurately reflect to the character of the fishery and support the use of InterCatch data for further mixed fishery analysis. In general, there was agreement between the two data sources with 100% of plaice, 104% of sole and 101% of *Nephrops* landings accounted for in the InterCatch. From gadoid species in the Irish Sea there is reallocation of landings from rectangles 33E3 and 33E4 in the Irish Sea to the Celtic Sea – and explains the under representation in InterCatch of the RDB landings of cod at 85%, haddock at 71%, and whiting at 71%.

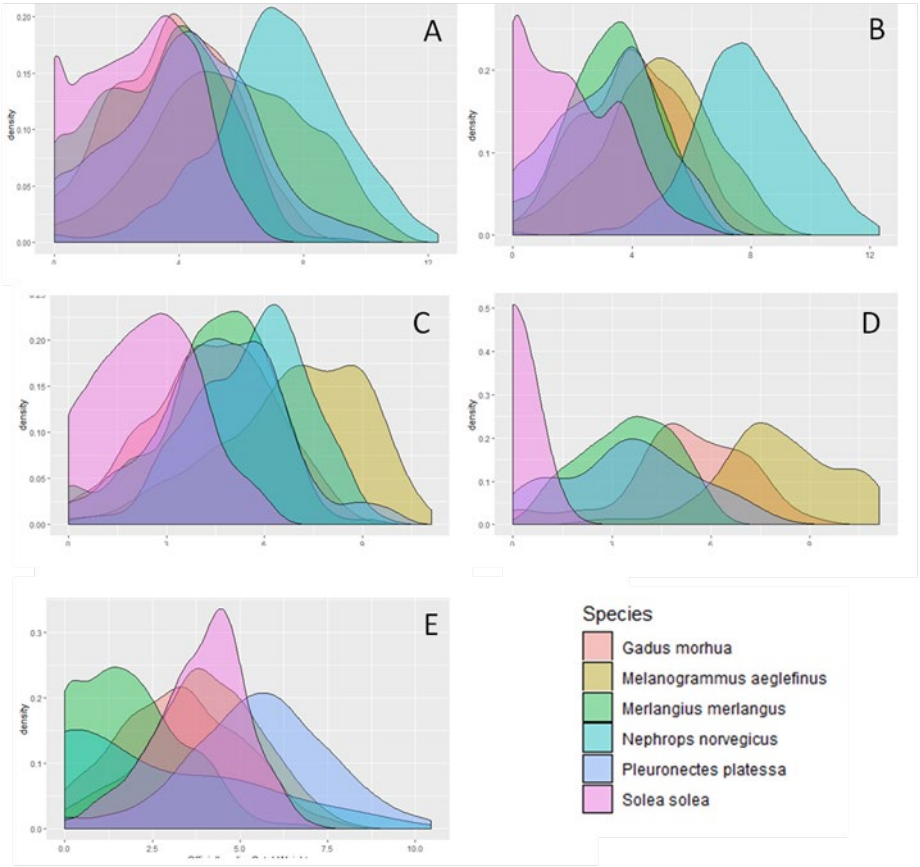


Figure 8.2. Continuous density histograms of log landings, by haul, from the RDB 2016–2018. A: All métiers; B) OTB_CRU; C)OTB_DEF; D) OTM_DEF and E) TBB_DEF.

8.4 Effort

National data submitted for the ICES 'MixedFish' data call was used to identify the main fishing fleets by effort in the Irish Sea (Figure 8.3). From the data, 34 unique fleets (métier, country and vessel length combinations) were identified. Some discrepancies were observed in the use of 'MIS_MIS' categories and the absence of the OTM_DEF métier in the effort and landings files submitted in response to the data call. This should be addressed at a national level to ensure accuracy of métier coding relevant to the Irish Sea. Fleets with <1% catch of any stock were

grouped as 'other'. Twelve fleets were remained. These included five otter trawl *Nephrops* fleets (Belgian; 24<40 m, Irish; 10<24, 24<40 and UK; <10, 10<24, 24<40), three beam trawl fleets (Belgian; 24<40 m, Irish; 10<24 24<40) three midwater / demersal fish (Irish; 10<24, 24<40, UK; 24<40) and a UK other fleet.

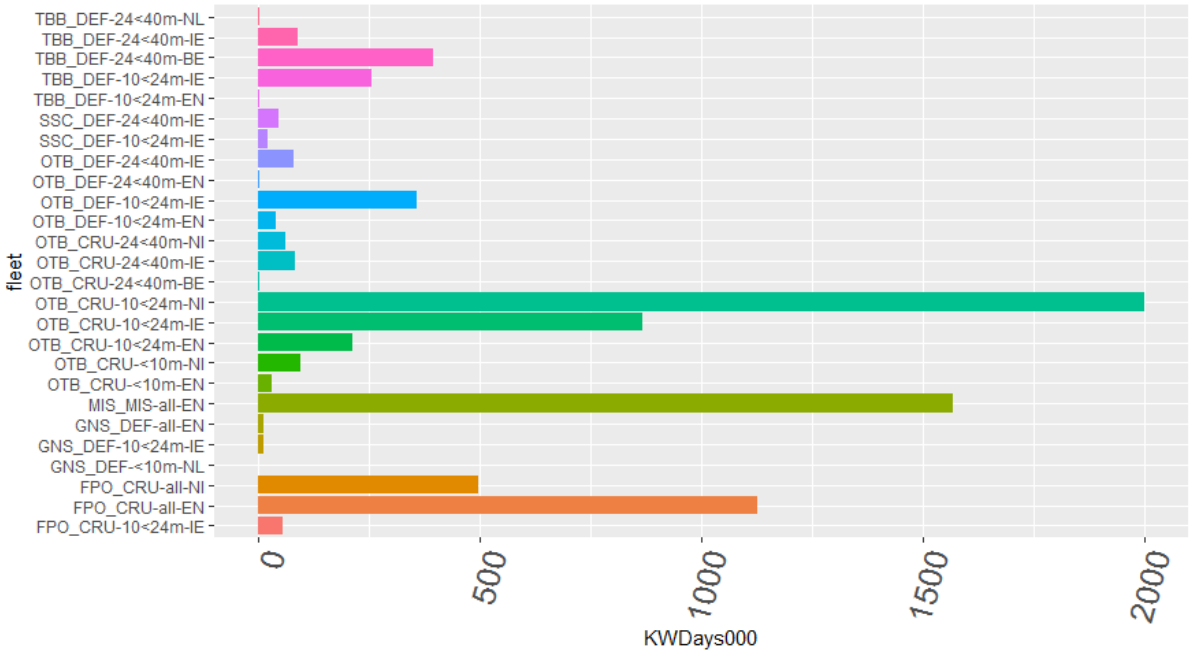


Figure 8.3. Fleet effort in the Irish Sea.

8.5 Mixed fishery scenarios

The ICES advice the five demersal stocks was recreated. The advice was recreated for 2017, as the final 2018 advice was not available at the time of the meeting. Using the fleets identified above although with landings and discards from 2014–2016 mixed fishery scenarios were applied using the FCube method (Figure 8.4). The scenarios that were applied were:

- Min – stop fishing when minimum advice achieved;
- Max – stop fishing when maximum advice achieved;
- Species (haddock (had-is), cod (cod-is), whiting (whg-is), plaice (ple-is) and sole (sol-is)) advice scenarios;
- *Status quo* effort – no change in level of effort as seen 2014–2016.

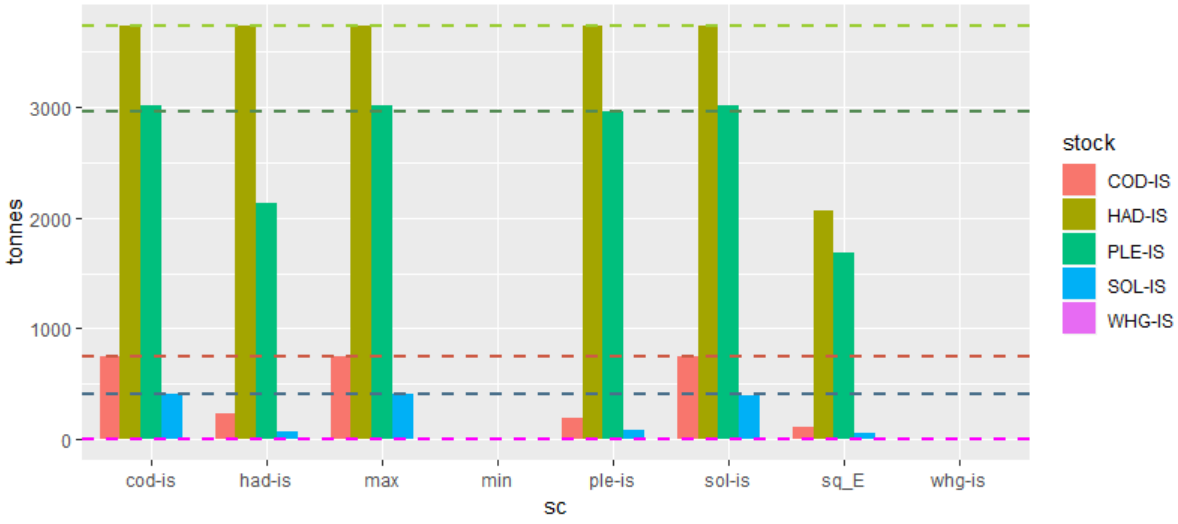


Figure 8.4. FCube estimates of potential catches by stock after applying the status quo effort scenario to all stocks in the intermediate year followed by the FCube scenarios. Horizontal lines correspond to the TAC set by the single-stock advice.

8.6 Summary

The results of the mixed fishery analysis of the Irish Sea support the need to considered mixed fishery interactions with the division. Species are landed (and caught) in a range of targeted and now targeted fisheries. The FCube scenario outputs from the 2017 advice for 2019 demonstrate that changes in the current stock status of the Irish Sea, and the corresponding advice, are markedly different from the recent years. For a number of stocks there would be significant above TAC catches if the advice for individual stocks was followed. This is a preliminary analysis and the method and Irish Sea model required further development. The work needed for the Irish Sea mixed fishery model includes the inclusion of *Nephrops* for both FU14 and FU15 and improved national coding of métiers, relevant to the Irish Sea in response to the mixed fish data call.

9 ToR G - Continue development of the combined implementation of FCube and FLBEIA in conjugation with economists

The current WGMIXFISH data call includes information on landings, effort and stock sale price (not age disaggregated) by country and métier. Information on fleet and métier costs (fixed and variable) have not been included in the current request because they have not – in the past - been required for the models used to provide mixed fisheries advice. There have also been difficulties in Member States producing estimates in a manner consistent with the biological data. With the expansion of the group's work to consider the economic consequences of management decisions and the desire to develop bioeconomic modelling approaches to support this the integration of economic data from other sources has been an ongoing goal of the group.

Economic data from the Annual Economic Report on the EU Fishing Fleet (e.g. STECF 2017) has been identified as the most relevant economic data source for WGMIXFISH modelling efforts, but its use has been hindered by the fact that the publically accessible version is aggregated to fleet and métier definitions that do not coincide with WGMIXFISH definitions. Specifically, data are aggregated over large areas (e.g. FAO Area 27 rather than ICES management areas of relevance to stock definitions) and gears (e.g. all demersal trawlers, regardless of mesh sizes, are code 'DTS'). Initial attempts at merging these data with (e.g. Graham *et al.*, 2016; Taylor *et al.*, 2018) have shown promise for use in economic simulations, but improved fleet/métier definitions are desired moving forward.

During the WGMIXFISH-METHODS meeting, we conducted a tele-conference with the newly-formed WGECON group, who was meeting during the same week, in order to discuss the issue of economic data merging and related points of collaboration. The first major outcome was agreement that the FLBEIA mixed-fisheries bioeconomic model (Garcia *et al.*, 2017) is the most immediately appropriate framework for conducting case study comparisons given its flexibility as well as the fact that models have already been implemented or are in development within WGMIXFISH for several systems (Bay of Biscay, Celtic Sea, Iberian Sea, and North Sea). A second major outcome is that WGECON has agreed to assist in the use of STECF economic data; specifically, R scripts are being developed to allow for aggregating the raw economic data according to WGMIXFISH fleet/métier definitions. The intention of the group is to progress incorporation of economic variables in the model by developing a workflow from the AER data so as it can be readily combined with the existing fleet and métier definitions used by the group.

10 ToR H - Present work from ProByFish group and explore future collaborations with WGMIXFISH

10.1 Summary of PROBYFISH task 3 on identifying and understanding the cause of technical interactions

10.1.1 Aim

The task 3 in PROBYFISH focuses on technical interactions. For each fleet included in the project, correlations in the catches of the different target and bycatch species are identified, and the relevant scale on which they occur are characterized. The task also aims at understanding the causes of the correlations.

In the context of the project, this task contains two distinct items:

- Extent and consistency of correlation between identified target and bycatch species: investigates which species are correlated and how this correlation relates to variations in time, space and the scale of analyses. The stability of the correlation is investigated for different fleet segments and fisheries units identified based on their observed and expected variability of catch composition.
- Analyses of the possible causes of consistent correlations: evaluates spatio-temporal patterns in catch composition together with results from task 4.3 on known gear selectivity patterns for each of the relevant fleet units and bycatch species. The content of this subtask is not developed here, as the methods applied are, to a large extend, described in section 5.2 of this report.

10.1.2 Extent and consistency of correlations

Data

In order to fully comprehend the extent of technical interactions between two species (i.e. the extent to which their fishing mortality are linked), it is necessary include the discarded fraction in the analyses, and hence consider catch information. It is also relevant to look at the scale of the fishing operation, as catch composition can vary between hauls during a trip. This points towards the use of observers data, as for the task 1 of PROBYFISH, which are the only data available that provide catch information on a fishing operation level. The same data as provided by the participants of ICES WKTARGET was hence used for task 3, and all scripts and results are stored on the WKTARGET Gitlab repertory (which is not public).

Métier level

The DCF métier levels defined to describe the activity of the fleets typically use generic target species (e.g. demersal fish, crustaceans). However, a given métier may encompass a variety of fishing strategies (varying between vessels, or between seasons) which may each involve different technical interactions. It was therefore decided to do the analyses of task 3 at the scale of métier level 7, which identifies the actual major species targeted during a fishing operation, instead of métier level 6 using generic species. The identification of métier level 7 was conducted using the methods proposed by Deporte *et al.* (2012), which combines a series of dimension reduction and clustering technics. The scripts used were available from the R library VMStools. As

the method is designed to identify the main species targeted by the fleet, the analysis was conducted on the landings expressed in value (as advised in the wiki: https://github.com/nielshintzen/vmstools/wiki/MetiersLogbook).

Application

The VMStools methods was apply on a country/métier level 5 basis (in the example below, the Dutch TBB_DEF_70-99) with all the years of data available combined. For this example, five clusters were identified, corresponding to hauls where turbot, sole, plaice, and *Nephrops* were the main species, and the hauls where not main species could be identified. The largest clusters - or métier level 7- in terms of landings are (by order of importance) métiers level 7 with main species sole, turbot and plaice representing respectively 50%, 23%, and 20% (graph on the left side of figure 10.1).

A first indication of the correlation between species in the catch can be given by the distribution of the catches of all the species between the different métier level 7 identified (central panel of Figure 10.1). For instance, the catches of sole mainly occur in haul were sole was identified as the main target. This is to be expected as sole is the main target species of this fishery and discarding rates for this species are low. Catches of brill, a valuable bycatch species, occur for 50% in haul with turbot as main species, and 40% in hauls with sole a main species. The high percentage for the sole métier level 7 can be explained by the fact that this métier is the most frequent. The high percentage for the turbot métier indicates however, that catches of brill tend to occur preferentially in hauls with turbot being the main species, indicating a strong interaction between the two species. Similarly, the catches of spotted ray also occur with a high percentage (with regard to the importance of the cluster) in the turbot métier level 7, indicating that by catch of this ray species are proportionally more frequent in the turbot fishery.

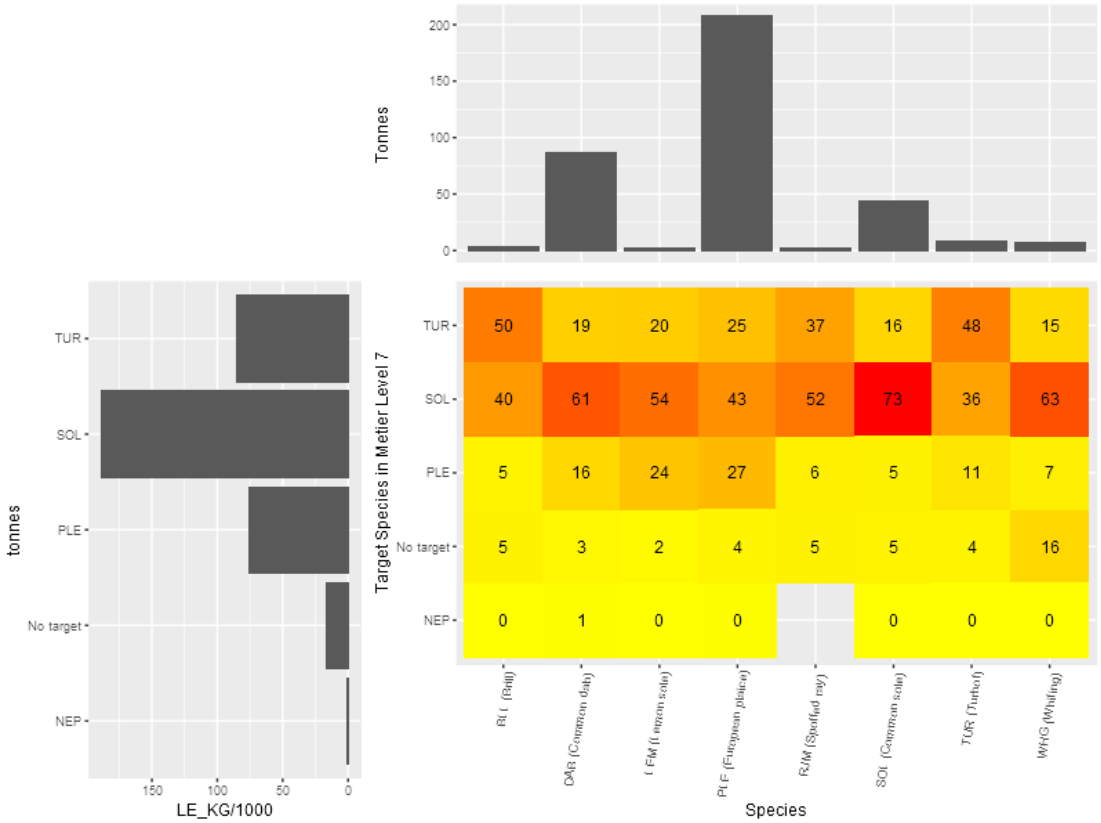


Figure 10.1. Classification of the hauls sampled during observer trips into métiers level 7 for the Dutch TBB_DEF_70-99_0_0. Bar plot on the left side: sum of the landings (in the observers data) per métier level 7; bar plot on the top : sum of the catches per species in the observer data (only species contributing to 99% of the catches in weight are shown); central panel : repartition of the catches per species between the métier level 7 identified.

The métier level 7 identified are clusters of fishing operations with similar landing species composition. These differences in landings compositions can be explained by spatial or seasonal factors, but they can also possibly occur randomly, even within the same trip. Looking at the spatial distribution of the hauls belonging to each cluster can provide indications on whether the clusters can be explained by spatial differences in species composition. In the example used here, the Dutch TBB_DEF_70-99, there is a clear separation between sole and plaice métier level 7, with sole mainly in the south and plaice mainly in the north, with little overlap (Figure 10.2). For these species, the choice of the fishing ground is probably the main factor determining métier level 7. The hauls classified as turbot métier level 7, however, are much more widespread, and overlapping with the distribution of the hauls of both sole and plaice métier level 7. This suggests that factors (smaller scale distribution patterns, seasonality, gear related) other than large-scale species distribution patters determine the occurrence of turbot métier level 7.

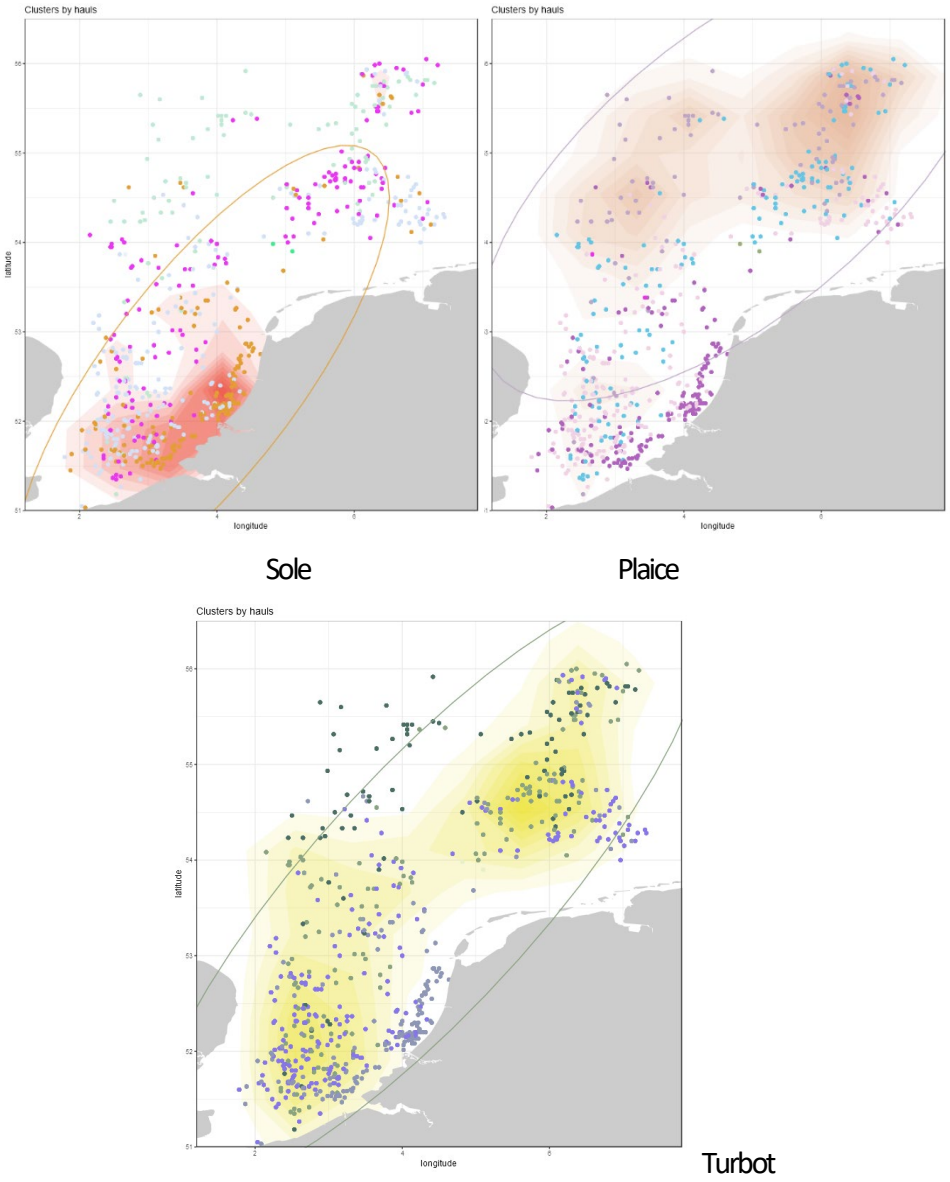


Figure 10.2. Spatial distribution of the three main clusters identified for the Dutch TBB_DEF_70-99_0_0 métier: top left: sole, top right: plaice, bottom left: turbot. The colour surface maps on each panel indicate the spatial density of the location of the hauls belonging to each cluster.

Haul by haul correlations

Technical interactions can also be described at a finer scale by looking at the correlation in the haul-by-haul catches of pairs of species in a given métier. Taking now the example in the Danish catches and witch flounder as a species of interest (Figure 10.3), and looking at the scale of métier level 6, it appears that catches of witch flounder are consistently significantly (positively or negatively) correlated to a number of other species in the OTB fleet, and to a lesser extent in the GNS fleet. In the OTB fleet, for example, significant (blue) positive correlations are consistently observed with ling, saithe and *Nephrops* and negative correlation with lemon sole, turbot and plaice.

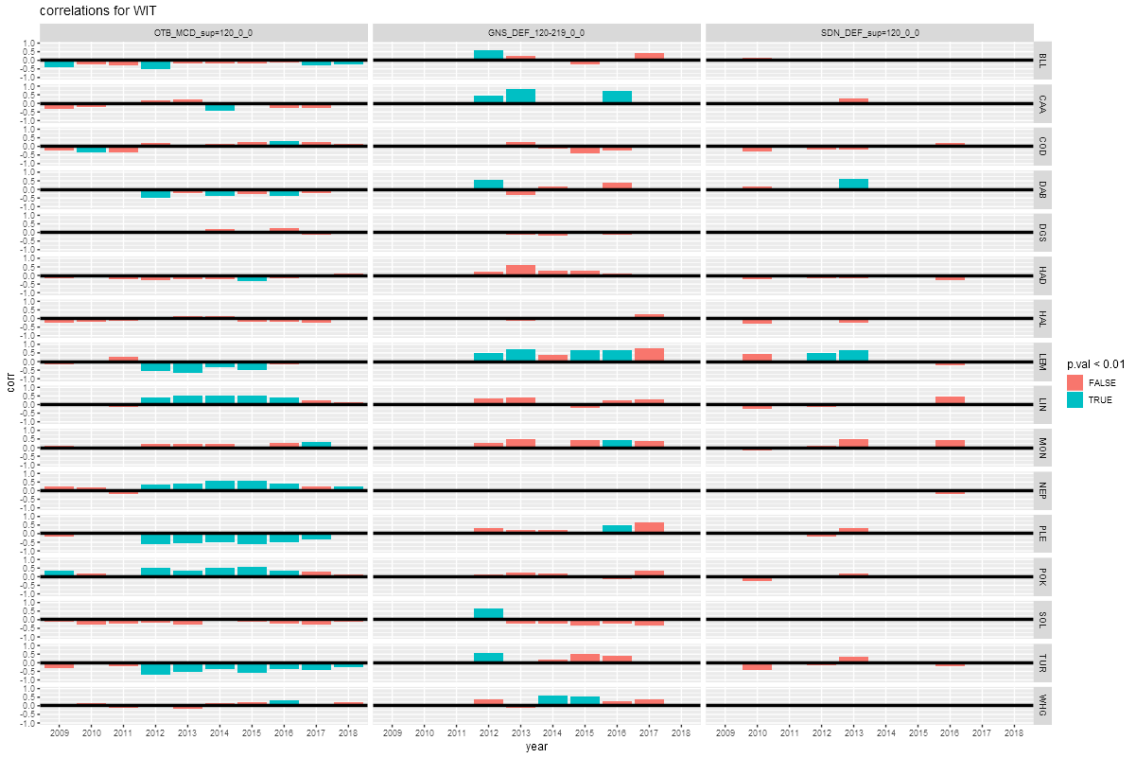


Figure 10.3. Correlations between catches at the haul level of witch flounder and other species in the Danish demersal fleets. Correlations are calculated on an annual basis for each métier. Blue and red bars correspond to significant and non-significant correlations, respectively.

10.1.3 Interest for WGMIXFISH

One of the aims of the identification of correlations in task 3 is to determine the appropriate level of aggregation of the fishing fleets (i.e. from individual vessel to métier) which should be used in mixed fisheries models to correctly represent the technical interactions. The outcome of the different analyses conducted in task 3 are presented in a shiny app, which makes is possibly to quickly select different time frames (selection of years, quarters), geographic area, or fleet level aggregation, and thereby test the robustness of the correlation identified to these different scales.

Currently, the fleet and métier definitions used in MIXFISH is partly a result of the upload procedures to the RCGs, which determine the format of the data in the RDB. Thence, this work must be conducted in close cooperation with the RCGS. The work will start with a review in August of the current RCG guidelines and compare to the results of task 3.1 after we which we will discuss the possibility for change with the RCGs.

10.2 ProByFish: Exploration of the RDB

10.2.1 Introduction

In January 2019, an ICES workshop was planned and arranged in collaboration with the EU project ProByFish (WKTARGET 2019), from the EASME tender EASME/EMFF/2017/022 to provide a scientifically based categorization of the different species in the catch according to the degree to which they are targeted by the fishery ("target", "hybrid", "valued bycatch" and "collateral bycatch"). The Workshop focused on developing methods, based on trip data, to identify "target", "hybrid", "valued bycatch" and "collateral bycatch" for each of the areas Bay of Biscay, Celtic Sea, English Channel and North Sea and the degree to which these stocks are concentrated across fleets, métiers, subareas and seasons. The ProbyFish project aims at applying these methodologies on all métier, across all areas. To achieve this Regional Data Base (RDB) was identified as the best database available in Europe to which Member States have provided all sampling data for over 10 years. During this meeting, the methodology was defined and accepted, however the analysis was incomplete as only a few Member States were present and able to provide a sample of their observer data. To resolve the issue and support this important project WGMIXFISH applied directly to Member States for complete access to the data they had submitted to the RDB for the purposes of producing the analysis proposed by ProByFish. Member States were responsive and granted access to the data. Once the data extract was received, two steps had to be taken before the ProByFish methodologies could be applied: Summarize the contents of the RDB, and assess the quality and consistency of the data.

10.2.2 Summary of contents

Olga Kalinin of the Informatics Project (Ireland) developed a shiny app to allow effective exploration of the vast data made available through the RDB. Due to the sensitive member state information, this app is only available to WGMIXFISH and ACOM members from the SharePoint site.

10.2.3 Quality and consistency

Youen Vermard of the ProByFish project (France) developed an Rmarkdown to assess the consistency and quality of the sample data in the RDB. As this extensive document contains sensitive Member State specific information, it is only available to WGMIXFISH and ACOM members from the SharePoint site.

10.2.4 Conclusions

In conclusion both analysis (10.2.2 and 10.2.3) show that the Regional Data Base, in its current state, is not suitable for the application of mixed fisheries analysis, due to missing information and inconsistencies in reporting by Member States. The primary issues is the incompatibility between the landings and sample tables. This incompatibility means that the observed length/age structures found in the sample tables cannot be raised to the level of total landings, rendering it impossible to produce the analysis defined during WKTARGET.

11 Recommendations

None.

12 References

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Annex 1: List of participants

Name	Address	Email
Claire Moore (Chair)	Marine Institute, Ireland	Claire.moore@marine.e
Clara Ulrich	DTU Aqua - National Institute of Aquatic Resources Denmark	clu@aqua.dtu.dk
Colin Millar	Data Centre, ICES	colin.millar@ices.dk
Dorleta Garcia	AZTI Spain	dgarcia@azti.es
Harriet Cole	Scottish Government UK	Harriet.Cole@scotland.gsi.gov.uk
Klass Sys	Flanders Research Institute for Agriculture, Belgium	klaas.sys@ilvo.vlaanderen.be
Lionel Pawlowski	Ifremer Lorient Station France	lionel.pawlowski@ifremer.fr
Marc Taylor	Institute of Sea Fisheries Thünen Institute Germany	marc.taylor@thuenen.de
Marianne Robert (by correspondence)	Ifremer Lorient Station France	Marianne.Robert@ifremer.fr
Mikel Aristegui Ezquibela (by correspondence)	Marine Institute, Ireland	Mikel.Aristegui@Marine.ie
Olga Kalinina	Marine Institute, Ireland	Olga.Kalinina@Marine.ie
Paul Bouch	Marine Institute, Ireland	Paul.Bouch@Marine.ie
Paul Dolder	Centre for Environment, Fisheries and Aquaculture Science (Cefas) UK	paul.dolder@cefas.co.uk
Paz Sampedro	IEO A Coruña Centre Spain	paz.sampedro@ieo.es
Shawna Sanfey	Marine Institute, Ireland	Shawna.Sanfey@Marine.ie

Name	Address	Email
Thomas Brunel	Wageningen Marine Research The Netherlands	thomas.brunel@wur.nl
Vanessa Trijoulet	DTU Aqua, Denmark	vtri@aqua.dtu.dk
Youen Vermard	Ifremer Boulogne-surMer France	youen.vermard@ifremer.fr

Annex 2: Proposed ToR for 2020 WGMIXFISH Meeting

2019/2/FRSGXX The Working Group on Mixed Fisheries Advice Methodology (WGMIXFISH-METHODS), chaired by Claire Moore, Ireland, will meet in Nantes, France 22-26 June, 2020 to:

a) Continued improvement of WGMIXFISH-ADVICE workflow, updating associated documentation and increasing transparency.
b) Respond to the outcomes of the Mixed Fisheries Scoping Meeting.
c) Respond to the outcomes and issues encountered during WGMIXFISH-Advice.
d) Review of updated data call, identifying possible areas of improvements.
e) Assess the fleet/métier definition in Bay of Biscay.
f) Development of Irish Sea FCube.
g) Continued development of the combined implementation of FCube and FLBEIA in conjugation with STECF/WGECON economists.

WGMIXFISH-METHODS will report by 3 August 2020 for the attention of ACOM.

Supporting Information

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

Annex 3: Data request form for single species stock coordinators

Dear stock coordinator,

WGMIXFISH are incorporating your stock (see attached list) into the production of WGMIXFISH advice in 2019. To achieve this, we will need two key elements from you the expert by May 20th 2019:

a) FLStock object of assessment outputs
b) Short-term forecast inputs, script and details

Details of these two requests can be found below. The member of WGMIXFISH would appreciate if you could please forward these requests to WGMIXFISH chair (claire.moore@marine.ie) by Monday May 20th 2019. Please feel free to contact me if you have any questions.

Thank you in advance and kind regards,

Claire

Details:

1) **Requirements for FLStock objects provided to WGMIXFISH**

The FLStock object should innclude information from the assessment output. Where data is available, all slots contained in an FLStock object should be filled; including (but not limited too) numbers-at-age (stock@stock.n), fishing mortality-at-age (harvest), weights-at-age (stock@catch.wt) stock@landings.n and stock@discard.n from the assessment output. Please ensure the correct unit assignments are supplied (i.e. units(stock@catch.wt)). The fbar range values and plusgroup should also be set (e.g. range(stock)[c("minfbar","maxfbar")]).

Note: If the assessment is SPiCT, please provide the SPiCT output in full.

2) **Details of the short-term forecast:**

Please supply the script and inputs used to calculate the short-term forecasts. Also please complete the table below.

Reference points:	Have they changed from last year?	
Recruitment:	What values were used and what was the basis (i.e. geometric mean…)? Should be 3 values: intermediate year, TAC year, TAC year + 1 Were any adjustments made to any other year classes for the forecast (e.g. RTC adjustments)?	
Weights-at-age:	What was the basis? (e.g. 3-year average) If non-standard, can you provide or point to report section for the values?	
Natural mortality	Year average basis	
Selection pattern:	Year average basis? Was Fbar rescaled? Anything unusual (e.g. discard assumptions)	
Intermediate year assumption:	Fishing mortality assumption (e.g. TAC, fsq)?	
Advice basis	e.g. Fmsy, Fmsy*(B/Bmsytrigger) etc..	

Anything else important we should know?

Annex 4: Data call format 2019

7.3.1 WGNSSK: All stocks (2018 data requested)

Provide data by filling the spreadsheets described in section 7.3.5 and in Annex 1.

7.3.2 WGCSE: All stocks (2018 data requested)

Provide data by filling the spreadsheets described in section 7.3.5 and in Annex 1.

Species catch data should be submitted according to the following:

ANF (aggregated ANF, MON, MNZ),

LEZ (aggregated LEZ, MEG),

RJA (aggregated RJC, SKA, RAJ, RJA, RJB, RJC, RJE, RJF, RJH, RJI, RJM, RJN, RJO, RJR, SKA, SKX, SRX),

SDV (aggregated DGS, DGH, DGX, DGZ, SDV),

COD, HAD, HKE, LIN, NEP, PLE, POK, POL, SOL, WHG.

All remaining catch to be aggregated into an '**OTH**' class.

7.3.3 WGBIE: (2018 data requested)

Provide data by filling the spreadsheets described in section 7.3.5 and in Annex 1.

Relevant stocks: southern hake (hke.27.8c9a), northern hake (hke.27.3a46-8abd), black-bellied anglerfish (ank.27.78abd), white anglerfish (mon.27.78abd), white anglerfish (mon.27.8c9a), black-bellied anglerfish (ank.27.8c9a), megrim (meg.27.8c9a), four-spotted megrim (ldb.27.8c9a), megrim (meg.27.7b-k8abd) and four-spotted megrim (ldb.27.7b-k8abd).

7.3.4 WGBFAS: (2018 data requested)

Provide data by filling the spreadsheets described in section 7.3.5 and in Annex 1.

7.3.5 WGMIXFISH-ADVICE Data format

Information on vessel length and *métier* used is kept separately in two columns in the .csv files (Annex 1, sheet WGMIXFISH-effort, sheet WGMIXFISH-catch). **To specify the *métier*, use exactly the same tags as used for InterCatch** (Annex 1, sheet IC Metier tags)**.**

A field is included to specifically flag FDF (Fully Documented Fisheries) Vessels. As some vessels are involved in FDF *métiers* in one area (e.g. North Sea), while being involved in non-FDF *métiers* in another (e.g. West of Scotland), it is important to flag these vessels at the fleet level,

and not only at the *métier* level. Please leave the field blank for the non FDF fleet, and write "FDF" for the FDF flagged vessels.

Two comma separated (.csv) files should be provided:

1) A single .csv file reporting *métier* and vessel length disaggregated effort;

2) A single .csv file reporting *métier* and vessel length disaggregated catch.

Both files should be sent electronically as .csv files to data.call@ices.dk, clearly indicating in the subject of the file name "2019 WGMIXFISH-ADVICE" [country] [*metier*_catch/*metier*_effort]" (example: 2019 WGMIXFISH-ADVICE U_ metier catch).

Annex 5: Proposed data call update for 2020

7.3.1 WGMIXFISH-ADVICE Data Requested

WGMIXFISH produces fleet-based mixed fisheries forecasts for four ecoregions, the Greater North Sea, Celtic Seas, Baltic, Bay of Biscay and Iberian Coast. WGMIXFISH intends to develop advice for the North Sea, Celtic Sea, and Iberian waters in 2020. This year the data call has been updated to provide consistency between ecoregions and advance the groups capabilities to explore biological and technical interactions. This data call is structured to provide biological and economic information at the level of DCF metier level 6 and the vessel length category, disaggregated by ICES divisions. ICES requests estimates of landings (tonnes and value) and effort (kwDays, days at sea and number of vessels) for 10 years of data (2009 – 2019), for the ICES divisions and species outlined in the table 1.

Table 1: ICES Divisions and species requested by the WGMIXFISH data call

ICES Areas	Species FAO code
27.3.a.20, 27.3.a.21, 27.3.a, 27.4.a, 27.4.b, 27.4.c, 27.6.a, 27.6.b, 27.7.a, 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.8.a, 27.8.b, 27.8.c, 27.8.d, 27.9.a	CAA (*Hippoglossus hippoglossus*) COD (*Gadus morhua*) DAB (*Limanda limanda*) FLE (*Platichthys flesus*) GUG (*Eutrigla gurnardus*) GUR (*Aspitrigla cuculus*) HAD (*Melanogrammus aeglefinus*) HER (*Clupea harengus*) HKE (*Merluccius merluccius*) HOM (*Trachurus trachurus*) LBD (*Lepidorhombus boscii*) LEM (*Microstomus kitt*) LEZ (*Lepidorhombus* spp.) LIN (*Molva molva*) MAC (*Scombrus scombrus*) MEG (*Lepidorhombus whiffiagonis*) MON (*Lophius piscatorius*) NEP (*Nephrops norvegicus*) *** **Note**: FU must be provided here, i.e. NEP.FU.16 NOP (*Trisopterus esmarkii*) PLE (*Pleuronectes platessa*)

	POK (*Pollachius virens*) POL (*Pollachius pollachius*) RJU (Raja *undulata*) RJA (aggregated rays and skates: RJC, SKA, RAJ, RJA, RJB, RJC, RJE, RJF, RJH, RJI, RJM, RJN, RJO, RJR, SKA, SKX, SRX) SDV (aggregated dogfish: DGS, DGH, DGX, DGZ, SDV) SOL (*Solea solea*) SPR (*Sprattus sprattus*) TUR (*Scophthalmus maximus*) WHB (*Micromesistius poutassou*) WHG (*Merlangius merlangus*) WIT (*Glyptocephalus cynoglossus*) All remaining catch should be aggregated into an **'OTH'** class.

7.3.1 WGMIXFISH-ADVICE Data Format

This data should be submitted in the following format. Failure to do so will result in file rejection and a request for resubmission.

Files: Two comma separated (.csv) files should be provided, one reporting 'effort', and the other reporting 'catch'.

Format: These two files should adhere to the following format outlined in Annex 1 for 'effort' (sheet "WGMIXFISH-effort") and 'catch' (sheet, "WGMIXFISH-catch").

Coding: Data entries must be fully consistent with the coding provide in the Annex 1 and outlined below:

- **ID:** Unique identifier
- **Country:** two letter short code as per Annex 1.
- **IntercatchMetierTag:** Métier should match what has been submitted to InterCatch. A list of accepted metiers can be found in Annex 1 (sheet "IC Metier tags").
- **VesselLengthCategory:** Vessel length categories are should be specified using one of these exact codes: "<10m", "10<24m", "24<40m", ">=40m".
- **FDFVessel:** Fully Documented Fisheries should be identified here using "FDF". Please leave the field blank for the non-FDF fleet.
- **Area:** ICES divisions should match those in Annex 1 (sheet "ICES area codes").
- **Species:** Should be consistent with the three letter FAO codes outlined in Table 1. Except in the case of *Nephrops*, which the Functional unit must be concatenated to the species name, i.e. a catch of *Nephrops* in FU 16 should be noted as "NEP.FU.16" in the species column. In the case of *Nephrops* caught outside of an FU please provide the subarea, i.e. for *Nephrops* caught outside of an FU in ICES Subarea 27.7 as "NEP.OUT.7".
- **Landings:** Estimated landings in tonnes (live weight). Including landings below minimum conservation reference size.
- **Value:** Estimated total value of the landings in euro.

- **Discards:** Only supply a discards in tonnes if none has been submitted to InterCatch. Or if specific discard information exist for each vessel length category.
- **KWdays:** Fishing effort in kW-days, i.e. engine power in kW times fishing days.
- **DaysAtSea:** Number of days at sea.
- **NoVessels:** Number of vessels executing this activity at this level of aggregation.

Submission: Both files should be submitted to data.call@ices.dk. File name must follow this format "2019 WGMIXFISH-ADVICE" [country] [*metier*_catch/*metier*_effort]" (example: 2019 WGMIXFISH-ADVICE U_ metier catch).

Annex 6: Issue lists by area

Iberian Waters

Data issues

1. Some of the landing data are not provided at the species level. Depending on the Country/Laboratory and year, landing data were submitted at the species level, at the group of species level or at both levels. Spain provides all data at group of species level: e.g. *Lophius spp*. Portugal submits data at the species and at group of species: *Lophius piscatorius*, *Lophius budegassa* and Lophius *spp*. Mixed fisheries advice requires working at species level so data must be split previously. This issue was detected for species included (or to be included) in the mix fisheries advice: Lophiidae, *Trachurus spp.* and *Lepidorhombus spp.* and *Solea spp*.
2. Discard estimates, BelowMinimumSize (BMS) catches and discards recorded in logbooks are not provided via Accessions. Using InterCatch as the source of discard information can only provide discard data for assessed stocks and for those where IC was used for discards raising. Discard data will not be available for other species.
3. RDBES: There are some inconsistencies in the scientific name of species across the years (e.g. *Scomber colias* appears in 2010-2011 instead of *Scomber japonicus* used since 2012 onwards). Also, in some cases the taxonomic group level changed (e.g. from genus to family), not being possible to follow the landings correctly. The RDBES should be updated to change the actual scientific names.
4. The following tasks were identified for the WGMIXFISH group:
    a. A thorough quality control of the time-series available to check the internal consistency of each source of data (Accessions, InterCatch and RDBES).
    b. A cross-validation analysis of data from the different sources.
    c. To evaluate the best source of data to be used for each piece of information.
    d. To set a workflow for the extraction and processing of input data for Iberian Waters Mixed Fisheries advice.

Data call

1. Several species were identified to be included in the data call for Iberian Waters. These species are target species of the demersal fleets considered in the mixed fisheries model (*Scomber scombrus, Trachurus trachurus, Nephrops norvegicus, Micromesistius poutassou, Pollachius pollachius, Solea solea)* and other vulnerable and potential choke species for these fleets *(Raja clavata, Raja brachyura, Raja montagui, Raja naevus).*

2. In the next data-call, data from a 3-year period (2017, 2018 and 2019), including these additional species, will be asked to be submitted through Accessions. It must be explicit in the data call that landings data shall be submitted at the species level and effort and landings at métier level 6.

Model

1. It is planned to include new species in the FLBEIA model for Iberian Waters in 2020. Most of the selected stocks to be included are ICES category 3 or higher. It is proposed to follow the methodology developed by García (WD, WGMIXFISH-METH, 2018) for the forecast estimations of these stocks.
2. At least three widely distribution stocks (blue whiting, mackerel and horse mackerel) are target species of the demersal fleets of Iberian Waters region. Their inclusion in the Iberian Waters model could be possible means the definition a special fleet responsible of catches out of the Iberian Waters geographical area.
3. Since 2018, the Norway lobster fishery was closed (TAC=0) in Functional Units 25 and 31 (Division 27.8.c), with a small catch allowed for a monitoring programme (sentinel fishery). This closure prevents from including these two stocks in the model in the short term.

North Sea

Data

- Inconsistencies in submission of metiers between effort and catch data submissions (i.e. metier has catch but zero effort)
- Inconsistencies in the metiers within the catch and effort data with metiers submitted to InterCatch
- Inconsistencies in the total landings per stock within the catch data with total landings by stock within InterCatch
- Aggregation levels in catch and effort submissions are sometime aggregated across ICES divisions
- Data from Norway are not consistently available
- InterCatch data prior to 2009 is incomplete for many stocks
- 5 Nephrops functional units do not have fishery independent abundance estimates
- Economic data at required level of disaggregation is currently unavailable
- Data needed on vulnerable/sensitive bycatch species

Model

- Discrepancies/issues in reproducing the advice
    - The stochastic nature of the SAM forecast, used for some stocks, results in discrepancies in the advice produced from FCube and single species advice.
    - The North Sea whiting and Northern Shelf haddock stocks both have an industrial bycatch component which is treated separately in the single species forecast but is combined with landings in the FCube forecast.
    - Northern Shelf haddock has non-standard forecast settings/procedures.
- Inclusion of age distributions by fleet

- Methods to include stocks without analytical assessments are being developed.
- Inclusion of vulnerable/sensitive bycatch species
- Development of bioeconomic model (FLBEIA) implementation to explore economic consequences of scenarios

Forecast

- TAC year catch opportunities by fleet are computed as a fraction of the TAC year single-stock advice, based on the proportion of wanted catch that fleet took last year (data year) compared to the total wanted catches of the stock. This assumption may not be completely relevant when a fleet did not catch its full quota of the considered stock in the previous year (data year). The model could be improved by adding additional considerations on the actual quota by fleet and/or country (final after swaps), provided that such data (from e.g. the FIDES database) can be made available in the data call.
- North Sea Nephrops is managed by whole area TAC for the North Sea but management takes place at a Functional Unit (FU) level. The mixed-fisheries analysis is based on the ICES catch advice for the individual FUs. As a consequence, fisheries behaviour between FUs will differ from the modelled runs and this influences the outcomes of the “Max” and ”Min” scenarios
- The scenarios do not assume any quota balancing through changes in targeting behaviour (i.e. changes in catchability and/or in effort distribution) and/or changes in access to quota, although the model used would allow investigating such alternative scenarios in the future.
- Addition of economic data will allow exploration of the economic consequences of the mixed fisheries scenarios

North Sea - Summary of data issues for 2019 submission

A summary of issues with catch and effort data submitted to accessions found during WGMIXFISH-METH 2019.

Outstanding:

- Odd metiers new for 2018 (though these will be automatically removed as there is zero catch)
    - DK "NA" effort = 248114 kwdays, landings = not in catch file
    - DK "" effort = 14437 kwdays, landings = not in catch file
    - FR "FYC-C", effort = 3408 kwdays, landings = not in catch file

- Lookup tables/code conversions
    - GUG - gug.27.3a47d added to InterCatch lookup table
    - WIT - wit.27.3a47d added to InterCatch lookup table
    - FU.6, 27.4outFU, - area 4, added to code
    - FU.11, FU.12, FU.13 - area 6A, added to code

Resolved:

- Submitted files
    - NL - submitted a large number of files. A resubmission has been received to reduce the number of files. This resubmission needed a unit conversion for landings (kg to tonnes).
    - UKS - Missing some stock codes in catch file (OTHER misnamed as ""). Resubmitted
    - BE - WGBIE catch data for 2009-2017 has been resubmitted in 2019. Resubmission of all records - total landings is the same but "Value" has changed.
    - UKE/UKN - effort file was missing from the sharepoint though it had been submitted. File now added to sharepoint
    - UKE/IE - IE WGCSE catch file has UKE data in it?? Colin and Claire has sorted this now.

- Effort data issues
    - GE - had some duplicate lines for 2018 arising from last year's submission which were updated in this year's submission

- Catch data issues
    - BE - removed older submissions for WGBIE as these are now updated with this year's submission
    - Some new area codes for NEP stocks - added to lists of NEP stock area codes

Celtic Sea

Documentation:

- Continued work moving code from GitLab to TAF
- Update stock annex
- Need to streamline the fleet data generation script (> 2000 lines of code).

Data:

- There may be some incomplete discard data in InterCatch, and we need to identify where.

Hake 3a46-8abd

- Difficulties reproducing exactly the catch forecast (~ 5% difference) and SSB forecast (~ 33% difference). This is a model issue.
- Difficult to account for catches from other areas (e.g. 4, 6, 8, 7a).

Meg 7b-k8abd

- Age-based Bayesian model, where we take the median from the assessment as input to a deterministic forecast. Some problems here in replicating the forecast to a reasonable degree of accuracy.
- Difficult to account for catches from other areas (e.g. 4, 6, 8, 7a).
- Some issues with splitting the catches among species due to multiple FAO codes in data submissions. Need to make assumptions consistent with the assessment.

Mon 7b-k & 8abd

- Some issues with splitting the catches among species due to multiple FAO codes in data submissions. Need to make assumptions consistent with the assessment.