Deliverable No. 5.5

Project acronym: **EcoFishMan**
Project title:
"Ecosystem-based Responsive Fisheries Management in Europe"
Grant agreement No: **FP7-265401**

Project co-funded by the European Commission within the

Seventh Framework Programme

Start date of project: **1st March 2011**
Duration: **36 months**

Due date of deliverable: 31st March 2013	
Submission date:	27th January 2014
File Name:	D 5.5 ECOFISHMAN Report on RFSM prototype 4 tested in case study 2 and 3
Revision number:	01
Document status:	Final
Dissemination Level:	PU[1]

Revision Control

Role	Name	Organisation	Date	File suffix[2]
Authors	Jónas R. Viðarsson, Sigríður Sigurðardóttir, Sveinn Margeirsson,	Matís	27.01.2014	JRV
	Cristina Silva, Laura Wise, Hugo Mendes, Aida Campos, Maria de Fátima Borges	IPMA	27.01.2014	CS
	Karim Erzini, Mafalda Rangel, Jorge Gonçalves	CCMAR		
	Paul George Fernandes, Alan R. Baudron, Christoph Konrad	UNABDN	20.01.2014	ARB
	Hazel Curtis, John Anderson	SEAFISH		
	Allan Gibb, Mike Palmer, Sasha McGuire, Louise Cunningham	MS		
	Rosa Chapela, Marta Ballesteros, Jose Luis Santiago	CETMAR		
	Kåre N. Nielsen, Michaela Aschan	UiT		
WP leader	Sveinn Margeirsson	Matís	27.01.2014	SM
Administrative Officer	Oddur M. Gunnarsson	Matís		
Coordinator	Anna K. Daníelsdóttir	Matís	27.01.2014	AKD

[1] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

[2] The initials of the revising individual in capital letters

Executive summary

This report is a deliverable in Work Package 5 (WP5 - Case studies) in the FP7 project EcoFishMan. It reports on how the RFMS (Responsive Fisheries Management System) prototype 4 was applied, developed and tested in the Portuguese Crustacean bottom trawl fishery and the North Sea mixed demersal fishery - TR1 Scottish vessels; which are case studies in the project. The RFMS prototype 4 is a framework for making a Results-Based fisheries Management system, detailing how such a management is to be developed and implemented.

This is the fourth and final iteration in the development phase of the EcoFishMan project, as RFMS prototypes 1,2&3 have previously been produced, applied, tested and assessed for the Icelandic lumpfish fishery, the Icelandic mixed demersal fishery, the Portuguese Crustacean bottom trawl fishery and the North Sea mixed demersal fishery – TR1 Scottish vessels. The outcome of that work contributed to a new and improved version of the RFMS, i.e. prototype 4. This final version of the RFMS will also be tested on the Mediterranean (GSA17) mixed demersal trawl fishery in a simulation and acceptance test (D5.6).

The two case studies presented in this report, used to test the RFMS prototype 4, provide highly variable examples for development and implementation of RFMS. The Portuguese case includes all the vessels involved in a fishery that is relatively confined to a specific geographical area and fleet. The North Sea case on the other hand includes a large number of variable vessel types, targeting stocks that can move to other parts of the North Sea area and the Scottish TR1 fleet is in competition with other fleet segments.

Each of the two case studies followed in detail the framework provided in the RFMS prototype 4 to make Management Plans (MPs) that fulfil all requirements set by the authorities. The MPs include for example a number of firmly established Outcome Targets (OTs), which are based on agreed policy objectives. Each OT is then linked to an associated indicator, providing measurable performance goals for the fishery. A management strategy was then developed with the OTs in mind where the operators (fishermen and their associations) took over responsibility for much of the implementation, operation, documentation and monitoring, along with most of the associated costs and effort. Monitoring systems and instruments were agreed upon, as well as compliance and sanctions systems. A certified documentation system was also developed, identifying which documentations are required in order to validate performance of the MP.

Once the MPs developed by the operators had been approved by the authorities, the plans were “implement” through simulation modelling, where the effects of implementation on OTs were predicted based on available historic data and scientifically based assumptions.

The outcome of the Portuguese case study indicates that adoption of a RFMS is plausible and might even be a good alternative towards achieving the discard ban proposed in the reformed CFP. The outcome of the North Sea case is also favourable in that respect that operators representing a significant portion of North Sea fishermen managed to develop a common MP that realistically could be implemented in real-life, indicating that the RFMS could potentially be an alternative in such a complicated fishery. The main challenge there is thought going to be to get a large enough share of the operators, using the common resource, to take part in the RFMS. This can obviously present a challenge when many fleet segments and nations are fishing from the same stocks. Simulation of the North Sea MP unfortunately returned conflicting- and unsatisfactory results which could not give reliable indications on the consequences of implementing the plan.

This is the fourth and final iteration of case studies in the EcoFishMan project. The RFMS has now been applied to a variety of case studies and the results indicate that the RFMS developed in the project can potentially be applied to different fisheries with success.

Table of contents

1 Introduction 1

2 RFMS prototype 4...3

3 RFMS prototype 4 tested in case study 2 - The Portuguese Crustacean Bottom Trawl Fishery 7

3.1 Stakeholder identification... 7

3.2 MP0: description of the fishery 7

3.3 Pre-invitation meeting 7

3.4 MP invitation.. 7

3.5 MP3: Management plan developed by the operators based on RFMS prototype 4..................... 8

3.6 Implementation and results... 10

4 RFMS prototype 4 tested in case study 3 – North Sea mixed demersal fishery 14

4.1 Stakeholder identification... 14

4.2 MP0: description of the fishery 14

4.3 Pre-invitation meeting 14

4.4 MP invitation.. 14

4.5 MP2: Management plan developed by SWFPA and NESFO based on RFMS prototype 4........... 14

4.6 Implementation and results... 16

5 Conclusion and discussion...23

References 24

Annex I: Testing of RFMS prototype 4 in the Portuguese crustacean bottom trawl fishery

Annex II: Testing of RFMS prototype 4 in the North Sea mixed demersal fishery – TR1 Scottish vessels

1 Introduction

This document is a deliverable in work package 5 (WP5 – Case studies) in the FP7 project EcoFishMan. It is a report on how the RFMS[3] (Responsive Fisheries Management System) prototype 4, which is a deliverable of WP4, was developed, applied and tested in the Portuguese Crustacean bottom trawl fishery (case study 2) and the North sea mixed demersal fishery - TR1 Scottish vessels (case study 3); which are case studies in the project.

This is the fourth and final iteration in the development phase of the RFMS. The outcome of this run will serve as an indication of whether the RFMS is realistically applicable for different fisheries. The case studies will also contribute to a policy brief on documented and tested RFMS design (D4.7) and a road map for implementation of recommendations of the RFMS (D7.5).

RFMS prototype 4 is the fourth and final blueprint/framework in EcoFishMan on how to adopt a RBM (Results-based management) in a fishery. EcoFishMan WP4, which has the title "overall design of RFMS", supplied WP5 with the RFMS prototype 4. It was then the job of WP5 to follow the blueprint/framework, so that it could be tested on the previously mentioned case fisheries.

In accordance with the defined RFMS prototype 4 work procedures, WP5 case study 2 and 3 partners based their work on the previous RFMS prototype 3 experience explained in detail in Deliverable 5.4. The RFMS approach aims at delegating the formal responsibility for developing a MP (management plan) to the operator/s[4], in cooperation with the authorities[5]. The MPs were developed according to a series of official procedures defined in RFMS prototype 4, which ensure enhanced stakeholder involvement throughout the whole process, as all interested stakeholders are given opportunities to influence the MP. Approval of the final MP was in the hands of the EcoFishMan authority[6] which took on the role of official authorities responsible for the case fisheries.

In order for a MP to be applicable for approval it has to meet certain requirements, for example in regards to policy objectives in current Fisheries Management Acts, acceptance from all major stakeholder groups, cost recovery, scientific monitoring, documentation of performance etc. An important component of a successful RFMS is the reversion of the burden of proof, which means that operators need to accept increased responsibility of collecting data.

---

[3]*Responsive Fisheries Management System* (RFMS): RFMS is a term generated for use in the EcoFishMan project, and it is used to refer to the new system that we are proposing to develop. The RFMS is an adaptive management system that is results-based and ecosystem-based. The RFMS attempts to reduce micro-management by involving stakeholders and may (or may not) include elements of rights-based management and co-management, as appropriate.

[4]The *Operator* is an organizational unit with delegated authority to develop management plans and oversee or conduct fishing operations within the standards decided by a management authority. It is an organization that represents a group of similar resource users. It could be a group of fishermen fishing for the same type of resource and/or could be specified in terms of gear type or areas.

[5] *Management authority*: Organizational entity enacting authority in pursuit of the management objectives decided for a fishery. It represents the interests of the public, and it is ultimately responsible for the management. Authority could be a coastal state or the European Commission.

[6] University of Tromsø, CCMAR and University of Aberdeen represented the authority in the development and approval stages of the EcoFishMan case studies 2 & 3. Contact persons from UiT are Michaela Aschan (michalela.aschan@uit.no) and Kåre Nolde Nielsen (kare.nolde.nielsen@uit.no). Contact persons from CCMAR are Karim Erzini (kerzini@ualg.pt), Mafalda Rangel (mrangel@ualg.pt), Jorge Gonçalves (jgoncal@ualg.pt). Contact persons from University of Aberdeen are Paul George Fernandes (fernandespg@abdn.ac.uk) and Alan R. Baudron (alan.baudron@abdn.ac.uk).

The case studies reported in this document are the Portuguese Crustacean bottom trawl fishery and the North Sea mixed demersal fishery - TR1 Scottish vessels. The Portuguese case includes 30 trawlers targeting rose shrimp and Norway lobster off the West and South coasts of Portugal. The fleet is represented in the project by Portuguese and Spanish vessel owners' associations[7]. The fishery is currently managed under a TAC and effort quota management. The North Sea case includes the TR1 category (TR1 stands for trawlers using gear with 100 mm minimum mesh size) operating in the mixed demersal fisheries of the North Sea ICES area IV. The fleet is represented by the Scottish White Fish Producers Association (SWFPA) with includes 225 vessels and the North East of Scotland Fishermen's Organisation (NESFO) which includes 38 vessels. The TR1 fleet is currently managed under a catch quota and effort management.

The Portuguese case includes all the vessels involved in a fishery that is relatively confined to a specific geographical area and fleet i.e. the crustaceans generally do not migrate to other fishing areas and there is little competition from other fleet types. The North Sea case on the other hand includes a large number of variable vessels, targeting stocks that can move to other parts of the North Sea area and the Scottish TR1 fleet is in competition with other vessel types, as well as vessels from other nations. These two fisheries proved therefore very different cases for testing of the RFMS, giving an important indication on whether the RFMS is applicable for a variety of fisheries.

This report is broken into four main sections i.e. short introduction of the RFMS prototype 4, summary of development/testing in each of the two case studies and finally a discussion on results/conclusions from the case studies. In addition, all relevant working documents have been attached in appendices to make each step in the process more transparent.

[7] ADAPI – Associação de Armadores Das Pescas Industriais; AAPG - Associação De Armadores De Pesca Do Guadiana; APAC - Associação De Pesca Do Arrasto Costeiro; AAPM - Asociación de Armadores de Punta del Moral; AIAP - Asociación Isleña de Armadores Pesqueros

2 RFMS prototype 4

The objective of this chapter is to introduce the RFMS prototype 4, which is the blueprint/framework for development and implementation of a RBM that was tested in the two case studies covered in this report. RFMS prototype 4 is a deliverable of WP4. For full version of RFMS prototype 4 see D4.4.

The development of RFMS prototype 4 drew on experience gained from the first three iterations in the project i.e.

a. First iteration, which included the making of RFMS prototype 1 in WP4 that was tested on the Icelandic lumpfish fishery in WP5 and then evaluated/audited in WP6
b. Second iteration, which included the making of RFMS prototype 2 in WP4 that was tested on the Icelandic mixed demersal fishery and the Portuguese crustacean bottom trawl fishery in WP5 and then evaluated/audited in WP6
c. Third iteration, which included the making of RFMS prototype 3 in WP4 that was then tested on the Portuguese crustacean bottom trawl fishery and the North Sea mixed demersal fishery – TR1 Scottish vessels in WP5 and then evaluated/audited in WP6.

It also incorporated inputs from discussions with stakeholders and external advisors at EcoFishMan meetings (e.g. in Ancona (IT), Faro (PT), Copenhagen (DK), Edinburgh (SC), Lisbon (PT) and Brussels (BE)) and experiences with RBM in fisheries elsewhere e.g. the south Australian Spencer gulf prawn fishery and the New Zealand rock lobster fishery.

The previously proposed models for RFMS prototype 1, 2 & 3 have thereby been incorporated into this prototype 4, which is the final version developed in the EcoFishMan project. A number of additions and adjustments have been made during this process, such as that there may now be more than one authority (though with only one authority that is responsible for the MP invitation and the approval of the MP), operator and assessor in the RFMS, and the resulting RFMS may be designed as/within a nested system, for instance in order to reflect the different levels that typically are involved in decision making in a EU context. A public hearing, including an evaluation of the MP by the assessor, is to be held before the authority gives the final approval to the MP. To ensure that the assessor is in the position to evaluate the management plan development process, a log of this process should be provided by the authority. In addition to provide documentation and monitor the fishery, the operators in RFMS are formally made responsible for delivering assessments of stocks. This responsibility is though in most cases forwarded to competent institutions, such as local Marine Research Institutes. It is advisable that a certain level of cost recovery is included in the RFMS in order to motivate the operators to take charge of documentation, monitoring and assessment tasks. In practice, the extent to which responsibility is delegated to operators will vary between cases, depending on the capacity and interests of the operators in charge.

In addition to the conceptualisation of the RFMS and the general guidelines for making a MP, The RFMS prototype 4 also includes a chapter on potential approaches to implement RFMS within the coming CFP and a chapter on the process involved when developing this final version of the RFMS.

For the purpose of testing the applicability of the RFMS prototype 4 in case studies 2 and 3, the main attention was though on the actual guidelines for making a RFMS. Figure 2.1 gives an overview of the RFMS prototype 4 methodology, identifying procedural steps, main participants/contributors and their roles and obligations.

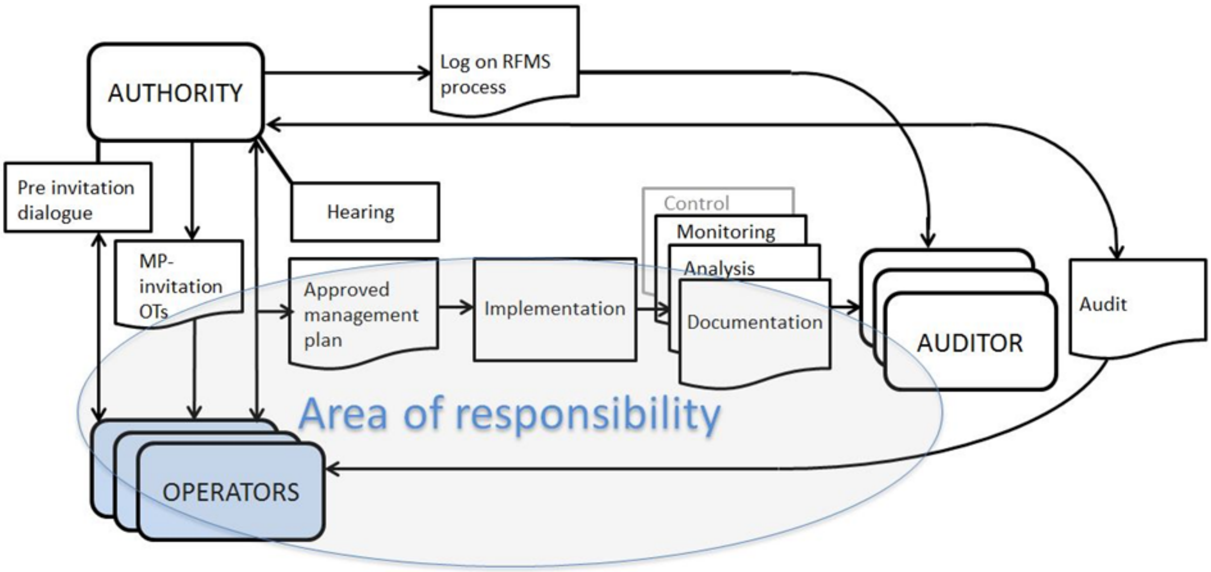

Figure 2-1: A conceptual model for RFMS Prototype 4

The procedural steps in developing and implementing a RFMS according to prototype 4 for a fishery are as follows:

Starting dialogues: The RFMS process according to prototype 4 begins with dialogues between the authority and the operator(s). The purpose of these dialogues is to create mutual understanding of the RFMS process: What does RFMS involve? What can operators and authority expect to achieve with RFMS, and what would it require from each party?

The MP invitation: If the parties agree that RFMS should be pursued in the given context, the authority prepares an invitation for a management plan. The MP invitation identifies the specific and measurable requirements - outcome targets (OTs) – that are to be achieved in the given context.

The management plan: Responding to the MP invitation, the operator proposes a management plan, which explains how the outcome targets can be achieved through a suggested set of management measures. The operator may cooperate with relevant scientific expertise about developing the plan. Such an expertise could among other things assist the operator with modelling the likely effect of suggested management strategies and measures. This would not only assist the operators in developing an effective plan but also render the plan more robust and convincing, hence making it more likely to be approved by the authority. The plan should also establish how the fisheries will be monitored and controlled.

Management plan evaluation: The authority will go through the operators MP proposal, and may request revisions or clarifications. In this way, communication between operator and authority will ensure progress with the MP draft. A complete MP draft will be "quality checked" by the authority. The focus of this check is two-fold: a) does the MP present a convincing strategy for achieving the OTs? b) Does it include an adequate strategy for obtaining information that allows the performance of the MP to be audited? If needed, the authority may seek expert support for undertaking this quality check of the MP from a relevant science community or the auditor(s) appointed in the MP. Quality check of the biological aspects of the MP may be compared to a management strategy evaluation, which often includes simulations of long term MPs, while evaluation of other (e.g. socio-economic) aspects of the MP aspects may require support from different types of expertise[8]. For

[8] Regarding biological aspects of MPs in a CFP context, it is relevant to note that the ICES and the STECF are already involved in similar work in the form of evaluating "long term management plans" and "recovery plans".

RFMS, however, the ex-ante evaluation of a MP may in practice involve less formalized processes of expert judgment. A less formalized process will be particularly relevant for RFMS in the context of small scale fisheries, low value fisheries, or data poor situations for which intensive scientific evaluation is either not possible or cannot be economically justified.

Management plan hearing and approval: If the authority finds that the plan is of a sufficient quality, it can approve it. Before doing so, however, it is recommended that the authority arranges a public hearing on the MP proposal, which allows comments to be raised by interested parties as wells as the wider public[9]. The purpose of this hearing is to promote public awareness, acceptance and public discussions regarding the MP. The role of the hearing will be consultative as it will be up to the authority to decide if and how issues raised in the hearing should be reflected in the MP before it can be approved.

MP implementation, control and documentation: If a MP is approved by the authority the operator can proceed with its implementation. Also at this stage the operator may cooperate with the authority (the authority may for instance supply enforcement services). While implementing the plan, the operator is responsible for collecting information required for assessing whether or not the outcome targets were (or will be) achieved.

Audit and management plan adaptation: The documentation provided by the operator during the implementation of an approved MP is reviewed by an auditor. The auditor should ideally be institutionally independent from both operator and authority, and be trusted by both.

The auditor assesses whether or not (or the extent to which) the outcome targets are achieved. Further, the auditor provides updated information about implemented management actions and their apparent consequences[10]. For the operator, the assessment will provide a basis for drafting modified MPs. For the authority, the assessment may be a basis for implementing sanctions or set conditions (if OTs were not achieved), for rewarding achievements, or for revising OTs.

If the audit shows that the OTs are achieved, the operator may continue with its MP. If the OTs are not met, the authority may request revisions for the MP, set stricter requirements, define conditions to be met within a certain time frame or implement other sanctions.

The operator's area of responsibility: The extent to which operators are made responsible for specific RFMS functions will vary between cases depending on the capacity and interests of the operators in charge. In the figure 2.1, this is illustrated by the ellipse with the text "areas of responsibility": the responsibility for the RFMS functions such as data collection, monitoring and control can be divided differently between operators, the authority or external contracted agencies. The operator may choose to leave specific functions (e.g. data collection or control) to be carried out by e.g. the authority in the way that they are carried out in the established management system. In any case, the division of responsibility for different functions should be made clear in the MP.

The RFMS process log: To enhance transparency and other aspects of good governance, a log of key events in the RFMS process should be provided by the authority, and be made available to interested parties. Such key events e.g. include main meetings between the operator and the authority, the submission of the MP invitation, hearing on the MP, and approval of MP. The authority should provide dates and brief minutes of such events. In addition to ensure that the RFMS is transparent to involved parties as well as external parties, the process log can be used by the auditor to provide a basis for evaluating the RFMS process (e.g. to assess the timeliness of responses from the authority).

[9] Some fisheries may not be devoted much wider public interest (e.g. very small or specialized fisheries). It is up to the authority to decide whether it is worthwhile to arrange a hearing in such cases.

[10] In practice, the effects of management actions may not be directly observed as this will depend on the type of management measures used as well as the type and quality of the collected information.

In simple terms the process can be broken into the following steps:

1. Identification of possible participants, such as authority, operators, assessors, stakeholders etc.
2. Making of a document describing the fishery and the current management system (MP0).
3. Pre-invitation meeting, where the authority presents the RFMS concept to interested operators.
4. MP invitation, which is a document containing a formal invitation by the authority to the operators to develop a MP according to RFMS.
5. Proposal for a MP, which is the first version of a MP developed by the operators sent to the authorities. Important elements in the MP are the OTs, associated indicators, management strategy, certified documentation system, cost recovery, allocating of responsibility and identification of auditor.
6. Feedback from the authority on the proposed MP.
7. Second draft MP presented to the authority.
8. Authority suggests changes and requests clarifications before holding a public hearing.
9. Public hearing, where different stakeholders can comment on the draft MP.
10. Final MP presented to the authority by the operators. Inputs from the public hearing are to be incorporated into the final MP where applicable.
11. Implementation according to the MP.
12. Documentation according to the MP.
13. Independent auditor evaluates performance and validates documentation. The auditor reports to the authorities and the operators, which decide if changes need to be made to the MP.

For the EcoFishMan project the case study implementation phase was simulated to provide indications on how the proposed MPs would perform in reality. The results were then forwarded to WP6, which represents the auditor in the project. Based on the report from the auditor (WP6) the authority (WP4) then made a decision regarding continuation of the contract (MP) and used it as input for making improved RFMS prototypes.

The RFMS prototype 4 was applied in case studies 2 and 3, in order to test and validate the applicability and potential performance of the proposed system. The case studies are discussed in the following chapters.

3 RFMS prototype 4 tested in case study 2 - The Portuguese Crustacean Bottom Trawl Fishery

This chapter reports on how the RFMS prototype 4 was tested in case study 2 – the Portuguese Crustacean Bottom Trawl Fishery – and what were the main results and lessons learned. The discussion below is a summary of a long and extensive process, but detailed documents covering each procedural step are attached in appendices.

3.1 Stakeholder identification

In accordance with the defined WP4 RFMS work procedures, the EcoFishMan case study 2 participants (IPMA and CCMAR) started by identifying possible stakeholders that could be included in the case study. Since this was the third run in the Portuguese case study the list from the previous runs could be used for reference and just revised in accordance with experience from the previous runs. The potential authority, operators and assessors were identified along with a large number of stakeholder groups and their representatives. Most of the identified stakeholders were contacted and given opportunities to provide input to the development of the MPs in the Portuguese case study. The full stakeholder list can be seen in Annex I.

3.2 MP0: description of the fishery

A detailed description of the Portuguese Crustacean Bottom Trawl Fishery was produced (MP0), highlighting the current management system, operators, authority, assessors and various stakeholder groups. Management objectives, stock status, importance of the sector for the national economy and regional development, fleet segments and target species; along with other environmental, social and economic factors to be considered in the RFMS. The full MP0 can be seen in Annex I.

3.3 Pre-invitation meeting

The next step in the RFMS process was to start the dialogue with potential operators i.e. the pre-invitation meeting. CCMAR represented the authority in this case, IPMA acted as advisors/consultants to the Portuguese operators and CETMAR did the same for the Spanish operators. CCMAR, IPMA and CETMAR presented the RFMS concept to representatives from the Portuguese and Spanish operators, government and other key stakeholders[11]. Both Portuguese and Spanish stakeholders associations, representing the fishing operators licensed to take part in the Portuguese crustacean bottom trawl fishery, showed immediate interest in the RFMS concept, although expressing some concern over some management objectives included in the Common Fisheries Policy.

3.4 MP invitation

Following the pre-invitation meeting a formal MP invitation was sent to the operators (see Annex I). The operators represented by their associations accepted the invitation and committed to enter the process of making a MP according to RFMS prototype 4. IPMA assumed the role of consultants, with

[11] ADAPI – Associação de Armadores Das Pescas Industriais; AAPG - Associação De Armadores De Pesca Do Guadiana; APAC - Associação De Pesca Do Arrasto Costeiro; AAPM - Asociación de Armadores de Punta del Moral; AIAP - Asociación Isleña de Armadores Pesqueros

the responsibility of assisting the Portuguese operators in the development of the MP with CETMAR helping in the involvement of the Spanish operators[12]. CCMAR, on the other hand, took the role of the authority (DGRM[13]), assisted by UiT.

3.5 MP3: Management plan developed by the operators based on RFMS prototype 4

The operators, assisted by IPMA and CETMAR, entered in a MP development phase, which had to take into consideration the long term ecological sustainability of the crustacean resources and the optimum utilisation by the resource users. The MP sets objectives and strategies that aim to maintain ecologically viable stock levels for the main crustacean target species, ensure a profitable fishing industry, promote social stability and provide a feasible research framework for the development and monitoring of the proposed MP with participative management from all stakeholders involved. During this work, they were able to draw up on experience form the first two iterations that this case study was involved in (see D5.3 and D5.4) and feedback received from the auditor (W6).

Based on the official management objectives, a series of seven OTs (Outcome Targets) and associated indicators were established, providing measurable performance goals for the fishery. The Management objectives, OTs, indicators and defined frequency of measurements can be seen in Table 3.1

Table 3-1: Outcome targets and associated indicators identified in MP3 for CS2

Management objective	Performance Indicator	Measurement Frequency	Outcome Target
1) *Sustainable* harvesting of **rose shrimp** stock (obligatory)	CPUE index	Quarterly (ruling)	Average Yearly $I_{trigger}$ = 3.12 kg/h Average quarter daily target CPUE[14] must be above: Quarter 1: 45 kg/day Quarter 2: 27 kg/day Quarter 3: 16 kg/day Quarter 4: 20 kg/day
2) *Sustainable* harvesting of **Norway lobster** stock (obligatory)	Fishing Mortality; CPUE index	Yearly (ruling)	$I_{trigger}$ = 3.21 kg/h Average target year CPUE must be above 45 kg/day
3) Improve knowledge of **red shrimp** and **purple shrimp** stocks (obligatory)	logbook available (yes/no)	Quarterly (ruling)	Report location of hauls, no. of hours and commercial size categories of related catch
4) Reduce **discards** (obligatory)	% discard	Yearly (monitoring) Each 5-yr period (ruling)	Discard rate ≤ 50% (5yrs) Discard rate ≤ 25% (10yrs)

[12] Most of the Portuguese operators cooperating in the development of the case study 2 MP belong to the national association of trawl owners (ADAPI), with 12 members operating in the crustacean trawl fishery. Also, there are other eight Portuguese vessels which are now Spanish owned (although working under Portuguese flag) and five licences for Spanish vessels to operate in this fishery, associated to Spanish operators' associations.

[13] Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos (General-Directorate for Natural Resources, Safety and Maritime Services)

[14] CPUE is an acronym for Catch per Unit of Effort, nominal or standardized.

Management objective	Performance Indicator	Measurement Frequency	Outcome Target
5) **Profitable** and stable fishing industry (recommended)	EBITDA	Yearly (monitoring)	Each operator EBITDA > 0
6) Promote **social stability** (recommended)	Number of trainees	Each 5-yr period (monitoring)	On board training opportunities for 25 trainees
7) **Research framework** for the development of the MP (recommended)	Operator compliance (yes/no)	Yearly (monitoring)	All operators cooperate with IPMA in the scientific monitoring program

A management strategy was then developed with the OTs in mind where the operators should take over responsibility for much of the implementation, operation, documentation and monitoring, along with most of the associated costs and labour effort. Monitoring systems and instruments were proposed, as well as compliance and sanctions systems. A certified documentation system was also developed, identifying which documentation is required in order to validate performance of the MP. Methodology for choosing an auditor was established and plausible auditors suggested as e.g. the Department of Oceanography of the Azores University. Finally the formal planning process for making a MP according to RFMS for the Portuguese crustacean bottom trawl fishery was defined.

In accordance with the RFMS prototype 4 guidelines, IPMA and CETMAR (working as consultants and on behalf of the operators) began by drafting a MP proposal. This draft was based on MP1 and MP2 from the previous iterations in EcoFishMan. When the draft had been circulated amongst the operators, commented on and improved, the operators sent it to the authority (represented by CCMAR and UiT) and stakeholders for comments. Once the authority is satisfied with the draft they will call for a public hearing, where all interested stakeholders will be given opportunity to comment on the MP. Once the stakeholder feedback had been incorporated into the MP, a final MP draft was produced and submitted to the authority. The authority approved the MP3 and it was then "implemented" trough simulation modelling.

An integral component of a MP according to RFMS is the establishment of a certified documentation system, which is to specify what documentation is required in order to validate performance of the MP. A documentation format/process was suggested to the authority, specifying:

- relevant indicators for each of the OTs
- who should provide data concerning each indicator
- who should be responsible for processing, analysing and assessing the data in regards to each OT
- what should be the appropriate actions in case OTs are not being met
- Who should be responsible for implementing corrective actions
- Who should bear the associated costs

After some deliberations the EcoFishMan authority approved the suggested certified documentation system. The MP3 can be seen in Annex I.

3.6 Implementation and results

The MP was implemented and performance evaluated through computer simulation modelling. The simulation was done using a Rule Based Fuzzy Cognitive Map (RB-FCM) model, which simulated for a 10-year period the effects of implementing the MP3 on the following indicators:

- CPUE Index for rose shrimp (OT 1).
- CPUE Index for Norway lobster (OT 2).
- Discard rate in the fishery (OT 4).
- Revenues as a proxy for the EBITDA of the fishery (assuming costs are fixed).

CPUE Index for each species was calculated as the fleet species total landings per trip divided by the total number of hours spent fishing per trip.

Discard rate was calculated per trip as the percentage of catch that is discarded.

Revenue was assumed as a proxy for the EBITDA of the fishery after several attempts to gather information on the overall costs of the fishery. In Portugal only the companies listed at the stock exchange market are obliged to report on the EBITDA. Unfortunately, neither the DGRM nor ADAPI have detailed costs information for this specific fishery. Nevertheless, the crustacean fishery is known for high profits as the main target species have high market value, and although the petrol prices have increased in the past several years it is still a very profitable fishery and with no reported unemployment. Overall the total sector generates an EBITA of about 10-12% of its operational income. Therefore, it was assumed that any change in revenues will reflect changes in the EBITDA.

The three OTs not included in the simulation model are dependent on the delivery of data from the operators i.e. log books (OT 3), number of new trainees (OT 6) and operator compliance in regards to scientific monitoring program (OT 7); and could therefore not be realistically simulated.

The RB-FCM was then connected with a model that represents the two main target crustacean species (rose shrimp and Norway lobster) and three main fish by-catch species (horse mackerel, hake and blue whiting) population dynamics. The model is based on a number of functions that represent the population of a given stock, including components for recruitment, growth and natural mortality, along with numerous other functions.

The simulation model was intended to take into consideration various causes and effects, identified in the following causal loop diagram.

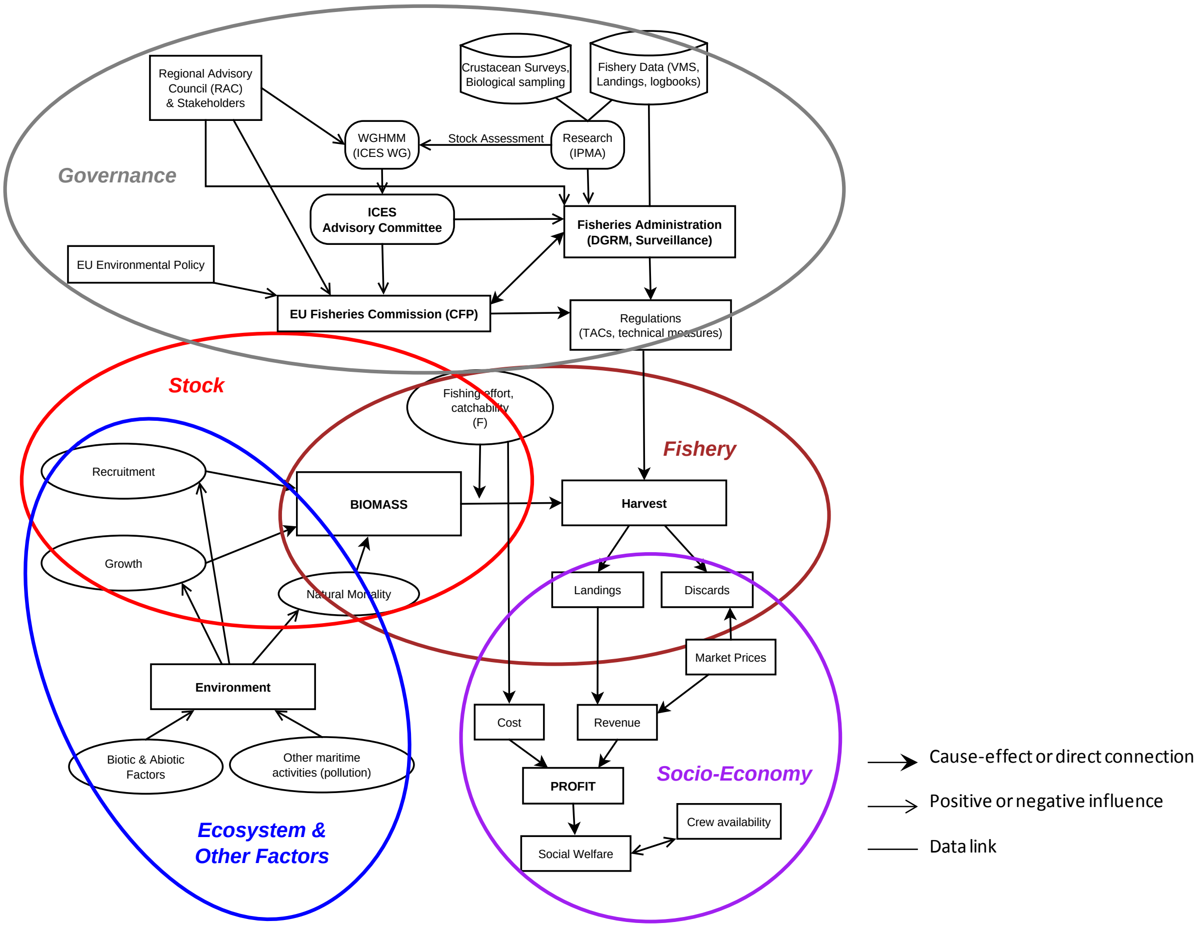

Figure 3-1: Causal loop diagram describing the dynamics of the crustacean bottom trawl fishery

Figure 3-1 shows that there are a large number of factors influencing the fishery, which could compromise the outcome of the model. The model was therefore validated by running MP0 and analysing the results in comparison with reality. The simulation of MP0 gave acceptable results, as the simulations showed good correlation with historic data.

Implementing the new management plan (MP3) sets two major challenges to the operators i.e. maintain a sustainable utilization of the target species (OT1 & OT2) and reduce discards (OT4). Currently, the deep-water rose shrimp stock is not included in ICES assessments, no reference points are defined and no TAC is set at European level. The assessment and management of this resource is responsibility of the Member State but still no quota is set. The establishment of OT1 means that the operators have to achieve an average yearly CPUE higher than 3.12 Kg/h which translates into a minimum biomass index for this species. Operators will have to find solutions to overcome this eventual limit, e.g. closed seasons or adjust fishing levels to obtain higher and sustainable revenue.

Reducing discards constitutes a major challenge for operators since estimates indicate that this fishery has a 35% to 70% discard rate (Azevedo et al., 2010). There are several causes for discards in this particular fishery, such as e.g. by-catch limits, low commercial value, MLS and quotas. In the several meetings IPMA and CETMAR had with the operators, discards and how to avoid them in this fishery were never properly discussed because the operators still do not envisage how to deal with this issue. Several options on how to avoid discards of species subject to landing obligation, namely the introduction of by-catch reduction devices (BRDs) to increase selectivity, and other options regarding market-based alternatives were discussed but stakeholders were never able to reach an agreement on how to tackle this problem. Therefore, two sets of several hypothetical scenarios, before and after the implementation of a zero discard-policy, were simulated to predict changes in discard rates. The main difference between these two sets is that in a context of a zero discard-policy, it is assumed that all catch from commercial species is landed but only the part of the catch above the minimum landing size (MLS) is sold. The scenarios were chosen from several hypothetical scenarios simulated using selectivity parameters from Campos *et al.* (2002) and Fonseca *et al.* (2005) on gear modifications to reduce fish by-catch and discards in this fishery.

The scenarios tested were as follows:

i) MP0, which is the current management plan where the fleet uses 55mm diamond mesh codend;
ii) SMC55, which includes implementation of MP3 where it is assumed that the fishery uses a 55mm square mesh codend;
iii) EG20, which includes implementation of MP3 where it is assumed that the fishery uses a grid with 20mm between bars associated with an escape opening in the upper trawl panel, designed to release fish by-catch, mainly small pelagic such as blue whiting;
iv) DMC55_Ban, which includes implementation of MP3 assuming that the fishery uses a 55mm diamond mesh codend, in the context of a zero discard-policy;
v) SMC55_Ban, which includes implementation of MP3 where it is assumed that the fishery uses a 55mm square mesh codend, in the context of a zero discard-policy;
vi) EG20_Ban, which includes implementation of MP3 where it is assumed that the fishery implements a grid with 20mm between bars associated with an escape opening in the upper trawl panel, in the context of a zero-discard policy.

Simulating implementation of these scenarios gives an indication whether the OTs set for the fishery are likely to be achieved.

In short, all scenarios achieved the CPUE OTs set for both deep-water rose shrimp (OT1) and Norway lobster (OT2). In the SMC55 scenario the CPUE for the deep-water rose shrimp showed much lower values when compared with the current situation, which is due to the fact that the square mesh codend presents an escape rate for this species above the escape rate of a diamond mesh codend with the same mesh size. The SMC55 on the other hand gave slightly higher CPUE of Norway lobster. The EG20 scenario rendered the same results as MP0 for CPUE of both deep-water rose shrimp and Norway lobster.

None of the scenarios where discarding was an option i.e. MP0, SMC55 and EG20 achieved the discard reduction outcome target (OT4). No discard reduction was observed using the SMC55 scenario and the grid scenario merely achieved an overall 2% discard reduction, due to 47% escapement ratio of blue whiting. Discard rates under a discard ban using diamond mesh, square mesh or grid all gave negligible discard rates (which is not surprising), ranging from 0,8%-1,5%, which is a big difference from simulation of the current MP0 that gave 55%-58% discard rate.

Results from the simulations show that revenues decreases slightly in scenario EG20 (i.e. grid scenario) when compared to MP0. The revenues however reduce significantly in scenario SMC55, where the application of square mesh codend results in 50-60% reduction in revenues. This is due to the escapement of both by-catch commercial species and deepwater rose shrimp resulting in lower CPUE for this species. In the scenarios under a discard ban, both the diamond mesh codend scenario and the grid scenario returned similar results, where catches were similar as within the current setup (MP0), but the by-catch was now sold instead of being discarded at sea. The profitability (or rather increased revenues) for both scenarios increased by 35%-55%, compared to MP0. The SMC55_Ban i.e. square mesh cod end under a discard ban, on the other hand resulted in a 20%-30% reduction in profitability (revenues), due to very low CPUE values for deep-water rose shrimp.

The results from the simulations indicate that the MP3 will achieve the CPUE and profitability OTs. However, implementing the SMC55 (square mesh codend) scenario results in considerable reduction in both CPUE and profitability, but manages nevertheless to stay above the OTs. The discard reduction OTs on the other hand will not be achieved applying a grid or square mesh codend, but combining that with a general discard ban is though a viable alternative.

The zero discard-policy results in a landing obligation and simulations show that operators' revenue increases due to added by-catch value. If operators are able to sell all commercial by-catch there is no motivation for them to use more selective devices. However, reducing by-catches is one of the main objectives of the new CFP and Member States must develop concrete measures to avoid unwanted catches. This MP already considers rewarding vessels using the most selective gears and that fish with more environment-friendly methods. Additionally, the European Commission will offer incentives and financial support for innovation and increased gear selectivity, anticipating that over time hauls will become more selective, saving fuel and handling time on board, and leading to less pressure on the ecosystems. Stocks will be able to recover faster and produce larger fish with improved market prices and better labelling of products, thus increasing the financial return for fishermen.

This MP3 gives an opportunity to reward vessels using the most selective gears to avoid by-catches and the implementation of discard reducing plans will surely be facilitated in a RFMS context, as the operators play an active role in designing the MP. The enhanced data availability considered in this MP would allow the operators to receive the right quota mix from the authority to reflect as much as possible on the actual fishing pattern from the crustacean bottom trawl fleet.

The conclusion is therefore that opportunities and procedures of this MP in a RFMS system can be ideal to face the new objectives of the CFP. Simplified rules and decentralised management will devolve power to the industry that will be able to choose how to best achieve the agreed outcomes adapted to the specificities of this fishery.

The guidelines provided by the RFMS prototype 4 were fairly easy to follow and the outcome suggests that the RFMS methodology could be successfully implemented for the Portuguese crustacean bottom trawl fishery.

The full description of the simulation model and the results from running it on MP0 and MP3 can be seen in Annex I.

4 RFMS prototype 4 tested in case study 3 – North Sea mixed demersal fishery

This chapter reports on how the RFMS prototype 4 was tested in case study 3 – the North Sea mixed demersal fishery (TR1 Scottish vessels) and what were the main results and lessons learned. The discussion below is a summary of a long and extensive process, but detailed documents covering each procedural step are attached in appendices.

4.1 Stakeholder identification

According to the procedural steps identified in the RFMS prototype 4 the EcoFishMan case study 3 participants (UNABDN, MS and Seafish) started by identifying possible stakeholders that could be included in the case study. The potential authority, operators and auditor(s) were identified along with a number of relevant stakeholder groups and their representatives. Most of the identified stakeholders were contacted and given opportunities to give input to the development of the MPs. The full stakeholder list can be seen in Annex II.

4.2 MP0: description of the fishery

A detailed description of the North Sea mixed demersal fishery was produced (MP0), highlighting the current management system, operators, authority, auditor(s) and various stakeholder groups. Management objectives, stock status, importance of the sector for the national economy and regional development, fleet segments and target species; along with other environmental-, social- and economic factors to be considered in the RFMS. The full MP0 can be seen in Annex II

4.3 Pre-invitation meeting

The next step in the RFMS process was the pre-invitation meeting, where Marine Scotland and UiT on behalf of the authority, presented the RFMS concept to some key operator representatives, government and other stakeholders. The Scottish White Fish Producers Association (SWFPA) and the North East of Scotland Fishermen's Organisation (NESFO) showed great interest in the concept and committed to receiving a formal MP invitation. SWFPA represents 225 vessels and is the largest organisation of its kind in the UK. The activity of its members accounts for 70% of the revenue of Scottish demersal fisheries. NESFO currently has 38 member vessels and is actively engaged in improving their operational environment and their overall efficiency through improved marketing and securing additional quotas.

4.4 MP invitation

Following the pre-invitation meeting a formal MP invitation was sent to the SWFPA and the NESFO (see Annex II). They both accepted the invitation and committed to enter the process of making a MP according to RFMS prototype 4. UNABDN and Seafish took on a role of consultants, with the responsibility of assisting the operators in the development of MPs, according to the RFMS. Marine Scotland and UiT, on the other hand, took on the role of the authority.

4.5 MP2: Management plan developed by SWFPA and NESFO based on RFMS prototype 4

SWFPA and NESFO, with the help of UNABDN and Seafish, entered in a MP development phase, which had to take into consideration the long term ecological sustainability of the North Sea resources and the optimum utilisation by the resource users. The MP had to set objectives and strategies that aim to maintain ecologically viable stock levels for the target species, ensure a profitable fishing industry and promote social stability.

Based on the official management objectives, a series of fourteen OTs and associated indicators were established, providing measurable performance goals for the fishery. The OTs and associated indicators can be seen in Table 4-1

Table 4-1: Outcome targets and associated indicators identified in MP2 for CS3

Management objective	Outcome Target	Priority	Indicator
Sustainable exploitation of fish stocks	Cod Partial F < 0.19	Obligatory	Partial F derived from stock assessment estimates by ICES (WGNSSK)
	Haddock Partial F < 0.3		
	Whiting Partial F < 0.22		
	Saithe Partial F < 0.3		
	Hake Partial F < 0.24		
	Reduce discards by 50% each year until 2017	Recommended	Estimates of discards from on-board observer programme
	Eliminate all discards of commercial species by 2017	Obligatory	Estimates of discards from fully documented fishery
	0% by-catch of total fin fish catch for any fin fish species	Recommended	Estimates of by-catches from on-board observer programme and from fully documented fishery
	LFI >= 0.3	Recommended	LFI as calculated from International Bottom Trawl Survey data (ICES)
Profitable fishing industry	EBITDA[15] > 15%	Obligatory	EBITDA
	Year to year change in landings <15%	Recommended	Landings statistics
Employment and settlement stability	Aggregated quota share of a single company < 12%	Obligatory	Quota share allocated
	Number of jobs in sector > 95% of number in of jobs 2013	Recommended	Employment statistics within fishing sector
	A minimum of 15% of vessels catch should be sold to local fish processors		Sales records

[15] Earnings before interest, taxes, depreciation and amortization

A management strategy was then developed with the OTs in mind where the operators took over responsibility for much of the implementation, operation, documentation and monitoring, along with much of the associated costs and labour effort. The management strategy consists of 22 articles, each specifying the rules that operators must obey to participate in the RFMS. Monitoring systems and instruments were proposed, as well as compliance and sanctions systems. A certified documentation system was also developed, identifying which documentation is required in order to validate performance of the MP. Methodology for choosing an auditor was established and an auditor suggested. Finally a formal planning process for making a MP according to RFMS for the North Sea mixed demersal fishery was defined.

In accordance with the RFMS prototype 4 guidelines, the operator (SWFPA and NESFO, aided by UNABDN and Seafish) began by drafting a MP proposal. This draft was then sent to the authority (represented by Marine Scotland and UiT) and stakeholders for comments. Once the authority and stakeholders had given their feedback, the operators produced a final MP draft. The authority then approved the MP.

An integral component of a MP according to RFMS is the establishment of a certified documentation system, which is to specify which documentation is required in order to validate performance of the MP. The operators suggested a documentation format/process to the authority, specifying:

- relevant indicators for each of the OTs
- who should provide data concerning each indicator
- who should be responsible for processing, analysing and assessing the data in regards to each OT
- what should be the appropriate actions in case OTs are not being met
- Who should be responsible for implementing corrective actions
- Who should bear the associated costs

After some deliberations the EcoFishMan authority approved the suggested certified documentation system. The full MP2 can be seen in Annex II.

4.6 Implementation and results

The MP2 was “implemented” and performance evaluated with computer simulation modelling. The simulation framework was composed of two distinct models i.e. the partial ecosystem model FishSUMS (Speirs *et al.*, 2010) and the Bio-economic simulation and optimisation model FishRent (Salz *et al.*, 2011). The ecosystem model component allowed simulating a mixed fishery where each species is modelled specifically and their prey-predator interactions are accounted for, while the bio-economic model component allows estimating economic outputs such as profits, costs and revenues. The end product allows for testing the MP against a wide range of dimensions, from biological (species-specific biomass) to economic (profit) and ecosystemic (Large Fish Indicator).

The methodology applied by running these two models to test the consequences of implementing the MP2 and comparing with the current situation was different from the other case studies in EcofishMan. As in the other case studies the specific results of each management measure applied were predicted, but in this case study the pre-given assumption was made that successful implementation of MP2 would gradually lead to best combination Fs (fishing mortality) for all species. The aim of the FishSUMS modelling was therefore to try to find the best combination of Fs for the respective species and what that would mean in regards to stock size, landing volumes and LFI. Those results were then be used as inputs into FishRent to model the bio-economic consequences of MP2 implementation. In other words, the two models were linked by substituting the biological component of FishRent with FishSUMS, as demonstrated in Figure 4-1.

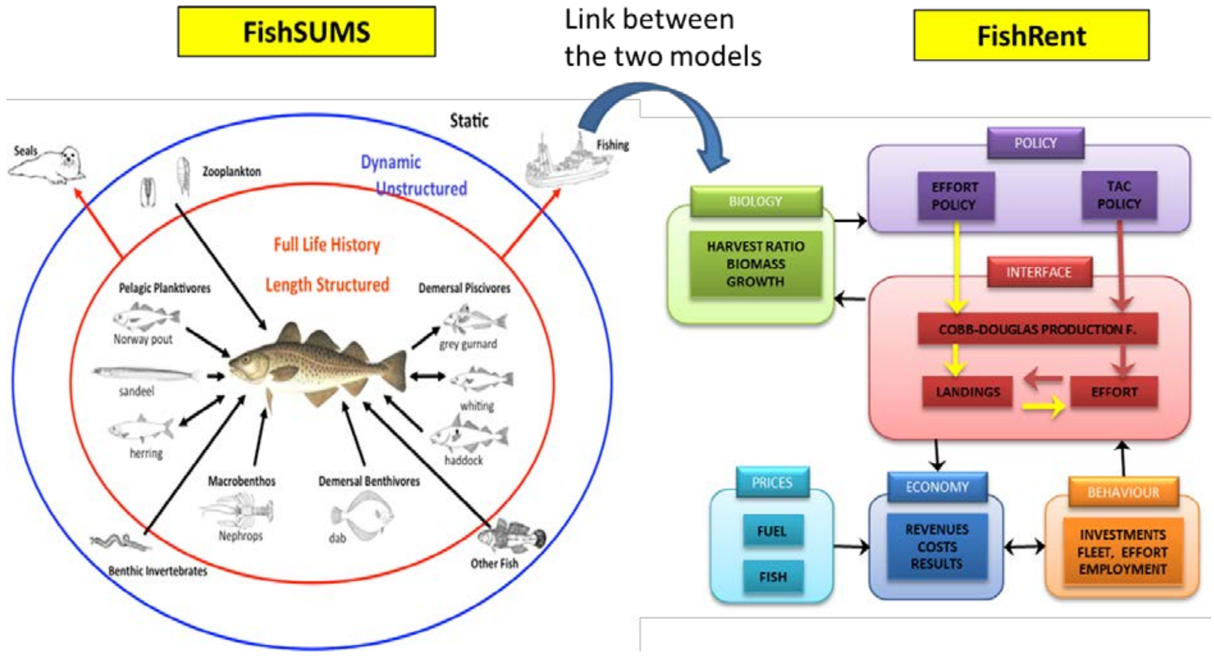

Figure 4-1: Schematic representation of the coupling between FishSUMS and FishRent

It was though fully recognised that by using results from FishSUMS, which is already parameter-rich, as input to FishRent, which then requires further parameterisation, inherently increases the complexity and reliability of the model. It is as well a “questionable” methodology to assume that the MP2 will in fact lead to best possible combination of Fs for all respective species.

4.6.1 FishSUMS

From a scenario-testing point of view, modelling a results-based management can prove challenging as it is not possible to simulate fishermen’s behaviour without introducing large uncertainty. However, when assuming a discard-free fishery with full compliance, as in the MP2, it is possible to simulate an ecosystem-based fishery with a multispecies approach. It is then possible to assess the impact of such approach on biomass, landings, and thus on the sustainability and the profitability of the fishery.

Given the limitation of the modelling, full compliance was assumed and MP2 was simulated for a mixed fishery operating without over-quota discards. Undersize discards, however, were assumed to persist. MP2 was developed for only a component of the North Sea mixed demersal fishery (i.e. Scottish TR1) in order to facilitate the exercise which involved frequent consultation with stakeholders. This constituted one of the major criticisms against the potential efficiency of such an MP when applied to only part of the mixed demersal fishery. Since Scottish vessels account for the highest contribution (22%, calculated from 2013 ICES Catch Statistics) to the North Sea landings of demersal finfish, for this exercise MP2 was simulated for the whole North Sea mixed demersal fishery. Considering the whole fishery instead of just a fleet segment, although a bold assumption, allowed us to bypass the limitation of simulating MP2 for Scottish TR1 only and to better assess the efficiency of MP. In order to simulate an ecosystem-based approach, all relevant species must be considered together since they interact with each other via prey-predator interactions. Therefore, MP2 was simulated to include the rest of the North Sea fisheries, including pelagic and industrial fisheries.

Although MP2 is planned for a 10 year period, simulations were run over a 20 year period (2011 to 2030) to ensure stabilisation of the model outputs. In order to estimate F_{MMSY} for the North Sea mixed demersal fishery, simulations have to be run for every possible combination of average fishing mortalities applied to the demersal species. Given the tremendous number of scenarios, only average fishing mortalities ranging from 0.1 to 0.5 with an increment of 0.1 were applied to the six demersal species in order to facilitate computation. The possible permutations resulted in 15,625 simulations that were tested. The six remaining species were subject to a constant fishing mortality equal to the one they experienced in the last year of the historical period i.e. 2010. In order to compare multispecies and single species approaches, an extra 15,626th simulation was carried out with the demersal species experiencing the single species F_{MSY} specified by ICES, shown in Table 4-2.

Table 4-2: F_{MSY} values for North Sea demersal species as specified by ICES

Species	FMSY
Cod	0.19
Haddock	0.30
Whiting	0.22
Saithe	0.30
Plaice	0.25
Hake	0.24
Herring	0.25

Following the simulation of the 15,625 possible scenarios, only scenarios which resulted in the SSB of North Sea stocks with biological reference points to be above specified reference points in 2030 were considered for further analysis to determine F_{MMSY}. These reference points were the precautionary biomass (B_{pa}) and the limit biomass (B_{lim}) and are given in the Table 4-3.

Table 4-3: Biological reference points for North Sea stocks as given by ICES

Species	B_{pa} (ton)	B_{lim} (ton)
Cod	150,000	70,000
Haddock	140,000	100,000
Whiting	315,000	225,000
Saithe	200,000	106,000
Plaice	230,000	160,000
Herring	1,300,000	800,000
Norway pout	150,000	90,000
Sandeel	215,000	160,000

In the eventuality of none of the tested scenarios achieving $SSB_{2030} > B_{lim}$ for all stocks, then scenarios with a maximum of species with $SSB_{2030} > B_{lim}$ were selected for further analysis.

To assess the productivity of each F_{MMSY} scenario, time series of total landings were computed over the 2011-2030 period for TR1 species as well as for all targeted species: TR1 species, pelagic species (herring), and industrial species (Norway pout and sandeel). These landings time series were also computed for the single species F_{MSY} scenario for comparison purposes. To assess the health of the ecosystem in each scenario, the 2011-2030 time series of LFI were calculated for each scenario and plotted along the single species F_{MSY} scenario for comparison. F_{MMSY} was identified as being the scenario achieving the highest TR1 landings in 2030, i.e. best long-term productivity for MP2, with a maximum of stocks with SSB in 2030 above B_{lim}.

None of the 15,625 possible scenarios tested achieved $SSB_{2030} > B_{pa}$ for all 8 stocks with reference points. A maximum of 6 out of 8 stocks with $SSB_{2030} > B_{lim}$ was achieved for 2500 F_{MMSY} scenarios, where either plaice or saithe had SSB_{2030} below B_{lim}.

The TR1 landings achieved with all the selected F_{MMSY} scenarios as well as with the F_{MSY} scenario stabilised by 2030 and were comparable to the TR1 landings observed in the first decade of the 2000s as can be seen in Figure 4-2.

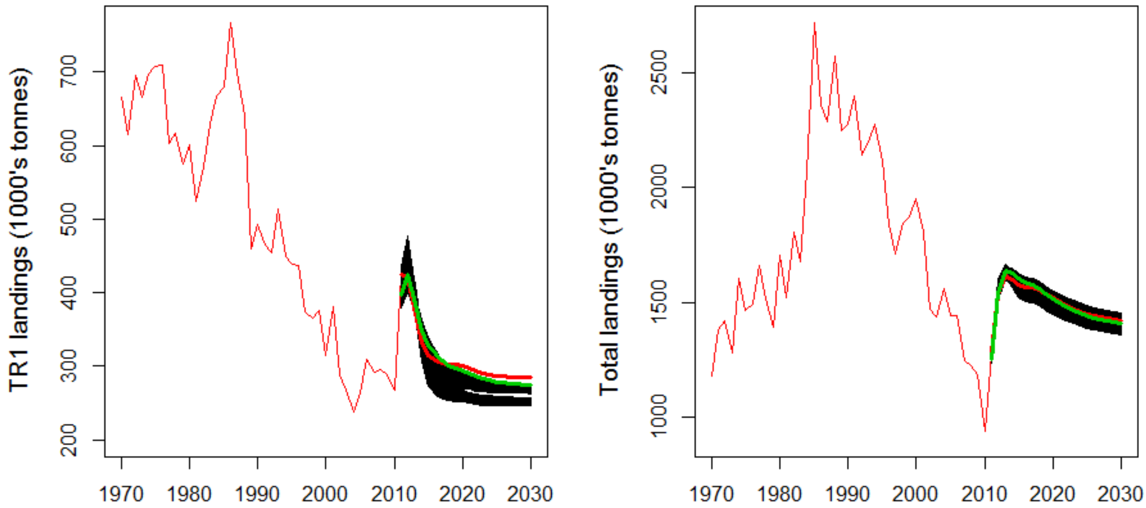

Figure 4-2: Sum of landings across the historical period and the simulated period (2011-2030) for the TR1 fleet segment (left-hand panel) and across all targeted species (right-hand panel), with the single-species F_{MSY} scenario in red, and the F_{MMSY} scenario which returned the highest yield at the end of the simulated period in green

The single-species F_{MSY} scenario resulted in the highest LFI by far, with a value of approximately 2.5 in 2030 which kept on increasing. In comparison, all selected F_{MMSY} scenarios resulted in a decline in LFI which stabilised at values between 1.5 and 2 approximately, while the best F_{MMSY} scenarios returned a LFI of 1.84 in 2030 (Figure 4-3).

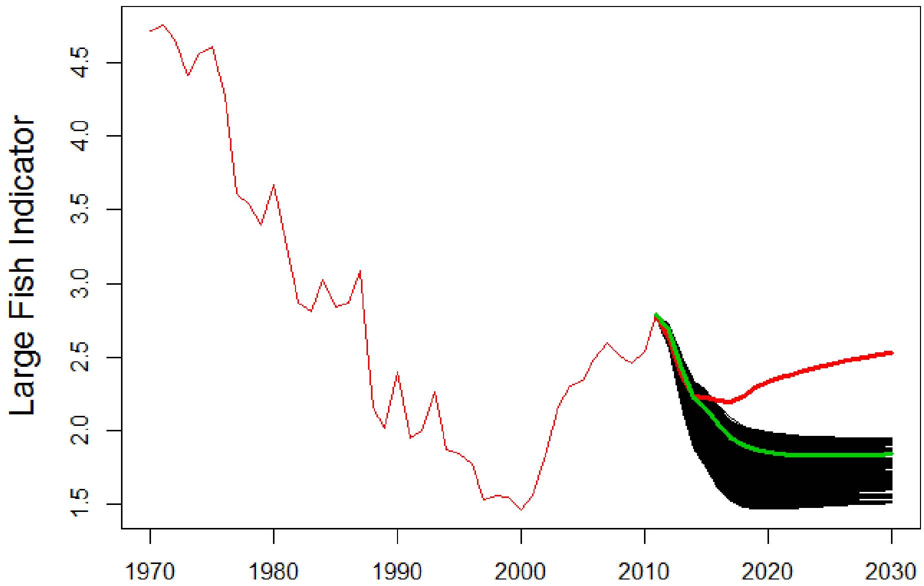

Figure 4-3: Large Fish Indicator index time series across the historical period and the simulated period (2011-2030), with the single-species F_{MSY} scenario in red, and the F_{MMSY} scenario which returned the highest yield at the end of the simulated period in green

Regarding the LFI => 0.3 OT, it is unlikely that MP2 will succeed in reaching this OT with the combination of Fs identified for the F_{MMSY} scenario.

The F_{MSY} approach led to a dramatic increase in cod SSB compared to the F_{MMSY} approach, while the levels of SSB achieved for all other species were similar with both scenarios excepted for whiting as mentioned above. The LFI projection curve returned by F_{MSY} also exhibited a shape similar to the cod SSB curve achieved with F_{MSY}. These two observations strongly suggest that the increase in LFI observed with F_{MSY} was driven by the increase in cod SSB and that the discrepancy between the LFI achieved with F_{MSY} and F_{MMSY} was due to one stock only. As a result, although F_{MSY} resulted in a much higher LFI it cannot be concluded that it achieved a healthier ecosystem than F_{MMSY}. In fact, F_{MMSY} maintained more stocks above B_{lim} and thus should be regarded a biologically safest option than F_{MSY}. A comparison of F_{MMSY} and the current situation of the North Sea TR1 fishery is given in Table 4-4.

Table 4-4 : Summary table comparing the current North Sea TR1 fishery with the identified F_{MMSY} scenario (SSB and landings are expressed in thousands of tonnes)

	TR1 stock	2010	2030
F	Cod	0.58	0.5
	Haddock	0.23	0.3
	Whiting	0.23	0.4
	Saithe	0.33	0.1
	Plaice	0.21	0.1
	Hake	0.16	0.3
SSB	Cod	47	107
	Haddock	227	229
	Whiting	366	231
	Saithe	208	1.12
	Plaice	342	153
	Hake	51	56
Landings	Cod	64	102
	Haddock	33	48
	Whiting	17	21
	Saithe	96	0.86
	Plaice	67	93
	Hake	3	9

Considering trophic interactions between commercial species revealed that the levels of fishing mortalities estimated by the single-species F_{MSY} approach failed to maintain the biomass of all commercial stocks within safe limits. In that regard, the F_{MSY} approach appears unsustainable. In comparison, the multispecies F_{MMSY} approach succeeded in maintaining the whiting stock within safe biomass limits but also failed to achieve a safe stock status for saithe and plaice and returned outputs closely similar to F_{MSY} regarding these two stocks. The plaice SSB achieved by 2030 by both F_{MSY} and F_{MMSY} was just below B_{lim} and comparable to the SSB experienced in the 1980s and 1990s, prior to the sharp increase in observed the late 2000s. The saithe stock, however, collapsed to a complete depletion by 2030 with both approaches, even when subject to a low fishing mortality (F=0.1) in the F_{MMSY} scenario.

This observation brings concern on the parameterisation of FishSUMS regarding saithe. Although the model outputs obtained during the parameterisation process matched the historical time series reasonably well for all stocks, it cannot be excluded that the set of parameters used for saithe do not allow the replication of the biological processes.

These results indicate that it is unlikely that the MP2 will achieve most of the ecological and biological OTs. However, given the assumption that MP2 will gradually lead to the best possible combination of fishing mortalities for all species and that the FishSUMS model practise has focused on searching for those best combinations, leaves a question if sustainable utilisation of the North Sea demersal stocks is then simply impossible. Either that; or the FishSUMS simulation methodology for implementing the MP2 is flawed in some way. This is a matter that requires further work.

4.6.2 FishRent

For the purpose of the socio-economic evaluation of MP2 in CS3, attempts were made over the last six months of the EcoFishMan project to couple the FishSUMS model used for the ecosystem simulation of the North Sea fisheries with the economic model FishRent (Salz *et al.*, 2011) which estimates the production (catches) and thus profit from capital (i.e. SSB), labour (effort in days-at-sea), species price per Kg, and costs. FishRent is the economic model used by the STECF (Scientific, Technical and Economic Committee for Fisheries) to assess fisheries economics, hence the choice of this model for the EcoFishMan project. This was an ambitious task which, to the best of our knowledge, has never been attempted before: most ecosystem models which return estimates of revenue do so by multiplying the landings by the species price.

The challenge arose in the parameterisation of such a modelling framework. FishSUMS, which is already parameter-rich, was first parameterised independently in order to carry out the ecosystem simulation of MP2 in CS3. Once the biological component of FishRent was replaced with the parameterised FishSUMS, the next step was to parameterise the Cobb-Douglas production function which is the 'engine' of FishRent in order to ensure that the new model returned reliable outputs. Coupling FishSUMS and FishRent increases the number of parameters and thus inherently increases the complexity of the model.

Given the complexity of the modelling framework, the parameterisation of the Cobb-Douglas function was first attempted using Bayesian statistical inference which is supposed to be more efficient than traditional frequentist methods when dealing with complex models. Unfortunately, in this case the use of Bayesian statistics proved unfruitful. A second attempt at parameterising the model was then carried out using generalised least squares. The parameterisation process proved challenging and time consuming as it appeared extremely difficult to produce outputs which matched the historical time series for all species.

The outputs returned by the best parameterisation achieved for the Cobb-Douglas production function matched the historical data reasonably well for all species with the exception of saithe for which the outputs underestimated the true values by several orders of magnitude. Despite considerable efforts, the reason for this mismatch remains unknown. A possible explanation would be that the data used in the parameterisation of saithe is flawed. The large discrepancy between the modelled and historical values for saithe resulted in the parameterisation not being considered satisfactory enough to allow for performing simulations. Given the short time left in the EcoFishMan project, no further work has been possible regarding this issue. While the ecosystem simulation of MP2 in CS3 has been successfully carried out, unfortunately the coupling of an ecosystem and economic model in order to perform socio-economic simulations proved too ambitious within the time frame allowed in the EcoFishMan project.

4.6.3 Conclusions and discussion

As mentioned above, further investigations are required to investigate the cause of the collapse of the saithe stock despite low levels of fishing mortalities. Aside a faulty parameterisation of the model, it is possible that the scenarios tested to identify F_{MMSY} are too restrictive. To facilitate computation, only average fishing mortalities ranging from 0.1 to 0.5 with an increment of 0.1 (i.e F=0.1, F=0.2, F=0.3, F=0.4, F=0.5) were applied to the six demersal species when simulating the various possible combinations of F. This resulted in 15,625 simulations which took 3 days to complete. However, such approach may well have overlooked other possible combination of Fs for TR1 species which would result in a better F_{MMSY} with all stocks within safe biomass limits. Ideally, average fishing mortalities ranging from 0.1 to 0.5 with an increment of 0.01 (i.e F=0.01, F=0.02, etc.) should be employed to investigate every possible combination of F across TR1 on a finer scale in order to identify F_{MMSY}. However, this would result in over 9.5 million of possible scenarios which, given the time frame of the EcoFishMan project, cannot all be assessed.

The full description of the simulated implementation of MP2 be seen in Annex II.

5 Conclusion and discussion

The work presented in this report has spanned over two years and the methodology applied has been developing as the project has progressed. It is the belief of those who have contributed to this work that the project has succeeded in making a generic framework (RFMS prototype 4) which can be adapted to variable fisheries. The two pilot cases described in this document provide variable challenges, which the RFMS has proven to be able to address with relatively good success. This does not necessarily mean that the RFMS could or should be applied in all fisheries, but it is at least a viable alternative.

The two management plans which are presented in this document have fundamentally the same main goals i.e. sustainable utilisation, profitable seafood industry and social sustainability. The Portuguese case study is though simpler and less data dependent; whilst the North Sea case is immensely complicated and data intensive. The management strategy in the Portuguese case is based on gear restrictions, CPUE and TACs; but the North Sea management strategy is based on catch quota restrictions and a comprehensive monitoring measures.

The variability between the two case fisheries provides a valuable insight into whether the RFMS is applicable for a variety of fisheries. The MPs developed also give the indication that it is realistically possible to make a MP based on RFMS that can be accepted by stakeholders and implemented in reality. The simulated implementation in the Portuguese case reveals that there are benefits associated with this approach which make the RFMS a viable alternative. The RFMS is also likely to be a valuable tool when it comes to meeting requirements of the reformed CFP i.e. the discard ban. The results and lessons learned from developing and simulating the implementation of the RFMS in the North Sea case showed that the RFMS is a plausible alternative when it comes to designing a Results-Based MP that operators and authorities can accept. The simulated implementation on the other hand failed to return reliable indications on the long-term consequences of implementation.

The application of the RFMS prototype 4 in the two case studies proved to be relatively easily understood by all stakeholders involved. The operators needed assistance from the EcoFishMan participants in some parts of the work, but that is to be expected. It is almost certain that in real-life circumstances the operators will have to hire experts to assist with various steps of the MP development. There have not been made many significant changes to the content of the RFMS framework between prototype 3 and the final prototype 4, but the main improvements are in respect to clarity i.e. it is easier for the operators to follow the framework and to understand what is required from them.

An important component of the RFMS prototype 4 is the public hearing, where various stakeholders are given opportunity to review, comment and impact the draft MP. Both case studies had difficulties getting a wide variety of stakeholders to take part in such a hearing. This may have resulted in lack of feedback from certain stakeholder groups. This is though a well-known problem that researchers have to deal with i.e. stakeholder participation is lacking because stakeholders do not have time or lack resources/incentives to participate in research projects. It is though the opinion of the EcoFishMan partners involved in the case studies that if/when a real public hearing on a potential MP according to RFMS will be held, there will not be a problem getting feedback or input from stakeholder groups. When faced with a "real case" RFMS implementation the stakeholders will be directly affected by the MP under advisement and will therefore have the necessary incentives to attend the public hearing.

When developing a MP according to RFMS guidelines it has become highlighted, both in case study 1 and case study 3, that when making a voluntary MP for a part of the resource users; the operators partied to the MP will not have adequate control over some of the OT and associated indicators. It is for example clear that the Scottish TR1 fleet does not have sole control over biological OTs in case study 3. This is a dilemma that resource users and policy makers have to deal with regardless of what management measures are being applied. It is though encouraging to report that the MP2 in the North Sea Case study was developed by two operators (associations) that that came up with a common MP.

It is important to keep in mind that the OTs in the MPs developed according to RFMS provide limits on (negative) impacts. This does not necessarily mean that achieving all OTs will lead to an optimal outcome for everyone. There will always be trade-offs between OTs, where increase in one OT can trigger a reduction in another. The RFMS seeks to ensure that broad spectrums of minimum acceptable limits are met and the results from testing RFMS prototype 4 in case studies 2 and 3 suggest that this can potentially be achieved.

References

Azevedo, M. Castro, J. Fernandes, A. C., Marín, M., and N. Prista (2010). Identification of fishing units with discarding level needed to be reduced. FAROS Project, Deliverable 1.1: 61 pp.

Campos, A., Fonseca, P., Erzini, K. (2002). Size selectivity of diamond and square mesh cod ends for rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) off the Portuguese south coast. Fish. Res. 58, 281–301.

Fonseca, P., Campos, A., Mendes, B., & Larsen, R. (2005). Potential use of a Nordmøre grid for by-catch reduction in a Portuguese bottom-trawl multispecies fishery. Fisheries Research 73, 49-66.

Salz, P., Buisman, E., Frost, H., Accadia,P., Prellezo,R., Soma, K. 2011. FISHRENT: Bioeconomic simulation and optimisation model. LEI report 2011-024. 73 pp.

Speirs, D. C., Guirey, E. J., Gurney, W. S. C., Heath, M. R. 2010. A length-structured partial ecosystem for cod in the North Sea. Fisheries Reasearch 106: 474-494.