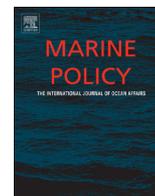




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## Development of a responsive fisheries management system for the Portuguese crustacean bottom trawl fishery: Lessons learnt



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### ABSTRACT

A prototype for a Responsive Fisheries Management System (RFMS) was developed in the context of the European FP7 project EcoFishMan and tested on the Portuguese crustacean trawl fishery. Building on Results Based Management principles, RFMS involves the definition of specific and measurable objectives for a fishery by the relevant authorities but allows resource users the freedom to find ways to achieve the objectives and to provide adequate documentation. Taking into account the main goals of the new Common Fisheries Policy, such as sustainable utilization of the resources, end of discards and unwanted catches, a management plan for the Portuguese crustacean trawl fishery was developed in cooperation with the fishing industry, following the process and design laid out in the RFMS concept. The plan considers biological, social and economic goals and assigns a responsibility for increased data collection to the resource users. The performance of the plan with regard to selected indicators was evaluated through simulations. In this paper the process towards a RFMS is described and the lessons learnt from the interaction with stakeholders in the development of an alternative management plan are discussed.

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### 1. Introduction

The new Common Fisheries Policy (CFP) is guided by principles of good governance, which include decision-making based on the best available scientific advice, broad stakeholder involvement and a long-term perspective. It recommends the development of specific multi-annual plans for each fishery, covering the stocks that are jointly exploited, with clearly defined time-frame and management objectives in order to contribute to the sustainable exploitation of the stocks and to the protection of the marine ecosystems concerned. These plans should be adopted in consultation with Advisory Councils, operators in the fishing industry, scientists and other stakeholders having an interest in fisheries management [1].

The European project entitled Ecosystem-based Responsive Fisheries Management in Europe (EcoFishMan) sought to develop a Responsive Fisheries Management System (RFMS) prototype based on Results-Based Management (RBM) principles involving

the division of responsibilities between a central authority and the resource users. The authority defines management objectives and specifications for a Management Plan, which will be developed by the resource users.

Within the scope of EcoFishMan, RFMS prototypes were developed and tested in an iterative process through role play with the purpose of testing its feasibility in four representative case studies, with gradual increase in complexity. The process developed in the Portuguese crustacean trawl fishery case study is described and the lessons learnt are discussed.

#### 1.1. Fishery description

The Portuguese crustacean trawl fishery is a limited access fishery. In 2011, the number of licensed Portuguese trawlers was 26, ranging from 358–414 kW, 90–150 GRT (Gross Register Tonnage) and 20–29 m of overall length. This fleet operates with two different cod-end mesh sizes, 55 mm for catching shrimps and 70 mm or greater for Norway lobster [2]. Besides Portuguese vessels, another 5 licenses are granted to Spanish fishing operators under a bilateral agreement between Spain and Portugal [3]. Most of the Portuguese and Spanish crustacean

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operators are associated to Producers Organizations (PO), with the Portuguese national association of trawl owners ADAMI<sup>1</sup> the most representative.

From 2008 to 2010, Portuguese crustacean trawlers annually landed nearly 2 thousand tons, corresponding to approximately 12 million euro of first sale at auction market, with the crustacean species accounting for 90% of the total value, with rose shrimp (68%) and Norway lobster (13%) as the most important species. With regard to the weight landed, rose shrimp ranked first (48%) followed by blue whiting (18%) (Source: DGRM<sup>2</sup> sales database).

No unemployment has been reported in the crustacean trawl fishing fleet and, to some extent, there is a deficit of working labor force since the number of new crew hirings has not kept pace with the increasing number of retirements.

The main fishing grounds are located at the shelf edge and continental slope off the southwest and south coast of Portugal, where the substrate is soft, composed of a mixture of mud and silt in different percentages, the preferential habitat of the main target species, the rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*). Rose shrimp occurs at depths between 150 and 400 m and although the areas of distribution overlap at depths of 300–400 m, the highest yields of Norway lobster are at the 500–600 m depth range [4–6]. Other deep water crustacean species, namely the red shrimp (*Aristeus antennatus*), the purple shrimp (*Aristaeomorpha foliacea*) and the scarlet shrimp (*Aristaeopsis edwardsiana*) [7], are only occasionally targeted or incidentally caught at depths greater than 500 m (Fig. 1).

Although the fishery aims to catch crustaceans, many other demersal fish species, which are targeted in other fisheries, are caught as by-catch. The most important commercial finfish by-catch species include blue whiting (*Micromesistius poutassou*), hake (*Merluccius merluccius*) and Atlantic horse mackerel (*Trachurus trachurus*) [9].

Discard ratios may vary considerably in this fishery, but were found to be generally high in all the studies previously carried out [10,11,12]. Discards are mainly composed of Atlantic horse mackerel, blue jack mackerel (*Trachurus picturatus*), undersized hake and blue whiting. Results from the discard sampling program onboard the Portuguese crustacean trawlers indicate that discards of rose shrimp and Norway lobster are negligible [13]. According to [14], the main reasons for discard practices of commercially valuable species in this fishery are by-catch limits of the crustacean fishery (e.g. horse mackerel and jack mackerel), minimum landing sizes (MLS) and quota limitation (e.g. anglerfish and hake). Many fish and invertebrate species are discarded due to low or null commercial value and/or no immediate market.

## 1.2. Present management regime

As in other multispecies fisheries, the level of knowledge with regard the state of the stocks exploited by this fishery is highly variable. Some stocks are assessed internationally, e.g. hake and Norway lobster (through the International Council for the Exploration of the Sea – ICES), while some are evaluated locally, e.g. shrimp species (through the national research agencies) and others have no formal assessment due to insufficient data or to low priority. Some of the stocks are managed through local and EU regulations (Total Allowable Catches or TACs, effort limits and technical measures) while others are subject only to national legislation.

An EU recovery plan is enforced since 2006 for Southern hake and Iberian Norway lobster stocks [15], aiming to rebuild the

stocks biomass within a 10-year period. The plan remains unchanged although the target biomass for Southern hake is no longer valid [16] and no clear objectives were set for Norway lobster. Based on this recovery plan, the Southern hake TAC is adjusted annually in accordance with the recommended fishing mortality under the ICES MSY framework approach and the number of allowed fishing days is reduced by 10% per year. An Individual Vessel Quota (IVQ) system is set for the Portuguese hake quota share distribution. With regard to Norway lobster, a 10% reduction in the TAC is added to the same effort reduction. Although catch advice is provided by areas smaller than the ICES Division, called Functional Units (FU), under the existing management system, the TAC is set for Division IXa as a whole [17]. This division is composed of five FUs (West Galicia, North Portugal, Southwest Portugal, South Portugal and Gulf of Cadiz).

Besides the TAC and effort control regime, the main EU regulation for technical measures, the Council Regulation No 850/98 [18], was amended by the Recovery Plan Regulation [15], to include catch restrictions in a box located off the Portuguese southwest coast, limiting the catch of Norway lobster to a by-catch of 2% of the total weight of the catch during the main fishing season (May–August) and 5% in the rest of the year.

The Portuguese regulation also establishes a 1-month closed season for the crustacean trawl fishery in January [19] and a limitation of 30% of fish by-catch, excluding blue whiting. On the other hand, the finfish trawlers operating for demersal fish in the area are limited to 30% of crustaceans by-catch [20]. Although the bilateral agreement does not require the Spanish operators to comply with the Portuguese regulations, they are only allowed to operate outside the 12-mile zone.

At present, the management system is top-down, although some interaction between the fisheries administration and the fishing associations occur. The fisheries administration is legally responsible for the management of the fisheries and all the related activities (licensing, regulation framework and control).

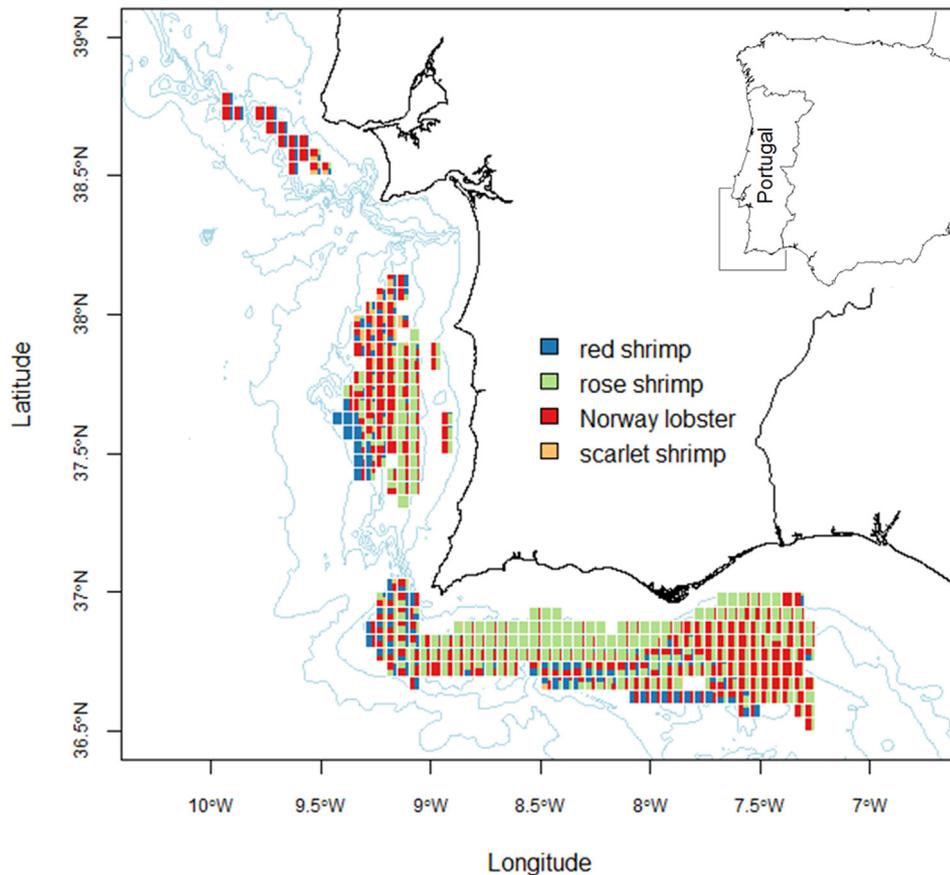
## 2. The new challenges of the Common Fisheries Policy

A new set of objectives and regulations for the CFP was agreed between Member States, to be effective from 1 January 2014, to bring fish stocks back to sustainable levels, put an end to wasteful fishing practices and create new opportunities for jobs and growth in EU waters [1]. To achieve this, the new CFP focuses, among other objectives, on banning discards, empowering the sector and decentralizing decision making, supporting small scale fisheries, improving the scientific knowledge on the state of stocks (data enhancement) and on the development of ecosystem multi-annual plans for the management of each fishery. The scope of the CFP also extends to measures related to processing and marketing for fishery and aquaculture products with, among other measures, the enhancement of eco-labeling for fisheries products and increased traceability, security and quality of the products marketed. The role of PO in monitoring, managing and ensuring the compliance of their members has also been strengthened.

With the reform of the CFP, effort must be devoted to address the governance, ecological, social and economic issues required to introduce an ecosystem-based approach to fisheries management (EAF) in Europe. Fisheries management needs to support the three pillars of sustainability (ecological, social and economic) and multi-annual fisheries ecosystem plans should be developed as a tool to assist managers and stakeholders in incorporating ecological, social and economic implications in their decisions. Because implementation of an EAF is complex and involves uncertainty and multiple objectives, the need for increased stakeholder participation in the management process is paramount. The involvement of

<sup>1</sup> Associação dos Armadores das Pescas Industriais.

<sup>2</sup> Direção Geral de Recursos Naturais, Segurança e Serviços Marítimos – the Portuguese Fisheries Administration agency.



**Fig. 1.** Crustacean species distribution in the crustacean trawl fishing grounds off southwest and south coasts of Portugal mapped using logbook data linked to VMS data [8].

fishers and the increased responsibility of PO are expected to increase the likelihood that management measures will be supported by the fishing industry and thus increase the likelihood of management success.

The new CFP aims to provide EU citizens with a stable, secure and healthy food supply for the long term. It seeks to bring new prosperity to the fishing sector, end dependence on subsidies and create new opportunities for jobs and growth in coastal areas. At the same time, it fosters the industry's accountability for good stewardship of the seas [21].

One of the major problems in fisheries, particularly within complex, multispecies fisheries like the Portuguese crustacean trawl fishery, is linked to the shortcomings of the particular form of micro-management that has been developed within the fisheries sector [22,23]. The implementation of the new CFP will hopefully reverse the prevalent perception that the existing management has generally failed to deliver well performing fisheries, especially from the perspective of the industry.

### 2.1. Responsive Fisheries Management System as a tool to implement the challenges of the new Common Fisheries Policy

RFMS is a term generated for use in the EcoFishMan project and refers to an adaptive management system that is results-based, ecosystem-based, ensuring long-term environmental, economic and social sustainability [24,25].

This innovative management system outlines a process of transferring responsibility for fisheries management to the resource users, provided that they document and achieve specified EAF objectives. The multi-annual Management Plan (MP) framework incorporates the three pillars of sustainability, reflecting ecological, social and economic objectives that should be reached

concurrently, as well as ways to improve cooperation and mutual understanding between policy makers and stakeholders to facilitate its implementation. Stakeholder involvement is strengthened by taking into account their knowledge and active participation throughout all the phases of the MP design, planning and implementation.

Overall, the RFMS seeks to reduce micro-management by involving stakeholders and increase the degree of co-management in a flexible system that can be specifically tailored to fit the principles of an ecosystem approach to a complex, mixed-fisheries and multi-stakeholder fisheries like the Portuguese crustacean trawl fishery.

The RFMS tackles some of the new challenges in the coming CFP with the development of multi-annual plans governed by an ecosystem approach with simplified rules and decentralized management. The burden of proof that the fishery is ecologically sustainable will be shifted towards the resource users, improving data exchange and more local management. By assuming an increased responsibility for management, the resource users gain enhanced opportunities for strategic planning and can design a management system to be responsive to the market aspects and time the harvest with regard to demand or product quality. The fishers will also have a better capacity to adapt their behavior to policy changes, such as the discard ban.

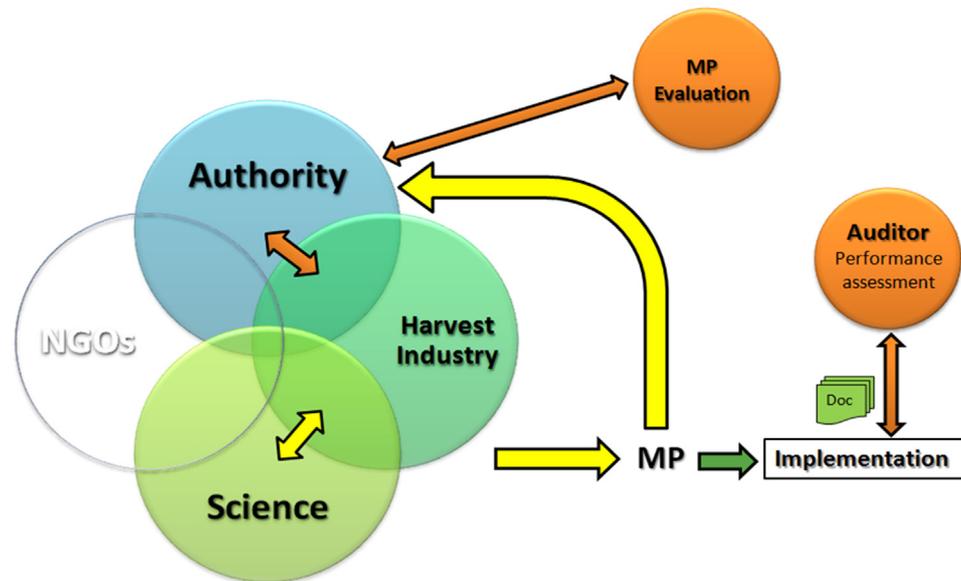
## 3. Responsive Fisheries Management System in the Portuguese crustacean trawl fishery

### 3.1. Management plan development

The experiment developing results based management system in the Portuguese crustacean trawl fisheries followed the concepts,

**Table 1**  
Common Fisheries Policy (CFP) goals and general objectives of the Portuguese crustacean trawl fishery case study within the framework of the Ecosystem Approach to Fisheries Management (EAF).

Pillars	CFP [1]	Case study
Ecological	-Populations above MSY levels -Minimize the negative impacts on the ecosystem -Gradually eliminate discards	-Sustainable exploitation of rose shrimp and Norway lobster -Do not increase effort -Reduce discards
Economic	-Economically viable and competitive fishery	-Profitable and stable fishery
Social	-Achieve social and employment benefits	-Promote social stability
Governance	-Appropriate involvement of stakeholders	-Involve resource users in planning (RFMS) [21]



**Fig. 2.** Iterative process used in the development of the Management Plan for the Portuguese crustacean trawl fishery following the Responsive Fisheries Management System (RFMS).

guidelines and protocols for RFMS, which were developed within the EcoFishMan project, and which were collectively referred to as the “RFMS prototype”. The RFMS prototypes were adapted throughout the project based on experiences with using them in case studies. The experiment referred to here followed the fourth and final RFMS prototype [26].

The understanding of the concepts and the participation of the operators (fishermen and/or fishermen organizations that take part in a specific fishery) in the planning process from the beginning are essential to develop a good cooperative environment and to enable operators to take on new responsibilities. In the Portuguese crustacean trawl fishery case study, the initial dialogue with the stakeholders included representatives of all the agents directly or indirectly dependent on, affected by or interested in the fishery (administration, fishing operators, research, market sector, consumers and non-governmental organizations). The main goals and priorities of the CFP based on an ecosystem approach were discussed and the general objectives of a 10-year MP for the Portuguese crustacean trawl fishery were outlined (Table 1). The possible related outcome targets (OT)<sup>3</sup> and associated indicators to measure the performance of such a MP were listed.

Based on this first interaction, specific outcome targets related to the biological, economic and social objectives were defined and the harvest industry, represented by the fishing associations, was invited to formulate a MP proposal. The MP was defined as a formal arrangement between the management authority and the operators and specifies the partners in the fishery and their respective roles, the agreed objectives for the fishery, the management rules and regulations that apply, and provides other relevant details about the fishery. In the MP proposal, the operators are required to establish how the OTs will be achieved and how the information is collected to allow an independent auditing. For practical reasons, some roles of the management authority and of the auditor were played by project partners, hereinafter referred to as “authority” and “auditor”.

An iterative process started (Fig. 2), with dialogues between the fishing operators representatives and the “authority” to develop a MP according to the RFMS specifications, with the Portuguese Institute for the Sea and Atmosphere (IPMA, I.P.) assisting the operators in this development. Considering that fishing activity is carried out by Portuguese and Spanish operators, the dialogues were extended to all operators, initiating cross-national discussions on mutual interests. The MP was presented to the “authority”, responsible for its evaluation

<sup>3</sup> Outcome Targets (OT), in the context of the EcoFishMan project are specific and measurable performance goals defined for a fishery on the basis of agreed and appropriately authorized general goals, standards and principles, as defined by the authorities based on the policy objectives. Outcome targets are found in policy documents, for instance the specific objectives for the future CFP listed in the Green

(footnote continued)

Paper on the future of the common fisheries policy (<http://www.ecofishman.com/about-ecofishman/definitions-a-interpretations-of-key-concepts>)

**Table 2**

Management objectives, Outcome Targets (OTs), performance indicators and compliance measures included in the Management Plan Proposal for the Portuguese crustacean trawl fishery according the Responsive Fisheries Management System (RFMS).

Management objectives	Outcome targets (OTs)	Performance indicators	Compliance
-Sustainable exploitation of the main target species	-Biomass indices $> MSY I_{trigger}$ for rose shrimp and Norway lobster	-CPUE index	-Monitor the fishery (quarterly and yearly) -Open/close areas or the fishery
-Reduce discards	-Gradually reduce discards	-% discards	-Change mesh size; introduce escapement devices/incentives -Land unwanted by-catch
-Profitable and stable fishery	-EBIDTA <sup>a</sup> $> 0$	-EBIDTA	-Fishing company internal measures
-Promote social stability	-25 on-board training opportunities	-Number of trainees	-Agree on a detailed on-board training program
-Involvement of resource users (RFMS); improve quality of data for stock assessment	-Formal cooperation with scientific institutions and collection of information on data poor species	-Established agreements for data collection and monitoring	-Improved quality of data

<sup>a</sup> EBIDTA is the acronym for Earnings Before Interest, Depreciation, Taxes and Amortization.

and approval. In accordance with the RFMS prototype 4, to be eligible for approval by the authority, the MP must:

- include a convincing strategy for achieving the outcome targets;
- include a documentation system that allows the assessment of whether or not the outcome targets are (or will be) achieved;
- allow a successful and rigorous auditing process conducted by an independent institution accepted by both authority and operators;
- go through a public hearing before final approval;
- have gone through a planning process in accordance with good governance principles.

In each iteration, the OTs were revised, the MP specifications were updated and the implementation of the MP was simulated using Rule-Based Fuzzy Cognitive Map modeling (RB-FCM) [27]. The final management objectives, outcome targets and indicators of the MP developed for the crustacean trawl fishery in Portugal after three iterations are shown in Table 2. OTs were based on up-to-date information at the beginning of the MP, and their reference levels can be adjusted during the MP period if additional information suggests that change is appropriate (e.g. environmental shift). The biological OTs aim to reach a sustainable exploitation of the main target species and gradually eliminate the discards of finfish species as discards of the crustacean species are considered negligible. The only OTs that were possible to implement by simulation were the biological and the economic. The other OTs (social and contribution to research) were not simulated because they depend on the delivery of documents by the operators.

As the crustacean species rose shrimp and Norway lobster have no analytical assessment, OTs were set using a historic low biomass index as a proxy of  $MSY B_{trigger}$ , the stock size below which more conservative catch advice is needed to avoid impaired productivity [28]. Measures to improve biomass are considered in the MP in case the biomass level drops below the established OT reference level. The gradual elimination of discards is one of the most important directives of the new CFP as unwanted catches and discards constitute a substantial waste that negatively affects the sustainable exploitation of marine biological resources and the financial viability of fisheries. The effects of the introduction of technical measures, such as the change in size or configuration of the cod-end mesh and the use of grids to exclude fish by-catch (hake, horse-mackerel and blue whiting), as well as the landing obligation for the entire 10-year period were simulated. Regarding the economic OT, revenues were estimated by the RB-FCM model using a function that simulates the

auction sale market of species landed by assuming that prices are inversely dependent on landings [29].

RFMS requires commitment from all involved stakeholders and incentives may be used to encourage participation and compliance and reward the best practices. These may include extra days-at-sea for vessels fishing with more environmentally friendly techniques, e.g. using by-catch reduction devices, more selective fishing gears or causing less damage to the bottom.

### 3.2. Control system and data enhancement

As mentioned before, the RFMS expects that the burden of the ecological sustainability of the fishery is shifted towards the resource users, which gives fishers more responsibility for managing and reporting their own activities. The accountability for gathering detailed information on the fishery is moved away from the centralized government towards the fishermen, thereby ensuring a higher degree of local ownership of the fish and of the data and an increase of transparency. Overall, it is expected that fishermen will provide better information about the fishery, improving data exchange and a more focused management.

The documentation system agreed on by the resource users as part of the MP requirements is an essential part of the RFMS system. The MP includes the operator's strategy for gathering and exchanging the data required to evaluate OTs and MP objectives.

The quality of the planned documentation system was audited to ensure reliable data and accurate information for both authority and operators, as adequate documentation is part of the requirement for access to the resource. Additionally, the "auditor" evaluated the MP (implemented through simulation) and the performance indicators to assess to what degree the MP fulfils the defined OTs.

## 4. Discussion

The Portuguese crustacean trawl fishery was used as a case study to test the feasibility of the EcoFishMan RFMS prototype. This multispecies fishery targets crustacean species but many demersal fish species are caught as by-catch and/or discarded. The level of knowledge of the different stocks is variable; some stocks are analytically assessed while others are evaluated by trends or have insufficient data. The fishing grounds are spatially defined and located off southwest and south Portugal. The fishery is carried out by Portuguese and Spanish vessels that have to comply with different regulations. Moreover, since 2006, this fishery has been constrained

by the Recovery Plan for the southern hake and Iberian Norway lobster stocks, which has been translated in a 10% reduction in Norway lobster TAC and in the number of fishing days every year. The complex characteristics of this mixed and multi-national fishery and the level of micro-management involved were considered appropriate for testing the RFMS because it provided a situation in which significant improvements could be imagined from a tailor made results based management system. Despite the presence of the fisheries administration in the initial stakeholders interactions, for practical reasons some of the tasks of the management authority were attributed to a project partner. For a broader discussion of the RFMS process, the fisheries administration should have been more involved in all iterations of the MP development.

At the beginning of the case study, the participation of fishers was weak and their cooperation with ongoing MP development was limited due to operational problems in the fishery at the time. The first iteration of the MP raised issues that triggered a more active participation of the operators. In particular, the stakeholders were motivated to participate in RFMS as this offered an opportunity to develop and propose a MP specific for the crustacean fishery as an alternative to the outdated management plan in place. The prospect of a coming discard ban represented an additional motivating factor. The involvement of the Spanish stakeholders, interested in continuing fishing for crustaceans in Portuguese fishing grounds, also resulted in the growing participation of all operators, concerned with maintaining their fishing opportunities.

During the dialogue meetings, the different regulations for Portuguese and Spanish fishers were a cause for conflict of interests and lack of trust among operators. The same and simplified rules for all were advocated by the operators, with the MP developed under RFMS as an alternative to replace the considered inadequate management. It should be emphasized that the successful implementation of the MP implies that all operators are included. Moreover, a cross national PO with all involved associations was included in the MP, to strengthen fishers' collaboration and influence the market by controlling the supply of the main target species and therefore enhance the fishery profitability. Interaction between Portuguese and Spanish operators and scientific research institutes was a milestone for this particular fishery. However, operators must enhance collaboration and collective thinking and become more aware of the ecological, economic and social impacts of their decisions before RFMS can surpass the present micro-management regime.

The opportunities and procedures of this MP in a RFMS system are well suited for facilitating achievement of the new objectives of the CFP. Simplified rules and decentralized management will devolve power to the operators who will be able to choose how to best achieve the agreed outcomes adapted to the specificities of this fishery. Reducing by-catches is also one of the main objectives of the new CFP and will require considerable attention in the coming years as the landing obligation should ideally be addressed in multi-annual management plans. The implementation of discard reducing plans will surely be facilitated in a RFMS context as the operators play an active role to design and jointly recommend a MP.

The documentation system established as part of the MP requirements enhances data availability, improves scientific advice and, in the context of the landings obligation, allows the operators to receive the right quota mix from the authority to reflect as much as possible the actual fishing pattern from the Portuguese crustacean trawl fleet.

A number of unresolved issues remain before RFMS can be successfully implemented in the Portuguese crustacean trawl fishery. In particular, incentives that can encourage the operators to participate in the MP need to be identified and mechanisms for financing documentation and monitoring systems found.

The RFMS prototype is in agreement with the principles of good governance set in Article 3 of the new CFP [1], namely (i) the

regionalized approach, (ii) a long-term perspective, (iii) the primary responsibility of the flag State, (iv) appropriate involvement of stakeholders at all stages and (v) transparency of data handling and availability of data to the appropriate scientific and management bodies.

The delegation of management responsibility to the operators requires collaborative relationships between industry and government and also that fishers fully understand EAF concepts and have the maturity and willingness to be responsible for management decisions [30]. In the present EU micro-management context, full RFMS will be difficult to justify as there are political barriers that bind fishers to the current management framework. However, self-management does not imply that total responsibility for management rests with the operators, as a number of core functions, such as management objectives, compliance prosecutions and auditing, will not be delegated.

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