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GHOTI

WILEY FISH and FISHERIES

A framework for results-based management in fisheries

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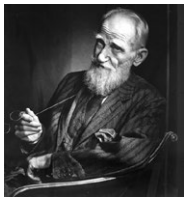
Abstract

We present a framework for results-based management (RBM) of commercial fisheries. The core idea of RBM is to reduce micromanagement by delegating management responsibility to resource users. The RBM framework represents an industrial



Ghoti papers

Ghoti aims to serve as a forum for stimulating and pertinent ideas. Ghoti publishes succinct commentary and opinion that addresses important areas in fish and fisheries science. Ghoti contributions will be innovative and have a perspective that may lead to fresh and productive insight of concepts, issues and research agendas. All Ghoti contributions will be selected by the editors and peer reviewed.

Etymology of Ghoti

George Bernard Shaw (1856–1950), polymath, playwright, Nobel prize winner, and the most prolific letter writer in history, was an advocate of English spelling reform. He was reportedly fond of pointing out its absurdities by proving that "fish" could be spelt "ghoti". That is: "gh" as in "rough", "o" as in "women" and "ti" as in palatial.

organization approach to co-management and comprises three defining processes, conducted by three independent "agents": (i) an "authority" defines specific and measurable and achievable objectives (outcome targets, OTs) for the utilization of fisheries resources, (ii) resource user organizations (termed "operators") take responsibility for achieving these OTs and provide documentation that (iii) allows independent "auditors" to evaluate the achievement of OTs. Using incentive mechanisms, notably deregulation, RBM grants operators the flexibility to develop and implement innovative and cost-effective ways to achieve OTs. The feasibility of implementing RBM in five European fisheries was investigated in cooperation with relevant stakeholders through artificial planning processes and computer simulations. The operators involved were enthusiastic, and new management plans were drafted based on the framework. These included socioeconomic OTs in addition to traditional stock objectives, encompassing an ecosystem approach. Several issues are in need of further research to consolidate the approach and prepare the ground for practical implementation, including: the specification of the legal and regulatory framework required to underpin RBM, details of transitional arrangements when shifting towards RBM (including cost-sharing) and the development of necessary organizational capacity for operators. Initially, we therefore envisage the framework being applied to high-value single-species fisheries, with a limited number of participants, which are adequately represented by a competent organization.

KEYWORDS

burden of proof, co-management, Common Fisheries Policy, results-based management, the EcoFishMan project

1 | INTRODUCTION

Many marine fisheries suffered from the "Tragedy of the commons" (Hardin, 1968) as they became overexploited in the 20th century (Worm et al., 2006), largely due to rapid industrialization, capitalization and poor management (Caddy & Cochrane, 2001). In response, a centralized fisheries management approach was consolidated by the New Ocean Regime, which instituted the coastal state as owner and manager of marine resources inside its Exclusive Economic Zone, with international collaborative management for straddling and migratory stocks (Dyke, 1995). This approach has begun to succeed in certain regional seas (Cardinale et al., 2013; Fernandes & Cook, 2013; Worm et al., 2009), but requires significant investments in compliance measures, regulation and monitoring. Such investments are typically covered by public funds and represent indirect subsidies (Schrank, Arnason, & Hannesson, 2003; Sumaila et al., 2007), and where they are insufficient, stocks continue to be overexploited (Costello et al., 2012; Fernandes et al., 2017; Worm et al., 2009).

This state-centred approach tends to lead to paternalistic (top-down) and regulation intensive management systems that exclude resource users from knowledge production and decision-making (Degnbol, 2003; Jentoft & Mikalsen, 2003; Lane & Stephenson, 2000). This contrasts with the growing recognition that successful management of fisheries and other socio-ecological systems must include the constructive engagement of users (Deacon, 2012; Degnbol, 2003; Gutiérrez, Hilborn, & Defeo, 2011; Lane & Stephenson, 2000; Ostrom, 2009; Parma, Hilborn, & Orensanz, 2006). The strategy of assigning management responsibility to user groups within a formalized management systems is not new (Jentoft, 1989) and has shown promise in some cases, but receives little attention (Deacon, 2012). There is little general discussion on how to design a framework for an "industrial organization" approach to co-management with relevance to modern capture fisheries (Lane & Stephenson, 1998).

Aiming to reinvigorate discussion, promote research and devise practical initiatives in this context, we present and discuss a specific approach which aims to delegate fisheries management responsibility to resource users. The conceptual basis for the proposed approach is results-based management (RBM), combined with incentive mechanisms for stimulating active involvement of user groups in management and information gathering, namely the notions of a "reversed burden of proof" (Degnbol, 2003; Fitzpatrick, Graham, Rihan, & Reid, 2011; Linke & Jentoft, 2012) and "cost recovery" (Stokes, Gibbs, & Holland, 2006). This is based on the idea that private users of public resources should be held accountable for the costs of implementing management measures and of monitoring to ensure that the negative impact of the resource use is acceptable.

Aligned with New Public Management ideas (Rhodes, 1996), RBM has guided reforms in national and international organizations, including UN agencies, the OECD and the World Bank (Binnendijk, 2001; Hatton & Schroeder, 2007; Mayne, 2007; UNDP, 2007). The core idea of RBM is to delegate responsibility for achieving defined results to a user level. The European Commission (EC) expressed this idea as follows:

> *The industry can be given more responsibility through self-management. […] instead of establishing rules about how to fish, the rules focus on the outcome and the more detailed implementation decisions would be left to the industry. Public authorities would set the limits within which the industry must operate, […] and then give industry the*

> *authority to develop the best solutions economically and technically (EC, 2009).*

The proposed framework for RBM was developed in an EC-funded research project. The main deficiencies that the framework aimed to address were the structural problems of the EC's previous Common Fisheries Policy (CFP): a top-down and micromanagement approach with insufficient opportunities for industry involvement, imprecise policy objectives, a short-term focus and poor compliance (EC, 2009). RBM shifts the burden of proof and delegates responsibility for planning and implementing management measures to organized resource user groups, the "operators." Relevant "authorities" still define policy goals for the public's natural resources, but it is left to operators to develop workable management plans (MPs) and to provide the information necessary for "auditors" to conduct an independent audit of the extent to which the goals are met. The policy goals are made explicit through the definition of outcome targets (OTs), which are specific, measurable and achievable objectives defined by the authority in consultation with operators.

The management of rock lobsters (*Jasus edwardsii*, Palinuridae and *Sagmariasus verreauxi*, Palinuridae) in New Zealand (Yandle, Hajj, & Raciborski, 2011) is regarded as an advanced example of RBM arrangements in fisheries on an organizational scale (Nielsen, Holm, & Aschan, 2015), as opposed to the scale of individual fishers or vessels (Fitzpatrick et al., 2011). Secure harvest rights created incentives for quota holders to rebuild resources to levels with higher productivity and profitability (Miller & Breen, 2010). In addition, a cost-recovery regime encouraged the industry to enhance the cost-effectiveness of management and research (Stokes et al., 2006). While the statutory requirement is that stock biomasses should be at, or above, levels that support Maximum Sustainable Yield (MSY), industry harvest strategies in some cases aim to achieve lower exploitation rates consistent with Maximum Economic Yield. In some cases, the industry refrained from harvesting its full allocation in order to build stocks up to more profitable levels (Breen, Sykes, Starr, Kim, & Haist, 2009; Miller & Breen, 2010).

Taking inspiration from this and other relevant cases (Dixon & Sloan, 2007; Featherstone & Rogers, 2008; James, 2008; see also cases referred to in Section 2), RBM is proposed as an ideal type (Cahnman, 1965) of an industrial organization approach to co-management. In this study, we describe an RBM framework and study its potential application in pilot studies of four European fisheries. To invoke change, such as that proposed here with RBM, the framework must be adapted to a given governance setting and build on the institutions and organizations already in place. In our conclusion, we consider the prospects of moving towards RBM arrangements and identify issues in need of further research to refine and consolidate the proposed approach.

2 | MATERIALS AND METHODS

Previously, Nielsen et al. (2015) developed an RBM prototype, based on relevant RBM literature (EC, 2009; Fitzpatrick et al., 2011), fisheries management systems with RBM aspects (Deacon, 2012; Lane & Stephenson, 2000; Molares & Freire, 2003; Townsend & Shotton, 2008; Yang, Cullen, Hearnshaw, & Macdonald, 2014; Yang, Frazer, & Rees, 2010; Zacharin, Dixon, & Smallridge, 2008), and advice from stakeholders and fishery managers in New Zealand and Europe. The initial prototype outlined a process for developing, approving and evaluating a MP, and specified the generic division of labour and manner of cooperation between the associated agents. The prototype was applied to pilot case-studies in a series of artificial planning processes as described below (Section 2.3). An evaluation of these processes provided a basis for extending and adapting further prototypes, which were subsequently applied and evaluated in a similar process. In the following section, we briefly present basic conditions that facilitate implementation of RBM (Section 2.1) before presenting the final prototype (Section 2.2).

2.1 | Enabling conditions for an industrial organization approach to co-management

With top-down management as the starting point, a move towards co-management will necessarily proceed from institutionally unfavourable conditions (Jentoft, 1989). Pomeroy and Berkes (1997) emphasize the need for a proactive government to make co-management work. The role of government is crucial with regard to establishing a legal framework that enables an effective and transparent delegation of responsibility to resource users. While the legal basis underpinning the proposed RBM is considered beyond the scope of this work, we draw attention to four essential aspects. First, membership of authorized resource user organizations should be mandatory as incomplete organizational representation will reduce the ability for resource user organizations to decide on comprehensive management actions. Second, resource user organizations must be able to make binding decisions on behalf of their members through an effective and legitimate decision-making mechanism (Jentoft, 1989; Townsend, 2010a, 2010b). Third, as RBM incurs a new practical and financial burden of management on users, it must also include strong positive incentives to foster industry acceptance. One important incentive in RBM is deregulation, granting operators the flexibility to design locally workable management solutions provided that OTs are met. Long-term user rights, either held individually or by a group, are likely to represent the most powerful type of incentive: promoting long-term sustainability also increases the productivity of the resource, and thereby the value of the rights (Deacon, 2012; Grafton et al., 2006). Fourth, resource user organizations need to foster leadership and develop the organizational capacity, know-how and the mechanisms for conflict resolution required to take on responsibility for management functions. These abilities are typically developed over long time spans, although recent experience with the Advisory Councils in Europe have helped (Hegland & Wilson, 2009; Stange, van Tatenhove, & van Leeuwen, 2014).

2.2 | Framework for results-based management in fisheries

The RBM (Figure 1) operationalizes RBM through a contract (Townsend, 2010b) between an "authority" and one or more "operators." In practice, this contract is an MP, proposed by the operator(s) and approved by the authority. The RBM stipulates a conditional reallocation of responsibilities and provides a template for a process that empowers resource users, enhances transparency and enables the use of locally adapted management measures. Representing public interests, the basic mandate of the authority is to ensure that its global policy objectives are fulfilled. This responsibility is not delegated with RBM. OTs are defined to contribute to the fulfilment of existing policies objectives.

The performance of an MP is evaluated by a third agent, an external "auditor," which also monitors that both parties stick to preagreed timelines and process steps. The auditor enhances mutual accountability and reduces the risk of imbalanced relationships between cooperating parties. Examples of these are as follows: a lack of downward accountability (Berkes, 2009), reduced proclivity of civil servants to defend public interests due to tight cooperation with industry (Singleton, 1999) and a reluctance of the authority to delegate power (Moynihan, 2006).

The RBM process begins with dialogues between the authority and operator(s) to facilitate a shared understanding of goals and expectations. Subsequently, the authority prepares an MP invitation, specifying the OTs to be achieved. The authority may arrange a process for involving potentially affected interests beyond those of the fisheries sector in the formulation of OTs. OTs can only be defined in terms of indicators that operators can be expected to be able to control to a sufficient extent through relevant management actions. The OTs define the area of responsibility for operators. Beyond the OTs, the responsibility to achieve policy goals remains with the authority.

The operator then proposes an MP detailing how OTs will be achieved through a set of measures. To do so, they need to harness and finance the required technical expertise, contracted externally or kept in-house at their own cost. The delegation of responsibility for planning and management requires that resource user organizations will employ this expertise, just as is the case for authorities in top-down management systems. The MP establishes how the fisheries will be monitored, controlled, documented and how and by whom data will be analysed. These functions require services that the operator may take upon itself or outsource to competent organizations. Finally, the MP identifies audit dates.

The MP includes (graduated) sanctions in case OTs are not achieved (e.g. a harvest control rule with inbuilt catch reductions if biomass thresholds are not met). The presence of such collective sanctions may encourage the operator to develop internal control mechanisms in order to avoid losses due to non-compliant members. Most likely, however, operators will need external control and enforcement (e.g. provided by the authority) to ensure compliance and to provide independent information (e.g. regarding the quality of catch data). From the perspective of the authority and its commitment to public policies,

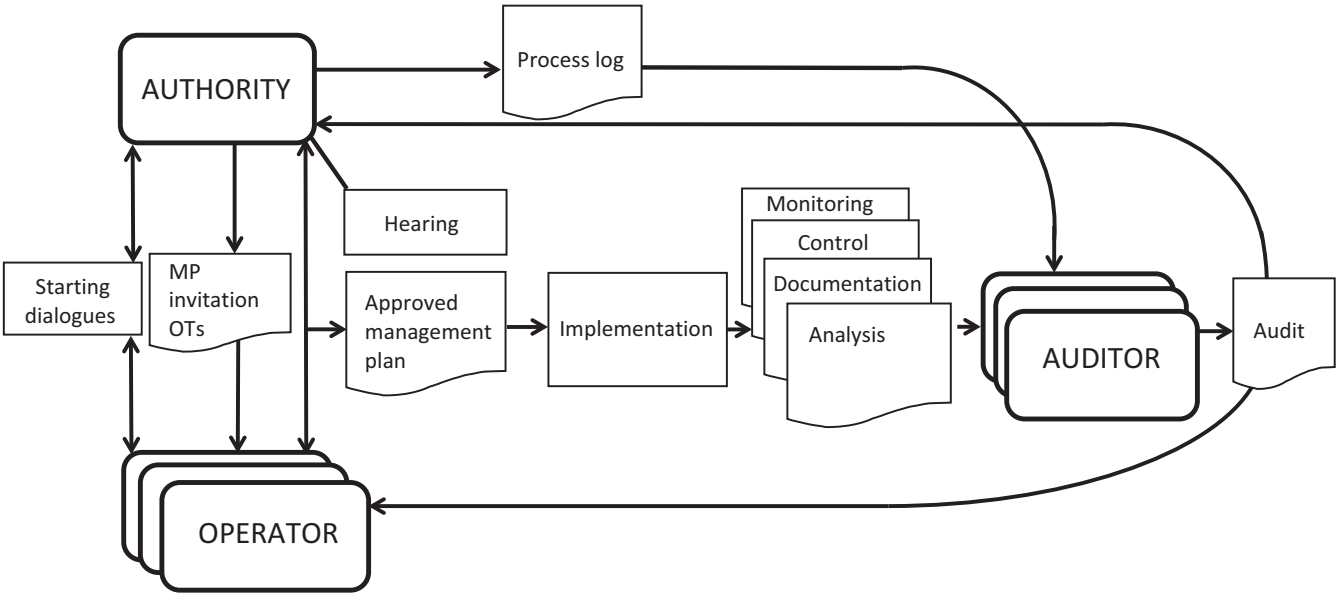


FIGURE 1 A framework for results-based management (RBM) in fisheries. The framework involves three agents: (i) the authority, a democratically accountable entity responsible for resource management. It oversees the RBM processes and issues management plan (MP) invitations, which include the specification of measurable and achievable objectives (outcome targets: OTs). It can approve or reject operators' MP proposals; (ii) the operator, an organized group of resource users, for example fishers, with rights in a given fishery. The operator develops, proposes and implements an MP, which includes strategies for achieving OTs and for documenting the effectiveness of chosen means; (iii) the auditor, an independent agent with capacity to audit MP performance. The auditor reviews documentation, evaluates the extent to which OTs have been achieved and submits the audit to the authority and operator(s). The system proceeds from left to right starting with the dialogues between operators and authority to agree on the involved process

the issue of control resorts simply to whether OTs are achieved. It is for the independent auditor to confirm such achievement, on the basis of its evaluation of the appropriate documentation.

The authority examines the MP proposal and may request revisions or clarifications until it meets pre-agreed conditions, that is a strategy for achieving OTs and for obtaining adequate audit information. This step could involve a thorough scientific evaluation, for example a Management Strategy Evaluation (Punt, Butterworth, Carryn, De Oliveira, & Haddon, 2017), but a less formalized expert judgement process could be used for small scale, low value or data-poor fisheries. The authority's approval serves to provide a safeguard against poor proposals and does not relieve operators of their principal responsibility to achieve OTs.

Before approving an MP proposal, the authority should arrange a public hearing to promote transparency and allow stakeholders other than those affiliated with operators to comment on the proposal. Representing public interests, the authority decides whether or not to take this feedback into account.

The operator is responsible for implementing the MP and for collecting the information required for an audit of its performance. As mentioned, it may do so in cooperation with relevant hired expertise. Based on the information provided by operators, an appointed auditor assesses the extent to which OTs are achieved. To maintain credibility and legitimacy, the auditor should be independent of both authority and operators. The audit provides the authority with a basis to make decisions: if OTs are met, the operator continues with activities according to the MP. If not, the authority may request revisions, set stricter requirements or implement pre-agreed sanctions. To enhance transparency, the authority should provide a log of key events in the process and make it available externally. As a minimum, the log includes the MP invitation and minutes of key meetings, including the MP hearing.

In the ideal model of RBM presented above, the industry bears the responsibility and costs for collection of fisheries data and implementation of management measures. In practice, however, it may not always be considered appropriate to confer these costs to the industry immediately. Cost-sharing arrangements, however, do not preclude that the industry could have the formal responsibility for the relevant tasks.

The MP is subjected to a range of uncertainties and externalities. This implies that operators cannot be expected to achieve OTs under all circumstances (e.g. unfavourable environmental conditions). This is a common contract situation in which it is impractical, costly or even impossible for the contracting parties to address all contingencies ex ante. In general, failure to deliver the terms of contracts is addressed ex post by the courts, which determine whether the contractor has performed in "good faith" (Armour, Hansmann, & Kraakman, 2009; Burton, 1980). Similarly in RBM, if OTs are not met, the auditor judges whether the operator has implemented the MP in "good faith," and taken reasonable measures to achieve OTs. This provides the basis for the authority to set new conditions when the MP is revised and/or to introduce sanctions. The ultimate sanction for operators consistently performing in "bad faith" could be termination of the RBM approach, and a consequent re-instalment of top-down management.

2.3 | Pilot studies

It was not possible to study actual implementation of the RBM in fisheries due to several reasons. First, this would require that the major outcome of the project, the proposed RBM approach, was available at an early stage of the project. Second, actual implementation would require much more time and support by policymakers and stakeholders than what is normally available to a research project. Third, and probably of most significance, the enabling conditions for the RBM (described in Section 2.2) were only partially available in the pilot studies.

The feasibility of implementing RBM was therefore studied through artificial planning processes in collaboration with candidate agencies in the respective roles of operators and authority. The pilot studies were presented to these agencies as an invitation to participate in a study with the aim to develop alternative management arrangements on a voluntary basis. The research was organized in accordance with the process outlined above for developing and evaluating an MP with the following steps:

1. An MP invitation was prepared for each pilot study by the relevant authority. The MP invitation defined the OTs for resource users to meet. It also contained a guideline for developing the MP and listed the required elements to be addressed.
2. Responding to the MP invitation, operators developed an MP. The MPs were refined until the authority had confirmed that all required elements were in place and thus could approve the MP.
3. The performance of MPs with regard to OTs was assessed using model simulations. This provided a basis for auditors to evaluate MPs regarding sustainability, applicability and risks.

The respective roles of authority and operators were performed by local relevant actors in the pilot studies to the extent possible and were facilitated by research teams from the project. To avoid the risks of ambiguity of roles of researchers (Dankel, Stange, & Nielsen, 2015), the project was organized such that teams of project researchers would facilitate one role only, consistent with the outlined RBM.

The pilot study approach faced a number of limitations of which the most significant were as follows:

1. The simulation of the RBM process was limited to the steps of developing and evaluating MPs. The subsequent steps of (i) the authority requesting revisions or implementing sanctions if OTs were not met and (ii) of operators adapting their MPs in response were not simulated. These steps need to be implemented and evaluated in order to consolidate the RBM approach, but this could not be achieved in a three 3-year research project.
2. The simulation approaches differed between pilot studies and could not provide a basis for evaluating outcomes of all OTs in some cases.

3. The simulated nature of the pilot studies implies that the expressed attitudes of the relevant agents in the pilot studies might have been influenced by the fact that the RBM was not implemented in reality.

The pilot studies were selected to provide a range from simple (single species, single nation) to complex (multispecies, multinational) fisheries and management contexts, and to reflect variation in the availability and quality of data (Table 1). The Mediterranean pilot study had resource constraints, which did not permit model simulation, so the evaluation of the feasibility of the RBM was limited to a role-play event with participation from relevant local user organizations and representatives of national fisheries administrations. This case is not considered further here, but information on this, as well as more details on concepts and pilot studies (e.g. MP, associated documentation needs and responsibilities, cost-sharing arrangements and feedback from stakeholders) are available in project reports at www.ecofishman.eu.

2.3.1 | The Icelandic lumpfish fishery

The Icelandic lumpfish (*Cyclopterus lumpus*, Cyclopteridae) gillnet fishery is relatively simple in terms of biology and management. Bycatches are limited and catch, effort and market statistics are available. However, the fishery is data poor with regard to stock assessment. The Marine Research Institute (MRI) estimates stock status based on indices from the Icelandic Groundfish Survey and a gillnet survey, which are considered to provide a reliable basis for advice (WGLUMP, 2015). Traditionally, only the lumpfish roe is sold, but niche markets for the meat have emerged, although these are unstable and involve low profit margins.

The Icelandic Ministry of Industries and Innovation (IMII) manages the fishery in consultation with the MRI, the Directorate of Fisheries and the industry, considering advice from the MRI, regional needs and market conditions. There is no MP. The MRI provides advice on Total Allowable Catches (TACs) based on fishing mortality (*F*) reference point proxies, but the fishery is regulated through licences and effort restrictions (Kennedy, Jonsson, Kasper, & Olafsson, 2015; MSC, 2016).

The fishery is of limited importance for the national economy but is of high socioeconomic importance in many small fishing villages. Participants in the fishery are all members of the National Association of Small Boat Owners (NASBO), which represents the entire fishery concerning most issues.

2.3.2 | The Icelandic mixed demersal fishery

This fishery is relatively simple in terms of biology and management, and benefits from high data availability. The fishery primarily targets Icelandic stocks of cod, haddock and saithe (respectively, *Gadus morhua*, *Melanogrammus aeglefinus* and *Pollachius virens*, all from the family Gadidae). A harvest control rule was adopted in 2009 for cod and in 2014 for haddock and saithe (IF, 2017). The fisheries management authority and the decision-making process are as in the previous case.

The fishery is managed by Individual Transferable Quotas (ITQs) and involves two groups of permanent quota entitlements. Group1 consists of about 400 small (<15 m) vessels restricted to using hand-line or long-line, accounting for ~14% of the demersal catches. Group2 involves around 300 larger vessels, including trawlers, accounting for ~84% of the demersal catches. The IMII allocates ~2% of the demersal TAC to an open access fishery for ~700 small (<13 m) hand-line boats. Finally, it allocates ~8% of the demersal TAC to facilitate new entries into the fishery, or support regional development or environmentally friendly initiatives. The latter "incentive quotas" are primarily utilized by vessels operating within Group1 or by small coastal vessels without quotas. Almost all NASBO members are within Group1 or own vessels without quotas. Group2 are members of Fisheries Iceland (SFS), formerly known as the Federation of Icelandic fishing vessel owners (LIU).

Operators in the mixed demersal fishery are engaged in shaping management policy. Unlike the lumpfish fishery, the cod fishery brings

TABLE 1 Overview of pilot studies investigated for the feasibility of RBM

	Icelandic lumpfish fishery	Icelandic mixed demersal fishery	Portuguese crustacean trawl fishery	North Sea mixed demersal fishery	Northern Adriatic mixed demersal trawl fishery
Complexity of Management context	Low: Single nation, national policy framework	Low: Single nation, national policy framework	Intermediate: Single nation; allocations to other country; CFP framework	High: Several nations; CFP framework	High: Several nations; GFCM and CFP frameworks
Complexity of fisheries	Low: one target species; low by-catch level	Low: mixed fishery with few target species	Intermediate: several target and by-catch species	High: several target and by-catch species; multiple fleets and gear types	Very high: high species diversity
Availability of data for stock assessment	Low: data collection does not prioritize the addressed species	High: abundant data of high quality	Intermediate: abundant data of intermediate quality	High: abundant data of high quality	Low: intermediate occurrence of data of relatively low quality

CFP, Common Fisheries Policy; GFCM, General Fisheries Commission for the Mediterranean; RBM, results-based management.
Cases are arranged, from left to right, in order of expected difficulty in applying RBM.

together heterogeneous harvesters that operate vessels within different fleet segments, and with potentially diverging fisheries interests. Whereas both SFS and NASBO support the current quota management system, those taking part in the open access coastal fisheries would like to see it changed. These differences make a comprehensive shift towards co-management difficult.

2.3.3 | The Portuguese crustacean trawl fishery

This mixed fishery targets several deepwater crustaceans located on soft sediments on the continental slope off the Southwest and South Portuguese coasts at depths >150 m. The most important target species are rose shrimp (*Parapenaeus longirostris*, Penaeidae) and Norway lobster (*Nephrops norvegicus*, Nephropidae) but red, purple and scarlet shrimps (respectively, *Aristeus antennatus*, *Aristaeomorpha foliacea* and *Aristaeopsis edwardsiana*, all from the family Aristaeidae) are sporadically targeted in specific areas. Significant commercial finfish by-catch species include blue whiting (*Micromesistius poutassou*, Gadidae), European hake (*Merluccius merluccius*, Gadidae) and Atlantic horse mackerel (*Trachurus trachurus*, Carangidae) (Silva, Murta, & Cardador, 2009; Silva et al., 2015).

The fishery is managed under the CFP. The responsibility for implementing the fisheries policy at national level lies with the Ministry of the Sea and is delegated to the Deputy State Secretary for the Sea. The Portuguese General Directorate for Natural Resources, Safety and Marine Services (DGRM) is responsible for fisheries management activities, drafting national regulations, distributing quotas, monitoring and enforcement.

The fishery includes 26 Portuguese trawlers (20–29 m length). In addition, five Spanish licences were granted under a bilateral agreement. Operators are organized in vessel owners' associations, with 12 Portuguese trawlers represented by the Associação dos Armadores das Pescas Industriais (ADAPI), and with Spanish vessels being presented by the Association de Armadores de Punta del Moral (AAPM). The fact that the fishery involves vessels from two different countries, which are not subjected to the same set of regulations, may impede progress towards common co-management arrangements.

2.3.4 | North Sea mixed demersal fisheries

North Sea demersal fisheries involve a number of fleets and species, but are data rich. The largest fleets are operated by the United Kingdom, France, Germany and Denmark (STECF, 2011). The fisheries target valuable species such as cod, haddock and whiting (*Merlangius merlangus*, Gadidae), but also saithe, plaice (*Pleuronectes platessa*, Pleuronectidae), sole (*Solea solea*, Soleidae), Norway lobster, European hake and anglerfish (mainly *Lophius piscatorius*, Lophiidae). A revised CFP was implemented in 2014 to improve conservation and achieve long-term economic viability for the fishing industry (European Parliament and Council, 2013). The reform includes a landing obligation (discard ban), which presents difficulties in the presence of species with small quotas, "choke species," which may induce a premature closure (Baudron & Fernandes, 2014).

Demersal fisheries in the North Sea feature many nations, fleet types, fishermen's associations and producer organizations (POs), which altogether may render a comprehensive co-management arrangement difficult. The fishing industry is organized into a number of national and international associations and POs (Santiago et al., 2015). The North Sea Advisory Council is a key arena for stakeholder participation in fisheries management, with representatives from the fishing industry organizations as well as environmental NGOs. However, its role in participatory governance may be hampered by difficulties to provide consensus-based advice (Hatchard & Gray, 2014).

3 | RESULTS

Outcomes from the pilot studies are reported with a focus on: description of the agents (authority, operator and auditor), OTs, details of the MP and an assessment of the simulated planning process. This assessment addresses the involved agents' perceptions of the RBM process and outcomes of model simulations indicating if the MP was likely to achieve the OTs.

3.1 | The Icelandic lumpfish fishery

Assisted by a group of project researchers, NASBO was the "operator" and developed the MP. The IMII was positive to the pilot study, but did not participate in it. A different group of project researchers therefore represented the role of the "authority." An accredited certification body was identified as potential "auditor," but the audit function was performed by a separate research group.

The Icelandic fisheries management act identifies the key objectives for the management of living marine resources in Icelandic waters (IP, 2006). The goals are to promote the conservation and efficient utilization of marine resources and ensure stable employment, economic viability and maintain settlement in rural areas. The "authority" and the "operators" agreed on two OTs: A biological OT for lumpfish to maintain fishing mortality (F_{proxy}) < 0.75, which is the MSY proxy used by the MRI to provide TAC advice (MSC 2016). A socioeconomic OT was defined which set requirements for the geographical distribution of issued licences due to the regional importance of the fishery.

An MP was developed in dialogue with various stakeholders. The MP built on existing regulations but included new elements, notably that NASBO would be responsible for issuing licences, deciding on annual effort limits, deciding on sanctions and for monitoring compliance. NASBO would obtain the funding necessary for meeting these responsibilities through the sale of licences (currently issued by the Directorate of Fisheries). A significant change, agreed by all parties, was an obligation to land the whole fish, not only roe, in order to enhance job creation and export value.

Likely outcomes of implementing the MP were estimated by a computer simulation in Stella™, taking into consideration recruitment, growth rate, harvest rate, effort, costs, revenues, profits, the number of jobs in catching and processing, as well as spatial considerations

regarding landings and job creation (Sigurðardóttir & Gunnlaugsson, 2012).

The Icelandic lumpfish fishery appeared as a promising case for RBM. Simulations over a 20-year period indicated that both OTs would be achieved, and that the obligation to land whole fish would result in a 50% increase in employment in the processing sector. The fishery is spatially well defined and little impact on other species or the marine environment. The prospects of applying RBM were strengthened by the fact that all operators are members of a single organization, which could act on behalf of the entire fishery. NASBO has an incentive to collect additional biological and market data to improve stock assessment, market forecasts and control of supply. A main weakness of the pilot study was that the actual authority was not involved.

3.2 | The Icelandic mixed demersal fishery

LIU did not participate in this pilot study and gave no particular reason. One obvious reason could be that LIU is content with the present quota management system. The ITQ system has been contested as it came into effect, with initial allocation and transferability of quotas and sharing of the resource rent being especially thorny issues (Agnarsson, Matthiasson, & Giry, 2016; Benediktsson & Karlsdottir, 2011; Chambers & Carothers, 2017; Kokorsch, Karlsdottir, & Benediktsson, 2015; Matthiasson & Agnarsson, 2009). Without LIU, the main agents involved were those involved in the previous case, restricting the pilot study to smaller jig and line vessels and vessels without quotas, comprising approximately 14%–18% of total demersal catches.

Representing almost all vessel owners within this category, NASBO was actively involved as the "operator." Groups of researchers, respectively, represented the agencies of "authority" and "auditor." The "authority" and NASBO agreed on 19 OTs (of which seven, outlined here in italics, were new): spawning stock biomass (SSB) for cod, haddock, saithe, golden redfish, Atlantic catfish, tusk and common ling > MSY thresholds; $F < F_{MSY}$ (for eight by-catch species); by-catch % limits by species; an obligation to land all catches; *20% of Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA) is paid as public resource rent*; zero non-fuel subsidies; *EBITDA of fishing companies > 0 (average for planning period); >17% of demersal TACs for J&L vessels <15 m; >80% of catches landed in villages with <5,000 inhabitants*; company specific ownership of quota <12%; *average wages in the sector > national average; annual recruitment of new workers >1%; all primary processing in Iceland*. NASBO's proposal incorporated the "incentive quotas" into Group1 and invited vessel owners without quotas into that system. The MP covered 17% of the total demersal catches in Icelandic waters, of which 12% would be allocated based on present quota ownership. The remaining 5% would be entrusted to a quota bank operated by NASBO to promote achievement of OTs and fund involved expenses.

NASBO committed to the operator role and invested work in developing an MP for the identified fishery share, although some of its members did not assent to all OTs. Part of the disagreement related to the reallocation of the "incentive quotas" through a quota bank. MRI would continue to provide stock information.

Likely outcomes of implementing the MP for a 10-year period were assessed mainly by computer simulation (Sigurðardóttir, Viðarsson, & Margeirsson, 2013), but status could be assessed for only nine OTs due to data limitations. The performance of the MP could therefore not be evaluated fully. The simulations suggested that the biological OTs for cod, haddock, saithe and golden redfish were likely to be achieved, but as the MP only covered 17% of the fishery, the achievement of biological OTs would be driven by the fisheries not participating in the MP (which were assumed to be governed by current harvest control rules). The fact that the operator would not be in a position to control the achievement of these OTs through their own actions represented a major drawback, and shows that these OTs were inappropriate. It may be possible to define achievable stock OTs for this operator by making them relative to catch proportions (partial SSB and *F*). Otherwise, defining stock OTs will either require sufficient operator participation to present a clear majority of the catches, or it will not be possible to delegate responsibility for achieving such OTs. The OT for Atlantic catfish could not be reached, and limited data made it impossible to make stock estimates for tusk and ling.

The high number of OTs complicated the RBM arrangements and set high requirements for the collection of data for assessment and audit. A smaller set of OTs would have been more feasible. The organization representing the majority of the catches did not participate in the pilot study, and this was a significant weakness. Hence, this pilot study demonstrated the importance of including a good majority of those engaged in the fishery in the MP.

3.3 | The Portuguese crustacean bottom trawl fishery

The DGRM was involved in the initial phase of the pilot study, where the general management goals and OTs were defined. Other interest groups, such as consumers' associations, market organizations and NGOs were also involved in this phase. The role of the authority was performed by a research group. Assisted by researchers, the operator comprised the two most important associations of ship owners involved in the fisheries, that is the Portuguese ADAPI and the Spanish (AAPM). Instituto Português do Mar e da Atmosfera (IPMA) acted as the auditor.

Stakeholders and authorities agreed on the following OTs (Silva et al., 2015): biomass indices Catch Per Unit Effort (CPUE) > *MSY* $CPUE_{trigger}$ for rose shrimp and Norway lobster; reduce discards to ≤50% in the first five years and to ≤25% in the following five years; fishing company EBITDA > 0 (average for 10-year period); on board training opportunities provided for at least 25 new workers during a 10-year period; establish formal cooperation between operators and a scientific institution for improving data collection to enhance stock assessment and advice. Performance indicators were defined in the MP to measure the success of the strategies used to achieve the OTs and the extent to which they were achieved. Depending on the OT,

these indicators were to be evaluated in different assessment periods during the 10-year MP period.

Rewards for compliance and good practices as well as sanctions and corrective measures concerning observed deviations from the OTs were defined, including fines and temporary fishing restrictions. Incentives (fishing days, quota) would encourage the use of selective gears and/or by-catch reduction devices. To ensure proper monitoring of OTs, a documentation system was proposed, which included the existing system of electronic reporting, more detailed paper logbooks for reporting the retained catches and discards, vessel activity information, economic and financial reports, and other arrangements between the operators and research institutions to gather data.

The design and application of the RBM process in the Portuguese crustacean bottom trawl fishery was understood by all stakeholders involved. Interaction between Portuguese and Spanish operators and scientific research institutes was regarded as a milestone for the fishery, and a cross-national PO was proposed to strengthen fishers' collaboration and market influence. The fishery is currently subjected to a high number of detailed regulations, which are perceived to be inappropriate. Chiefly, the prospect of developing an alternative to the recovery plan for Southern hake and Iberian Norway lobster (EC, 2005) promoted stakeholder involvement.

The implementation of the MP was simulated using a Rule-Based Fuzzy Cognitive Map model (Wise et al., 2015). Four different scenarios were simulated corresponding to gear modifications aimed at reducing discards. Outcomes regarding Economic (EBITDA) and social OTs could not be simulated and effects of a cooperation to improve data collection could not be assessed. The model estimated outcomes regarding CPUE for the two main target species and total revenue as a proxy for EBITDA. Results indicated that these OTs would be achieved throughout the planning period in most scenarios (Wise et al., 2015).

Some issues need to be resolved before RBM can be successfully implemented in this fishery. In particular, additional incentives must be deployed to encourage operators to participate in RBM, and ways to finance the monitoring and auditing processes must be established and agreed on (Silva et al., 2015). RBM was well accepted by the operators because clear objectives for the crustacean fishery were set. Other positive aspects of the MP development, as opposed to the present management regime, included that it implied the same rules for all and would replace an unpopular recovery plan.

3.4 | North Sea mixed demersal fisheries

The pilot study was restricted to the Scottish TR1 fleet (trawlers other than beam trawl, with a cod-end mesh size >100 mm) to ensure MP development in consultation with stakeholders within a reasonable timeframe. Following the example set by Kerby, Cheung, and Engelhard (2012), using ICES Catch Statistics, Scottish fleets were identified as the largest contributor to the North Sea landings of demersal finfish species in 2013 (22%) followed by Norway (15%) and the Netherlands (12%). Three key agents were identified. The authority was Marine Scotland (MS), which is a directorate of the Scottish government, responsible for the promotion of sustainable, profitable and well-managed fish resources. The operator was the North East group of Scotland Fishermen's Organisation (NESFO) which represents and assists Scottish fishers as catchers and producers. The auditor was Marine Scotland Science (MSS), which undertakes research and provides scientific and technical advice on fisheries issues, and is a distinct Division of Marine Scotland reviewed by an independent Science Advisory Board.

Biological, economic and social OTs were identified to address the sustainable exploitation of fish stocks, a profitable fishing industry and employment stability. Biological OTs were the following species-specific fishing mortalities (F) targeting MSY as defined by ICES (2012): $F_{cod} < 0.19$, $F_{haddock} < 0.3$, $F_{whiting} < 0.22$ (no F_{MSY} value was defined for whiting and ICES (2012) recommended an F_{Target} of 0.22), $F_{saithe} < 0.3$ and $F_{hake} < 0.24$. Fishers were required to land all catches of commercial species by 2017. Economic OTs aimed at achieving a 15% EBITDA, while maintaining year-to-year changes in landings below 15%. Social OTs specify that the quota share of a single company to be <12% and that a minimum of 15% of the catch should be sold to local processors (the town of the landing port).

The MP included new management strategies developed specifically to reach the OTs, including the Danish example of catch quota trials (Dalskov & Kindt-Larsen, 2009) but also built on existing regulations: skippers in the MP were allocated catch quotas, which were slightly higher than the current landing quotas and these could be traded among skippers. Remaining quota (attributed to non-active skippers) was administrated by the operator and could be purchased as extra quota by skippers. To facilitate a gradual use of quota as needed throughout the year, and to avoid a race to fish, the price of the extra quota would be set by the operator at a high level at the start of the year and subsequently decline to reach the actual market price at the end of the year. Each year, skippers in the MP must have agreed individually with the operator on a fishing plan specifying how they will use their allocated quotas for each species throughout the year. These fishing plans took into account the seasonality of species, helping the operator foresee related complications such as discards. Discards were to be monitored by fully documented fishery schemes as implemented in experiments in Scotland and Denmark (Kindt-Larsen, Kirkegaard, & Dalskov, 2011). Participating vessels should be equipped with a Remote Electronic Monitoring system including winch weight sensors and cameras recording catch information on each fishing event. Skippers would have equal opportunities to purchase additional quota provided that they follow the obligation to land all catches of TAC species. To avoid speculation, a single purchase could not exceed 5% of the total available quota. Skippers were to sell at least 15% of their production to local fish processors or markets for local consumption. When committing to sell at least 50% of their catches locally, skippers would be selling under a label of locally and sustainably caught fish set by the operator in agreement with the authority and regulations in place, which would guarantee transparency of the supply chain and reduced carbon emissions from transport, potentially granting access to new markets.

The RBM concept was well received, and stakeholders showed interest in being involved in MP development. Most of the MP elements proposed by the operator were already in place and/or ready to be implemented (e.g. NESFO already trades quotas to provide member skippers with additional quota to avoid discarding). Therefore, it would be relatively straightforward, in theory, to merge these elements in order to implement RBM. Stakeholders' enthusiasm towards potential involvement in developing management strategies showed promise for an actual implementation of RBM. The iteration process as designed by RBM performed well: the first MP version was reviewed by the authority (MS), allowing the operator to address raised issues and improve the MP. The authority and the operator came up with constructive ideas about the implementation of RBM without any major conflicts between the two agencies.

The most significant weakness of this pilot study was that it included only a single fleet segment of a single country of the North Sea mixed demersal fisheries. A full-scale implementation of RBM would be a much more complex given the high number of countries and fleet segments involved, and would require that a clear majority of skippers join in and abide by the MP. Nonetheless, the cooperation on developing an MP through RBM proved rather successful and could be reproduced on a larger scale. Although the operator welcomed the RBM concept and their increased involvement in management decisions, concerns were raised about the possible lack of incentives (i.e. only slight increases in quotas) for skippers to join and commit to the MP as participation is voluntary. While biological and economic OTs were widely accepted, criticisms were raised regarding technicalities of the social OTs. For instance, the OT stating that 15% of vessels catches should be sold locally was judged problematic because local processors do not always exist, however mitigating clauses could be inserted.

4 | DISCUSSION

4.1 | Performance of the RBM framework in pilot studies

The methodology of using artificial planning and evaluation processes to assess the feasibility of alternative management arrangements sets constraints for the type of conclusions that can be drawn from this study. First, the actors might have displayed different attitudes if the RBM was going to be implemented in reality. Second, the pilot studies were limited to the initial steps of planning and evaluating the MP and did not allow simulations of the further process of implementing and adapting MPs. Conducted in cooperation with relevant agents, the pilot studies nevertheless illustrate potentials and constraints with regard to using RBM as a model for an industrial organization approach to co-management.

Most of the identified relevant operators expressed genuine interest in participating, motivated from the belief that the RBM initiative would potentially contribute to a more effective and legitimate management system. Most enthusiasm came from cases which had significant weaknesses in the current approach (Icelandic lumpfish fishery and the Portuguese case).

In the Icelandic mixed demersal case, disagreements about allocation issues surfaced in relation to NASBO's proposal of operating a quota bank. This illustrates the importance of avoiding that the implementation of any new system, including RBM, is used as an arena for arguing about allocation rights.

The organization that represented the largest collective share of the Icelandic mixed demersal fisheries (LIU), declined to participate. This severely limited the potential of an MP, as operators would not be in a position deliver on OTs relating to the whole stock. This case also illustrated that in an ecosystem approach, as pursued here, there is a need to avoid too many OTs with associated indicators (Jennings, 2005) as this will complicate the MP and undermine the scope for flexible and efficient management arrangements.

As in the previous case, the MP for the North Sea mixed demersal fishery was constrained by the fact that the operators represented only about 22% of the total catch. In this case, it would be highly challenging to achieve full coverage of the fisheries in question due to the international scope of operators, distributed over several countries and speaking different languages.

Except for the North Sea study, a major problem was the lack of participation and support from relevant authorities in the pilot studies. In the Icelandic studies, the authorities seemed reluctant to participate due to concerns that this would be perceived to reflect approval of initiatives that were not established within the existing policy context, and hence exempted from democratic accountability. Besides the fact that the pilot studies represented a research initiative, with no actual implementation considered, this concern seems unjustified, as RBM is designed as an approach to implement existing policies by making their objectives explicit, and by delegating responsibility for their achievement. The reluctance of authorities to delegate power is well-known from other contexts. However, power delegation is necessary to allow users to design and implement effective means to achieve required results (Moynihan, 2006). In general, RBM depends on trust and cooperation between contracting partners, and it cannot be pursued without broad political support.

Finally, in many pilot studies, it proved difficult to define OTs with all required properties: relevant, measurable and achievable through actions taken by the operators. Fitzpatrick et al. (2011) argue that outcomes in RBM preferably should be defined in terms of in situ measures, which are directly observable and can be controlled by actions taken on a vessel level. However, RBM on organizational level makes it necessary to rely on OTs defined in terms of ex situ measures (e.g. stock indicators). Drawbacks of ex situ measures include that they are not observable in real time and that outcomes are likely to be influenced by external factors. The challenges with relying on ex situ measures will remain when delegating responsibility to resource users. Limitations of OTs and systems for information and control must be considered when evaluating how operators in RBM can be held to account for management outcomes. Operators should not be judged by a higher standard of accountability and proof than expected from authorities in an equivalent top-down management system.

4.2 | Advantages and drawbacks of the RBM framework

Different approaches to fisheries governance are underpinned by different rationales and values (Gray, 2005). RBM combines advantages from participatory and representative governance approaches as public authorities remain in control of the policy setting, while the responsibility for management and implementation is conditionally delegated to user groups. RBM is aligned with market-based governance as it deploys incentive structures that reward operators for innovation and for contributing to the knowledge base for fisheries management. The flexibility of the RBM allows operators to improve the cost-efficiency of management and implementation strategies as long as they provide adequate documentation and achieve OTs in the agreed period. This allows operators to tailor management strategies to comply with policy requirements while advancing their own objectives and making use of local knowledge and resources. RBM is responsive as its documentation system and audit framework allow for timely interventions and adaptive management. The system enhances transparency through the public hearing of the MP and publication of the audit report and process log. RBM is aligned with cost recovery as it shifts management responsibilities and the burden of proof, and the associated costs, to resource users.

Operators should represent a good majority of the participants in the fishery. This necessitates strong incentives, or that RBM is made mandatory. RBM is likely to involve relatively high costs for operators, mainly in the short term, as they take on increasing responsibility for data collection and the implementation of management measures (Townsend, 2010a). This suggests that voluntary RBM arrangements will only be feasible and worthwhile to pursue for operators when they can plan and make decisions for the large majority of the fishery. This requires that participants are sufficiently homogenous regarding interests and perspectives to enable common planning, which is more likely in simple governance situations (fewer nations, gear types, etc.). It is difficult for resource users to manage large-scale, transboundary resource systems, as this requires that they cooperate effectively through joint organizations (Singleton, 1999). The high costs also imply that voluntary RBM arrangements will be more likely to be pursued for resources of high values or large volumes, or for fisheries where a large number of fishers are organized by one effective operator.

Alternatively, authorities may require that resource users develop acceptable MPs and document the sustainability of their activities in exchange for access to exploit publically owned marine resources. This approach will likely be resisted by the industry where access has previously been granted without such obligations. However, the flexibility of the RBM framework allows for alternative distributions of resource management responsibilities and costs.

RBM requires that operators develop the necessary organizational capacity and foster leadership. For instance, the disagreement between members of operator organizations regarding certain OTs illustrates how leadership and approaches to collective decision-making become important when resource user organizations are involved in management processes. This requires that the organizations develop ways to resolve conflicts, clarify mandates and establish processes to ensure legitimacy of decisions. Operators will initially have limited experience and organizational capacity. However, once developed, an increased organizational capacity is a generic asset that provides a basis for adapting in response to environmental or regulatory change (McClenachan, O'connor, & Reynolds, 2015).

5 | CONCLUSIONS

The RBM framework presents a model of an "industrial organization" approach to co-management, distinguished by entrusting operators with new management responsibilities specified in relation to the achievement of objectives and documentation requirements. While the functions of a given management system may remain quite similar when shifting from a traditional management system to RBM, the responsibility for undertaking most of them shifts from the authority to operators and auditors. This, however, represents a significant change, which requires that such agents develop new capacities, and that legal and regulative frameworks are reconsidered. Our pilot studies suggest that a rapid switch to RBM is unlikely to be acceptable to authorities and operators. Therefore, a change to RBM will probably be gradual, enabling operators and authorities to develop trust and capacity, while the scope of mutual responsibilities is specified. The reversal of burden of proof may be phased in, as responsibility for tasks of monitoring, documentation and control is transferred. The process and the above-mentioned issues need to be properly documented when RBM is implemented in real life cases to promote learning and allow for further research.

The factors identified by Ostrom (2009) to enhance the likelihood of achieving sustainable social-ecological systems through self-organization are also relevant here. These suggest that RBM is most likely to succeed where resources are well contained, of limited mobility, potentially productive, valuable, have predictable dynamics, leadership is effective, there are shared values, and there is good knowledge about the fisheries. Some of our case-studies had these traits, but none had them all. European examples of fisheries with all of these traits include high-value shellfish and some pelagic fisheries.

Trends towards RBM like arrangements are observed in Europe as stakeholder organizations increasingly get involved in management (Hegland & Wilson, 2009; Holmes et al., 2011; Stange et al., 2014). Deploying RBM ideas, the 2014 CFP reform aspires to reduce micromanagement and move towards regionalized management, enabling regulations to be adapted to specific areas. A new proposal for technical regulations is very much in line with RBM as presented here as it is formulated as a *generic* regulation, which establishes a basis for decentralized technical regulations, tailored to achieve policy objectives (EC, 2016). Hence, although our research indicates that a full-scale RBM is unlikely to be implemented in the near future, it is also clear that European fisheries governance is moving in that direction. The rock lobster fishers of New Zealand have successfully adopted principles that characterize the presented RBM and it remains to be seen how and when others will follow suit.

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