

A Framework for Results Based Management in Fisheries

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1 **A Framework for Results Based Management in Fisheries**

2 **Abstract**

3 We present a framework for Results Based Management (RBM) of commercial fisheries. The
4 core idea of RBM is to reduce micro-management by delegating management responsibility
5 to resource users. The RBM framework represents an industrial organization approach to co-
6 management and comprises three defining processes, conducted by three independent
7 “agents”: 1) an “authority” defines specific and measurable and achievable objectives
8 (outcome targets, OTs) for the utilization of fisheries resources, 2) resource user organizations
9 (termed “operators”) take responsibility for achieving these OTs and provide documentation
10 that 3) allows independent “auditors” to evaluate the achievement of OTs. Using incentive
11 mechanisms, notably deregulation, RBM grants operators the flexibility to develop and
12 implement innovative and cost-effective ways to achieve OTs. The feasibility of
13 implementing RBM in five European fisheries was investigated in cooperation with relevant
14 stakeholders through artificial planning processes and computer simulations. The operators
15 involved were enthusiastic, and new management plans were drafted based on the framework.
16 These included socio-economic OTs in addition to traditional stock objectives, encompassing
17 an ecosystem approach. Several issues are in need of further research in order to consolidate
18 the approach and prepare the ground for practical implementation, including: the specification
19 of the legal and regulatory framework required to underpin RBM, details of transitional
20 arrangements when shifting towards RBM (including cost-sharing) and the development of
21 necessary organizational capacity for operators. Initially, we therefore envisage the
22 framework being applied to high value single species fisheries, with a limited number of
23 participants, which are adequately represented by a competent organization.

24 **Keywords:** Burden of proof, co-management, Common Fisheries Policy, results based
25 management, the EcoFishMan project.

26 1. Introduction

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

39 This state-centred approach tends to lead to paternalistic (top-down) and regulation intensive
40 management systems that exclude resource users from knowledge production and decision-
41 making (Lane and Stephenson, 2000; Degnbol, 2003; Jentoft and Mikalsen, 2003). This
42 contrasts with the growing recognition that successful management of fisheries and other
43 socio-ecological systems must include the constructive engagement of users (Lane and
44 Stephenson, 2000; Degnbol, 2003; Parma *et al.*, 2006; Ostrom, 2009; Gutiérrez *et al.*, 2011;
45 Deacon, 2012). The strategy of assigning management responsibility to user groups within a
46 formalised management systems is not new (Jentoft, 1989) and has shown promise in some
47 cases, but receives little attention (Deacon, 2012). There is little general discussion on how to

48 design a framework for an ‘industrial organization’ approach to co-management with
49 relevance to modern capture fisheries (Lane and Stephenson, 1998).

50 Aiming to reinvigorate discussion, promote research and devise practical initiatives in this
51 context, we present and discuss a specific approach which aims to delegate fisheries
52 management responsibility to resource users. The conceptual basis for the proposed approach
53 is Results Based Management (RBM), combined with incentive mechanisms for stimulating
54 active involvement of user groups in management and information gathering, namely the
55 notions of a “reversed burden of proof” (Degnbol, 2003; Fitzpatrick *et al.* 2011; Linke and
56 Jentoft, 2012) and “cost recovery” (Stokes *et al.*, 2006). This is based on the idea that private
57 users of public resources should be held accountable for the costs of implementing
58 management measures and of monitoring to ensure that the negative impact of the resource
59 use is acceptable.

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

65 The industry can be given more responsibility through self-management. [...] instead
66 of establishing rules about how to fish, the rules focus on the outcome and the more
67 detailed implementation decisions would be left to the industry. Public authorities
68 would set the limits within which the industry must operate, [...] and then give
69 industry the authority to develop the best solutions economically and technically (EC,
70 2009).

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

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

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

104 2. Materials and Methods

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

117

118 2.1 Enabling conditions for an industrial organization approach to co-management

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

142 2.2 Framework for Results Based Management in Fisheries

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

151 [Fig. 1 about here]

152 The performance of an MP is evaluated by a third agent, an external “auditor”, which also
153 monitors that both parties stick to pre-agreed timelines and process steps. The auditor
154 enhances mutual accountability and reduces the risk of imbalanced relationships between
155 cooperating parties. Examples of these are: a lack of downward accountability (Berkes, 2009),
156 reduced proclivity of civil servants to defend public interests due to tight cooperation with
157 industry (Singleton, 1999), and a reluctance of the authority to delegate power (Moynihan,
158 2006).

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

165 area of responsibility for operators. Beyond the OTs the responsibility to achieve policy goals
166 remains with the authority.

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

175 The MP includes (graduated) sanctions in case OTs are not achieved (e.g. a harvest control
176 rule with inbuilt catch reductions if biomass thresholds are not met). The presence of such
177 collective sanctions may encourage the operator to develop internal control mechanisms in
178 order to avoid losses due to non-compliant members. Most likely, however, operators will
179 need external control and enforcement (e.g. provided by the authority) to ensure compliance
180 and to provide independent information (e.g. regarding the quality of catch data). From the
181 perspective of the authority and its commitment to public policies, the issue of control resorts
182 simply to whether OTs are achieved. It is for the independent auditor to confirm such
183 achievement, on the basis of its evaluation of the appropriate documentation.

184 The authority examines the MP proposal, and may request revisions or clarifications until it
185 meets pre-agreed conditions, i.e. a strategy for achieving OTs and for obtaining adequate
186 audit information. This step could involve a thorough scientific evaluation, e.g. a
187 Management Strategy Evaluation (Punt *et al.*, 2017), but a less formalised expert judgment
188 process could be used for small scale, low value, or data-poor fisheries. The authority's

189 approval serves to provide a safeguard against poor proposals and does not relieve operators
190 of their principal responsibility to achieve OTs.

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

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

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

210 The MP is subjected to a range of uncertainties and externalities. This implies that operators
211 cannot be expected to achieve OTs under all circumstances (e.g. unfavourable environmental

212 conditions). This is a common contract situation in which it is impractical, costly or even
213 impossible for the contracting parties to address all contingencies *ex ante*. In general, failure
214 to deliver the terms of contracts is addressed *ex post* by the courts, which determine whether
215 the contractor has performed in ‘good faith’ (Burton, 1980; Armour et al., 2009). Similarly in
216 RBM, if OTs are not met, the auditor judges whether the operator has implemented the MP in
217 ‘good faith’, and taken reasonable measures to achieve OTs. This provides the basis for the
218 authority to set new conditions when the MP is revised and/or to introduce sanctions. The
219 ultimate sanction for operators consistently performing in ‘bad faith’ could be termination of
220 the RBM approach, and a consequent re-installment of top-down management.

221 2.3 Pilot studies

222

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

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

235 1. An MP invitation was prepared for each pilot study by the relevant authority. The MP
236 invitation defined the OTs for resource users to meet. It also contained a guideline for
237 developing the MP, and listed the required elements to be addressed.

238 2. Responding to the MP invitation, operators developed an MP. The MPs were refined until
239 the authority had confirmed that all required elements were in place and thus could approve
240 the MP.

241 3. The performance of MPs with regard to OTs was assessed using model simulations. This
242 provided a basis for auditors to evaluate MPs regarding sustainability, applicability and risks.

243 The respective roles of authority and operators were performed by local relevant actors in the
244 pilot studies to the extent possible, and were facilitated by research teams from the project. To
245 avoid the risks of ambiguity of roles of researchers (Dankel *et al.*, 2015), the project was
246 organised such that teams of project researchers would facilitate one role only, consistent with
247 the outlined RBM.

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

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

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

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

270 [Table 1 about here]

271 *2.3.1 The Icelandic lumpfish fishery*

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

280 The Icelandic Ministry of Industries and Innovation (IMI) manages the fishery in
281 consultation with the Marine Research Institute (MRI), the Directorate of Fisheries and the
282 industry, considering advice from the MRI, regional needs, and market conditions. There is no
283 management plan. The MRI provides advice on Total Allowable Catches (TACs) based on
284 fishing mortality (F) reference point proxies, but the fishery is regulated through licenses and
285 effort restrictions (MSC, 2016; Kennedy *et al.*, 2015).

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

290 *2.3.2 The Icelandic mixed demersal fishery*

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

297 The fishery is managed by Individual Transferable Quotas and involves two groups of
298 permanent quota entitlements. Group1 consists of about 400 small (<15 m) vessels restricted
299 to using hand-line or long-line, accounting for ~14% of the demersal catches. Group2
300 involves around 300 larger vessels, including trawlers, accounting for ~84% of the demersal
301 catches. The IMI allocates ~2% of the demersal TAC to an open access fishery for ~ 700
302 small (<13 m) handline boats. Finally, it allocates ~ 8% of the demersal TAC to facilitate new
303 entries into the fishery, or support regional development or environmentally friendly

304 initiatives. The latter “incentive quotas”, are primarily utilized by vessels operating within
305 Group1 or by small coastal vessels without quotas. Almost all NASBO members are within
306 Group1 or own vessels without quotas. Group2 are members of Fisheries Iceland (SFS),
307 formerly known as the Federation of Icelandic fishing vessel owners (LIU).

308 Operators in the mixed demersal fishery are engaged in shaping management policy. Unlike
309 the lumpfish fishery, the cod fishery brings together heterogeneous harvesters that operate
310 vessels within different fleet segments, and with potentially diverging fisheries interests.
311 Whereas both SFS and NASBO support the current quota management system, those taking
312 part in the open access coastal fisheries would like to see it changed. These differences make
313 a comprehensive shift towards co-management difficult.

314

315 *2.3.3 The Portuguese crustacean trawl fishery*

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

325 The fishery is managed under the CFP. The responsibility for implementing the fisheries
326 policy at national level lies with the Ministry of the Sea and is delegated to the Deputy State
327 Secretary for the Sea. The Portuguese General Directorate for Natural Resources, Safety and

328 Marine Services (DGRM) is responsible for fisheries management activities, drafting national
329 regulations, distributing quotas, monitoring and enforcement.

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

337

338 *2.3.4 North Sea mixed demersal fisheries*

339 North Sea demersal fisheries involve a number of fleets and species, but are data rich. The
340 largest fleets are operated by the United Kingdom, France, Germany and Denmark (STECF,
341 2011). The fisheries target valuable species such as cod, haddock, and whiting (*Merlangius*
342 *merlangus*, Gadidae), but also saithe, plaice (*Pleuronectes platessa*, Pleuronectidae), sole
343 (*Solea solea*, Soleidae), Norway lobster, European hake and anglerfish (mainly *Lophius*
344 *piscatorius*, Lophiidae). A revised CFP was implemented in 2014 to improve conservation
345 and achieve long-term economic viability for the fishing industry (EU, 2013). The reform
346 includes a landing obligation (discard ban) which presents difficulties in the presence of
347 species with small quotas, “choke species”, which may induce a premature closure (Baudron
348 and Fernandes, 2014).

349 Demersal fisheries in the North Sea feature many nations, fleet types, fishermen's
350 associations and producer organizations, which altogether may render a comprehensive co-
351 management arrangement difficult. The fishing industry is organized into a number of

352 national and international associations and Producer Organizations (POs) (Santiago *et al.*,
353 2015). The North Sea Advisory Council (NSAC) is a key arena for stakeholder participation
354 in fisheries management, with representatives from the fishing industry organizations as well
355 as environmental NGOs. However, its role in participatory governance may be hampered by
356 difficulties to provide consensus based advice (Hatchard and Gray, 2014).

357

358 3. Results

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

364 3.1 The Icelandic lumpfish fishery

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

370 The Icelandic fisheries management act identifies the key objectives for the management of
371 living marine resources in Icelandic waters (IP, 2006). The goals are to promote the
372 conservation and efficient utilisation of marine resources and ensure stable employment,
373 economic viability and maintain settlement in rural areas. The “authority” and the “operators”
374 agreed on two OTs: A biological OT for lumpfish to maintain fishing mortality ($F_{\text{proxy}} < 0.75$,

375 which is the MSY proxy used by the MRI to provide TAC advice (MSC 2016). A socio-
376 economic OT was defined which set requirements for the geographical distribution of issued
377 licenses due to the regional importance of the fishery.

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

385 Likely outcomes of implementing the MP were estimated by a computer simulation in
386 StellaTM, taking into consideration recruitment, growth rate, harvest rate, effort, costs,
387 revenues, profits, the number of jobs in catching and processing, as well as spatial
388 considerations regarding landings and job creation (Sigurðardóttir and Gunnlaugsson, 2012).

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

398 3.2 The Icelandic mixed demersal fishery

399 LIU did not participate in this pilot study, and gave no particular reason. One obvious reason
400 could be that LIU is content with the present quota management system. The ITQ system has
401 been contested since it came into effect, with initial allocation and transferability of quotas,
402 and sharing of the resource rent being especially thorny issues (Matthiasson and Agnarsson,
403 2009; Benediktsson and Karlsdottir, 2011; Agnarsson, Matthiasson and Giry, 2016;
404 Kokorsch, Karlsdottir and Benediktsson 2016; Chambers and Carothers, 2017). Without LIU,
405 the main agents involved were those involved in the previous case, restricting the pilot study
406 to smaller jig and line vessels and vessels without quotas, comprising approximately 14-18%
407 of total demersal catches.

408 Representing almost all vessel owners within this category, NASBO was actively involved as
409 the “operator”. Groups of researchers respectively represented the agencies of “authority” and
410 “auditor”. The “authority” and NASBO agreed on 19 OTs (of which seven, outlined here in
411 italics, were new): spawning stock biomass (SSB) for cod, haddock, saithe, golden redfish,
412 Atlantic catfish, tusk and common ling $> MSY$ thresholds; $F < F_{MSY}$ (for eight bycatch
413 species); bycatch % limits by species; an obligation to land all catches; *20% of Earnings*
414 *Before Interest, Taxes, Depreciation and Amortization (EBITDA) is paid as public resource*
415 *rent; zero non-fuel subsidies; EBITDA of fishing companies > 0 (average for planning*
416 *period); $> 17\%$ of demersal TACs for J&L vessels < 15 m; $> 80\%$ of catches landed in*
417 *villages with < 5000 inhabitants; company specific ownership of quota $< 12\%$; average*
418 *wages in the sector $>$ national average; annual recruitment of new workers $> 1\%$; all*
419 *primary processing in Iceland. NASBO’s proposal incorporated the “incentive quotas” into*
420 Group1 and invited vessel-owners without quotas into that system. The MP covered 17% of
421 the total demersal catches in Icelandic waters, of which 12% would be allocated based on

422 present quota ownership. The remaining 5% would be entrusted to a quota bank operated by
423 NASBO to promote achievement of OTs and fund involved expenses.

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

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

442 The high number of OTs complicated the RBM arrangements, and set high requirements for
443 the collection of data for assessment and audit. A smaller set of OTs would have been more
444 feasible. The organization representing the majority of the catches did not participate in the

445 pilot study, and this was a significant weakness. Hence, this pilot study demonstrated the
446 importance of including a good majority of those engaged in the fishery in the MP.

447

448 3.3 The Portuguese crustacean bottom trawl fishery

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

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

465 Rewards for compliance and good practices as well as sanctions and corrective measures
466 concerning observed deviations from the OTs were defined, including fines and temporary
467 fishing restrictions. Incentives (fishing days, quota) would encourage the use of selective

468 gears and/or bycatch reduction devices. To ensure proper monitoring of OTs, a
469 documentation system was proposed, which included the existing system of electronic
470 reporting, more detailed paper logbooks for reporting the retained catches and discards, vessel
471 activity information, economic and financial reports, and other arrangements between the
472 operators and research institutions to gather data.

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

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

488 Some issues need to be resolved before RBM can be successfully implemented in this fishery.
489 In particular, additional incentives must be deployed to encourage operators to participate in
490 RBM, and ways to finance the monitoring and auditing processes must be established and
491 agreed on (Silva *et al.*, 2015). RBM was well accepted by the operators because clear

492 objectives for the crustacean fishery were set. Other positive aspects of the MP development,
493 as opposed to the present management regime, included that it implied the same rules for all
494 and would replace an unpopular recovery plan.

495

496 3.4 North Sea mixed demersal fisheries

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

509 Biological, economic and social OTs were identified to address the sustainable exploitation of
510 fish stocks, a profitable fishing industry and employment stability. Biological OTs were the
511 following species-specific fishing mortalities (F) targeting MSY as defined by ICES (2012):
512 $F_{\text{cod}} < 0.19$, $F_{\text{haddock}} < 0.3$, $F_{\text{whiting}} < 0.22$ (no F_{MSY} value was defined for whiting and ICES
513 (2012) recommended an F_{Target} of 0.22), $F_{\text{saithe}} < 0.3$ and $F_{\text{hake}} < 0.24$. Fishers were required to
514 land all catches of commercial species by 2017. Economic OTs aimed at achieving a 15%
515 EBITDA, while maintaining year-to-year changes in landings below 15%. Social OTs specify

516 that the quota share of a single company to be less than 12% and that a minimum of 15% of
517 the catch should be sold to local processors (the town of the landing port).

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

540 guarantee transparency of the supply chain and reduced carbon emissions from transport,
541 potentially granting access to new markets.

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

553 The most significant weakness of this pilot study was that it included only a single fleet
554 segment of a single country of the North Sea mixed demersal fisheries. A full-scale
555 implementation of RBM would be a much more complex given the high number of countries
556 and fleet segments involved, and would require that a clear majority of skippers join in and
557 abide by the MP. Nonetheless, the cooperation on developing an MP through RBM proved
558 rather successful and could be reproduced on a larger scale. Although the operator welcomed
559 the RBM concept and their increased involvement in management decisions, concerns were
560 raised about the possible lack of incentives (i.e. only slight increases in quotas) for skippers to
561 join and commit to the MP since participation is voluntary. While biological and economic
562 OTs were widely accepted, criticisms were raised regarding technicalities of the social OTs.
563 For instance, the OT stating that 15% of vessels catches should be sold locally was judged

564 problematic because local processors do not always exist, however mitigating clauses could
565 be inserted.

566

567 4. Discussion

568 4.1 Performance of the RBM framework in pilot studies

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

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

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

585 The organisation that represented the largest collective share of the Icelandic mixed demersal
586 fisheries (LIU), declined to participate. This severely limited the potential of an MP, as

587 operators would not be in a position deliver on OTs relating to the whole stock. This case also
588 illustrated that in an ecosystem approach, as pursued here, there is a need to avoid too many
589 OTs with associated indicators (Jennings, 2005) as this will complicate the MP and
590 undermine the scope for flexible and efficient management arrangements.

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

596 Except for the North Sea study, a major problem was the lack of participation and support
597 from relevant authorities in the pilot studies. In the Icelandic studies, the authorities seemed
598 reluctant to participate due to concerns that this would be perceived to reflect approval of
599 initiatives that were not established within the existing policy context, and hence exempted
600 from democratic accountability. Besides the fact that the pilot studies represented a research
601 initiative, with no actual implementation considered, this concern seems unjustified, as RBM
602 is designed as an approach to implement existing policies by making their objectives explicit,
603 and by delegating responsibility for their achievement. The reluctance of authorities to
604 delegate power is well known from other contexts. However, power delegation is necessary to
605 allow users to design and implement effective means to achieve required results (Moynihan,
606 2006). In general, RBM depends on trust and cooperation between contracting partners, and it
607 cannot be pursued without broad political support.

608 Finally, in many pilot studies, it proved difficult to define OTs with all required properties:
609 relevant, measurable, and achievable through actions taken by the operators. Fitzpatrick *et al.*
610 (2011) argue that outcomes in RBM preferably should be defined in terms of *in-situ* measures,

611 which are directly observable and can be controlled by actions taken on a vessel level.
612 However, RBM on organizational level makes it necessary to rely on OTs defined in terms of
613 *ex-situ* measures (e.g. stock indicators). Drawbacks of *ex-situ* measures include that they are
614 not observable in real time and that outcomes are likely to be influenced by external factors.
615 The challenges with relying on *ex-situ* measures will remain when delegating responsibility to
616 resource users. Limitations of OTs and systems for information and control must be
617 considered when evaluating how operators in RBM can be held to account for management
618 outcomes. Operators should not be judged by a higher standard of accountability and proof
619 than expected from authorities in an equivalent top-down management system.

620

621 4.2 Advantages and drawbacks of the RBM framework

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

635 process log. RBM is aligned with cost recovery as it shifts management responsibilities and
636 the burden of proof, and the associated costs, to resource users.

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

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

656 RBM requires that operators develop the necessary organisational capacity and foster
657 leadership. For instance, the disagreement between members of operator organizations
658 regarding certain OTs illustrates how leadership and approaches to collective decision-making

659 become important when resource user organisations are involved in management processes.
660 This requires that the organisations develop ways to resolve conflicts, clarify mandates, and
661 establish processes to ensure legitimacy of decisions. Operators will initially have limited
662 experience and organizational capacity. However, once developed, an increased
663 organizational capacity is a generic asset that provides a basis for adapting in response to
664 environmental or regulatory change (McClenachan *et al.*, 2015).

665

666 5. Conclusions

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

681 The factors identified by Ostrom (2009) to enhance the likelihood of achieving sustainable
682 social-ecological systems through self-organisation are also relevant here. These suggest that

683 RBM is most likely to succeed where resources are well contained, of limited mobility,
684 potentially productive, valuable, have predictable dynamics, leadership is effective, there are
685 shared values, and there is good knowledge about the fisheries. Some of our case studies had
686 these traits but none had them all. European examples of fisheries with all of these traits
687 include high value shellfish and some pelagic fisheries.

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

699

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701

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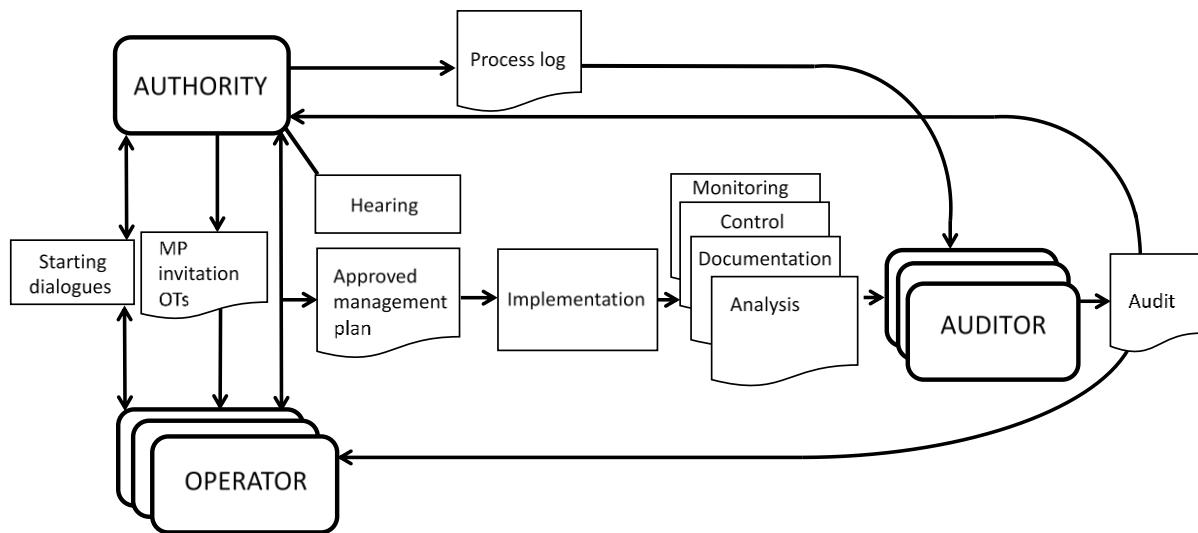
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927 **Table 1.** Overview of pilot studies investigated for the feasibility of RBM. CFP = Common
 928 Fisheries Policy; GFCM = General Fisheries Commission for the Mediterranean. Cases are
 929 arranged, from left to right, in order of expected difficulty in applying 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 bycatch level	Low: mixed fishery with few target species	Intermediate: Several target and bycatch species	High: several target and bycatch 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

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

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