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Challenges and opportunities for fleet- and métier-based approaches for fisheries management under the European Common Fishery Policy

[Clara Ulrich^a](#), [Douglas C.K. Wilson^b](#), [J. Rasmus Nielsen^a](#), [Francois Bastardie^a](#), [Stuart A. Reeves^{c,1}](#), [Bo S. Andersen^d](#), [Ole R. Eigaard^a](#)

^a DTU Aqua, Charlottenlund Castle, DK-2920 Charlottenlund, Denmark

^b IFM AAU, Department of Development and Planning, Fibigerstræde 13, 9220 Aalborg Ø, Denmark

^c Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, NR33 0HT, UK

^d DTU Aqua North Sea Science Park, DK-9850 Hirtshals, Denmark

ABSTRACT

The inconsistency of single-species objectives in a mixed-fisheries context has repeatedly been highlighted as a key issue in the current European Common Fishery Policy, and it has long been suggested that this issue would be better addressed through fleet (group of vessels) and métier (type of activity) – based approaches. Since the late 1980s, when such approaches were first introduced, there have been substantial developments in this area of science, to the point where the concepts of fleet and métier now underpin the whole EC Data Collection Framework. However, their implementation in the management system has been slow and difficult, being hampered by a number of intrinsic issues. Mixed fisheries are an ongoing “governance headache” combining management complexity, scientific uncertainty and political sensitivity.

This paper summarises the current state of play for fleet-based approaches in EU fisheries management, and highlights our views on both their potential and the challenges they face in the context of the future CFP. As a convenient layer between the current single-stock level and the level of the individual vessel, fleet/métier- approaches could potentially address a wide range of issues, especially with regards to the policy emphasis on ecosystem-based fisheries management. However, the rigid categorisation they induce may not properly address the flexibility of individual vessels, and should therefore be supplemented by more detailed considerations at the local scale.

Keywords: Common Fishery Policy (CFP), Data Collection Framework (DCF), métier, fleet dynamics, Ecosystem-Based Fisheries Management (EBFM), mixed-fisheries, results-based management

*Corresponding author: clur@aqu.aqua.dtu.dk

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23 1 Introduction

24 1.1 *The problem*

25 There is a general understanding that mixed-fisheries aspects are a key issue in the traditional single-
26 stock management approach, because of the evidence that catches of the various species are
27 interlinked due to technical interactions between different fleets and gears (Figure 1). In addition,
28 availability, abundance and economic attractiveness differ across species, adding to the complexity of
29 the problem. This issue is well illustrated by the demersal fisheries in the North Sea over the 2000s.
30 The North Sea cod stock had declined to a very low biomass while the stock of haddock, which to a
31 large extent is caught together with cod, had reached very high biomass levels (ICES, 2011b). Effort
32 reductions have been introduced through the successive European cod management plans (EC, 2004
33 and EC, 2008b), but the central management measure for these stocks has remained single-stock Total
34 Allowable Catches (TACs), which in practice have regulated landings rather than catches. One result
35 is that vessels may exhaust the cod TAC before the haddock TAC, and the subsequent cod catch may
36 then have to be discarded. Hence the cod TAC, despite being based on advice consistently intended to
37 reduce fishing mortality, has not achieved its intended conservation benefit (STECF, 2011a).
38 Bannister (2004) identified the mixed-species nature of the fishery, along with its international
39 dimension, as the two main factors contributing to the cod decline.

40 In theory, fleet-based approaches are valuable improvements to the current approach of managing
41 single-species fish stocks (Vinther et al., 2004; Nielsen and Limborg, 2009). The long history of the
42 EU Common Fisheries Policy (CFP) of aiming at, but often failing to, manage complex fisheries
43 through TACs provides an illustration of the limits of the current stock-based management approach.
44 When implemented in their most usual form in EU, i.e. involving competitive shared quotas and
45 landings control, single-stock TACs are not able to control total removals and fishing mortality in
46 mixed-fisheries (ICES, 2011b, STECF, 2011a).

47 In practice however, the implementation of fleet-based approaches in the management system has
48 been slow. Since the seminal work of Laurec et al. (1991), the topic has attracted considerable
49 scientific attention. Twenty years of European research in fleet and fishery analyses have led to
50 substantial improvements in the data collection, understanding of processes and improved
51 standardization across nations. In spite of this, the scientific advice provided by the International
52 Council for the Exploration of the Sea (ICES) has only recently made some progress in accounting for
53 technical interactions in a quantitative way (ICES, 2011a; Ulrich et al., 2011). Some of this inertia
54 undoubtedly reflects the complexity of the fisheries involved. ICES (2011a) compiled data for all
55 countries, fleets and gears catching demersal target species in the North Sea. Even after aggregation of
56 the minor fleets and gears, the data still include 72 different fleet, gear and métier groupings.
57 However, the problem is clearly not only a scientific one. In 2011, the paradigm that decreasing
58 single-stocks TACs is the path towards sustainability is still prevalent in the political action of the
59 European Commission (EC, 2011a). The maintaining of the principle of relative stability, ensuring
60 fixed shares of the individual TACs to the various Member States, has inhibited the political ability to
61 apprehend mixed-fisheries in a sensible and integrated approach. With such a combination of high
62 uncertainty, high political sensitivity, and associated complex science, Wilson and Jacobsen (2009)
63 call mixed-fisheries management a “governance headache”.

64 This paper aims thus both at describing the current state of play regarding the actual implementation of
65 of fleet- and fishery based approaches in EU, focusing on some intrinsic issues that have been of
66 hindrance,, and at discussing the opportunities and challenges for these approaches under the future
67 CFP. Our case is based on our experience (mainly from North Sea and Baltic Sea regions), both as
68 providers of scientific advice for fisheries managers and as collaborators on a suite of research projects
69 studying fleet dynamics and fisheries management. It should therefore only be taken to represent a
70 subset of the wide range of knowledge and opinions to be found around this broad topic.

71 **1.2 Glossary**

72 First of all, the basic concepts must be defined. The terminology has evolved over the years. ICES
73 (2003) initially considered three types of fishing units: the fleet, the fishery, and the métier. In 2008,
74 the European Data Collection Framework (DCF; EC, 2008a) retained only two concepts, which we
75 adopt for this paper: A *fleet* (or *fleet segment*) is a group of vessels with the same length class and
76 predominant fishing gear during the year. Vessels may have different fishing activities during the
77 reference period, but might be classified in only one fleet segment. A *métier* is a group of fishing
78 operations targeting a similar (assemblage of) species, using similar gear, during the same period of
79 the year and/or within the same area and which are characterized by a similar exploitation pattern. As
80 such, the fleet describes the vessels while the métier(s) describes the fishing activity(ies) in which the
81 fleet engages (Figure 1).

82 **2 State of the art: Current implementations at the European** 83 **Union level**

84 **2.1 Fleets and métiers in the CFP**

85 The European Commission (EC) has long expressed its interest in fleet-based approaches. In 2001 the
86 Green Paper (CEC, 2001) underlined that “*TACs can only play a limited role in the management of*
87 *fisheries in which many species of fish are taken simultaneously by each operation of the fishing gear*
88 *(the mixed or multi-species fisheries) (...). Mixed fisheries are prevalent in Community waters and*
89 *therefore it may be preferable to manage groups of stocks for well-defined fisheries. The setting-up of*
90 *a true effort management regime could be one of the means to approach multi-species management.*”

91 A more recent Green Paper (CEC, 2009), recognized again fleet-based approaches as a one key area of
92 interest for the future. Ultimately, the proposal on the reform of the European Union’s CFP (EC,
93 2011b) provides a concrete context for this. Long-term management plans have been an important

94 component of EU fisheries management since 2002. Public consultation in relation to the recent
95 reform proposal has found very strong support for the implementation of long-term management
96 plans. The current proposal widens the basis for the use of management plans as follows:
97 “*Multi-annual plans should where possible cover multiple stocks where those stocks are jointly*
98 *exploited. The multiannual plans should establish the basis for fixing fishing opportunities and*
99 *quantifiable targets for the sustainable exploitation of stocks and marine ecosystems concerned,*
100 *defining clear timeframes and safeguard mechanisms for unforeseen developments.*”

101 These ideological seeds, thus planted long ago, have so far yielded two major realizations. We
102 describe them below.

103 ***2.2 The Data Collection Framework***

104 Many years of development in data collection programs have led to a standardized European sampling
105 program for fisheries biological and economic data based on fishing activities as sampling strata (EC,
106 2008a). It specifies the standard for national sampling programs, using the fleet as the basis for
107 economic data sampling, and the métier as the basis for biological data sampling. Integrating fishing
108 activities represents a major change compared to the EU Data Collection Regulation (DCR) previously
109 in force (EC, 2001).

110 The DCF defines métiers according to a hierarchical structure using six nested levels: Level 1-
111 Activity (fishing/non fishing), Level 2- Gear class (e.g. trawls, dredges), Level 3- Gear group (e.g.
112 bottom trawls, pelagic trawls), Level 4- Gear type (e.g. Bottom otter trawl, Bottom pair trawl), Level
113 5- Target assemblage based on main species type (e.g. Demersal fish vs. Crustaceans or Cephalopods),
114 Level 6- Mesh size and other selective devices. In addition, economic variables should be reported for
115 fleet segments defined by the dominant gear (in terms of fishing effort) used by vessels, and for six
116 length classes.

117 The definitions of the DCF métiers were initiated during two pan-European workshops (EC, 2005a,
118 2006), and are still extensively debated (ICES, 2010). No unified quantitative method has yet been
119 agreed (see section 3 below), leaving some room for interpretation at the national level. This has
120 slowed the development of a standard, generic EU approach, leading to continuing national differences
121 in métier definitions within the same EU region.

122 In summary, the DCF has from 2009 led to major steps towards quantification and monitoring of fleets
123 and métiers, through improved agreement on the basic concepts and definitions, as well as increasing
124 facilities and collaboration to exchange data. However, it is also true that substantial national
125 differences still exist, and further initiatives are still necessary in order to achieve full consistency
126 across member states (STECF, 2011b, Deporte et al., 2012).

127 ***2.3 Métier-based effort management***

128 In parallel to the work undertaken within DCF, but without any linkages to it, métier-based effort
129 regulations have been enforced in European waters. Effort restrictions (days at sea) were first
130 introduced in 2003 to supplement TACs in areas covered by the cod recovery plan (EC, 2004), and
131 have been updated annually since then. Subsequently, similar effort restrictions were introduced in
132 relation to southern hake and *Nephrops*, western channel sole and sandeel fisheries. Categories
133 (métiers) for days at sea limits were defined in terms of gear type and cod-end mesh size
134 combinations. ‘Special condition’ categories were also defined such that a vessel qualifying for such
135 status would be entitled to a greater number of days at sea than the default value for the same gear-
136 mesh size group.

137 These categories are therefore quite different from the DCF métiers described above, and only limited
138 consideration has been given to this. Reeves et al. (2008) provided a useful overview on the processes
139 and scientific issues underlying these days at sea regulations. While the establishment of the DCF
140 involved an extensive and long scientific process based on available information, in contrast, the days
141 at sea regulations were designed and implemented over a very short period of time and without any

142 clear scientific basis. Subsequently, sub-groups of the European Commission's Scientific, Technical
143 and Economic Committee for Fisheries (STECF) were tasked to evaluate the effects of these
144 regulations. This requires extensive compilation of effort and catch data, aggregated such that the
145 hierarchy of gear, mesh size and special condition status match those in the annual Council
146 Regulations fixing EU fishing opportunities and associated conditions in EU Community waters (see
147 for example STECF 2010a). These exercises proved to be difficult, time-consuming, error-prone and
148 inconsistent across EU Member States. A main reason is that the scientific data are collected following
149 DCF standards, while monitoring the days at sea management requires more detailed information of
150 gear descriptors, which are not usually available in the data provided to national scientific institutes..

151 Furthermore, the implementation of the days at sea system led to strong protests from the fishing
152 industry questioning both its fairness and its basis. The system was implemented as a top-down
153 command and control system, and was conceived on the assumption that cod catches could simply be
154 reduced by reducing the cod-directed fishery. As cod is caught by most gears in the North Sea, most
155 demersal fisheries were affected by the system and the industry considered this conservation measure
156 to be neither efficient nor fairly shared. The protests pressured the Member States to exempt some of
157 their fleets. This resulted in increasingly detailed micromanagement, and an even more complex set of
158 regulations that basically changed every year (Table 1). In 2008, the system was no longer considered
159 sustainable, controllable and effective by the EC, and a complete new approach for effort control was
160 agreed with Members States. This moved from limitations at the level of the individual vessel and
161 métier to limitations at the level of the Member States over broader gear/mesh size categories, thus
162 allowing for more flexibility. This system was implemented in 2009 (EC, 2008b), based on a reduced
163 number of categories, but with new mechanisms aiming at encouraging cod-avoidance behavior in the
164 fishing industry. STECF (2011a) conducted a detailed evaluation of that plan. The increased use of
165 incentives-based management was evaluated as a positive innovation, but it was also pointed out that
166 there was still little support from the industry towards the effort constraints induced by the plan.
167 Interestingly, the so-called incentives in the cod plan are in reality almost all negative in the sense that

168 action to avoid cod will result in reductions in income (sub-optimal areas; loss of fish through changes
169 in selectivity), as will no action (reduction in fishing effort opportunities). Each business needs to
170 weight up the degree of loss associated with these negative choices, leading to a somehow unclear
171 perception of the incentivizing mechanisms and a difficult monitoring of their effects (Holmes et al.,
172 2011, Needle and Catarino, 2011).

173 **3 A fundamental challenge: agreeing on basic definitions and** 174 **categorization.**

175 The two initiatives described in section 2 are the most advanced attempts to implement operational
176 fleet- and métier-based approaches so far. They clearly illustrate the difficulties faced in practice and .
177 there is also a striking difference in the definition of métiers that have been used in these two cases.
178 The two processes have been conducted independently, illustrating the risks of mismatch occurring if
179 science is setting its agenda without a solid anchor to management rules, or if management regulations
180 are implemented without insuring that scientific support will have the ability to monitor and evaluate
181 their outcomes. This difference leads us to reflect on a fundamental issue in fleet- and métier-based
182 approaches, which relates to the basic difficulty of categorizing fishing activities.

183 Obviously, implementation of any fleet based approach requires the definition of management units
184 (fleets and/or métiers), as well as of quantifiable rules to populate fishing trips into métiers and fishing
185 vessels into fleets. The concepts of fleets and métiers are appealing as they offer a convenient and
186 valuable trade-off between reducing the complexity of the system into few tractable categories, while
187 maintaining sufficient information on its characteristics and dynamics. However, defining these
188 concepts has in itself been a primary hindrance to their operational implementation so far. It is not
189 simply, as we often hear, that things are not “clearly defined”, it is more than that. Many of the
190 concepts we have to deal with in mixed fisheries are ‘essentially contested concepts’ (Gallie 1955),
191 meaning that their definition always depends on the speaker’s interest in how it is defined (Wilson and
192 Jacobsen, 2009).

193 Fleets and métiers are only aggregations of individual operations and vessels operated by humans, and
194 as such are not natural entities but social entities created and continually redefined by human beings.
195 Because each vessel (and each trip, respectively) is unique in terms of catch rate, fishing type,
196 profitability, incentives, etc., it is very difficult to get simple and meaningful averages and to identify
197 key fishing patterns.

198 Métiers were created by scientists and managers as analytic and bureaucratic units, being relevant to
199 management measures in terms of e.g. vessel size and gear. These kinds of definitions are necessary
200 for both promulgating and analyzing the impacts of management measures, but may not reflect the
201 true dynamics and reality of fishing (Wilson and Jacobsen, 2009). We illustrate here the differences,
202 and even antagonisms, that arise in different approaches to the problem of categorization.

203 ***3.1 Scientific approach***

204 As explained above, the DCF requires the categorization of fishing activities based on hierarchical
205 criteria, but this can be achieved in any number of ways. ICES (2003) provided general concepts and
206 ideas, but no clear quantitative guidelines. Indeed, a variety of approaches have been used in a number
207 of case studies over the last two decades: see reviews in Marchal (2008), Reeves et al. (2008) and
208 Deporte et al. (2012), and references herein. Recalling that métiers should reflect the fishing intention
209 but that this often cannot be observed directly, Marchal (2008) described the classification approaches
210 as being either input-based, output-based, or combined methods. Input-based methods either make use
211 of existing records of the technical features of fishing trips, e.g. gear and mesh size used, fishing
212 grounds visited, season, fishing power; or build on direct interviews with stakeholders. Output-based
213 methods assume that catch profiles perfectly reflect fishing intention, and build therefore on empirical
214 or statistical analyses of landings or catches in weight or in value. Combined methods relate catch
215 profiles (outputs) to fishing trip characteristics (inputs). Marchal (2008) compared some of these
216 approaches analytically, and concluded that they could result in contrasting outcomes for a number of
217 fleets. Species assemblages cannot be easily defined from logbooks, since (1) as primary issue,

218 discards are usually not included in these analyses due to low sampling levels, and therefore the data
219 available provide an imperfect estimate of the actual catch compositions. This can furthermore be
220 biased by factors such as quota availability, market prices, traditions, etc, (2) species assemblage is an
221 outcome of the fishing action, but may not accurately reflect the true targeting intention of the fishers
222 due to imperfect knowledge of the underlying resource distribution, being therefore significantly
223 influenced by skipper skills (Mahévas et al., 2011) and (3) clustering of fishing operations based on
224 species assemblage is not very robust when a continuum is observed between different types of target
225 species (e.g. “mixed categories” in between clear “*Nephrops*” operations and clear “demersal fish”
226 operations). Clusters are also not necessarily constant over time if species abundance varies.

227 Similar methods and issues apply to the grouping of fishing vessels into fleet segments. Vessels can be
228 aggregated on the basis of their main activity following identical statistical approaches (e.g. Pelletier
229 and Ferraris 2000, Ulrich and Andersen, 2004), on the basis of their technical characteristics (e.g. main
230 gear and vessel size, ICES, 2011b) or according to their fishing efficiency (Marchal et al., 2001). In
231 these cases, further work may be necessary to distinguish between the vessels belonging to one
232 management unit and area from one belonging to another, for example using revenues thresholds or
233 home port.

234 In conclusion, no unified methods have yet been agreed upon for the standard scientific definition of
235 fleets and métiers, despite a significant activity in this field. There is no easy solution to these issues
236 and problems, which are intrinsic to the categorization process. The only way forward is to increase
237 the regional and European collaboration in order to establish European standards which would be
238 agreed as supranational compromises (Deporte et al., 2012). Defining regional métiers would also
239 reduce the needs for costly sampling at the national métier level, both by potentially reducing the
240 number of categories to the broader common and significant patterns (Deporte et al., 2012), and by
241 promoting exchanges of biological samples across nations within unified categories.

242 **3.2 Fishers' approach**

243 Some stakeholders are questioning these approaches to fleets and métiers. Stakeholders recognise the
244 need for such definitions to address a number of complex issues in fisheries management, but their
245 perception may differ widely from the above views. Indeed, the categorization issue has been relevant
246 to them only recently, since they did not have to deal with it under the usual single-stock TAC system,
247 where they would individually “race for fish” under national competitive quotas or operate under
248 individual transferrable quotas (ITQs). Under such a system, fishers could with relative ease switch
249 from one fishery to another based on seasonal fluctuations of species abundances and prices. The
250 introduction of rigid and somewhat arbitrary fisheries-based regulations (such as the days at sea
251 limitations), represented a major violation of their free choice and a significant restriction to their
252 traditional fishing patterns (STECF, 2011a), and this made them consider the fairness of the category
253 definitions. Jacobsen et al. (2009) and Wilson and Jacobsen (2009) performed an extended analysis of
254 stakeholder views on the issue of fleet and métier definition and concluded that fishers have a strong
255 wish to preserve their seasonal flexibility, arguing that gear says very little about what kind of fish will
256 be caught, particularly for the coastal multi-purposes vessels. They are therefore reluctant to
257 management based on narrow categories and would prefer broader and less constraining grouping
258 allowing for individual variability. However the focus of management on the individual stocks, with
259 individual quotas and licenses, may force the vessels towards a growing polarization and
260 specialization in one type of fishing instead of shifting according to e.g. season and/or area (Pascoe et
261 al., 2010) This, in turn, may lead to the somehow paradoxical situation mentioned above, where , in
262 order to cope with pressure from their own industry, Member States have pushed the initial broad cod
263 plan categories defined in 2003 towards detailed micro-management and multiple categorization.

264 In terms of fisheries, one interesting example was a reflection by a stakeholder within the North Sea
265 Regional Advisory Council (RAC), quoted by Wilson and Jacobsen (2009). The stakeholder noted that
266 the fisheries referred to bear no resemblance to the kinds of fisheries and métiers explained above,
267 being based on the main (group of) target species in the demersal North Sea fishery but without

268 reference to the mesh size. Wilson and Jacobsen (2009) also found that the issue of defining target
269 species and by-catch may be just as problematic to fishers. It is of no direct concern for stock
270 assessment whether mortality results from catching a targeted or non-targeted fish (unless this results
271 in unrecorded discard or inaccurate commercial CPUE indices). Therefore these concepts have not
272 been systematically investigated by fisheries scientists. NGOs are often more concerned by target and
273 by-catch issues. A clearer distinction between the two categories would make it easier to claim for
274 more selective fishing practices limiting unwanted by-catch. Fishers on the other hand aim at gaining
275 profit from the species assemblage that they harvest, and do not support assigning certain fish to by-
276 catch categories that may be more subject to restrictions, unless there is a strong reason to do so
277 (Wilson and Jacobsen, 2009).

278 In summary, harmonizing the categorization of the basic units (fleets, métiers and target species) is a
279 fundamental prerequisite for any future implementation in management. The groups defined should
280 ultimately be quantifiable (i.e. should link to the data available for monitoring), manageable and
281 supported by stakeholders.

282 **4 Additional issues and challenges in fleets/métiers-based** 283 **approaches**

284 In addition to the above, a number of issues remain in the implementation of fleet-based
285 approaches, mostly linked to the quantification of effort. These are not new topics, so we will not
286 develop these here, but refer instead to comprehensive reviews such as those by Motos and Wilson
287 (2006) and Reeves et al. (2008). In short, important issues are i) there is a continuous change in the
288 fishing power of the fleets, among other as a result of technological improvements and increased
289 fishers knowledge (Branch et al., 2006; Eigaard, 2009; Eigaard and Munch-Petersen, 2010). ii) The
290 detailed dynamic of effort and catches is insufficiently monitored, with logbook declarations at the
291 scale of the fishing day and geographical square (Branch et al. 2006; Andersen et al. 2012; STECF,
292 2010a). iii) The relationships between fishing effort, fishing mortality and catches are still poorly

293 understood (e.g. Marchal et al., 2001, 2006, 2007; van Oostenbrugge et al., 2008; STECF, 2011a), iv)
294 There is still limited knowledge about the basic drivers of the fleet's dynamics, which may jeopardize
295 the anticipated effects of management (Andersen et al., 2010, 2012; [Fulton et al., 2011](#)); and v) The
296 effective fishing effort being a combination of input factors, the regulation of one type of input (e.g.
297 fishing days or vessel size) may be compensated by increasing other unregulated inputs (input
298 substitution, Pascoe and Robinson, 1998).

299 These issues make it very difficult to measure, compare and scale the efficiency of métiers and fleets
300 between each other and between countries. Interestingly, most of these issues represent mainly a
301 hindrance to prescriptive input control. This underlines that, against a common belief (cf. e.g. CEC,
302 2001), mixed-fisheries may actually not necessarily be better addressed by effort control rather than
303 catch control. One concrete example of this is shown by the Faroe Islands, which have moved from
304 TAC management to effort-based management. In spite of a relatively favourable environment
305 comprising a small scale and local fishery, limited extent of mixed-fisheries interactions and sustained
306 stock productivity, the system has overall proven to be little flexible and not fully successful in
307 reducing fishing mortality (Nielsen et al., 2006; Jákupsstovu et al., 2007, Baudron et al., 2010, Eigaard
308 et al., 2011).

309 **5 Opportunities for fleet-based approaches in the future**

310 **Common Fisheries Policy.**

311 The previous chapters have underlined the challenges linked to any implementation of fleet-based
312 approaches to management. However, these nevertheless bear great potential for improvements
313 compared to the current system.

314 ***5.1 New technologies for monitoring and modelling***

315 As a counterpart to the many arguments above that would argue against the operational use of effort
316 control in fleet-based approaches, it is worth emphasising that rapid technological developments are

317 providing new monitoring tools, which increasingly address some of these shortcomings, and improve
318 the feasibility of the approach. For example (with regards to point ii) above), access to individual
319 Vessel Monitoring System (VMS) data allows the derivation of more precise estimates of the spatial
320 distribution of effort and landings (Bastardie *et al.*, 2010b; Hintzen *et al.*, 2012), and more in-depth
321 investigation of the links between both. These tools can also supplement other particular concerns
322 when assessing e.g. the impact of fleet-specific activities on the sea floor and benthic communities
323 (Fitzpatrick *et al.*, 2011), and provide information to the broader marine spatial planning and EU
324 Marine Strategy Framework Directive (MSFD, see also section 5.3 below). Improved monitoring is
325 also reinforced by the introduction of electronic logbooks, or by mounting video cameras on fishing
326 vessels to report for fully documented fishery (Kindt-Larsen *et al.*, 2011). Thanks to these tools,
327 continuous improvements on the quantification (nominal vs. effective) and the qualification (e.g., low
328 vs. high impact for a given pressure indicator) of the fishing effort are expected to be gained in a near
329 future. these should give further insights to support the development of fleet-based management.

330 The requirements for assessing potential uncertainties, misuses (e.g. non-compliance), pitfalls or side
331 effects of management options to properly meet the overall objectives of sustainability also call for
332 appropriate modelling tools (with regards to points i) and iii) in section 4 above). A variety of
333 modelling frameworks have been developed in recent European research projects, and some are
334 particularly generic and flexible for addressing a wide range of issues (e.g., the FLR library in R, Kell
335 *et al.*, 2007). Their continuous development provide improved options for coupling and integrating the
336 complex dynamics of multiple stocks, fleets and management layers (Figure 2), allowing the
337 evaluation of various management scenarios at different scales (cf. recent works by e.g. Pelletier *et al.*,
338 2009, Andersen *et al.*, 2010, Bastardie *et al.* 2010c, Ulrich *et al.* 2011, and reviews in Reeves *et al.*,
339 2008, Prellezo *et al.*, 2012).

340 One step further into effort modelling is maybe done by directly simulating the economic activity of
341 individual vessels in an Individual-Based Model (e.g. Millischer and Gascuel, 2006, Beecham and
342 Engelhard 2007, Bastardie *et al.* 2010a, Poos *et al.*, 2010), which can advantageously capture the

343 differences in characteristics, incentives and dynamics existing across individual vessels and thus
344 improve the bio-economic realism of the modelling (addressing the points iv) and v) above). Pros and
345 cons of fleet-based modelling vs. individual-vessel-based modelling will certainly shape future
346 developments in the implementation and monitoring of fishery management and spatial marine
347 planning.

348 In conclusion, the landscape of fisheries and fleet-based science and technology is evolving rapidly,
349 opening for new usages and potentials. We have considered a number of these, which could contribute
350 directly to the objectives of the future CFP and MSFD.

351 ***5.2 Mixed-fisheries management plans***

352 An increasing number of European stocks are being managed through long-term management plans
353 (LTMP). In many cases these plans are based on F-indicators resulting from single-stock assessments.
354 As such, they are mostly an extension of the current stock-based system incorporating more long-term
355 considerations. Single-stock TAC-based management is not challenged, it is simply made less
356 dependent on scientific uncertainty through limitations in its inter-annual variability. However, the
357 complex processes involved in the actual harvesting are often disregarded or loosely summarized into
358 “implementation uncertainty” (Rosenberg and Restrepo, 1994) when evaluating the effectiveness of
359 these management plans, even though, fleets dynamics might potentially affect this effectiveness in
360 ways that cannot be necessarily anticipated (e.g. Bastardie et al. 2010c, Andersen et al., 2010). There
361 are currently only few cases where technical interactions have been explicitly integrated in EU
362 fisheries management. One is the case of the North Sea flatfish (sole and plaice) management plan
363 (EC, 2007), whose setup built on a long previous history of modeling of mixed-fishery interactions in
364 the Dutch beam trawl fishery (e.g., Kraak et al., 2008 and reference therein). Noticeably, this fishery
365 presents a relatively simple configuration with only two species and relatively few and homogeneous
366 fleets involved, implying that the pre-required categorization of fishing activity described above was
367 easier to solve. Another exception is the management plan of *Nephrops* in the Iberian Peninsula (EC,

368 2005b), the harvest control rule of which explicitly accounts for the fishing mortality of Southern
369 hake, which is caught in the same mixed fishery.

370 Clearly, fleet-based approaches have a real potential for designing integrated mixed-fisheries
371 management plans at the regional level, even in complex fisheries. Furthermore, accounting for fleets
372 and métiers is central to integrated bio-economic management and advice. It allows for more direct
373 and effective bio-economic and socio-economic evaluation of consequences of management. The
374 recent history of demersal fisheries in the North Sea again provides a useful case study. In spite of the
375 well known and relatively well studied mixed-fisheries interactions, separate single-species
376 management plans have been adopted for cod, haddock, saithe and whiting. A *Nephrops* management
377 plan is also under development. The linkages between stocks have so far not been integrated in the
378 design of these plans, and only the *ex-post* evaluations conducted afterwards shed light on the risks of
379 implementation error linked to their potential inconsistencies (Hamon et al., 2007, Ulrich et al., 2011,
380 STECF, 2011a).

381 To summarise, we believe that in spite of the implementation hurdles explained above, acknowledging
382 these mixed-fisheries issues and integrating these from the beginning in the design of the management
383 plans would be less risky than ignoring these. As mentioned in the introduction, integrated regional
384 approaches have long been acknowledged by the EC, but it is only now, in the frame of the current
385 reform of the CFP, that the consideration of fleet-based management plans is starting to take its entire
386 political dimension, and new developments in their design will emerge in the very near future. Indeed,
387 a STECF Expert Group is scheduled in 2012 to formulate suggestions for bringing the North Sea cod
388 management plan in its wider mixed-fisheries context (see also section 5.4 below), and this work
389 might yield useful learning.

390 ***5.3 Ecosystem-Based to Fisheries Management***

391 Management of fisheries and marine resources is moving towards Ecosystem-Based Fisheries and
392 Marine Management (EBFM / EBMM) as anticipated by the EU MSFD. Spatial planning in particular

393 is coming increasingly into focus, and both ecosystem aspects and all types of anthropogenic impacts
394 on the marine environment have to be considered, within an integrated fisheries management
395 approach. Advice on impacts on non-target commercial species, but also on those other components of
396 the ecosystem that are impacted by fishing activities, is needed. In this respect, the incorporation of
397 fleet and fishery information provides a bridge between the traditional single species advice and the
398 ecosystem approach to fisheries management, by recognizing that fisheries can have a wider and
399 diverse range of impacts than just on the major target species (Nielsen et al., 2006; Tserpes et al.,
400 2006; Ulrich et al., 2008, Gascuel et al., 2012). The explicit representation of métiers and fleets also
401 means that these can be more easily mapped and distinguished in the areas to be managed (e.g.
402 Hintzen et al., 2012), than is the case with the stock-based approach alone.

403 Importantly, there is an inherent difficulty in applying fleet- and métier-based approaches at a highly
404 disaggregated spatial scale. Complex interactions between stocks, fleets, management measures, and
405 the environment are common components of mixed fisheries at the local scale. Several types of
406 regulations may act on top of each other, making it difficult to evaluate the impacts of the individual
407 regulations on fishers' access to their livelihood. Therefore, attempts to locally manage mixed
408 fisheries based on complex definitions of fleets, may reduce fishers' operational flexibility, which can,
409 in turn, interfere with the implementation of EBFM. An example of this was given by the "Invest in
410 Fish" initiative, (Squires and Renn, 2011) which aimed to gather information on all usages of marine
411 living resources in the South West of England through detailed description of commercial and
412 recreational activities and stakeholder's negotiations. While this project led to a positive experience of
413 good communication and governance, no consensus emerged about management actions to be taken
414 because of the high complexity and uncertainty.

415 This local complexity makes us believe that, while considering fleets- and métiers for EBFM is fully
416 relevant for defining objectives at a regional scale and monitoring trends in fisheries development, the
417 actual management implementation to achieve these objectives would potentially be more successfully

418 achieved by leaving it up to the individual actors to reach given results within this frame rather than
419 prescribing fixed rules to fixed groups. This idea is developed in the next section.

420 ***5.4 Results-based management***

421 The European Commission has acknowledged that the current centralised and “one size fits all”
422 single-stock management might not account properly for the diversity of regional situations,
423 particularly with regards to mixed-fisheries interactions.. Hence, the development of regional
424 approaches to management might be encouraged in the future CFP (EC, 2011b).

425 One direction that is already promoted within the current CFP is the “results-based management”
426 (RBM) or “outcome-oriented management” (Holland, 2007) linked to a “reversal of the burden of
427 proof” so that the industry is responsible for demonstrating that it is in compliance with the limits that
428 have been set on its ecological impacts (Fitzpatrick et al., 2011). A results-based management
429 approach envisions two complementary processes. One of these is the setting of management
430 objectives and corresponding limits on the environmental impacts that will be allowed for user groups.
431 In an ecosystem-based approach this process would mean developing operational constraints based on
432 limits set at government level. The second process is the development of exploitation plans that allow
433 the user groups to undertake economic activities while remaining within these limits. The latter of the
434 two processes is carried out by the user groups, in cooperation with scientists, and centred on meeting
435 the reversed burden of proof, i.e., how the industry will be monitored and held accountable for staying
436 within the set limits would have to be part of their plan.

437 One highly relevant benefit of RBM for mixed-fisheries management is the removing of the need for
438 precise and detailed fisheries definitions for prescriptive management; as they would be defined by
439 users themselves. Management measures proposed within the context of RBM are applied at the level
440 of local fishery or fleet segment, rather than at the level of the stock. Fleets and métiers will still have
441 to be defined in a political sense to define the groups entering into these contracts. Therefore, this
442 model suggests a strategy for handling the multi-scale, multi-stakeholder problem of processing

443 information and making decisions for mixed-fisheries management. It would also allow the industry
444 flexibility in shifting to changes in markets, fish abundance and avoiding ecological impacts (Wilson
445 and Jacobsen 2009). Reliance on a single type of management measure with an extensive impact such
446 as a TAC may therefore be supplemented or supplanted by local measures operating within the frame
447 of this global approach.

448 RBM approaches have been used successfully in various places around the world. An example with
449 relatively small scale fishing enterprises is Nova Scotia's RBM approach for mixed groundfish
450 fisheries. Fishing Conservation Harvest Plans are adopted by groups of fishers as a formal contractual
451 agreement with the Canadian Authorities. These contracts meet the sustainability requirements while
452 shifting much of the management responsibility to county-based Management Boards (Loucks 1998,
453 Ulrich and Wilson 2009). The Management Boards are all operated differently, which is part of the
454 idea of local control (Charles et al. 2005). A much larger scale example is found in the pollock fishery
455 in the Gulf of Alaska. Here the industry is organized into cooperatives that fulfil three functions: 1)
456 The allocation and transfer of both pollock harvest shares and limitations on species other than pollock
457 including prohibited species catch; 2) bycatch reduction; and 3) monitoring and enforcement
458 (Witherell et al. 2000). Wolff and Hauge (2009) found that this system has worked very well,
459 especially in regard to fisheries conservation. The Marine Stewardship Council (MSC) eco-labelling
460 scheme is increasingly one of the best examples of a basic RBM approach in fisheries. MSC has
461 created a broad set of criteria for sustainable fishing based on three principles: sustainable fish stocks,
462 minimising environmental impact and effective management. The first two principles set the
463 groundwork for the limits that MSC imposes on a fishery if it is to carry an MSC label, and the third
464 sets the burden on the fishery to prove it is meeting the standards. The MSC uses scientist certifiers to
465 work in detail with fishing fleets to decide how indicators to express these principles can be fairly
466 established, measured and met in their particular situation.

467 In Europe, the current EC Cod Plan (EC, 2008b) provides again a useful illustration of attempts at
468 implementing RBM in complex mixed-fisheries. There, the metiers are defined at the level of Member

469 State and broad range of activity, but internal flexibility is left to individuals to comply with the
470 allocated effort threshold. Significant changes in dynamics of entire fleet segments have been initiated
471 (Kindt-Larsen et al., 2011; Needle and Catarino, 2011, STECF, 2011a), underlying the importance of
472 setting the incentives right at the level of the vessel or group of vessels (Hilborn, 2007).

473 Implementing RBM in Europe will not be easy, both with regards to implementation and enforcement
474 (Fitzpatrick et al., 2011) and evaluation (Holmes *et al.*, 2011, STECF, 2011a). RBM moves
475 evaluation away from writing detailed prescriptions for activities, but it also brings with it a new set of
476 problems. The environmental impacts have to be clearly defined, and this raises questions such as
477 defining both temporal and spatial definitions of these impacts. From a legal point of view reversing
478 the burden of proof is routed in the precautionary principle. The issue of “who must prove” cannot be
479 treated without looking at the issue of “what must be proved”. Secondly, concerning compliance,
480 reversal of the burden of proof comes down to the industry having to foresee the instruments for
481 monitoring and reporting of fishing activities so as to allow for an effective control that the strategies
482 are implemented correctly. Uncertainty in the marine environment is high. In regulatory contexts that
483 uncertainly accumulates over a series of uncertain scientific decisions (Wilson 2009). Under RBM
484 precautionary limits on impacts must be identified with their related indicators, and translated into a
485 burden of proof that has to be met (and paid for) by the industry. While we use the term “industry”, it
486 must be kept in mind that a very substantial portion of fishing enterprises in Europe are small
487 businesses taking place in vulnerable rural communities. Hence, there is a strong need to develop
488 methods by which the decrease of uncertainty is cost effective and possible for industry.

489 **6 Summary and Conclusions**

490 Stock-based management has the advantage that the units managed and advised upon are broadly
491 agreed upon in e.g. the European fishery system. Even though some stocks are not well defined as
492 actual biological stock units, they are not really questioned as robust advisory and management units
493 today. A fish belongs to a stock and does not change to another stock from time to time. As long as the

494 management system keeps focusing on allocation issues for a number of well-defined commercial
495 stocks, stock-based approaches present undeniable advantages in relation to monitoring, control and
496 sharing of resources. However, EBFM requires more comprehensive, integrated, multi-disciplinary
497 and detailed advice for an increasing number of ecosystem elements, even while the available data
498 supporting that advice are limited. It is difficult to see how stock based management alone could
499 provide this.

500 We believe that a better knowledge of the characteristics and dynamics of the various fishing activities
501 is an obvious and necessary move forward for achieving these new requirements, both for minimising
502 impacts on the ecosystem and ensuring the sustainability of the fisheries exploiting its multiple
503 components. The whole harvesting process cannot be simply reduced to a single fishing mortality
504 estimate that can be tuned in ecosystem-based marine models. Therefore broad conservation objectives
505 can only be reached through a proper understanding and management of the drivers and incentives of
506 the dynamics of the fishery. In this regard, fleet/metier- approaches represent an intermediate layer
507 between the current single-stock level and the level of the individual vessel, which can therefore be
508 used as a convenient and tractable way to define and evaluate management and conservation
509 objectives at the regional level. We have also shown that such fleet-based approaches may not be
510 necessarily best achieved through effort control due to the inherent issues linked to effort definition
511 and quantification, implying that output-based management with a proper control of catches rather
512 than landings (catch quota management, cf. www.fvm.dk/yieldoffish) may indeed be the most suitable
513 path in mixed-fisheries.

514 Recent history has however clearly shown how difficult it has been to implement such an approach to
515 management within a classical command and control system. Mixed fisheries management is a serious
516 political challenge for managers because questions of fairness among groups of fishers (and between
517 countries) arise more quickly than in any other set of fisheries management problems, and because of
518 the imperfect link between the inputs used for fishing and its outputs in terms of global ecosystem
519 impact. This explains why twenty years of development of management science in this field have not

520 fully resolved the key definitions issues that were described here. A bottom line is that the
521 management and monitoring systems requires analytic and bureaucratic definitions of fisheries, but the
522 industry, and sometimes even the environment and marine ecosystems, may pay some real costs when
523 these definitions become overly detailed and restrictive.

524 There is neither quantitative nor qualitative answer to this issue of definition, and a beneficial way
525 forward is to work towards increased cooperation to establish agreed compromises. At first, it is
526 necessary that the different actors harmonise their views internally. On the scientific and management
527 side, the highest priority should be given to full consistency between the fleet /métier management
528 measures and the scientific data available to monitor and evaluate them. Progress in this direction is
529 encouraging. On the industry side, highest priority should be given to moving away from single-stock
530 management plans and towards integrated regional plans; and to agreeing on the qualitative categories
531 of fleets and métiers they would acknowledge as a relevant basis for management. From that, it might
532 then be possible to link the two, in that the qualitative categories empirically defined by stakeholders
533 may be crossed with the scientific data for quantification and modelling. The continued improvement
534 in the resolution of scientific data may contribute to this at the fine scale. Yet, even when the questions
535 of definitions and categories are resolved, fleet-based approaches to management may still have to be
536 robust and adaptive, rather than precise and prescriptive, because of the changing dynamics of the
537 system.

538 However, the fundamental issues that the imposition of pre-determined, generic categories poses at the
539 local level, with its evident risk of increased command and control micro-management, suggest that
540 these objectives may be potentially better achieved through results-based management. Here, local
541 actors are left with the flexibility to decide upon the optimal paths towards sustainability. Results-
542 based management also allows the complex challenges of an EBFM to be structured hierarchically
543 from the regional stock level using fleet and métier concepts, to the local level of the fishery. This
544 suggests that in the EU, the current efforts towards fleet-based approaches to management should not
545 be decoupled from the other ongoing key issues, such as regionalization or the implementation of

546 rights-based management. We also believe that the current EC cod management plan (EC, 2008),
547 while imperfectly designed and implemented so far (STECF, 2011a), is nevertheless a significant and
548 innovative step in this direction, in that it acts at different scales. This plan involves setting broad
549 objectives at the stock level, quantifying the impact of the various fleets and métiers and defining
550 limits to these, as well as encouraging responsible and results-based individual behaviour within fleet
551 segments independent of the activity of others. Improvements and further extensions of this innovative
552 approach are anticipated in the revised CFP (CEC, 2011b).

553

554 In conclusion, we underline that although the premises of fleets and métier-based approaches to
555 management were initiated twenty years ago, the main developments have occurred over the most
556 recent years . This has taken place within the scientific community through the DCF and a number of
557 large scale research projects investigating fleet dynamics, as well as the movement towards EBFM and
558 spatial planning. It has also taken place within the management system and with the stakeholders
559 through effort limitation systems. Therefore, experience and lessons are continuously being gained,
560 and the whole system is evolving rapidly towards improved consistency and cooperative management.
561 We hope that a mature stage will be reached in the near future.

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865 **9 Figures Caption**

866 Figure 1. Conceptual diagram of the links between fleets, métiers and species in a mixed-fishery
867 context.

868 Figure 2. Conceptual view on scales for modeling the fishing mortality F on an hypothetical stock in a
869 given management area (a) Stock-based F applying an overall stock-specific F on the stock; (b) Fleet-
870 or metier-based F after pooling vessels and/or activities with similar exploitation patterns; (c) Spatially
871 and seasonally explicit fleet-based F and (d) Individual vessel-based F describing the catch removal
872 over the area vessel by vessel. Situations a and b are irrespective of the stock distribution while
873 situations c and d are applied on an hypothetical underlying stock abundance distribution (grey levels).

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877 Table 1. Overview over the number of regulated gear categories (top value) and corresponding
 878 special conditions (bottom value) by year in the EU Cod Management plan for the North Sea,
 879 Skagerrak and Eastern English Channel. (From ICES, 2009)

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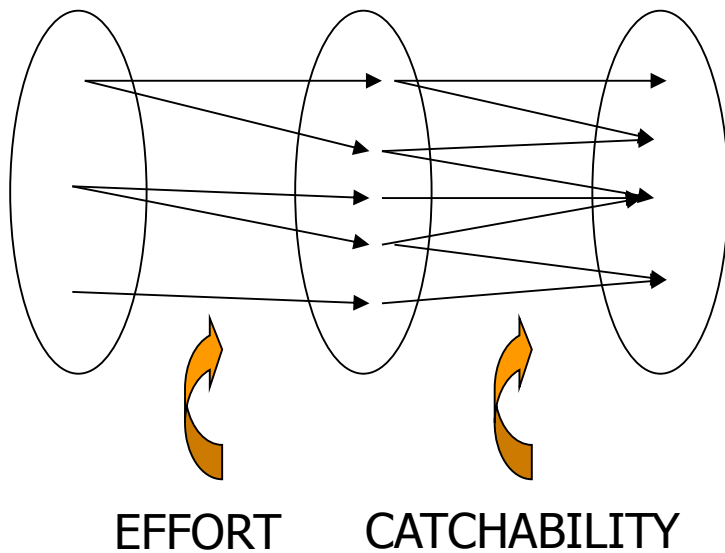
Gear type	2003	2004	2005	2006	2007	2008	2009
Demersal Trawls, seines, towed gears	3	3	3	5	5	5	3
	-	2	4	15	17	17	-
Beam trawl	1	1	1	4	4	4	2
	-	-	1	5	5	5	-
Static demersal nets	1	1	1	-	-	-	-
	-	2	2	-	-	-	-
Gillnets	-	-	-	2	4	4	1
	-	-	-	1	1	1	-
Trammel	-	-	-	1	1	1	1
	-	-	-	1	1	1	-
Long lines	1	1	1	1	1	1	1
	-	-	-	-	-	-	-
Total	6	10	13	35	39	39	8

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883 Figure 1.

Fleet (vessel) Métier (trip) Species (catches)



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