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FISHERIES ECOSYSTEM PLANS: HOW WILL THEY WORK AND WHAT DATA DO WE NEED?

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ABSTRACT

The Green Paper on the Reform of the Common Fisheries Policy identified the need for an ecosystem approach to fisheries management (EAFM), stated an intention to move towards a longer-term approach to fisheries management, and made commitments to greater stakeholder involvement, and management to support the three pillars of sustainability: ecological, social and economic. The proposed transition would have considerable implications for the knowledge base required to underpin management and the need for approaches to integrate data from the three pillars. Through structured interaction with stakeholders (interviews and workshops) we have developed operational Fisheries Ecosystem Plans (FEPs) for three European regional seas (North Sea, North West Waters and South West Waters) to support this transition. Central to the FEPs is an objectives-by-management scenario planning matrix that can be used to explore the potential impacts of different combinations of management measures on ecological, social and economic descriptors. In this paper the management support tool is demonstrated using a case study fishery and gaps in knowledge (ecological, social and economic), which may limit our ability to successfully implement EBFM, are identified. The move to implement EBFM increases the range and quantity of fisheries data required by managers with consequences for those providing the data, in terms of the skill base and resources required to identify, collect and analyse appropriate data and provide advice.

KEYWORDS: Ecosystem based fisheries management; sustainability; governance; regionalisation; knowledge base

INTRODUCTION

The Green Paper on the Reform of the Common Fisheries Policy (CFP; Com(2009) 163) examined the short-comings of the 2002 Reform of the CFP (Council Regulation (EC) No 2371/2002) and identified the need for an ecosystem approach to fisheries management; stated an intention to move towards a longer-term approach to fisheries management; and made commitments to greater stakeholder involvement, and management to support the three pillars of sustainability: ecological, social and economic. The 2002 Reform has also been criticised due to the absence of guidance in terms of scaling and trade-offs between ecological, social and economic objectives, and for failing to specify what timeframe should be used when considering these objectives (Sissenwine and Symes 2007). This presented an immediate issue for fisheries managers faced with multiple, and potentially incompatible, ecological, social and economic objectives. Outcomes of debates about sustainability have tended to reflect short-term national priorities of member states (e.g. short-term economic and social viability of the fishing industry) over longer-term ecological sustainability of target species and the wider marine environment (Jennings and Rice 2011). Albeit that long term sustainability of stocks has the potential to deliver long-term ecological, social and economic benefits (Sissenwine and Symes 2007).

Ecosystem based fisheries management (EBFM) is a central tenant of the FAO (UN) Code of Conduct for Responsible Fisheries (FAO 1995) and is consistent with commitments through the Convention on Biological Diversity (1992) and the subsequent World Summit on Sustainable Development (2002). The transition to EBM has considerable implications for the knowledge base required to underpin management, the need for approaches to integrate and combine the data from the three pillars, and the need for appropriate institutional structures for successful implementation.

Understanding the links between ecological, social and economic systems is essential in order to ensure that management decisions are appropriately informed. One of the greatest challenges of management, and to managers, is finding ways to achieve objectives simultaneously; in practice achieving multiple objectives is difficult and trade-offs have to be considered. In the US, Fisheries Ecosystem Plans (FEPs) have been used to further the development of the EBFM as a tool to assist managers to consider the ecological, social and economic implications of their management decisions (Fluharty et al. 1998). The aim of FEPs is to provide managers with a strategic rather than prescriptive plan for the adoption of EBFM. FEPs are thus a guide for use in fisheries management planning and development (or amendment of fisheries management plans); they should be realistic, focussing on critical features and processes of the ecosystem vital in managing fisheries resources (Link 2002).

To support the transition to EBFM in Europe the MEFEPO project has developed operational FEPs for three regional seas (North Sea, NS; North West Waters, NWW; South West Waters, SWW; Fig.

1). A regional sea scale was chosen given delineation of European waters based on biological criteria and their direct relation to fisheries management through the established Regional Advisory Councils (RACs). Thus ensuring that the plans are of relevance to the RACs and on scales directly comparable to the advice they provide to the Commission. The NS, NWW and SWW regions were selected as they represent a range of challenges in terms of: knowledge; data availability; the number of national interests; spatial extent; and a broad range of physical and biological characteristics. FEPs have been developed through structured interaction with stakeholders (interviews and workshops) and the aim of this paper is to describe the progress made to date.

Fig. 1 MEFEPO project regions based on Regional Advisory Council (RAC) areas: North Sea (NS), North Western Waters (NWW) and South Western Waters (SWW).

THE APPROACH

The MEFEPO project developed a set of operational environmental objectives on the basis of commitments through the Marine Strategy Framework Directive (MSFD). The current status of three RAC regions was assessed with respect to these objectives, using (operational) indicators that had been identified and developed in previous EU projects (Borges et al. 2010; Le Quesne et al. 2010; Nolan et al. 2010). This was this was the first attempt to assess the impacts of fishing on multiple environmental objectives across large marine regions within the context of the MSFD.

The efficiency of the different fisheries management tools were assessed in relation to their intended effect on four specified aspects (politically acceptability, cost effectiveness, ecological effectiveness and dynamical effectiveness). The operation of the CFP, and its appropriateness as a tool for managing the EU fisheries was found to be dependent on the actors (stakeholders groups) involved and the governance structure in which it operated (Aanesen et al. 2010). More specifically, the option of regionalising the CFP was explored. Stakeholders had broad and varying reasons for wanting to regionalise the CFP, which has implications for what they perceive as the best way to move forward; legitimacy was identified as the key factor. There was varying degrees of stakeholder support for a range of different theoretical models for regionalisation; *Regional Fisheries Management Organisation* and the *Regional Fisheries Co-Management Organisation* models were most likely to receive stakeholder support (Raakjær et al. 2010)

More recently, a framework was developed that allowed the combination of scientific information (modelling or expert judgement) with stakeholder preferences, to examine a range of management scenarios to achieve ecological objectives, and the social and economic impacts of the proposed management measures. It was demonstrated that the decision-support tools could be used to deliver a preferred management scenario to achieve policy objectives in a formal and transparent process, provided that the management scenarios utilised are meaningful and that there is sufficient appropriate and reliable information to parameterise the underlying modelling approaches. However, there were major issues with the availability and quality of information (ecological, social and economic) to underpin this framework (Piet et al. 2011).

Drawing upon earlier work, 3 key operational challenges to introducing an ecosystem approach to fisheries management were indentified:

- Governance structure: how should (existing and new) stakeholders groups be included in the management system?
- Regionalisation of the management system: who, what, where and how?
- Knowledge base underpinning the management system, how do we deal with uncertainty and the absence of data?

RISING TO THE CHALLENGES

A stakeholder workshop (Haarlem, April 2011) was held to develop consensual solutions to the operational challenges identified. In total, 34 representatives from across the MEFEPO project regions, and a broad range of stakeholder groups (including representatives from the fishing industry, eNGOs and policy makers), attended the workshop. Following a brief plenary session, stakeholders

were assigned to one of 3 groups - Governance structure; Regionalisation; and Knowledge base - in order to address each of the operational challenges. The assignment of stakeholders was carried out based on stated preferences where possible, while simultaneously securing broad coverage of backgrounds in each group. Discussion papers on each of the operational challenges had been prepared and distributed to stakeholders in advance of the workshop; they included key questions to help structure discussion which was facilitated by invited experts. On the second day of the workshop, each group delivered a short PowerPoint presentation in plenary, summarising the main findings and conclusions. Discussion from both group sessions and the final plenary was captured. The findings from this workshop are summarised in the following sections and stakeholder proposals have been utilised in the development of the FEPs. A case study from the NWW region is presented to demonstrate the application of the management strategy matrix developed.

INSTITUTIONAL STRUCTURES

Governance structure and regionalisation were treated separately within the discussion papers and the stakeholder groups; the paper on governance structure was focussed on effects of having different stakeholders involved in fisheries management, whilst the regionalisation discussion paper was focussed on how the CFP could be made regional. However there is clearly overlap between the two discussion groups and overall the findings of the two groups complimented one another.

Governance

The 2002 Reform of the CFP acknowledged the need for greater stakeholder involvement and Regional Advisory Councils (RACs) were established to facilitate participation for fishermen and other relevant groups (e.g. eNGOs and consumer groups). RACs have become the formal channel through which stakeholders communicate with and provide advice to the Commission; however they have no formal power within the management process and operate in a sub-ordinate role to the Commission and member states.

Stakeholders proposed adoption of a symmetric governance structure to make EBFM operational (Fig. 2), with an enhanced role for the RACs within the management process to request information and assist in the formulation of long-term management plans (LTMPs). Within the wider context of EBM, stakeholders recognised the need to work closely with other sectors and a desire for management at appropriate regional scales. Stakeholders highlighted that appropriate scales may differ depending on the policy being considered (e.g. CFP at RAC scale; MSFD at regional seas convention scale e.g. OSPAR), and warned against duplication of roles and responsibilities.

However, stakeholders did not think it was necessary to involve other sectors for the development of fisheries management, instead proposing that the RACs and member states operate in a more symmetric role to develop LTMPs management plans collaboratively (Fig. 2). If there was consensus between member state and RACs, the proposed plan would then be presented to the Commission by the Member State; if approved, the plan would be implemented by the member state. This governance structure raises the need for the provision of scientific input for both Member States and the RACs to enable management plans to be developed in collaboration, with both parties having access to appropriate data.

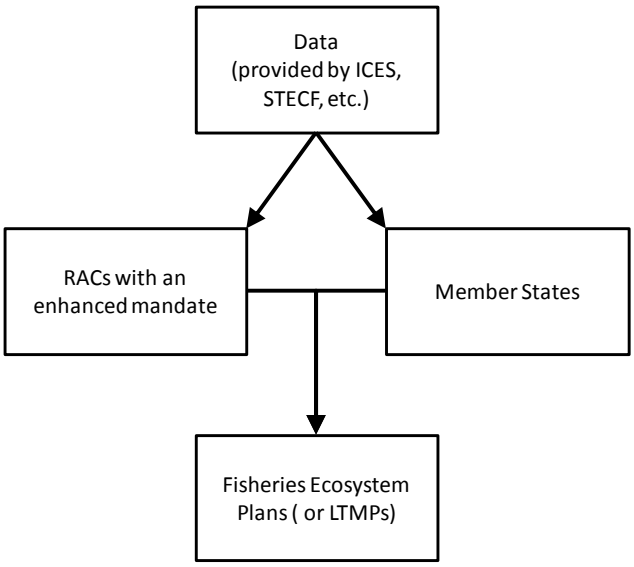


Fig. 2 Symmetric gonvernance structure support by stakeholders for the delivery of ecosystem based fisheries management

Allowing new stakeholders a say in the fisheries' management through the RACs would have consequences for their operation and resultant regulations should they be given an enhanced role in the development of LTMPs. RACs have been operational for some time now, and some have moved towards consensus action by the members (fishermen, eNGOs, etc.); the preferred path being to prepare joint actions. However, RACs are aware that member states and the Commission are not required to heed their advice. RACs are not looking for any new stakeholders, they are looking for closer cooperation with existing stakeholders and institutions, and there is a desire to move towards a more co-management approach working with scientists and the member states. Furthermore, stakeholders highlighted that some "external parties" (e.g. eNGOs) that had been offered a seat within the RAC choose to remain outside of this structure because they feel they can have more influence outside of the RACs rather than as a minority within the RAC.

Stakeholders underlined the need for flexibility regarding the governance structure and stakeholder involvement, both geographically and temporally, to engage appropriate parties as and when required. They also felt that overarching, high-level, binding objectives were required to ensure that the structure operated effectively.

Regionalisation

It is acknowledged that the move to EBFM requires appropriate geographical scale, both in terms of the ecosystem *per se* and the governance system responsible for management. Regionalisation is considered a vehicle to overcome the present shortcomings of the CFP, however, stakeholders repeatedly stressed that another layer of bureaucracy would not benefit European fisheries.

The model put forward for regionalisation of the CFP (Fig. 3), based on the establishment of so called *Decentralized Fisheries Management Boards* (DFMBs), would largely keep the institutional structure and formal distribution of powers unchanged, and is based on voluntary agreements, soft law and *de facto* authorities based on quality of input rather than *de jure* authority to take decisions. DFMBs would be established for each of the existing 5 geographical RACs (Baltic Sea, North Sea, North Western Waters, South Western Waters and Mediterranean Sea) and for the two RACs dealing migratory stocks covering more than one of the present geographical RAC areas (Long Distance Waters and Pelagic). DFMBs would address fisheries management issues specific to their geographic area or stock, and member states with fishing interests in a regional sea or migratory stocks would become members of the respective DFMB.

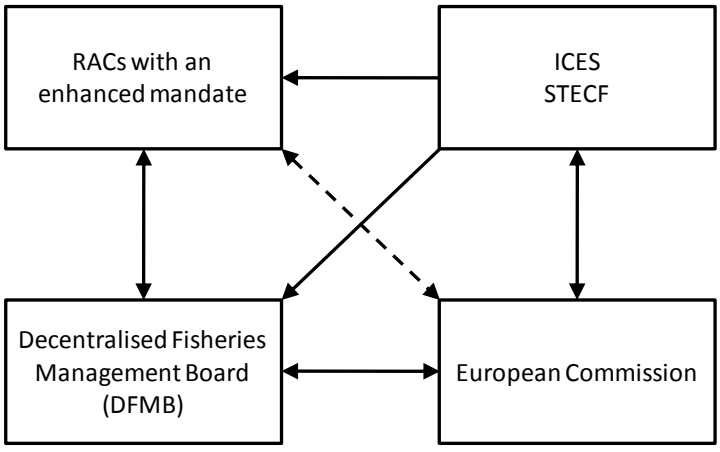


Fig. 3 Proposed model for regionalisation of the CFP based on the establishment of *Decentralized Fisheries Management Boards*.

The mandate of DFMBs would be to draft long term management plans (LTMPs), in accordance with high level objectives set by the Council and Parliament, and establish implementation strategies and thus become *de facto* involved in drafting proposals. This setup is close to what has previously been described as *co-management by informal partnership* (Raakjær et al. 2010), and would provide RACs with an enhanced mandate to be involved in the decision-making process (through the DFMB) and create incentives for tailor-made management to suit regional needs reducing off-the-peg and one-size-fits-all solutions in European waters. The DFMBs would forward their recommendations to the Commission for formal approval; the Commission would retain responsibility for auditing existing, proposed and future plans to ensure they are implemented in accordance to the EU's principles and long-term objectives. The Council and the Parliament would retain overarching decision-making powers and setting high level objectives.

The enhanced RACs would become a working group for DFMB, and indirectly to the Commission, and provide input to and suggestions for LTMPs and their implementation. RACs would also be able to identify and put forward requests for provision and improvement of scientific advice. In most cases, the enhanced RAC would advise the mini-council rather than the central EU institutions; the weight given to stakeholders' input in the recommendation could be assessed on a case-by-case basis.

MANAGEMENT FRAMEWORK

The knowledge based required to underpin EBFM is a key operational challenge to implementation. Fisheries policy and management will incorporate input from a broader range of stakeholders (through the institutional change proposed by the other stakeholder groups) and will be required to incorporate more complex ecosystem-based ecological components, alongside social and economic components to deliver ecological, social and economic sustainability.

The stakeholders supported the structure of the "three pillar" matrix developed through the project (Fig. 4; Piet et al. 2011), to be used in the development of the FEPs to explore the potential impacts of different combinations of management measures on ecological, social and economic descriptors, and assist managers and stakeholders to understand the implications of management decisions.

The increase in data requirements for EBFM has consequences for those providing the data, in terms of the skill base and resources required to identify, collect and analyse appropriate data and provide advice. Scientific representation should be broadened to include social, economic and ecological knowledge; we need to start thinking of fisheries management in terms of inter-disciplines. However, stakeholders warned against "gather more data" being the only reflex in response to EBFM, highlighting that management decisions cannot always be made on quantifiable data. This is particularly relevant in the case of the social sciences and in regions where data is currently lacking.

We need to build upon what data is available in the context of adaptive management, i.e. being able to modify the matrix in light of new data in keeping with the premise of EBFM.

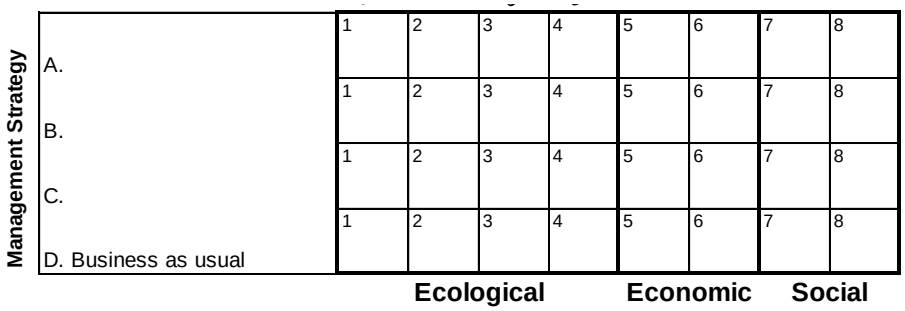


Fig. 4 Management strategy evaluation matrix supported by stakeholders.

Stakeholders did not specify which descriptors or indicators should be used in the matrix for each of the pillars, partly because there was concern over the descriptors that had previously been used within the MEFEPO project. Whilst there was support for the ecological descriptors utilised (drawn from the MSFD), there was a perception that development of appropriate social and economic descriptors was lacking, and stakeholders stressed the importance of context when considering these descriptors. Stakeholders also noted the importance of understanding the interactions among pillars and associated descriptors.

APPLYING THE MANAGEMENT STRATEGY MATRIX APPROACH: A CASE STUDY

A range of case studies within each project region have been used with the FEPs to demonstrate the application of the management strategy matrix approach, and evaluate the performance of a limited suite of management strategies on ecological, social and economic descriptors. The aim of the matrix being to help decision-makers understand the implications of management decisions rather than to pass comment on the "best" management strategy. Ultimately the decision on which management strategy to adopt will be based on overarching management objectives (ecological, social and environmental).

A management strategy consists of a portfolio of management tools aimed at delivering management objectives. The efficacy of the management strategies (consisting of the application of multiple management tools) is considered in the context of the high level management objectives for European fisheries arising from international commitments (e.g. WSSD; OSPAR; BCD; MSFD). The current suite of management tools comprises the "business as usual" (BAU) strategy and is examined with respect to: (1) the extent to which it can deliver MSY for the target species; and (2) the impact of this strategy on the ecological, social and economic components ("descriptors") of the fisheries system;

descriptors (Table 1; see Annex 1 and Piet et al. 2011 for further details) provide metrics of performance.

Ecological descriptors were drawn directly from the MSFD and were selected, after deliberation at a stakeholder workshop, based on consideration of the direct impacts of fishing activities on ecosystem components (biodiversity, commercial fish, food-webs and seafloor integrity). Economic descriptors examined effects of management strategies on fishers' ability to take a given harvest at the lowest possible cost (efficiency) and minimising fluctuations in harvesting possibilities over time (stability). Social descriptors related to employment opportunities within the catching sector (community viability) and securing catch potential (food security).

The next step was to investigate whether or not a reduced (simplified) set of management tools, or a set of alternative management tools, could deliver the objectives more effectively or more efficiently. Information on the application and success of management tools from earlier project work (Aanesen et al. 2010), scientific literature and expert opinion was used to inform the choice of management tools in the development of the management strategies. Information on stakeholder preferences for particular management tools (e.g. from EFEP) is used to provide commentary on which strategies might receive better stakeholder support.

Table 1 Descriptors chosen for the three pillars of sustainability (further details in Annex A).

Ecological				**Economic**		**Social**	
Biodiversity	Commercial fish	Food-webs	Seafloor integrity	Efficiency	Stability	Community viability	Food security

The results of the evaluation are presented using the management strategies matrix; the matrix was populated based on the best available evidence (modelled, empirical and expert opinion) to ensure robustness of the approach. Assessments of the management strategies were made under the following assumptions:

- Time frame: in keeping with the principles of the ecosystem based fisheries management (EBFM), the management strategies matrix was populated based on expected medium to long-term (5-10 year) outcomes. This means that other effects may take place in the short term.
- Partial assessment: we have examined changes in one (or a few) selected management tools and assume all other measures used in the fishery are kept constant.
- Constant external environment: we have assumed that all exogenous conditions (e.g. market price on fish, fuel prices, water temperature, fish food availability, etc.) are constant.

Case study fishery: *Nephrops*, North Western Waters

Introduction to the fishery

Nephrops require a muddy seafloor habitat in which to burrow and the distribution of suitable sediment defines the species distribution. *Nephrops* are primarily fished using bottom otter trawls; direct effects of bottom trawls on benthic habitat is related to physical disturbance by contact with the seafloor. A large proportion of the catch in the *Nephrops* fishery in NWW is made up of non-target, invertebrate by-catch species; non-marketable by-catch is discarded at sea. Commercial fish species (e.g. cod, whiting) are also caught as by-catch; marketable fish are landed (if quota allows), undersized or over-quota fish are discarded.

State of the stock

Functional Units in VI (FUs 11 to 13): Two out of the three FUs in VI were fished above FMSY in 2009. For 2011 an EU TAC of 13,681 tonnes applies in area VI, ~15% reduction on 2010.

Functional Units in VII (FUs 14 to 22): FUs 14 and 15 were fished above FMSY and FU 16 had falling catch and abundance in 2009; FU 18, Aran, was fished below FMSY. FMSY is unknown for FUs 19-22 but LPUEs were stable. For 2011 an EU TAC of 21,759 tonnes applies in area VII, ~3% reduction on 2010.

Current management (Business as usual)

The following tools are currently being employed for *Nephrops* management in NWW:

- Total allowable catch
- Effort (days at sea)
- Minimum landing size
- Mesh size restrictions (reduction of by-catch)
- Seasonal closures

BAU performance (see Table 2, row E)

- Effort controls effective due to low gear efficiency and direct relationship between effort & catch.
- Fails to address "poor" condition of ecological descriptors and hence objectives of the MSFD.
- TACs successful in reducing overall landings but allow redistribution of fishing effort among FUs as set at ICES level, and thus may negatively impact stocks in more vulnerable FUs.
- Discarding of by-catch is high in some FUs.

Alternative management strategies

Management at Functional Unit level

The overarching consideration is that management should be at FU level to ensure that catch opportunities and effort are in line with the scale of the resources in each FU (ICES 2010; NSRAC 2011). This initiative is a key component of each of the alternative management strategies.

Management Strategy A. Increase Closed Fishery Areas (Table 2, Row A)

Seasonal closures would apply to 100% of the FU to reduce effort when the highest proportion of females would be caught.

Management Strategy B. Minimise By-catch (Table 2, Row B)

Reduction in by-catch (and thus discarding) through an increase in the minimum mesh size for *Nephrops* trawls from 70mm to 90mm and the use of "Swedish Grid" separators in all FUs.

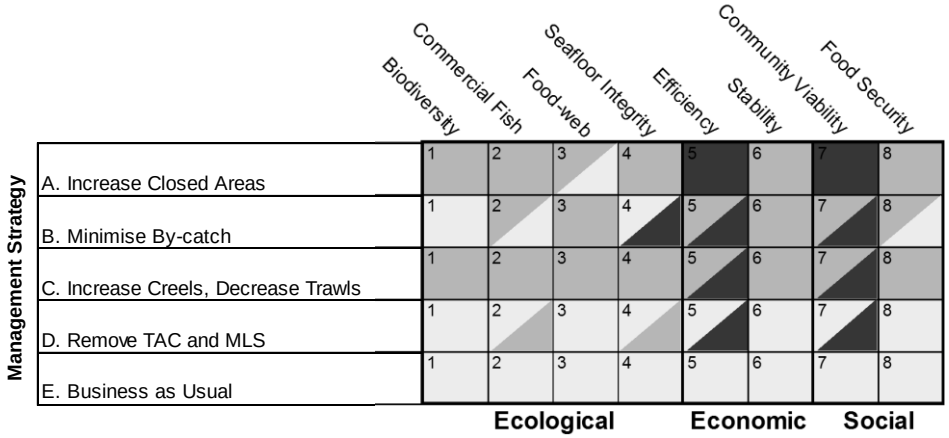
Management Strategy C. Increase Creels, Decrease Trawls (Table 2, Row C)

Reduction in use of trawls; some areas of each FU would be open to creel fisheries only which have significantly less impact on the seafloor and less by-catch.

Management Strategy D. Remove MLS and TAC (Table 2, Row D)

Streamlining of current management: removal of minimum landing size (a market for larger *Nephrops* and a mesh size restriction curbing the by-catch of undersize prawns means that the MLS may be redundant); and restriction of catch by limiting effort rather than TAC.

Table 2 Management strategies matrix for the *Nephrops* fishery, in the North Western Waters region (light grey, stable; mid-grey; improve; dark grey, deteriorate).



Management guidance

It is predicted that the BAU strategy will fail to address the "poor" condition of the ecological descriptors and hence fail to meet the objectives of the MSFD; it may also reduce economic

efficiency. Review of the alternative management strategies indicates that it is possible to modify management in the *Nephrops* fishery to provide improvement in the ecological descriptors with varying degrees of impact on social and economic descriptors. Ultimately the choice of management strategy will depend on overarching management objectives.

If the overarching management objective is to work towards GES in the context of the MSFD, then strategy C is considered to be the most appropriate given that a reduction in trawling and replacement by creels is predicted to provide improvement across all four ecological descriptors (biodiversity, commercial fish, food webs and seafloor integrity). This strategy is also predicted to provide improvement in terms of stability of catches and food security due to improvement in commercial stocks but may have negative effects on some parts of the *Nephrops* fleet if individuals are unable to afford the switch between gears (community viability) or where catches are reduced (efficiency).

If the overarching management objective is employment, strategy A is considered to be least appropriate, given that closed fishery areas are considered to negatively impact upon fishers by limiting choice on where they can fish, the potential for increased effort in areas where fishing is not restricted and potentially limiting access to areas of high profitability. Furthermore, depending on the location of the closures, and the scale of the fleet operating in their proximity, additional fisheries closures may exclude some fishers due to their inability to switch effort to different (non-protected) areas. However, this strategy does provide improvement for the majority of ecological descriptors.

Finally, none of the strategies considered would significantly improve efficiency as they do not control fishing effort at the individual level, meaning that boats would continue to fish until their costs are equal to revenues. It may be possible to improve efficiency through introduction of a rights based management (RBM) system, to ensure that fishing rights end up with the most efficient fishers (those with the lowest harvesting costs) and this could be used in conjunction with the strategies considered. However, acceptability of the various forms of RBM differs among stakeholders and further investigation is required to examine application in this fishery.

CONCLUSIONS

Appropriate institutional structures, to facilitate stakeholder participation in management at appropriate regional scales, are considered a prerequisite for successful implementation of the FEPs and adoption of EBFM within Europe. Building upon what was developed in the project, and adjusted by the stakeholders, the FEPs provide guidance on the institutional framework required to support EAFM. This is based on a decentralised management structure with decision-making power devolved to Member States (MS), enhanced Regional Advisory Councils (RACs) with appropriate scientific support, and a more collaborative approach between MS, RACs and science to develop long

term management plans. If effectively implemented, this structure should serve to increase the legitimacy of the CFP and associated regulations among stakeholders (which presently is low) through their involvement and reduced conflict between administrators and the industry due to differences in how these groups view the goals and means of the management regime. It is hoped that greater stakeholder involvement may lead to more responsible behaviour among fishermen.

Whilst management decisions will ultimately be made by politicians or managers (at EU and MS level), the joint development and evaluation of management strategies in the format described here has the potential to develop common understanding of the long-term implications of management decisions and build communication and trust between industry and managers. However, whilst the matrix concept itself is relatively simple, a considerable amount of data is required to populate the matrix. The transition to EBFM and stakeholder involvement in the formulation of management plans requires both a broader spectrum and context of data (biological, ecological, social and economic), and that scientific advice is presented in a format that meets the needs of a wider range of stakeholders, outside of the traditional advice provision. Examining the performance of management strategies is more complex for mixed-species fisheries case studies as it may not be possible to achieve MSY for more than one species at the same time. Thus management strategies explored possible trade-offs in terms of prioritising stocks.

The traditional knowledge base for decision making in fisheries relies heavily on an objectified version of science. Science is often treated as an external third party that can supply knowledge on demand. In many policy situations however "facts" are uncertain (and in some cases unknown) and stakes are high. In these circumstances one can argue that there is a need for new, trans-disciplinary approaches (among disciplines and with stakeholders), an awareness of how values are embedded in the framing of policy questions and the choices of scientific methods, and that uncertainty be addressed more adequately. Closer collaboration is required among tradition fisheries sciences (biologists), ecologists, social scientist and economists, to develop effective management advice. Furthermore, effort is required to indentify relevant social and economic descriptors and indicators, similar to the process for the MSFD to enable better integration across the sectors.

The CFP Reform (2002) stated an intention to move away from annual decisions making on Total Allowable Catches towards a more long-term approach based on multi-annual or long-term plans. Initially multi-annual plans were introduced for stocks which had been depleted to dangerously low levels ('recovery plans'), but they are now being implemented as the method of choice for managing a number of the EU's major commercial fish stocks. The aim of multi-annual planning is to provide greater stability for the industry and enable operators to plan ahead. However, longer-term plans create additional challenges to the implementation of EBFM, due to inherent uncertainty in the data available to shape the policy process and mechanisms must be developed to deal with this uncertainty.

Despite the emphasis on longer-term management plans, in keeping with the premise of adaptive management, it is essential that the management framework must be able to adapt to changes in environmental conditions, and new knowledge and understanding on the marine environment when it becomes available. It must also be able to respond to advances in technology and associated changes in fishers' behaviour to ensure that the long term sustainability is not compromised.

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Annex 1 Descriptors, related indicators used in MEFEPO, and their consideration within the case study fisheries' management strategies matrices in the development of the Fisheries Ecosystem Plans.

Pillar	Descriptor	Indicator(s) used in MEFEPO	Consideration
Ecological	Biodiversity	Conservation Status of Fish	Related to fishing pressure (mortality) applied to fish. Measures of genetic diversity are not taken into account. The existence of "sub-species and populations where they need to be assessed separately" is included. It may also be related to more specific known impacts (particular gears impacting particular vulnerable species) that may be mitigated by specific spatial or technical regulations.
	Commercial fish	Proportion of stocks within safe biological limits (SBL) with regard to SSB and fishing mortality (F)	Related to the state of the case study fishery stock and other commercial stocks that interact with the case study fishery.
	Food-webs	Large fish indicator (LFI)	Related to fishing pressure on the fish community (especially larger longer lived fish). Indirectly, it may also be related to effects of discards on local food webs.
	Seafloor integrity	Proportion of area not impacted by mobile bottom gears	Pressure indicator of the extent of trawling impacts, related to the effort applied by mobile bottom gears and to the areal coverage of bottom trawling.
Economic	Efficiency	Fishers' ability to take a given harvest at the lowest possible cost	Related to benefits and costs: social, economic (e.g. input) and ecosystem (externalities e.g. costs of by-catch and discarding).
	Stability	Minimising fluctuations in harvesting possibilities over time	Related to stability in fishing opportunities (e.g. fluctuations in TAC). If stock above SBL it is more likely that it will be more robust to short term environmental 'noise', therefore less need for regular changes to quotas to respond to changes in recruitment/environmental noise. Note that this is only true for stocks with strong stock-recruit linkages.
Social	Community viability	Employment linked with fisheries	Related to employment (e.g. catching, amount and type of employment, processing, administration, science, etc.). As this is a social descriptor, including cultural values, it is not only linked to "efficiency".
	Food security	Securing a sustainable and sufficient supply of marine protein as food	Related to marine protein caught from the sea, hence this is related to yield, but not exclusively to commercial fish stock status.