Making the European Fisheries Ecosystem Plan Operational (MEFEPO)

Bloomfield, H. J.; Le Quesne, W. J. F.; Piet, G. J.; Raakjær, Jesper; Aanesen, M.; Armstrong, Claire; Nolan, C; Borges, M. F.; Rui Pinho, M.; Porteiro, C.; Rockmann, C.; Miller, D.; Velasco, F.; van Hal, R.; van Hoof, L.; Hegland, Troels Jacob; Christensen, A.; Abreu, H.; Ounanian, Kristen; Mendes, H.; Hily, C.; Duchêne, J.; Pastoors, Martin A.; Christiensen, Steen; Ramirez, Paulina; Zetterholm, S.; Paramor, O.A.L.; Rogers, S.I.; Connolly, P.; Frid, C.L.J.

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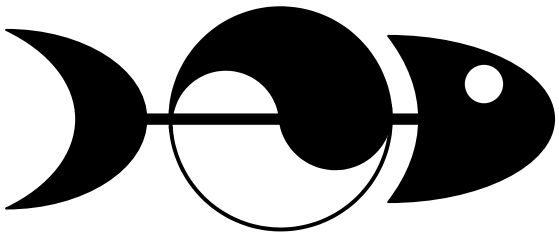

Making the European Fisheries Ecosystem Plan Operational (MEFEPO):

Synthesis and review of progress towards an ecosystem approach to fisheries management

WORK PACKAGE 8 REPORT

EC FP7 project # 212881

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EXECUTIVE SUMMARY

- The Making the European Fisheries Ecosystem Plan Operational (MEFEPO) project was designed to further development of a framework, and the supporting evidence base (natural and social science), to integrate the Marine Strategy Framework Directive (MSFD) objectives within a reformed Common Fisheries Policy in the context of ecosystem based fisheries management.
- The framework consisted of two key elements: (1) an institutional structure that can support greater stakeholder involvement in fisheries management at an appropriate geographical (regional) scale; and (2) a decision-support management tool (management strategy evaluation matrix) to help stakeholders and decision-makers to simultaneously consider ecological, social and economic implications of management decisions.
- Assessment of progress was measured against the ICES (2005) 11-step test; we considered the extent to which each step had been achieved based on evidence from the work undertaken within the project. Whilst we are able to report progress in the development of EBFM, operational EBFM has yet to be achieved and we identified the need for further research and development against all steps before implementation of an ecosystem approach could be considered to be complete.
- There was: (1) uncertainty with respect to choice of appropriate, specific and measurable social and economic objectives, descriptors and associated indicators, comparable to those being developed for the ecological pillar through the MSFD; and (2) an absence of indicators for key ecosystem components impacted by fishing activities and reference levels ("operational objectives").
- Management priorities should focus on:
    - Implementing of appropriate governance mechanisms, at appropriate geographical scales, that facilitate true stakeholder engagement in the development of fisheries policy and management.
    - Developing of fisheries management plans for each of the region's fisheries considering the ecological, economic and social implications for ecosystem components, which can then be integrated into regional FEPs. The absence of data must not be allowed to prevent decisions from being made and management advice should be formulated based on the best available evidence and then implemented within an adaptive management regime, responsive to changes in environmental conditions, and new knowledge and understanding on the marine system.
- Resolution of the trade-offs required to deliver the overarching objectives is not a technical or scientific decision, however application of decision support framework such as the management strategy evaluation matrix, coupled with agreed (and formalised) guidance on the priority to be given to objectives when trade-offs have to be made, will aid managers in making appropriate decisions on the basis of the best available information.
- While much progress has been made in developing an operational Fisheries Ecosystem Plan approach a number of areas would benefit from further research and these are set out in Annex 3.

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BACKGROUND: DRIVERS OF CHANGE IN EUROPEAN FISHERIES

The 2009 Green Paper on the Reform of the Common Fisheries Policy (CFP; EC 2009) and subsequent communications on the upcoming reform of the CFP (EC 2008a; EC 2011) have identified the need for ecosystem based fisheries management (EBFM); 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 concept of an ecosystem approach has been recognised in a number of international agreements, and derives from the 1992 Convention on Biological Diversity and the subsequent declaration of the 2002 World Summit on Sustainable Development. EBM is also a central tenant of the FAO (UN) Code of Conduct for Responsible Fisheries (FAO 1995), and new policies are being developed in response to these drivers to integrate marine management across sectors rather than focussing on a particular sector (Pascoe 2006) (e.g. Canada's Oceans Act 1997; Australia's Oceans Policy 1998; and the UK's Marine and Coastal Access Act 2009).

Within the EU, the cross-sectoral approach is being pursued under the Integrated Maritime Policy (IMP) which has been implemented to take account of the multiple pressures from the different sectors and address interactions between European policies and maritime activities (EC 2007). The Marine Strategy Framework Directive (MSFD) forms the environmental pillar of the IMP and is the thematic strategy for the protection and conservation of the marine environment "*with the overall aim of promoting sustainable use of the seas and conserving marine ecosystems*" (EC 2008b). Economic and social sustainability are acknowledged as being dependent on productive fish stocks and healthy marine ecosystems, and commitments have been made to manage European fisheries within the constraints of the MSFD to achieve good environmental status (GES) (EC 2009; EC 2011).

The Making the European Fisheries Ecosystem Plan Operational (MEFEPO) project was designed to further development of a framework, and the supporting evidence base (natural and social science), required to integrate the MSFD objectives within a reformed CFP. Understanding of the links between ecological, social and economic systems is essential in order to ensure that management decisions are appropriately informed and the transition to EBFM has considerable implications for the knowledge base required to support management. Fisheries Ecosystem Plans (FEPs) have been developed as a tool to assist managers and stakeholders simultaneously consider the ecological, social and economic implications of management decisions (Fluharty et al. 1999). FEPs are a guide for fisheries management planning and development (or amendment of fisheries management plans), helping stakeholders and decision makers to identify and focus on critical ecosystem features and processes (Link 2002).

Through structured interaction with stakeholders through the Regional Advisory Councils (RACs), interviews and workshops (Aanesen et al. 2010; Raakjær et al. 2010; Piet et al. 2011a; van Hoof et al. 2011), the MEFEPO project has developed FEPs for the North Sea (Piet et al. 2011b), North West Waters (Bloomfield et al. 2011) and South West Waters (Borges et al. 2011). These regions were selected as they represent a range of challenges in terms of: knowledge; data availability; the number of national interests; spatial extent; and physical and biological characteristics. The aim of this report is to assess

progress towards development and implementation of an ecosystem approach to fisheries management in European waters and identify the immediate priorities for research and governance development. Progress has been assessed against the 11 point test developed by ICES (2005, see Annex 1); the ecosystem approach would be considered to be fully applied when all of the test components have been passed.

DEVELOPING FISHERIES ECOSYSTEM PLANS

Development of the Fisheries Ecosystem Plans (FEPs) for the North Sea (Piet et al. 2011b), North Western Waters (Bloomfield et al. 2011) and South Western Waters (Borges et al. 2011) drew upon the wealth of information and outputs from earlier MEFEPO project work packages (Table 1). The FEPs also considered the next steps required for implementation of an ecosystem approach to fisheries management in European Fisheries. The following sections provide an overview of the supporting institutional framework required to support the transition to EBFM, and of the decision-making support tool developed to combine ecological, social and economic data in support of sustainable EBFM.

Table 1 Key components of the Fisheries Ecosystem Plans (FEPs) developed by the MEFEPO project for the North Sea, North Western Waters and South Western Waters Regional Advisory Council (RAC) Areas, and the main contributing work packages (see Annex 2 for details of work package reports).

Component (and associated FEP Section)	Contributing work packages
Governance and institutional frameworks (Section 2)	WP3, WP4, WP6
Critical regional ecosystem components (Section 3)	WP1
Ecological state of the regional ecosystem (Section 4)	WP2
Case studies: evaluating management strategies (Section 5)	WP1, WP3, WP5, WP6

Supporting institutional framework

Reform of the governance and institutional structure was considered to be a key element for successful transition and implementation of EBFM. Through structured interaction with stakeholders (Raakjær et al. 2010; van Hoof et al. 2011), the MEFEPO project developed an institutional framework based on a decentralised management structure with decision-making power devolved to Member States (MS) co-ordinated at the regional level, enhanced Regional Advisory Councils (RACs) with appropriate scientific support, and a more collaborative approach between MS, RACs and scientists to develop fisheries management plans (Fig. 3). Whilst the institutional structure and formal distribution of powers remains largely unchanged, this model would: enhance stakeholders' participation in management at the regional scale; facilitate involvement in the development of management objectives and appropriate

descriptors for all three pillars, and in the evaluation of management strategies; and thus give credibility to the management process and foster stakeholder support (Bloomfield et al. 2011).

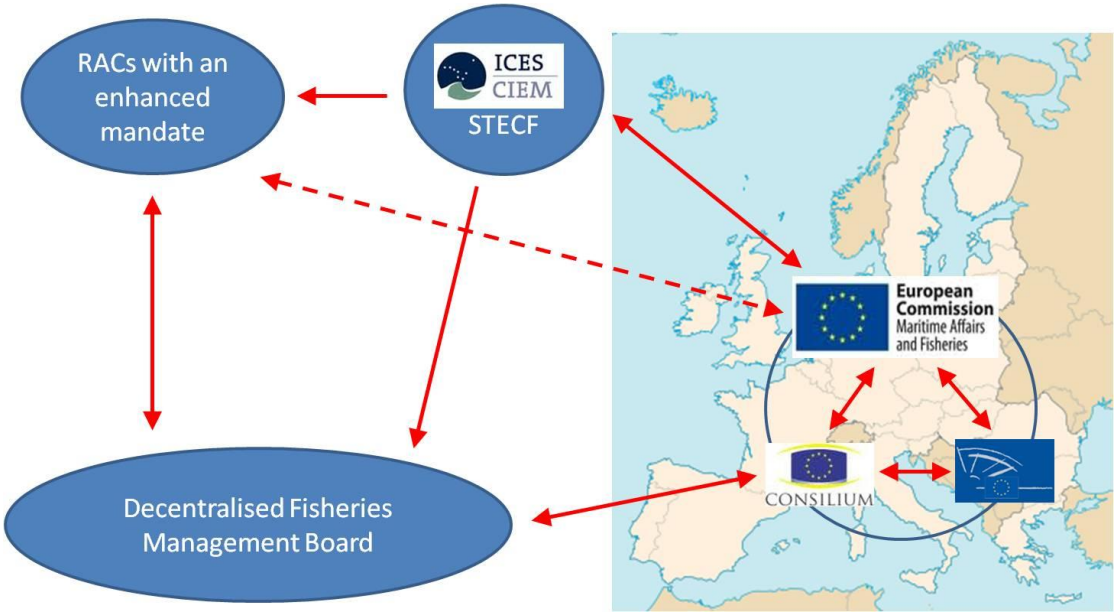

Fig. 1 Governance model for regionalisation of the Common Fisheries Policy developed by stakeholders at the MEFEPO workshop in Haarlem, April 2011 (van Hoof et al. 2011).

Supporting decision-making

Central to the FEPs was a management strategy evaluation matrix (Table 2, van Hoof et al. 2011), which could be used to explore the potential impacts of different management strategies on multiple objectives (ecological, social and economic) for the marine environment. 'Descriptors' for the ecological, social and economic status of the fisheries were developed to enable simultaneous consideration of the potential impacts of different management strategies on the three pillars of sustainability (Fig. 2). Ecological descriptors, drawn directly from the MSFD (EC 2008b), were selected at a MEFEPO stakeholder workshop as those most impacted by fishing activities (biodiversity, commercial fish, food-webs and seafloor integrity) (Le Quesne et al. 2010). Social and economic descriptors were defined to monitor the main aspects of fishing contributing to the economic and social wellbeing of society, in particular coastal communities (Piet et al. 2011a). Economic descriptors focus on fishers' ability to maximise economic efficiency of fishing operations (efficiency) and minimising fluctuations in harvesting possibilities over time (stability). Social descriptors monitor employment opportunities within the catching sector (community viability) and securing catch potential for human consumption (food security).

Table 2 Management strategies matrix developed to assist decision-making; the matrix can be used to incorporate ecological, economic and social descriptors and indicators (van Hoof et al. 2011).

	Ecological objectives		Economic objectives		Social objectives	
	Indicator A	Indicator B	Indicator C	Indicator D	Indicator E	Indicator F
Strategy 1						
Strategy 2						
Strategy 3						
Strategy 4						
Strategy n...						

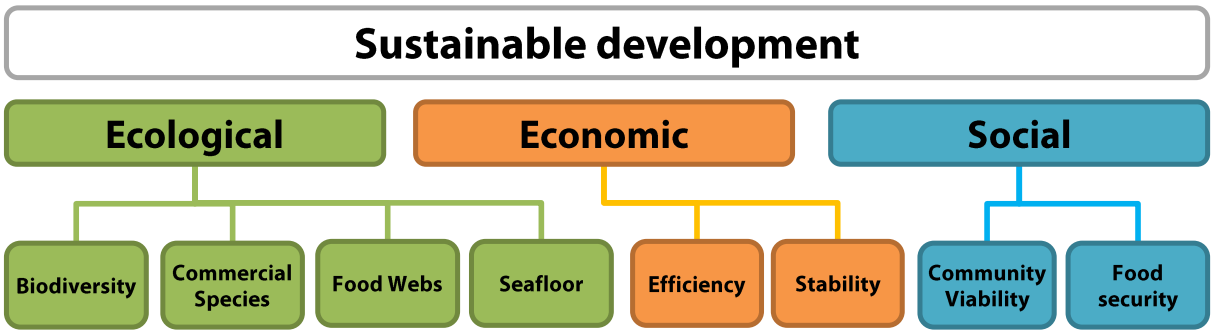

Fig. 2 Ecological, economic and social descriptors used in the application of the management strategies matrix approach in the development of Fisheries Ecosystem Plans (Le Quesne et al. 2010; Bloomfield et al. 2011; Piet et al. 2011a).

Application of the management strategy matrix was demonstrated using case study fisheries within each region. In each case, the potential performance of a limited number of management strategies were evaluated; the efficacy of the management strategies was considered in the context of high level management objectives for European fisheries. The suite of management strategies comprised of "business as usual" (BAU) and alternative strategies applying different management tools, to explore how the objectives of EBFM may be most effectively achieved, and trade-offs associated with different management approaches were examined. Management strategy matrices were completed based on the best available evidence (modelled, empirical and expert judgment) and predicted change in descriptor status associated with implementation of each strategy was assessed as: improvement, stable, deterioration or unknown.

ASSESSMENT OF PROGRESS TOWARDS THE IMPLEMENTATION OF AN ECOSYSTEM APPROACH

The MEFEPO assessment of project progress towards implementation of an ecosystem approach to fisheries is detailed in Table 3, as measured against the ICES (2005) 11-step test; we considered the extent to which each step had been achieved based on evidence from the work undertaken within the project. Whilst the project was able to report progress in the development of EBFM, further research and development was required against all steps before implementation of an ecosystem approach could be considered to be complete. Most notable was the uncertainty with respect to choice of appropriate, specific and measurable social and economic objectives, descriptors and associated indicators, comparable to those being developed for the ecological pillar through the MSFD (Table 3; rows c, d, e, f and j). These findings echo those of Jennings and Rice (2011) in a recent assessment of the degree to which an ecosystem approach to fisheries in Europe had been implemented, utilising the same 11-step test, which recommended additional work for all steps of the process, concluding that many of the steps had been limited by the absence of operational objectives.

The ecological status of the regional system was evaluated in relation to the high levels objectives defined, based on the MSFD descriptors considered to be directly impacted by fishing activities (Table 3; rows b and d). ICES (2005) identified the need for operational objectives, goals and targets (constraints) for EBFM. Whilst some of the indicators for ecological objectives were available (e.g. commercial species), indicators could not be calculated for all ecosystem components impacted by fishing activities and reference levels ("operational objectives", Sissenwine and Mace 2003) to set target were often unavailable. Due to this, and the absence of targets for social and economic descriptors and indicators, predicted change in descriptor statuses for all three pillars was classified as "improving", "stable" or "deteriorating", compared to the BAU management strategy.

Within the EU, considerable effort is being channelled to the development of descriptors, indicators and target levels for the ecological objectives under the MSFD (e.g. Rice et al. 2012). However, concerns remain over the choice and application of the social and economic descriptors utilised, and definition of social and economic descriptors, appropriate indicators and targets require further scrutiny and development if this approach is to be taken within a formal advisory framework. We recommend that this process is undertaken collaboratively (Member State, scientists, and industry), and subject to periodic review to ensure that descriptors and indicators for all pillars are fit-for-purpose (Table 3; rows i, j and k).

The 2002 Reform of the Common Fisheries Policy was 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). For example, long term sustainability of fish stocks has the potential to deliver long-term ecological, social and economic benefits but may have short term economic and social costs. Policies should be established, and subsequent management implemented, with a long-term horizon and agreed (and formalised) guidance must be developed on the priority to be given to objectives when trade-offs have to be made (Jennings and Rice 2011). Further work is also required to establish the political and social

acceptability of management tools and to fine-tune management strategies to meet objectives (Table 3; rows g and h).

Consistent with Garcia et al. (2003) and Sissenwine and Mace (2003), consultation with stakeholders (industry, managers and NGOs) demonstrated a desire for a more collaborative (and transparent) approach to fisheries management with greater stakeholder involvement in the development of fisheries management and policy, implemented at appropriate regional scales (Raakjær et al. 2010; van Hoof et al. 2011). The reformed institutional structure proposed by the MEFEPO project builds upon the Regional Advisory Council model implemented through the 2002 Reform of the CFP (EC 2002), and would help to support commitments under the MSFD to achieve "good ecological status" at a regional level, with actions devolved to member states (EC 2008b; Foden and Wentworth 2010). However, further research is required to harmonise differences in spatial scales among policies and resolve conflicts among policies and their associated objectives, including the development of approaches to incorporate management of and interactions among a broader range of activities (Table 1; rows a and c).

Table 3 Assessment of the MEFEPO project against the 11 point test developed by ICES (2005) to measure the development and implementation of an ecosystem approach; evidence of progress is cross-referenced with MEFEPO project reports (see Annex 2 for report details).

Question	To what extent has this been achieved?	Evidence for this?	Further work needed/Priorities for future research
a. Have management regions with unambiguous boundaries been defined and have responsibilities for the management of all activities at all scales been identified?	There is no regional unit of management. Regional management in relation to CFP has been considered based on regional advisory council areas (North Sea; North Western Waters and South Western Waters). RAC regions were chosen as they delineate natural ecosystem boundaries. Assessment of ecological status for fisheries was based on individual stocks as coherent ecological entities. Stocks distribution varies between stocks and is not regional areas. The selection of stocks to include as part of the region should thus become part of the definition of the management region. Whilst the focus of the project was on European fisheries, we have considered management and governance at a range of spatial scales where appropriate for case studies. MEFEPO has not addressed management of activities other than fisheries.	Case studies utilised within the regions (WPs 1, 2 and 7) are predominantly managed by the European Union (EU) under the Common Fisheries Policy (CFP). However the approach we have developed for management strategy evaluation (WP7) is not limited to management under the CFP, as demonstrated by its application for the scallop fishery, and could be utilised at a range of spatial scales. As things currently stand, fisheries management of key stocks remains the sole competency of the EU. However, with stakeholders we have explored the role of regionalised governance under the CFP to allow management at appropriate spatial scales, and to incorporate appropriate MSs in relevant discussion.	**Management** Where possible regional delineation (CFP/MSFD etc.) should be harmonised. **Research** Spatial differences in marine policy exist (e.g. CFP at RAC level; MSFD applying their specific (sub) regions) and further research is required to resolve conflicts among policies, objectives and spatial scales. Approaches are required to look at incorporating management of a broader range of activities / sectors.

b. Has the current status of the ecosystem been described and contrasted with the Vision?	The ecological status of the system was evaluated in relation to MSFD descriptors, identified as impacted by fishing, based on current available evidence. The available evidence allowed state or pressure indices to be calculated in relation to the predominant impacts of fishing. Indicators could not be calculated for all ecosystem components impacted by fishing. Reference levels to set targets that define the vision were often not available.	In WP1 the system was described. In WP2 we assessed the status against the Vision for the case study RAC regions.	**Management** A clearer statement of the 'vision' needs to be elaborated. In terms of the ecological vision this work is currently underway in developing Marine Strategies within the MSFD. If the ecosystem approach is to encompass the social and economic aspects of the ecosystem a vision needs to be developed for these aspects. **Research** See scientific developments proposed under j.
c. Have the properties of the ecosystem and the associated threats been fully documented and likely additive or synergistic threats identified?	The ecosystem properties and threats to it were documented for each region included in the project. While all threats were documented in the initial high level analysis, in subsequent work consideration of interactions focussed on fisheries effects.	WP1 technical reports, regional seas atlases, for interactions D6. Additive and synergistic effects were considered in WP5.	Research is needed to understand interactions among fisheries sectors and with other human activities. There is a growing body of work on cumulative impacts of fishing on ecological components but little information regarding interactions within and with social and economic properties.
d. Have ecological objectives and operational objectives with appropriate properties (SMART) been identified and agreed in all regions, based on an inclusive and consultative process?	Ecological objectives were defined as the GES descriptors impacted by fishing and an operational objective as an indicator and associated target related to each ecological objective. For each ecological objective (descriptor) we identified an indicator and adopted a target if some appropriate level was available (e.g. for LFI or F). If not we assumed the target was an improvement to the current situation.	Development in WP2, application in WP5. To some degree this involved consultative processes which were implemented through stakeholder workshops in London (WP2) and Dublin (WP5).	The scientific basis for setting targets should be further developed. The actual setting of the targets should be developed through consultative processes for all fisheries. This process should be explored and implemented through regionalised governance structure (see k for more details).

e. Have all incompatibilities of ecological objectives, operational objectives, and scales of management been identified and rectified?	Compatibility between overarching objectives of the MSFD and the CFP was considered. It was observed that there may be incompatibilities among operational objectives both within and between MSFD and CFP. In addition, incompatibilities of ecological, social and economic objectives were identified and explored for fisheries case studies.	See WP2 and WP5, WP6, WP7	Further research is required to identify appropriate scales of management for the social and economic descriptors and integrated spatial management.
f. Have indicators, limits, and targets been established for each operational objective and are they inter-compatible?	Indicators were identified for ecological descriptors (MSFD), and descriptors and indicators were identified for the social and economic pillars. Targets were not set, but indicator status was assessed as either "improving", "stable" or "deteriorating" relative to the status quo. High level objectives can potentially be conflicting. Descriptors were used in the management strategy evaluation matrix to explore trade-offs; due to the nature of trade-offs it may not be possible to satisfy all high level objectives (or stakeholder groups) simultaneously.	WPs 5, 6 and 7.	Further work is required to develop descriptors, indicators, limits and targets. This process is underway for the ecological pillar, through the MSFD, but particular effort is needed for the social and economic descriptors, which require a peer reviewed process of determination. Appropriate descriptors may be region specific.
g. Have sufficient management tools to support the operational objectives been identified and put in place?	We explored suites of management tools, and assessed them according to criteria of efficiency and acceptability. Management strategies, consisting of combinations of management tools, were evaluated for their ability to deliver the objectives, compared to "business as usual" (BAU) management regime.	WP3 and WP7.	**Research** More detailed assessment of management strategies is required. **Management** Management strategies/tools should be assessed in terms of political acceptability.

h. Will all proposed management tools be effective in supporting the ecological objectives and operational objectives of management and are the management methods coordinated and compatible?	Within the management strategy evaluations we explored the ability of different management strategies (based on applying different management tools) to achieve the ecological, social and economic objectives defined for ecosystem based management toward sustainable fisheries. Not all management strategies are equally effective in achieving the multiple objectives of EBFM.	Generic management tool effectiveness was evaluated in WP 3. The predominant evaluation of applying different management strategies was explored in WP7, and also examined in WP 5.	**Research** Further work is required to develop predictive assessment tools to examine the performance of different management strategies on multiple objectives, for example extending fishing impact assessment models to include aspects relating to wider ecological objectives or social or economic objectives. Decision-support tools for integrated management strategies should then be developed.
i. Has a process for providing quality-controlled supporting science been established, and is there a clear route by which the science is fed into the decision-making process?	A general process for feeding science into the decision making process has been proposed. The more detailed institutional and logistical arrangements and links required to enable the general process to actually become operational has not been elaborated. A quality control process has been considered, it is envisaged that initially this would simply involve clearly stating the source of the assessment.	The scientific advice would be fed into the enhanced RAC in the governance structure defined in WP 6 based on potential models developed in WP4.	**Management** The practical process by which existing bodies (e.g. ICES and STECF) can contribute to the development of FEPS within the enhanced RACs needs to be elaborated and specified. **Research** Further work could examine the ability to express uncertainty and confidence in relation to advisory inputs generated by different processes ranging from qualitative assessments based on limited data through to formal quantitative assessments based on extensive data.

j. Is the science advice supported by adequate monitoring and assessment, and are the monitoring and assessment procedures also quality controlled?	We focussed on developing advice (and a framework to incorporate this) on the basis of evidence that is currently available, rather than initially defining the evidence required and then attempting to proceed. The data used predominantly came from formal datasets (e.g. Datras) and we did not attempt to evaluate the quality control procedures implemented within existing data collection processes.	Evidence of the data used in developing the scientific advice is presented in reports for WPs 1, 2, 3, 5, 6 and 7.	**Research** The monitoring data only allows status to be defined in relation to some ecosystem components. Specific limitations relate to i) habitat maps showing location of threatened and declining habitats, ii) regional scale datasets on abundance of benthic organisms, large pelagic fish, seabirds and cetaceans, and iii) abundance of coastal fish communities. However further research is required to assess the need to individually monitor fishing impacts on each component as the response of components may be correlated. See also e regarding social and economic data.
k. Has a process for management feedback and decision-making been established and will it ensure ongoing compatibility of management methods?	A governance approach operating within an adaptive framework, having in-built feed-back mechanisms has been elaborated.	Two management cycles were identified: management assessment and advice, and objective definition and assessment (WP7). Best available evidence (WPs 6 and 7) is utilised to inform and contribute to the management strategy evaluations, involving stakeholder engagement through the RACs (Fig. 3).	More detailed logistical structures to ensure feed-back of information in to decision-making process need to been elaborated, and mechanisms to deal with trade-offs should be specified. More research is required on the governance framework to support EBFM.

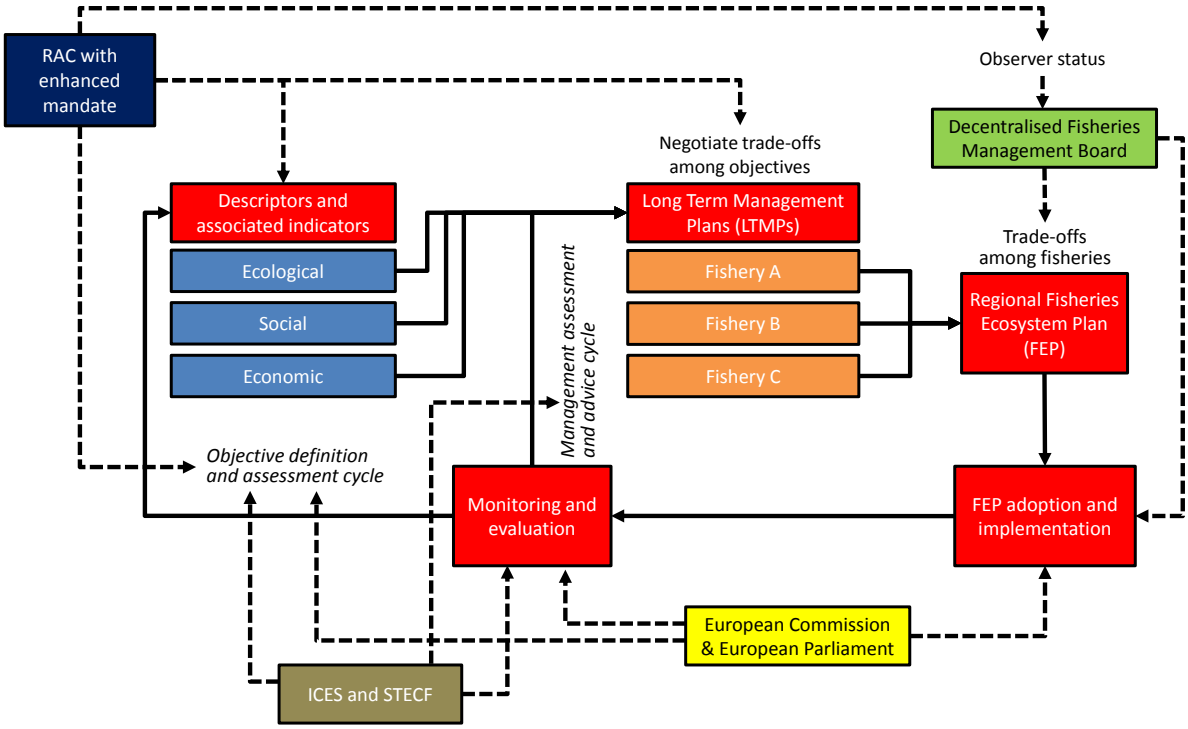

Fig. 3 Adaptive management cycle (solid arrows) proposed for the development of Fisheries Ecosystem Plans (FEPs) to support implementation of ecosystem based fisheries management (EBFM) in European waters; dashed lines indicate where the different components of the proposed governance framework provide input.

SUMMARY AND NEXT STEPS

The MEFEPO project has developed a framework to support implementation of EBFM in Europe, and applied this framework to the development of FEPs for the NS, NWW and SWW. The framework consists of two key elements: (1) an institutional structure that can support greater stakeholder involvement in fisheries management at an appropriate geographical (regional) scale; and (2) a decision-support management tool (management strategy evaluation matrix) to help stakeholders and decision-makers to simultaneously consider ecological, social and economic implications of management decisions and inform the development of EBFM for European fisheries.

The approach taken forwarded by the MEFEPO project is consistent with the FAO (2003) definition of an ecosystem approach to fisheries which "....*strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries*." However, this assessment and others highlight that operational EBFM has yet to be achieved.

The MEFEPO project has identified management and research priorities to support the development of EBFM in Europe (Annex 3). In summary, to make EBFM a reality in European waters requires:

- Implementation of appropriate governance mechanisms, at appropriate geographical scales, that facilitate true stakeholder engagement in the development of fisheries policy and management. This includes involvement of stakeholders in both the definition of objectives (ecological, social and economic) and appropriate (region specific) indicators and in the development and evaluation of resultant management (Fig. 3). Closer integration among stakeholders, fisheries scientists, ecologists, social scientists and economists will help to develop more effective management advice, generate credibility in the management process and foster stakeholder support.
- Fisheries management plans to be developed for each of the region's fisheries considering the ecological, economic and social implications for ecosystem components, and then integrated into regional FEPs. Management plans should be developed based on best available evidence; the absence of data must not be allowed to prevent decisions from being made and management advice should be formulated based on the best available evidence (be it modelled, empirical or expert opinion), consistent with the FAO Code of Conduct for Responsible Fisheries (FAO 2005) and the precautionary principle. Qualitative assessments and expert judgement are needed to supplement analytical modelling if EBFM is to be made operational in the near future, and effort should be expended on developing approaches to incorporate qualitative data, expert judgment and data from outside of the traditional scientific advice domain (e.g. from industry) to ensure that management decisions are appropriately informed.
- Implementation of management plans within an adaptive management regime, responsive to changes in environmental conditions, and new knowledge and understanding on the marine environment. Furthermore, management should be able to respond to advances in technology and associated changes in fishers' behavior to ensure that the long term sustainability is not

compromised. Monitoring should be implemented to report on progress in meeting management objectives, with action taken where objectives are not being met.

Ultimately management decisions will be made on the basis of overarching objectives, and the European Council and Parliament have sole competency for high level decisions in terms of setting overall policy and deciding the balance between social, economic and environmental objectives (Foden and Wentworth 2010). Multiple objectives for managing the human activities within the marine environment means that trade-offs are required (Brodziak et al. 2004), both between the pillars of sustainability in the development of fisheries management plans, and between individual fisheries when integrating fisheries management plans into regional FEPs. Due to the nature of the trade-offs, it may not be possible to meet all objectives or satisfy all stakeholder groups simultaneously, particularly given the short-term incompatibility of environmental, social and economic objectives of the CFP and the potential short-term negative effects of implementing management measures to meet environmental objectives (e.g. GES under the MSFD or stock recovery) on social and economic objectives (Sissenwine and Symes 2007; Jennings and Rice 2011).

Resolution of these trade-offs is not a technical or scientific decision, however application of decision support framework such as the management strategy evaluation matrix, coupled with agreed (and formalised) guidance on the priority to be given to objectives when trade-offs have to be made (Jennings and Rice 2011), will aid managers in making appropriate decisions on the basis of the best available information. Furthermore, development and assessments of management strategy evaluations, and subsequent implementation of FEPs, through a reformed governance structure such as that proposed here (Fig. 3) would facilitate greater stakeholder involvement in the management process in line with international approaches to EAF, and help to foster trust and support of subsequent management measures, and thus increase the likelihood of successful transition to EBFM for European fisheries.

ACKNOWLEDGEMENTS

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ANNEX 1 Assessing progress towards Ecosystem Based Fisheries Management

The ICES (2005) 11 point text for measuring progress towards implementation of the ecosystem approach.

1. Have management regions with unambiguous boundaries been defined and have responsibilities for the management of all activities at all scales been identified?
2. Has the current status of the ecosystem been described and contrasted with the Vision?
3. Have the properties of the ecosystem and the associated threats been fully documented and likely additive or synergistic threats identified?
4. Have ecological objectives and operational objectives with appropriate properties (SMART) been identified and agreed in all regions, based on an inclusive and consultative process?
5. Have all incompatibilities of ecological objectives, operational objectives, and scales of management been identified and rectified?
6. Have indicators, limits, and targets been established for each operational objective and are they inter-compatible?
7. Have sufficient management tools to support the operational objectives been identified and put in place?
8. Will all proposed management tools be effective in supporting the ecological objectives and operational objectives of management and are the management methods coordinated and compatible?
9. Has a process for providing quality-controlled supporting science been established, and is there a clear route by which the science is fed into the decision-making process?
10. Is the science advice supported by adequate monitoring and assessment and are the monitoring and assessment procedures also quality controlled?
11. Has a process for management feedback and decision-making been established and will it ensure ongoing compatibility of management methods?

ANNEX 2 MEFEPO Project Reports

Table A2 MEFEPO project reports by work package (WP) for cross-reference with Table 2. Project reports are available at www.liv.ac.uk/mefepo

WP	Region	Reference
WP1	NS	van Hal et al. (2010)
	NWW	Nolan et al. (2010b)
	SWW	Goikoetxea et al. (2010)
WP2	NS	Le Quesne et al. (2010)
	NWW	Nolan et al. (2010a)
	SWW	Borges et al. (2010)
WP3	-	Aanesen et al. (2010)
WP4	-	Raakjær et al. (2010)
WP5	-	Piet et al. (2011a)
WP6	-	van Hoof et al. (2011)
WP7	NS	Piet et al. (2011b)
	NWW	Bloomfield et al. (2011)
	SWW	Borges et al. (2011)

ANNEX 3 Research priorities identified by the MEFEPO Project Team

Building upon the assessment of MEFEPO project progress towards development and implementation of an ecosystem approach to fisheries management (Table 3), a number of research priorities were identified and are summarised below:

1. Spatial differences in marine policy exist (e.g. CFP at RAC level; MSFD applying their specific (sub) regions) and inconsistencies occur between policies, objectives and sectors operating in the marine environment. Research is required to examine the potential for harmonising management across regions. Where this is not feasible protocols need to be defined to cope with the inconsistencies in spatial boundaries of different management and assessment areas applied under different polices and sectoral management processes.
   Research is required to develop tools and mechanism to help resolve conflicts between policies, between objectives and across spatial scales, and examine the impacts of management decisions across activities / sectors.
2. Understanding of the links between ecological, social and economic components – for fisheries and other activities in the marine environment – need to be improved. There is a particularly urgent need to understand the relative magnitude of the different impact pathways. Research is also required to develop understanding of synergistic and cumulative impacts within and among sectors (and activities). Tools must be developed to incorporate information (qualitative and qualitative, empirical/modelled/stakeholder derived) on a broader range of activities and their associated impacts to inform decision for sustainable use of the marine ecosystem.
3. Fisheries models remain rooted in single species population models. In order to support ecosystem based approaches there is the need for predictive tools that take account of other ecological and human drivers in the system. There is a growing body of work on cumulative impacts of fishing on ecological components but little information regarding interactions within and with social and economic properties. It is extremely unlikely that a single tool will deliver the necessary information and hence research is required to: (a) identify the most critical components and interactions in each regional ecosystem; (b) develop appropriate indicators of system status, to understand how the indicators respond to system changes; (c) establish limits and targets for the selected indicators; and (d) to develop management tools to influence the indicators. This needs to be done for ecological, economic and social aspects of the system.
4. Building upon (3), research should examine regional differences in potential social and economic descriptors (and thus indicators, limits and targets) based on region- specific objectives.
5. The EAFM broadly considers the impact of fishing on the environment, and the impact of the environment on fishing. The MSFD elaborates the higher level objectives for the acceptable limits of fishing impacts on the environment. However further research is required to translate these higher level objectives into a comprehensive set of SMART objectives and targets. In particular there is a need to increase understanding of the links between environmental status and delivery of ecosystem goods and services so that target levels for what constitutes 'good' environmental status can be defined in relation to impacts on the delivery of ecosystem goods and services.
   Beyond ecological objectives, the EAFM considers the social and economic 'status' of fisheries and associated coastal communities, and further research is required to elaborate social and economic objectives of fisheries, and to define the boundaries of the extent to which fisheries managers should try and manage the social and economic status of fisheries and associated communities.

6. Building upon the application of the management strategy evaluation matrix developed in the MEFEPO project (and the other research activities proposed above), case study fisheries should be identified for more detail examination based on finer resolution differences in management strategies (consisting of one or more management tools). Building on the premise of collaborative working, this could for example be taken forward collaboratively for the case study fisheries with one of the RAC regions to build upon the development of Fisheries Ecosystem Plans (FEP), taking account of trade-offs among objectives (within a particular fishery) and across fisheries when integrated into the FEP.
7. In addition to the development of tools to measure and report on ecosystem status, development of management requires tools to evaluate, in a simulation environment, the consequences of management actions. While part of this response is biological, much of it is mediated through human behaviour – how do people respond to the management regime? Therefore research is required to both develop management scenario simulations and to provide information on the behaviour of key players with which to parameterise the models.
8. Research is required to develop and critique methods that can be used to express uncertainty and confidence in relation to advisory inputs generated by different processes (e.g. modelled, expert judgement, stakeholder derived) ranging from qualitative assessments based on limited data through to formal quantitative assessments based on extensive data.
9. In relation to the ecological pillar, monitoring data currently available only allows status to be defined in relation to some ecosystem components. Research is required to address specific limitations related to: i) habitat maps showing location of threatened and declining habitats, ii) regional scale datasets on abundance of benthic organisms, large pelagic fish, seabirds and cetaceans, and iii) abundance of coastal fish communities. Research is also required to assess the need to individually monitor fishing impacts on each ecological component as the response of components may be correlated.

   This second point also stands for the social and economic pillar but assessment of status for the social and economic components is currently being impeded by the absence of clear objectives, descriptors etc. (see (1), (3) and (4)), and this remains a key research priority.
10. Further research needs to be undertaken to support the implementation the MEFEPO proposed adaptive management cycle including the science-policy interface, appropriate regional governance structures and multi-stakeholder involvement.

    Alternative models of the advisory and management process need to be developed to propose options for coupled advisory and management systems that are able to provide, and respond, to broader remit of EAFM than currently operates under the 'single stock advisory and management process'.