



Towards Delivering Ecosystem-Based Marine Management: The ODEMM Approach



ODEMM
Options for Delivering Ecosystem Based Marine Management



ODEMM Partners



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Recommended Citation: Robinson, L.A., Culhane, F.E., Baulcomb, C., Bloomfield, H., Boehnke-Henrichs, A., Breen, P., Goodsir, F., Hussain, S.S., Knights, A.M., Piet, G.J., Raakjaer, J., van Tatenhove, J. and Frid, C.L.J. (2014). Towards delivering ecosystem-based marine management: The ODEMM Approach. Deliverable 17, EC FP7 Project (244273) 'Options for Delivering Ecosystem-based Marine Management'. University of Liverpool. ISBN: 978-0-906370-89-6 : 96 pp.

This work was supported by the European Commission's 7th framework project 'Options for Delivering Ecosystem-Based Marine Management' (ODEMM, Theme ENV.2009.2.2.1.1)

EXECUTIVE SUMMARY

I. It is widely accepted that ecosystem-based management (EBM) is required to deal with the increasing human use of the marine environment. However, consideration of the whole system, including the links between human use, ecological state and ecosystem services, leads to an immensely complex array of factors that need to be accounted for; as such, fully operationalising a holistic approach like EBM is not straightforward.

II. The ODEMM (Options for Delivering Ecosystem-Based Marine Management) project considered there to be five key principles to an approach that would make EBM operational. It must:

1. Have clear objectives that are determined by society and set in relevant policy, and then link these objectives to specific components of the ecosystem (i.e. work within a fully integrated ecosystem assessment framework);
2. Account for all possible interactions that are relevant to the policy objectives no matter how insignificant they may at first seem (be holistic), and then be able to weight and rationalise what is important and what management and/or monitoring and research should focus on;
3. Be based on structured, transparent and repeatable analyses that can work in data-poor situations (as well as those that are data-rich), because EBM should be holistic in evaluation of objectives and thus needs to account for issues even if there is little data available on them;
4. Include evaluation of management options that considers the implications in terms of ecological, social and economic outcomes (be able to consider trade-offs);
5. Have clear consideration of the relevant governance settings and how these might influence performance in achieving the EBM goals, at both a broad and specific (e.g. Management Option Evaluation) level.

III. Based on the principles outlined above, ODEMM developed an approach including a series of resources that can help support decision-makers to implement operational EBM. The approach is illustrated using Europe's Marine Strategy Framework Directive (MSFD) as the context. ODEMM's resources are designed to allow consideration of the state of relevant policy objectives (e.g. the 11 MSFD Descriptors of Good Environmental Status), building on this to elaborate an operational process of creating, appraising and choosing management options, where full consideration of trade-offs across ecological, economic and social issues, and evaluation of the governance complexity surrounding this, are all considered. This report documents the overall approach (Chapter 1) and individual resources developed in seven separate chapters (Chapters 2-8), before reflecting on how the work completed emulates what decision-makers might need to implement EBM, with suggestions made for any further work required (Chapter 9).

IV. A key aspect of any policy-relevant EBM work must be the periodic assessment of the status of key policy objectives at the spatial scale at which the policy is relevant. Europe's MSFD is based on achievement of Good Environmental Status (GES) measured against a range of Descriptors (covering aspects such as Biodiversity, Commercial Species and Marine Litter) and applied at the scale of the regional sea. In practice, the initial assessments conducted by the signatory countries to the MSFD have been undertaken at the scale of the national jurisdiction and there is little regional coherence in approaches used. ODEMM noted a gap in assessment methodologies that could be applied at the scale of the regional sea, and therefore developed an approach that evaluates the degree of departure of the regional sea from the different descriptors of GES. This approach has been applied in all four regional seas using a combination of existing assessments and/or expert judgement. The outcomes provide insights to facilitate the identification of regional management priorities to support achievement of GES by 2020, and the broader lessons learnt in developing and applying such an approach are discussed with reference to the requirements of status assessments in operational EBM (Chapter 2).

V. Having assessed the status of key policy objectives, threats to those objectives need to be identified and relevant management options selected and evaluated. As described under Principles 1 and 2 in para. II above, integrated ecosystem assessment is required at this point and this assessment must be based on a structure that includes all relevant and linked components of the ecosystem. ODEMM developed a linkage framework that is a systematic structure that firstly lists all relevant components (sectors, pressures, ecological components, ecosystem services and policy objectives) of the ecosystem for the policy in question, and then describes all the causal-chain links between those individual components in a system of linkage tables (matrices) to give a fully connected ecosystem (Chapter 3). The linkage framework provides the structure within which management options can then be explored.

VI. With all possible interactions relevant to any EBM-based policy objective identified, there are then a series of analyses that can be undertaken to weight and rationalise what is important and what management and/or monitoring and research should focus on. In Chapter 4, the ODEMM Pressure Assessment approach, which weights interactions between sectors, pressures and ecological components (impact chains), is described. Each impact chain is categorised in terms of exposure, severity and recovery lag; when considered either solely or in combination, these three aspects can each provide useful information to help prioritise management and monitoring of marine ecosystems. For example, those sector/pressure combinations of greatest threat in any one regional sea ecosystem will be those that affect ecological components with a high degree of impact (acute or chronic severity), over wide areas relative to the total area being assessed and, where there are only chronic effects, frequently enough to maintain the pressure. Where the ecological component also has low resilience (i.e. poor recovery potential) and/or the pressure can persist in the environment for a very long time, threat can be even higher and management potential lower.

VII. Building on the Pressure Assessment approach, ODEMM went on to explore how risk assessment could be used to consider the overall threat from sectors or pressures on components of the ecosystem and policy objectives themselves (Chapter 5). The ODEMM ecological risk assessment adds numerical scoring to the pressure assessment categorical data, allowing for the exploration of impact risk and recovery lag aggregated by sector, pressure or ecological component. This allows for high level prioritisation of management across sectors or components within and between regional seas, using ODEMM's integrated management strategy evaluation (iMSE) tool, which links management options (MOs) with the risk assessment data, allowing users to select MOs to target different aspects of risk in the ecosystem (Chapter 6). The effectiveness of any MO can then be evaluated in terms of the reduction in risk of adverse impacts on individual ecological components, the ecosystem as a whole, or at the level of policy objectives (e.g. the GES Descriptors). It is possible to consider how effective MOs will be over a number of different time horizons.

VIII. As stated in points 4 and 5 under para.II, evaluation of MOs within an EBM context, should consider not only the effectiveness from an ecological perspective, but also the implications in terms of social and economic outcomes and the feasibility in terms of the relevant governance settings, allowing for appropriate consideration of trade-offs in decision-making.

IX. Early in the project it was noted that there were many gaps in terms of the tools and understanding required to complete assessments for economic and social benefits arising from application of MOs, in particular when these are based on an ecosystem services approach (Chapter 7). There were also gaps in terms of guiding comprehensive cost assessment. Emphasis within ODEMM was therefore placed on development of typologies of ecosystem services and costs, to ensure that an appropriate structure is in place for full evaluation of trade-offs in terms of social and economic outcomes of management options. Examples explored in ODEMM highlight that a failure to apply EBM (with its focus on the supply of ecosystem services) will mean that policy choices may not be economically efficient, and can easily miss key trade-offs. Furthermore, ODEMM developed a qualitative approach to predict the relative change in ecosystem service supply following application of MOs, to facilitate exploring consequences across all ecosystem services. This was deemed important because otherwise decisions made about the selection of MOs are based on assessments of the few relatively well studied ecosystem services (Seafood, Tourism and Recreation) which leaves the likelihood that full trade-off analysis of benefits cannot be achieved.

X. ODEMM also explored the likelihood of adoption and implementation of both broad policies (e.g. the MSFD) and specific management options, considering the complexity of the related governance system (legislation, institutions and stakeholders) and (lack of) institutional interaction (Chapter 8). Early work in ODEMM identified high levels of ambiguity in terms of understanding of both EBM in general, and the MSFD specifically in terms of how it would be implemented at all levels of governance around Europe. Novel work going forward was thus focused on addressing two key challenges in implementation of the MSFD: the development of (1) governance models that would help facilitate thinking about the options and possibilities of stakeholder involvement and regional cooperation and collaboration, and (2) a nested hierarchical structure for linking emerging regional governance requirements with existing sectoral governance arrangements. This work provides a first step towards understanding how governance will need to transition to support EBM in regional seas.

XI. The role of the ODEMM approach is to provide a solid evidence base to inform decision makers and allow them to make trade-offs with the necessary information available. The tools and approaches do not give the ‘right’ answer but allow decision-makers to consider trade-offs and likelihood of management success. Despite any inherent subjectivity in the approach, the ODEMM framework captures ecosystem complexity and translates this into simple metrics (i.e. single figures in each cell of a matrix) that allow comparison across management options (see resources at www.odemm.com). We consider this to be a starting point for EBM implementation and a flexible approach which can adapt to changing needs.

XII. The approaches we have developed to date are what we consider to be best practice with the available knowledge and techniques that we currently have at our disposal, but naturally, these can be improved and built on. In the final chapter of this report we reflect on how we can move forward with improving EBM, based on feedback from our roadshow participants on the ODEMM tools and approach, as well as feedback from our Advisory Committee and lessons learnt by the project team. We believe that moving forward with implementation of EBM requires both advances in research and in the practical organisation of how management of the marine environment takes place. Our final statements propose 10 steps towards successful implementation of EBM.

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Chapter 1

Ecosystem-Based Management and the ODEMM Approach

1.1 Ecosystem-Based Management

The approach to management of the marine environment is evolving, from a traditionally detailed but narrow approach that focuses on single ecological components or single sectoral human activities, to one in which there may be less detail but greater overall understanding of the whole system (Elliott, 2002). Ecosystem-based management (EBM) and the ecosystem approach (EA) allow for all the complexities of the system to be taken into account, moving away from a reductionist approach, which focuses on individual ecological components, pressures or sectors, to a holistic view that includes humans and their activities, and the ecosystem services that ecosystems provide to humans as an integral part of the ecosystem¹. As such, ecosystem-based management options must consider the trade-offs that may occur between ecological, social and economic factors (the Brundtland Definition - three dimension concept of sustainable development; UN,1987). EBM is based on the principles of sustainable development and recognition that we can only manage human activities, and not the ecosystem itself (Rogers and Greenaway, 2005). It is largely accepted that an ecosystem-based approach to management is required to deal with the increasing human use of the marine environment (e.g. Crain et al., 2009; Tallis et al, 2010, Halpern et al, 2012).

...an ecosystem-based approach to management is required to deal with the increasing human use of the marine environment...

1.2 Ecosystem Based Management in Policy

Over time, the need for an ecosystem-based approach to management has been recognised in policy, from an international level to regional and national levels worldwide², with progression from the appreciation of the place of human activities in the ecosystem, to the clear objective of achieving an ecosystem approach to management. Internationally, the Convention on Biological Diversity (1992) put forward the aims of conservation of biological biodiversity alongside sustainable development, thereby including human use of the environment as part of the system (UN, 1992). The 2002 World Summit on Sustainable Development set the objective of applying the EA to management of the

¹ For an extensive summary of the relevant literature on EBM and the EA see Section 1.1 in R. Long, "Legal Aspects of Ecosystem-Based Marine Management in Europe" in A. Chircop, M. L. McConnell, S. Coffen-Smout (ed.), OCEAN YEARBOOK Vol. 26, (Boston/Leiden, Brill Academic Publishers, 2012) pp.417-484.

² See also in Long (2012)

oceans by 2010 (UN, 2002). In Europe's marine policy area, the focus of policy has shifted from management at an ecological component perspective e.g. the EU Water Framework Directive (EC, 2000), to an inclusive perspective in which the human dimension of the ecosystem has been explicitly considered e.g. the Integrated Maritime Policy, which promotes sustainable use of the marine environment alongside objectives for improving ecological status (EC 2007). Nevertheless, fully implementing a holistic approach like EBM is not straightforward.

1.3 Making EBM Operational

Consideration of the whole system, including the links between human use, ecological state and ecosystem services, leads to an immensely complex array of factors that need to be accounted for.

ODEMM considered there to be five key principles to an approach that would make EBM operational. It must:

1. Have clear objectives that are determined by society and set in relevant policy, and then link these objectives to specific components of the ecosystem (i.e. work within a fully integrated ecosystem assessment framework)
2. Account for all possible interactions that are relevant to the policy objectives no matter how insignificant they may at first seem (be holistic), and then be able to weight and rationalise what is important and what management and/or monitoring and research should focus on
3. Be based on structured, transparent and repeatable analyses that can work in data-poor situations (as well as those that are data-rich), because EBM should be holistic in evaluation of objectives and thus needs to account for issues even if there is little data available on them
4. Include evaluation of management options that considers the implications in terms of ecological, social and economic outcomes (be able to consider trade-offs)
5. Have clear consideration of the relevant governance settings and how these might influence performance in achieving the EBM goals, at both a broad and specific (e.g. Management Option Evaluation) level.

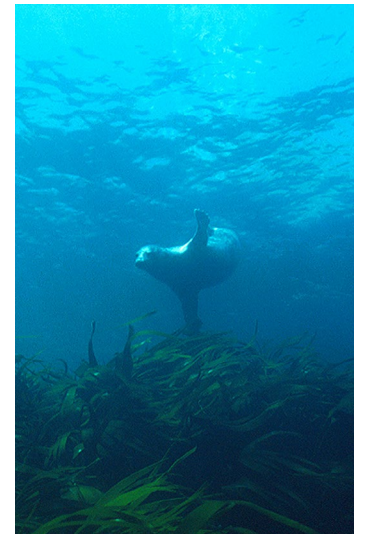
1.4 The ODEMM Approach

The ODEMM approach was developed based on the principles described above, and building on elements of the DPSIR approach (Drivers, Pressures, State, Impact, Response; which links human use in the system to pressures and ecosystem state and includes feedback loops, integrating the response to change (Atkins et al., 2011)), in addition to experience in developing concepts for Integrated Ecosystem Assessments (Levin et al., 2009; Tallis et al., 2010; ICES, 2010).

A key aim was to develop a series of resources (understanding and tools) to support decision makers in an EBM context (each of which is covered in the chapters that follow in this report). Specifically we have developed:

- a method to undertake a [rapid assessment of the state of policy objectives](#) using available information on the specific ecosystem components that are relevant to those objectives (Chapter 2);
- a [linkage framework](#) that identifies all relevant interactions between key ecosystem components – human activities or sectors, their pressures, ecological components and ecosystem services, and the relevant policy objectives (Chapter 3);
- a [pressure assessment](#) that can be used to weight and rationalise the key threats to ecological components and policy objectives (Chapter 4);
- an [ecological risk assessment](#) that summarises information from the pressure assessment into overall risk that can be grouped by different elements (e.g. sectors, pressures, ecological components) and related to management options (Chapters 5 & 6);
- an [integrated management strategy evaluation \(iMSE\) tool](#) that can be used to create management options (MOs) that can target different areas of risk to policy objectives and then evaluate the effectiveness of those MOs (Chapter 6);
- a series of [methods for analysing the costs and benefits of different MOs](#) based on an ecosystem services approach (Chapter 7); and
- a series of [methods for appraising the governance complexity](#) associated with EBM, relevant policies and specific MOs (Chapter 8).

With these resources, policy driver objectives can then be related to an operational process of creating, appraising and choosing management options to inform decision makers, allowing for full consideration of trade-offs across ecological, economic and social issues and the governance complexity surrounding this.



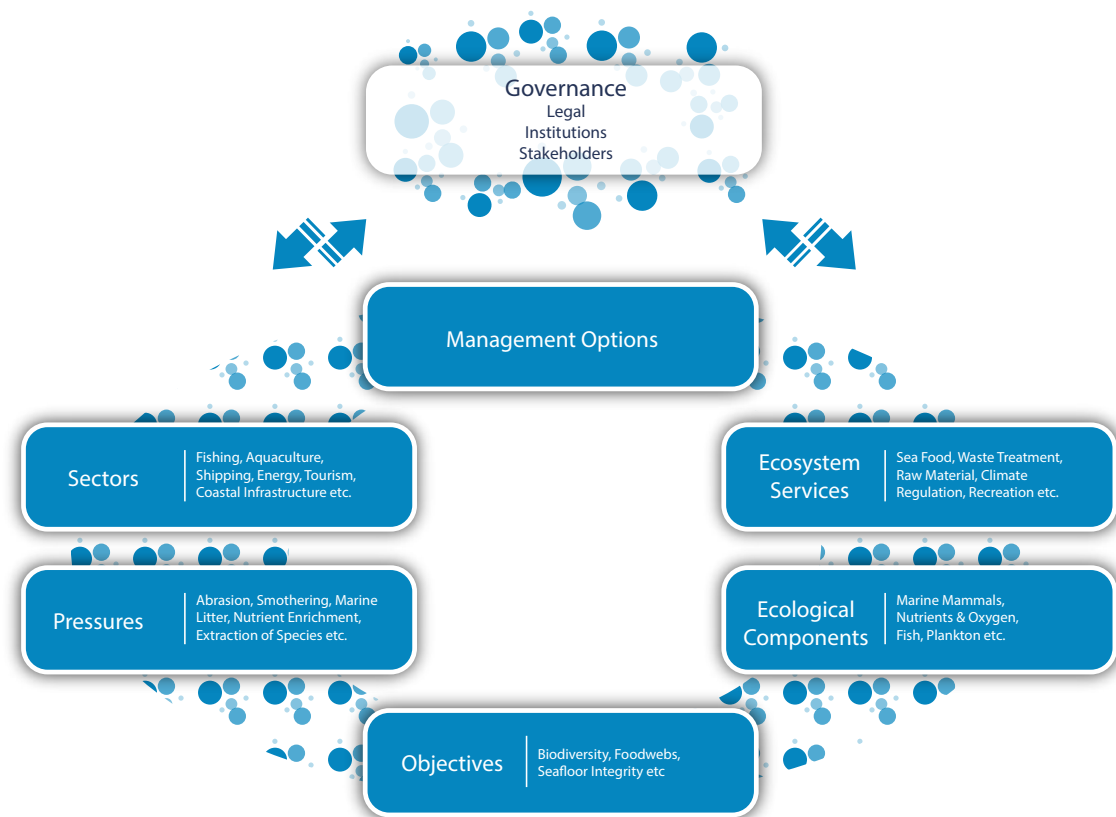


Figure 1.1 The ODEMM approach. Boxes represent the major components that should be considered (in bold) and examples of each of these are given. The process is non-linear, represented by the centre circle. Different linkages between boxes are more or less relevant depending on the specific issue being considered (see examples in the chapters that follow). All of the components lie within the relevant governance setting (signified by the blue bubbles), which determines the policy drivers, legal obligations, who is involved, and who makes the decisions.



The overall ODEMM approach can be illustrated as shown in Figure 1³, and the resources listed above are all considered to be essential aspects of any assessment undertaken with this approach (see illustrations of how each resource fits within the overall ODEMM approach in the chapters that follow). In the final chapter we discuss the criteria that influence decision-making and reflect on how the ODEMM approach fits within this context, as well as commenting on the next steps towards implementing fully operational ecosystem-based management in marine ecosystems.

³ For a fully interactive version of the ODEMM Approach diagram that directs users to the relevant resources developed for any one issue (e.g. how to assess the importance of links between sectors, pressures and ecosystem components; methods for analysing the relevant governance context for a particular issue/policy) visit www.odemm.com

1.5 Applications of the ODEMM Approach to Date

There are multiple potential users of the approach, from those involved in making management decisions, to those carrying out analyses and providing advice to decision makers.

In the work undertaken to date, the ODEMM approach has been applied using Europe’s Marine Strategy Framework Directive (MSFD) (EC, 2008) as the context. This policy is the environmental pillar of the Integrated Maritime Policy (EC, 2007) and thus the objectives are related to the state of ecological components and the human pressures acting on those components. The applications have achievement of these policy objectives as the key aim and thus **the ODEMM approach has a pragmatic grounding for practical implementation by those currently working in decision making and providing advice to decision makers** in European regional seas. However, the resources developed and described herein can be adapted to any geographic area or policy context where EBM is key.

The examples explored throughout this document are taken from the four European regional seas (Figure 1.2), allowing exploration of the approach where there is wide variation in the relevant governance settings, environmental conditions and human use of the sea areas.

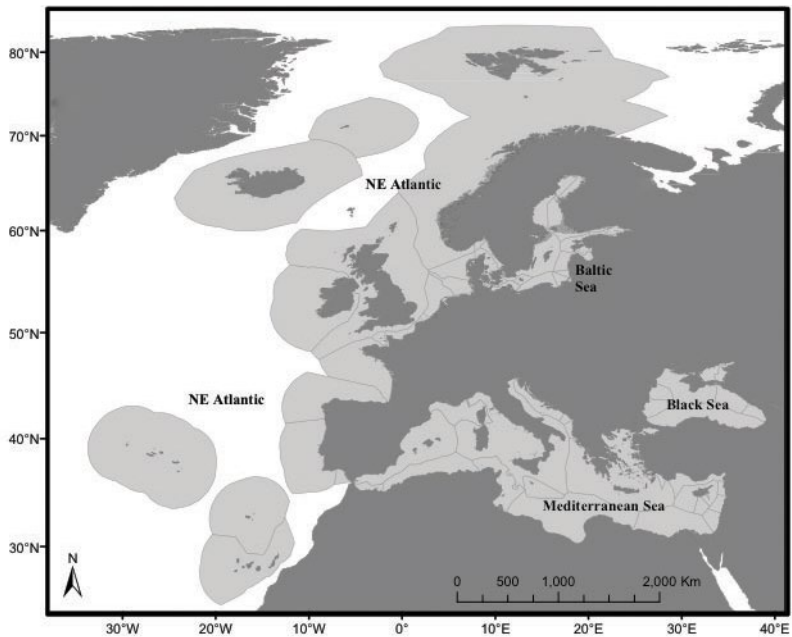


Figure 1.2 The four marine regions of Europe considered in ODEMM, also showing the boundaries of the Exclusive Economic Zones (EEZs) of the countries surrounding those seas.

Chapter 2

State of Policy Objectives: ODEMM's Method for Analysing Risk of Departure from Good Environment Status

2.1 Introduction

A key aspect of any policy-relevant ecosystem-based management (EBM) work must be the periodic assessment of the status of key policy objectives. The over-arching objective of Europe's Marine Strategy Framework Directive (MSFD) is to provide ecologically diverse and dynamic oceans that are clean, healthy and productive, and exploited in a sustainable manner. Assessment of this objective is measured in terms of good environmental status (GES) against 11 qualitative descriptors (Box 2.1). Progress to date has seen all EU member states submit in 2012, an initial assessment of the state of their seas, with reference to national expectations for GES. However, there is great variation in terms of the interpretation of GES even within the regional seas. ODEMM therefore developed an approach to undertake an assessment at the regional sea scale so that it would be possible to relate national priorities to regional issues in a coherent manner.

Following an extensive literature review, ODEMM collated all the information describing status and trends in ecological components, pressures and impacts, relevant to any one of the 11 GES Descriptors that was available in each of the four European regional seas (Annexes 1-4, Knights et al., 2011). Assessing the status of the GES Descriptors can require information on particular ecological components (e.g. Descriptor 1: Biodiversity; Descriptor 4: Food webs) and/or pressures and their impacts (e.g. Descriptor 10: Marine litter; Descriptor 5: Eutrophication) (Figure 2.1).

Relevant information from existing assessments, from both national and regional sources, was found for most descriptors in most regional seas (See Annexes 1-4, Knights et al., 2011). However, whilst existing assessments are useful in the context for which they were developed, the specific criteria and methodology used to determine status and trends do not allow for easy inter-comparison. This is due to the differing motivations, spatial scales and objectives for which existing assessments have been carried out, which may or may not align with the issues highlighted by the MSFD's descriptors of GES.

Chapter Highlights

- Summary of ODEMM's method for analysing risk of departure from GES
- Regional overview of levels of departure from GES
- Key lessons learnt in applying the approach

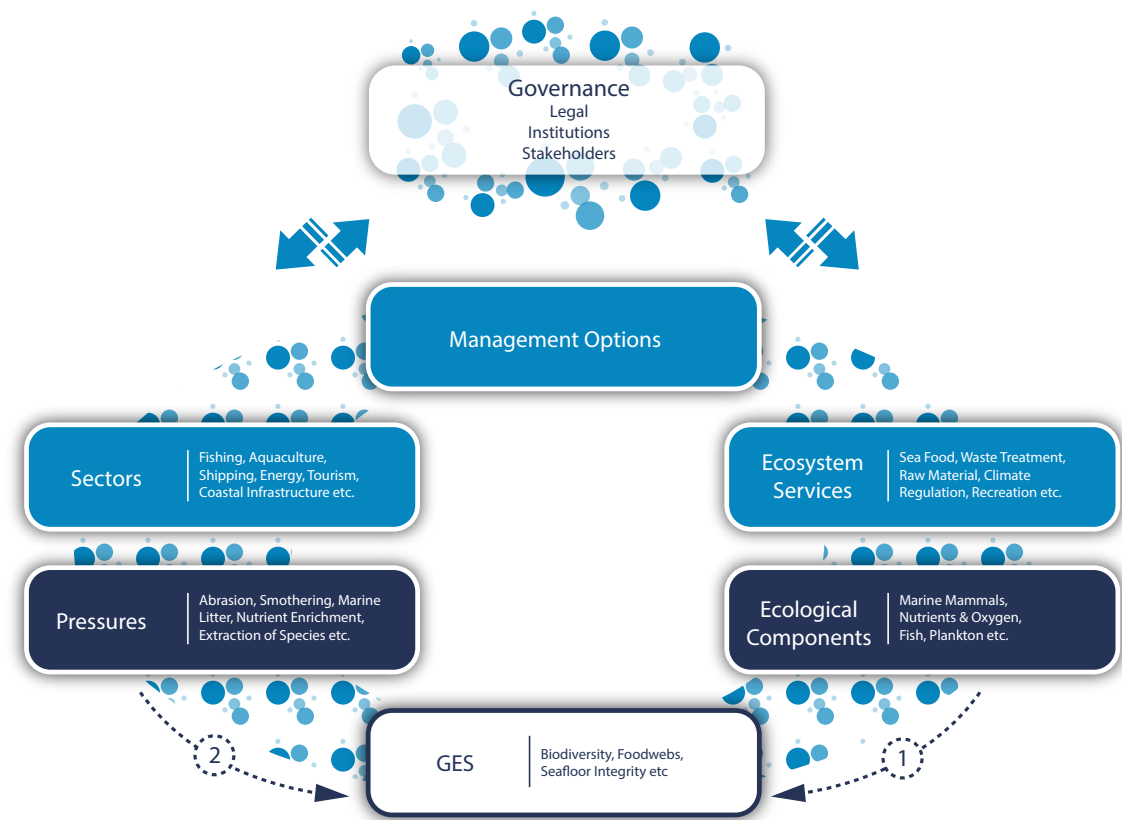


Figure 2.1 The ODEMM Assessment of Risk of Departure from Good Environmental Status (GES). Information on either the state of (1) ecological components, and/or (2) pressures, is used to inform the risk of departure from GES high level objectives (descriptors from the MSFD, see Box 2.1).

Thus the background information collected cannot, on its own, tell us the current performance against the policy objective (e.g. the likelihood of achieving GES for Biodiversity by 2020). As a solution, ODEMM developed a method to undertake a rapid assessment of the current state of the GES Descriptors, using the information available from disparate sources/assessments. The degree of departure from GES is categorised for each descriptor, based on the current situation and best evidence in the region, giving a measure of the level of effort required to achieve GES for each descriptor.

This approach has been applied in all four regional seas using a combination of existing assessments and/or expert judgement (Breen et al., 2012; also covered in Knights et al., 2011 where background information is also summarised). The outcomes provide insights to facilitate the identification of regional management priorities to support achievement of GES by 2020. **ODEMM's approach is thus complementary to the work undertaken by individual Member States on the initial assessment of the state of their individual waters that was completed in 2012.**

Box 2.1 Descriptors of Good Environmental Status (GES) from the EU Marine Strategy Framework Directive

1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions
2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

2.2 Summary of ODEMM’s Approach for Assessing Risk of Departure from GES

The approach provides risk criteria, in conjunction with a working definition of GES, for each of the GES Descriptors (see example in Box 2.2)⁴. Confidence assessment criteria are also given based on the quality of information available, interpretability of information and level of agreement between experts carrying out the assessment.

2.21 Defining GES and risk criteria

Each MSFD Descriptor of GES was defined in the Directive (Annex I, EC, 2008; listed here in Appendix A), but in many cases the definitions failed to provide sufficient detail to determine if GES is likely to be achieved. For example, Descriptor 2 is defined as “Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems” but it is not clear what would constitute adverse effects on the ecosystem, or how these might be linked to the distribution or number of non-indigenous species. For each of the descriptors assessed under ODEMM’s risk of departure approach (Breen et al., 2012), a more detailed definition of each high-level objective is given, against which to assess the likelihood of departure (i.e. the risk of failing to achieve the objective) (see example in Box 2.2).

For each clarified definition associated with achievement of each descriptor, criteria describing high, moderate and low levels of departure from GES are provided, corresponding with different levels of risk of failing to achieve the objective (see example in Box 2.2). In some cases, several different criteria for each level of risk are given, largely corresponding with the indicators outlined in the Commission Decision document (EC, 2010), in order to allow the assessment to be applied broadly (in this case across the four European regional seas).

⁴ All risk criteria and GES definitions developed are listed in Breen et al., (2012) and Annex V of Knights et al. (2011).



Another feature of the approach is how to address the integration of potentially opposing evidence when there is information available on many different indicators relevant to the assessment of any one Descriptor. Cardoso et al. (2010) provided information about integrating several different pieces of evidence i.e. whether this should use an integrated or worst case scenario approach. An integrated approach meant that information should be combined before a final assessment was given, whilst a worst case approach followed a ‘one-out all-out’ principle, whereby if one piece of evidence suggested that the risk was ‘high’ then ‘high’ was automatically indicated for the entire descriptor. In order to reflect this, this approach uses an ‘and’ or an ‘or’ between criteria to indicate which method to use.

Box 2.2 An example of the elaborated definition of a GES descriptor that was developed by ODEMM, followed by the risk categories that relate to this. For definitions and risk criteria used for each of the GES Descriptors see Breen et al. (2012)

Descriptor 5: Eutrophication

GES definition used: GES with regard to eutrophication has been achieved when the biological community remains well-balanced and retains all necessary functions in the absence of undesirable disturbance associated with eutrophication (e.g. excessive harmful algal blooms, low dissolved oxygen, declines in seagrasses, kills of benthic organisms and/or fish) and/or where there are no nutrient-related impacts on sustainable use of ecosystem goods and services.

Risk categories for Eutrophication

High	Undesirable disturbance* caused by eutrophication is widespread (even or patchy) and frequent in the region (> once a year)
Moderate	Undesirable disturbance* caused by eutrophication is widespread but rare in the region (< once a year) And/or Undesirable disturbance* caused by eutrophication only occurs at a site or local scale in the region, but it occurs at least once a year
Low	Undesirable disturbance* caused by eutrophication does not occur in the region, or where it does occur it only occurs rarely (<once a year) and on a very local scale (site or local patchy)

*Undesirable disturbance includes one or more of the following: harmful algal blooms, low dissolved oxygen, associated declines in perennial seaweeds or seagrasses, kills of benthos and fish, dominance by opportunistic macroalgae

2.3 Regional overview of Levels of Departure from GES

Application of the approach allowed a cross-regional comparison of the current level of departure from GES. Experts from all four regional seas completed the assessments in a series of workshops and later work was carried out to ensure consistency and rationalisation of the approach between regional teams (see full details in Breen et al., 2012 as well as results for the confidence assessment). The level of risk in the achievement of GES varied across descriptors and between regions, however when summarized across descriptors, there was little difference in the overall level of risk between regions (Table 2.1). For the North East Atlantic, six of the 14 descriptor categories were assessed to be at high risk, whilst seven were assessed as high for the other three regions. In general, those objectives that are described by pressures (i.e. underwater noise, marine litter) or those that are related directly to impacts from pressures (e.g. commercial fish and shellfish and seafloor integrity) exhibited higher risk than state objectives. Five common descriptors were assessed as having high risk across all four regions, namely Non-indigenous species, commercial fish and shellfish, food webs, sea floor integrity and marine litter. Several others were identified as high risk within particular regions.

Table 2.1 Risk of departure from GES for MSFD descriptors for the four European regional seas using the ODEMM GES risk assessment (Breen et al., 2012)

GES Descriptor (and characteristics)	NE Atlantic	Mediterranean Sea	Baltic Sea	Black Sea
Biodiversity-Phyto-zooplankton	Low-Moderate	Moderate	Moderate	Moderate
Biodiversity-Fish	Moderate	Moderate	Moderate	Moderate
Biodiversity-Marine mammals and reptiles	Low-Moderate	High	Moderate	Moderate-High
Biodiversity-Seabirds	Moderate	Moderate	Moderate	High
Biodiversity-Predominant habitat types	Moderate	Moderate	High	Moderate-High
Non-indigenous species	High	High	High	High
Commercial fish and shellfish	High	High	High	High
Food webs	High	High	High	High
Eutrophication	Moderate	Moderate	High	Moderate
Sea floor integrity	High	High	High	High
Contaminants	Moderate	Moderate	Moderate-High	Moderate-High
Contaminants in fish and shellfish	Low-Moderate	Low	Moderate	Moderate
Marine litter	High	High	High	High
Underwater noise	High	High	Moderate-High	High

2.4: Key lessons learnt in applying the approach

This approach combines information on status and human impacts within a regionally consistent framework to assess the level of risk to GES. **The need for such a methodology was highlighted in the process of conducting regional assessments from existing information, when specific national or sub-regional status reports were inconsistent with overall regional views.** For example, UK predominant habitats (DEFRA, 2010) are reported as being in poor status, but when assessing risk to GES based on Biodiversity of predominant habitats for the whole regional sea (in this case the NE Atlantic), the level of risk was classified as ‘moderate’ (see Table 2.1) indicating the importance of considering spatial scale of assessments when evaluating status at a regional sea level.

The assessment of risk of failing to achieve these GES definitions identified issues for regional prioritisation in addition to those identified in existing status reports. For example, the Baltic Sea and Black Sea Action Plans (BSC, 2009) (HELCOM, 2007) focus on issues relating to the descriptors (1) Biodiversity, (5) Eutrophication, (6) Seafloor Integrity and (8&9) Contaminants and Contaminants in Fish and Shellfish. However, the risk assessment undertaken here suggests that Non-Indigenous Species, Food Webs, Marine Litter and Underwater Noise are also potential areas of concern. **This shows that translation of the outcomes of even spatially comparable assessments and their placement in the context of the MSFD may be precluded by differences in assessment objectives.**

Our experience of applying this approach across Europe's regional seas supports the need for a common tool if the results from the initial assessments are to be in any way comparable.

Risk outcomes are closely linked to the level of ambition of the descriptor and these differed between the descriptors. There were few high risk Biodiversity components, although other descriptors that we might expect to have consequences for Biodiversity such as Non-Indigenous Species (NIS) classified as at high risk. In this example, the crucial difference in GES ambition is in the definition of acceptable 'loss'. High risk under Biodiversity requires the likelihood of "loss of biodiversity or maintained change in dominance/assembly structure", whereas for NIS, significant adverse effects of an invasive species do not have to be as severe as elimination of a population and can include effects such as increased seasonal dominance of algal blooms in the region⁵.

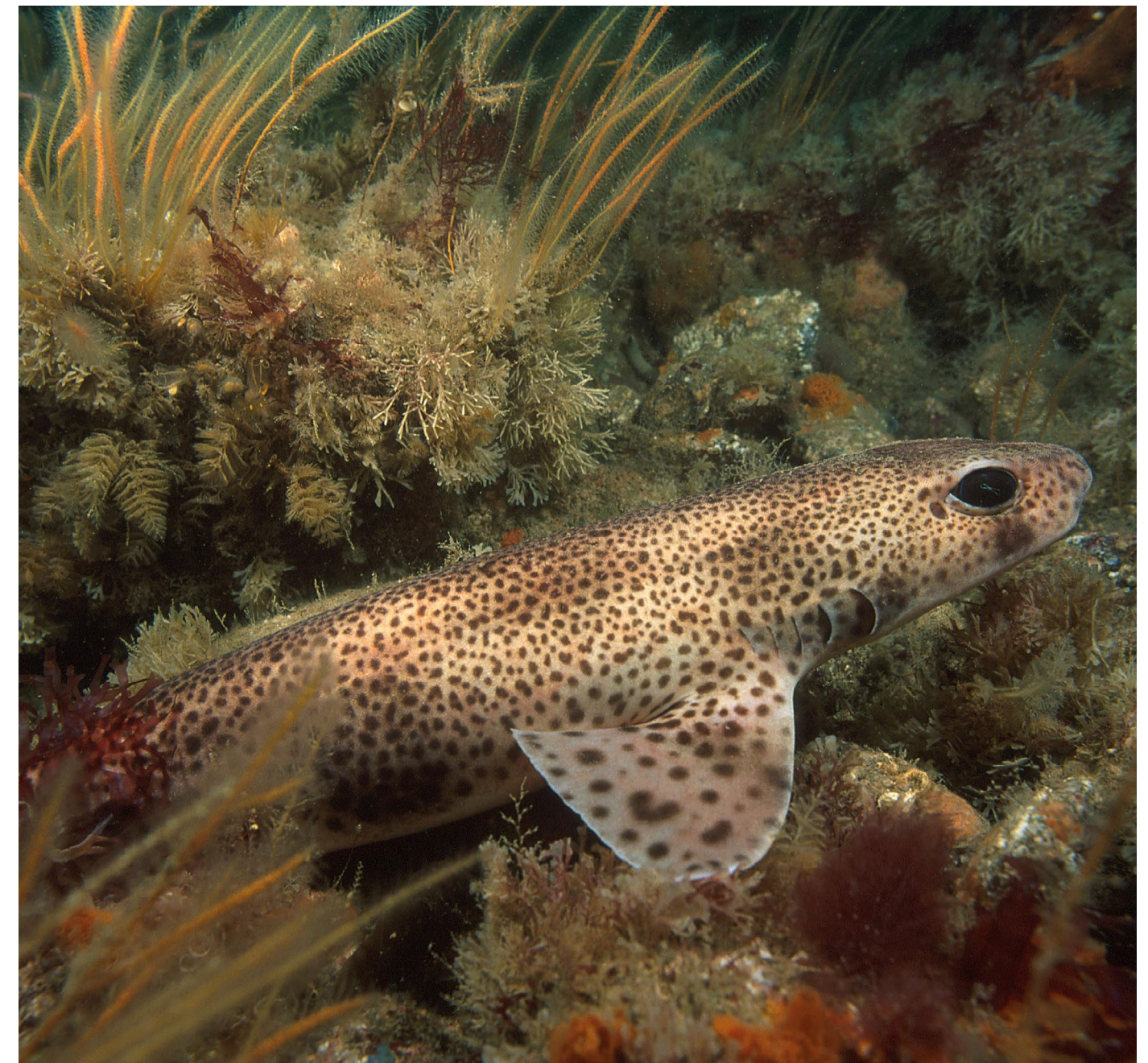
Risk scores may also depend on the ability to assess the criteria with the available information. Confidence in assessment⁶ can be interpreted in terms of prioritization of action to help achieve GES for particular descriptors where there are few data or a lack of understanding of the limitations of the data. As such, when confidence is low or low-moderate, recommended actions might include: (i) implementing monitoring programmes to improve data knowledge, (ii) re-analysing data to make our current data more useful for the MSFD, (iii) further development and research to improve understanding and use of the descriptors.

Where improving data provision is not possible, it may be more sensible to use a precautionary approach whereby high risk in one descriptor (e.g. Seafloor Integrity) automatically triggers high risk categorisation of a related descriptor i.e. Biodiversity of predominant habitats. This would ensure that at a minimum, monitoring and evaluation of biodiversity aspects would occur. There are clear inter-relationships between some of the descriptors of Europe's MSFD (Borja et al., 2010) and our results suggest that it will be important to recognise the links between descriptors such that high risk issues identified for one descriptor can trigger a similarly high level of priority in others.

⁵ See further discussion on this and the importance of the timeline set for risk criteria in the Discussion of Breen et al. (2012)

⁶ See full results of the confidence assessment in Breen et al. (2012)

The framework allows the state of policy objectives to be assessed at any regional scale and the methodology can be easily adapted to other policy drivers and their targets/objectives. In combination with other tools, the high risk outcomes presented in this work can be used to help prioritise management measures. In the following Chapters a range of approaches developed in ODEMM to further guide selection and evaluation of measures are covered.



Chapter 3

The ODEMM Linkage Framework and Matrices

3.1 Introduction

The relationships between human activities and ecological components have commonly been described using linkage-based frameworks, which adopt the causal-chain concept to infer pressure-state relationships (Rounsevell et al., 2010). The ODEMM linkage framework is a systematic structure that firstly lists all relevant components of the ecosystem for the policy in question, and then describes all the causal-chain links between those individual components in a system of linkage tables (matrices) to give a fully connected ecosystem. Thus, **the linkage framework provides the structure within which management options can be explored.**

In the application of this to Europe's Marine Strategy Framework Directive (MSFD), the policy objectives (i.e. achieving Good Environmental Status (GES) for the Descriptors) are linked to ecological components (e.g. seabirds or intertidal rock habitats) and pressures acting on these (e.g. marine litter), which in turn are linked to each-other and then back to sectors and human activities (e.g. shipping) through the pressures, and to ecosystem services (e.g. provision of raw materials) through change in state of ecological components (Figure 3.1).

The importance of including economic and socio-cultural components within integrated ecosystem assessments has been recognised within the MSFD as fundamental to the sustainable use of marine resources. The ODEMM approach integrates these interactions within a single linkage framework that allows for feedback and complexity. Thus, the ODEMM linkage framework and specifically, the underlying tables (see 3.2 below), can be used to identify those management options that minimise the impact of human activities on ecological components, whilst juxtaposing these against the demand for ecosystem services and the benefits arising from them. This will allow a thorough appraisal of any measures proposed to help achieve high-level objectives such as those of the MSFD for GES.

Chapter Highlights

- Description of the ODEMM linkage framework and underlying matrices
- Summary of different ODEMM applications that are based on the linkages
- Impact outside of ODEMM and future developments

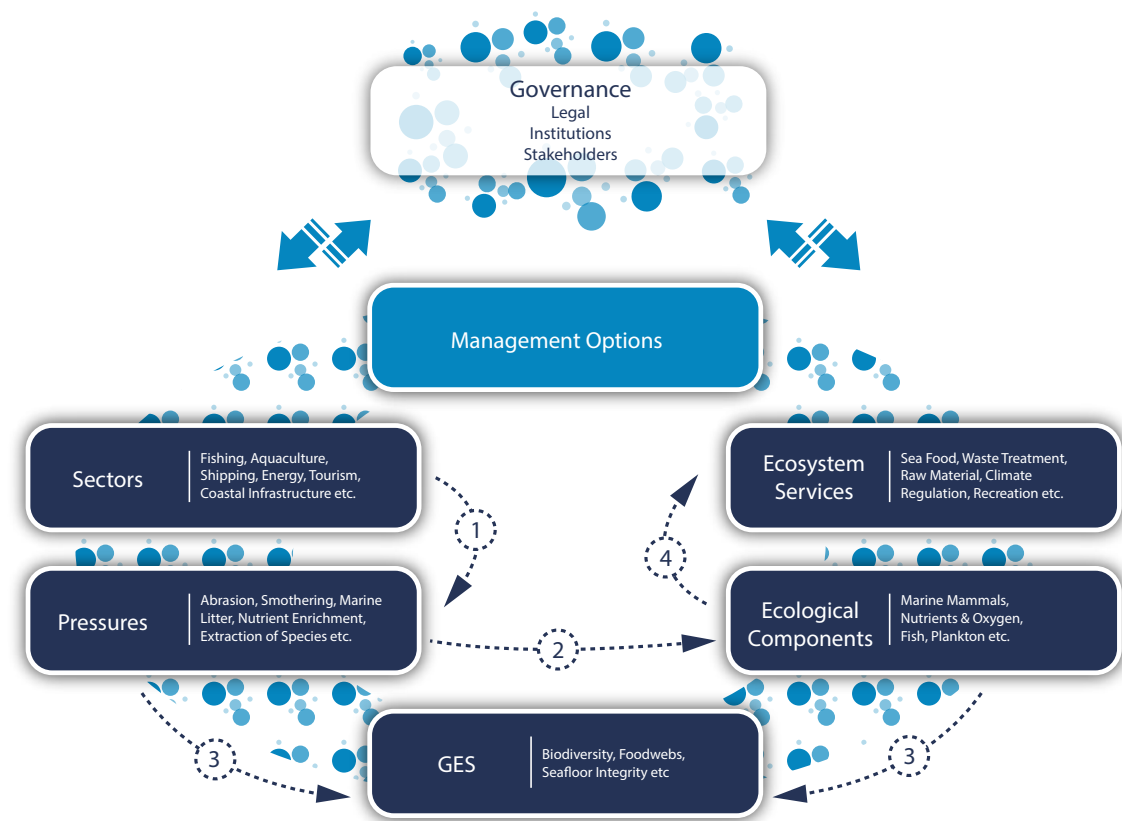


Figure 3.1 The ODEMM linkage framework. All relevant examples of each of the ecosystem components are listed and links between these then made. Full linkage table matrices are available⁷ for the links between (1) Sectors and Pressures, (2) Pressures and Ecological Components, (3) Ecological Components, Pressures and the GES (Good Environmental Status) Descriptors, and (4) Ecological Components and Ecosystem Services.

3.2 Summary of linkage framework approach and underlying matrices

For each of the interactions underlying arrows numbered 1-4 in Figure 3.1, all relevant components have been listed and the links between them specified (see summary in Table 3.1 and representations of links in Figures 3.2 and 3.4). The resultant matrix for each interaction is represented in an excel linkage table and these are available to download with an accompanying guidance document⁸. For every numbered interaction shown in Figure 3.1, the guidance document describes how the individual components were categorised and the nature of the interactions shown in the accompanying linkage table.

⁷ All linkage tables and the accompanying guidance can be downloaded from www.odemm.com/content/linkage-framework
⁸ Available to download from June 2014 from our website www.odemm.com/content/linkage-framework

Table 3.1 Summary of the interactions included in each of the individual linkage matrices that make up ODEMM’s linkage framework

Interaction	Included in matrix	Total possible interactions
Sectors - Pressures	18 sectors (98 sector-activities) interacting with 24 pressures	193
Pressures – Ecological Components	24 pressures interacting with 11 ecological components	201
Ecological Components & Pressures – GES Descriptors	11 ecological components and 6 pressures interacting with 11 GES descriptors	77
Ecological Components – Ecosystem Services	11 ecological components interacting with 21 ecosystem services	155

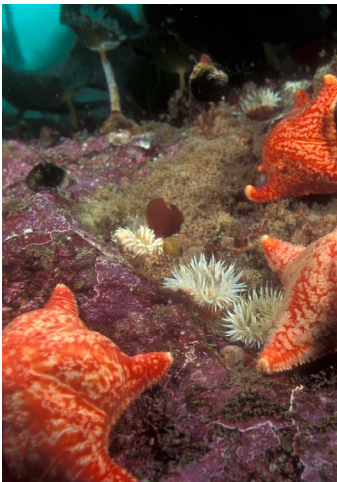
The linkage matrices that are available give all possible interactions for European regional seas, but for any specific application (see examples under 3.3 below), the first step is to identify which interactions are *actually* relevant to the system being analysed. For example, not all sectors listed may be relevant in any area assessed, and not all ecological components may be found there (e.g. no deep sea habitat in some areas). Once the linkages that are relevant to a region being assessed are selected, it is then possible to use the underlying matrices to provide the structure for a number of analyses (see 3.3).

3.3 Summary of applications based on the linkage framework

Connectivity and complexity in the ecosystem

By simply taking the linkage matrices, it is possible to examine the complexity and connectivity in the ecosystem. Knights et al. (2013a)⁹ have explored this, using analyses taken from foodweb ecology and network analysis theory. This helps to highlight aspects such as: which sectors interact with most ecological components (Figure 3.3), which pressures are most pervasive in the system in terms of connectivity between sectors and ecological components, and where there are similarities between sectors and/or pressures in terms of how they interact with the ecological components of the ecosystem.

⁹ Please note the finalised linkage matrices and terminology have been updated since the analysis presented in Knights et al (2013a) but the categories and interactions relate closely



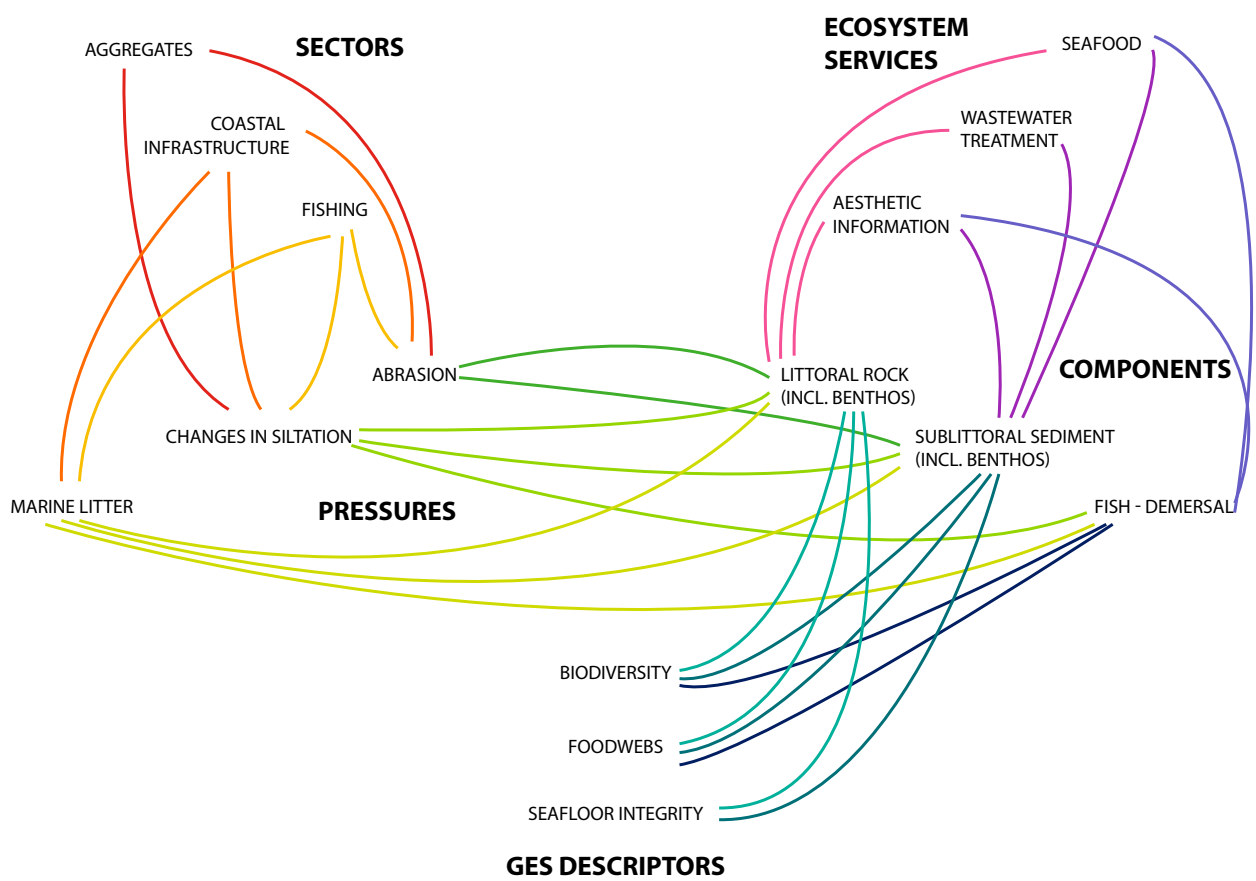


Figure 3.2 An illustration of the full linkage framework showing linkages between a subset of elements of the ecosystem.

Weighting the links between sectors-pressures and ecological components

The linkage matrices set the structure for examining the ecosystem, but a weighting is required to help focus on which of the >6000 interactions should be prioritised for management or monitoring purposes. ODEMM thus developed a pressure assessment methodology (Robinson et al., 2013) that weights the interactions between sectors, pressures and ecological components based on the exposure, severity and recovery lag associated each interaction. This approach is described in Chapter 4 of this report and is then developed further under Chapters 5 and 6 to show how threats based on the ODEMM pressure assessment, can be summarised as risks and then linked to management options to evaluate their effectiveness.

Linkages from sector-pressures through to change in supply of ecosystem services

Using the linkages between ecological components and ecosystem services, it is possible to weight the contribution of each ecological component to the supply in individual ecosystem services. For example, certain habitat types will contribute more to coastal erosion protection than others will. Approaches to explore this are summarised in Chapter 7 of this report and covered in more detail in Hussain et al. (2013). ODEMM took this one step further to relate how change in risk in the ecological system through application of management options then translates into a change in the potential supply of ecosystem services . This uses links 1, 2 and 4 from Figure 3.1 and a combination of the results from the ODEMM integrated Management Strategy Evaluation tool (summarised in Chapter 6) with a qualitative assessment of the relative contribution of ecological components to ecosystem services (see summary in Chapter 7).

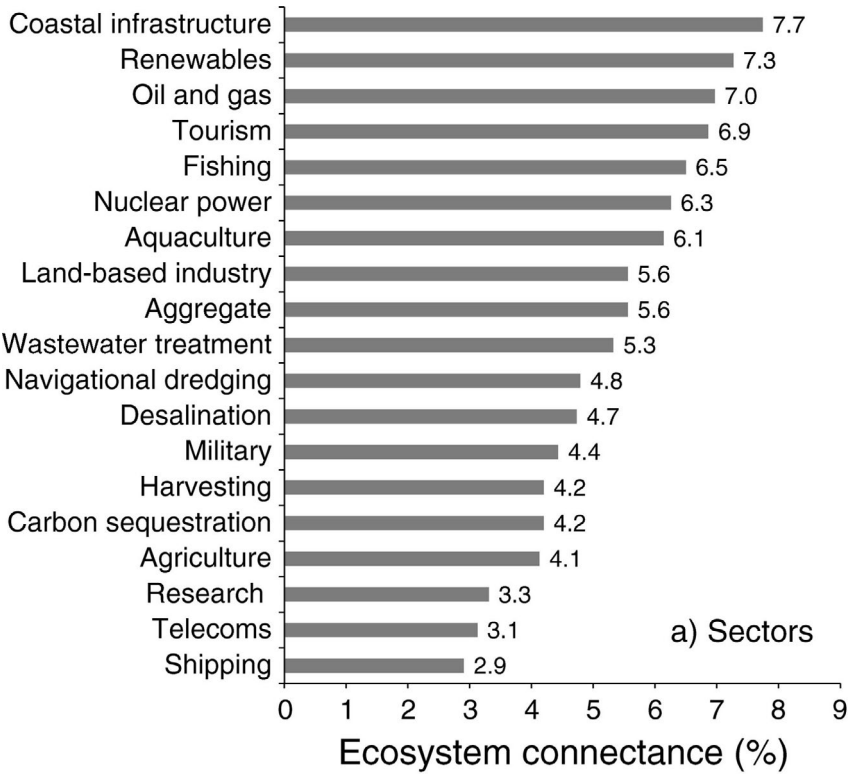


Figure 3.3 Taken from Knights et al. (2013a), showing the number of linkages (proportional connectance) associated with the sectors in European regional seas. Proportional connectance is calculated as the number of linkages associated with the sector, divided by the total number of linkages in the ecosystem model. Absolute proportional connectance values are shown at the end (right side) of each bar.

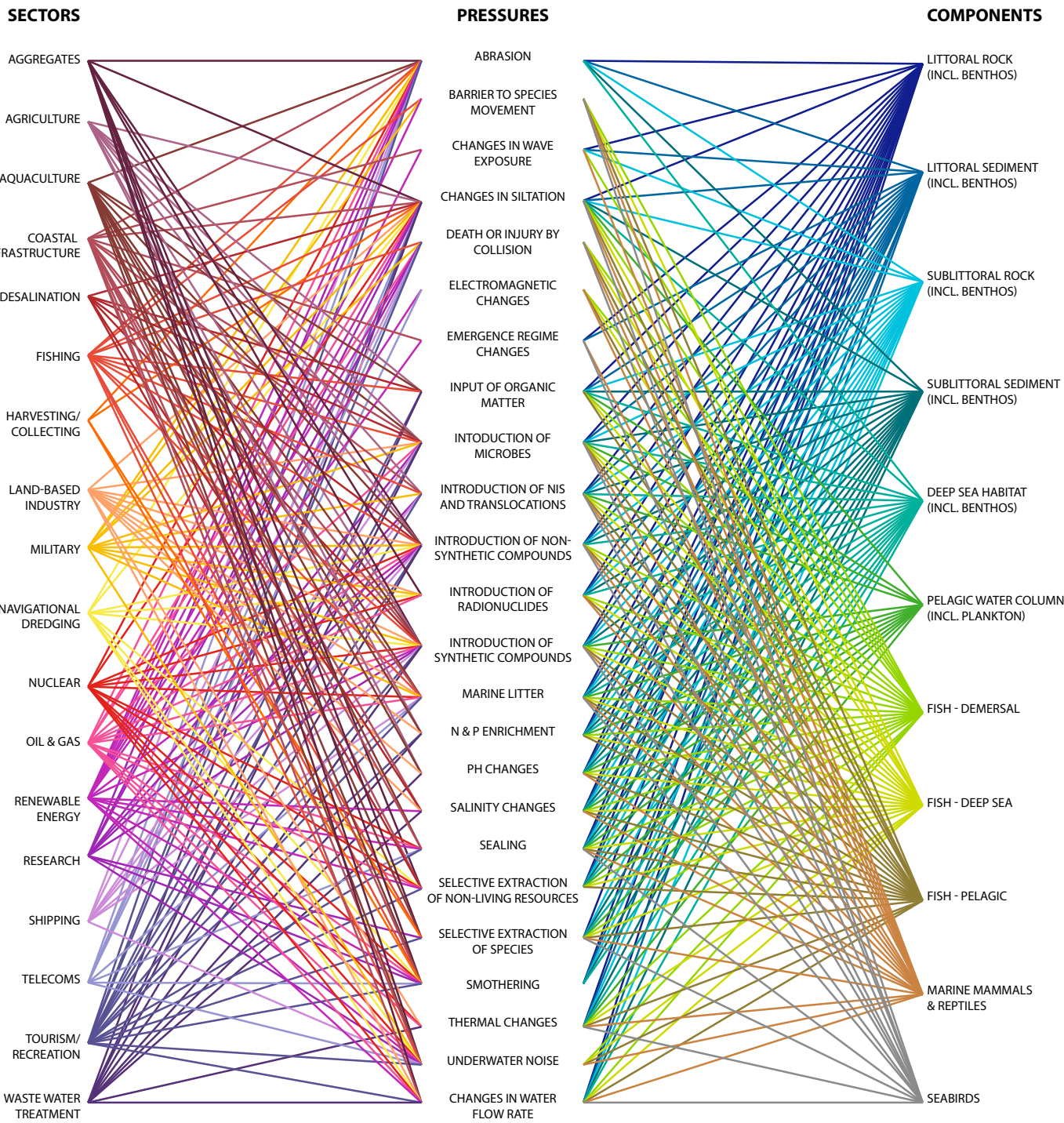


Figure 3.4 The full set of linkages between sectors, pressures and ecological components noted to be a possible interaction in at least one of Europe’s regional seas.

3.5 Additional applications of the ODEMM linkage framework and future work

The ODEMM linkage framework and matrices are being utilised by agencies such as the European Environment Agency and the UK’s Joint Nature Conservation Committee to compare with other typologies of ecosystem interactions for Europe’s regional seas. These will be combined to produce an ecosystem assessment framework with a number of potential applications for different policy commitments. Individual linkage matrices (e.g. sectors-pressures and pressures-ecological components) have also been requested by ongoing European projects such as DEVOTES, PERSEUS and the Celtic Seas Partnership Project.

At this stage, links have not been listed and specified to specific management options, as the list of possible management options for any one issue tends to vary in time and/or location due to factors such as economic and political climate. An approach is described in Chapter 6, however, whereby the type and focus of management options can be used to link to relevant aspects within the broader linkage framework (e.g. joining up MOs with relevant sectors, pressures and/or ecological components). It is also recognised that future work could expand on this to include linkages between relevant institutes, policies and stakeholders (the governance setting) and the aspects already included in the ODEMM linkage matrices (e.g. from stakeholder groups or policies to sectors or ecological components).

...an ecosystem assessment framework with a number of potential applications for different policy commitments...



Chapter 4

Threats to Policy Objectives: the ODEMM Pressure Assessment

4.1 Introduction

Many aspects of Europe's regional sea ecosystems are currently threatened in terms of achieving the Marine Strategy Framework Directive (MSFD) objectives for Good Environmental Status (GES) (see Chapter 2; Breen et al., 2012). In order to comply with the MSFD, Member States are obliged to implement a programme of measures that will help to achieve GES (EC, 2008). As described in Section 1.3, a key principle in making ecosystem-based management (EBM) operational is the need to: **"Account for all possible interactions that are relevant to the policy objectives no matter how insignificant they may at first seem (be holistic), and then be able to weight and rationalise what is important and what management and/or monitoring and research should focus on."**

The ODEMM approach provides a full assessment of the linkages in the system, considering all sectors, pressures and their relationship with ecological components that are relevant to the MSFD's policy objectives (Chapter 3). Using these linkages it is thus possible to extract all possible interactions that are relevant to any one of the MSFD's policy objectives.

ODEMM went on to develop a methodology, the Pressure Assessment (PA) approach (Robinson et al., 2013), which can be used to weight these interactions in order to focus management on the greatest threats to policy objectives. The ODEMM PA weights the relationships between human activities and ecological components using pressures as the links between them. This recognises that not all activities undertaken by broad sectors are necessarily as harmful as each other. By centring the approach on pressures, where these are defined as "the mechanism through which an activity has an effect on any part of the ecosystem", we are able to focus on the most damaging aspects of human activities and to thus target management with a higher level of precision (see more on this in Chapter 6).

The Pressure Assessment was developed acknowledging another key principle of operational EBM (Section 1.3); that any approach must **"be based on structured, transparent and repeatable analyses that can work in data-poor situations (as well as those that are data-rich), because EBM should be holistic in evaluation of objectives and thus needs to account for issues even if there is little data available on them."**

Chapter Highlights

- Description of the ODEMM Pressure Assessment (PA) approach
- Application of the PA to Europe's regional seas
- Summary of additional ODEMM applications based on the PA

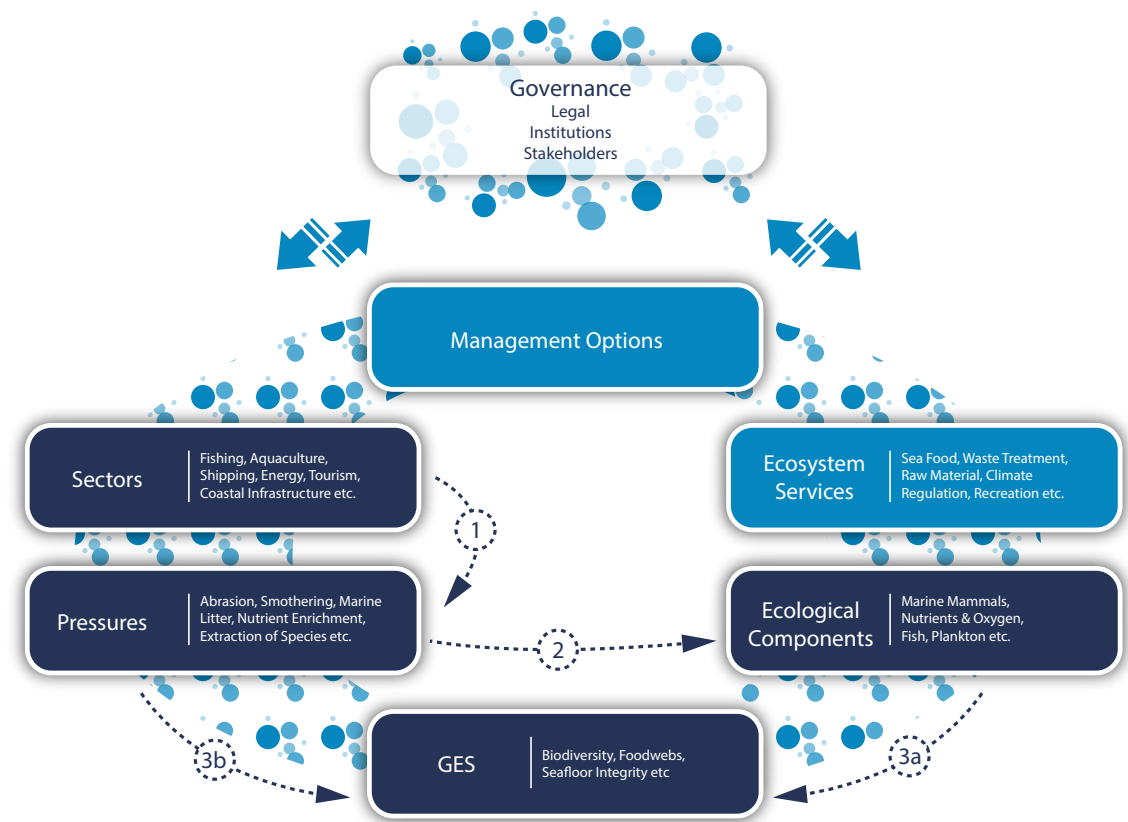


Figure 4.1 The ODEMM Pressure Assessment. (1) Sectors cause pressures through their activities. The interaction of these pressures with ecological components (2) can then impact on the state of ecological components. The Pressure Assessment weights the interactions between sectors, pressures and ecological components to generate results about threats to individual ecological components. Results can also be interpreted in terms of the consequences for achieving GES high level objectives (descriptors from the MSFD) (3a) and, information on the state of pressures can be directly related to the achievement of certain MSFD descriptors (e.g. underwater noise, marine litter, and eutrophication) (3b).

4.2 Summary of ODEMM’s Pressure Assessment Approach

Pressures can be physical (e.g. abrasion), chemical (e.g. introduction of synthetic components) or biological (e.g. introduction of microbial pathogens) and the same pressure can be caused by a number of different activities. For example, both aggregate extraction and navigational dredging cause abrasion, a physical pressure that can affect a number of different ecological components. By including pressures as the key link between sectors and ecological components, we are thus also able to group activities by their pressure types (see Knights et al., 2013a) and again this can help with prioritisation of management and monitoring, as well as highlighting issues such as potential for cumulative and combined effects of multiple activities (see Section 4.5).

The initial step for carrying out the PA is the identification and linking up of all of the sectors, pressures and ecological components of the system (see Figure 4.1 and detail on linkages in Chapter 3). Any one sector-pressure-ecological component combination can be described as an impact chain (Figure 4.2) and the pressure assessment gives a relative weighting to each impact chain. The weightings allow for comparison of the relative threat of different sectors and pressures to the range of components in any ecosystem, and for comparison between ecosystems.

The ODEMM Pressure Assessment (PA) approach weights each impact chain in terms of five criteria (underlined below) under three broad aspects:

- (i) the footprint of the sector/pressure combination in the sea area being assessed where it overlaps with the ecological component (spatial extent and frequency of occurrence) (see Figure 4.3);
- (ii) the severity (in terms of likely degree of impact) of any sector/pressure interaction with the ecological component (i)
- (iii) the recovery lag in terms of persistence of the pressure acting on the affected ecological component should the activity cease and the inherent resilience of the component given its’ status at the time of the assessment.

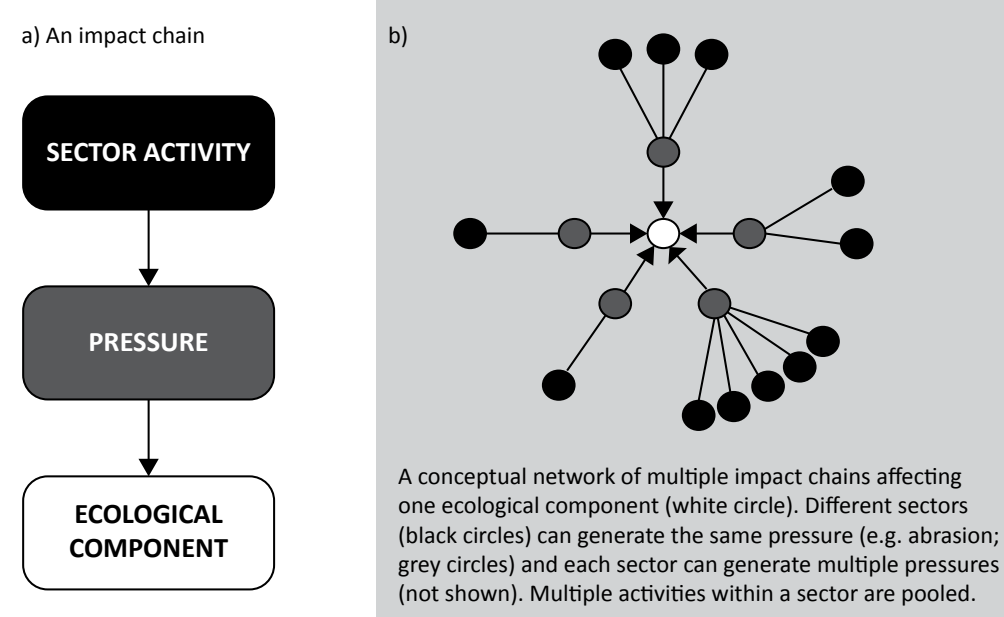


Figure 4.2 Taken from Knights et al (2013a), Impact chains. (a) A generic hierarchical impact chain linking sectors and activities to an ecological component via a specific pressure. An ecological component can be impacted by multiple sectors and multiple pressures, forming (b) a complex network of sector–pressure impact chains. A separate impact chain is generated for every combination of sector (black circles), pressure (grey circles), and ecological component (central white circle).

When considered either solely or in combination, these three aspects can each provide useful information to help prioritise management and monitoring of marine ecosystems. Those sector/pressure combinations of greatest threat in any one regional sea ecosystem will be those that affect ecological components with a high degree of impact (acute or chronic severity), over wide areas relative to the total area being assessed and, where there are only chronic effects, frequently enough to maintain the pressure. Where the ecological component also has low resilience (i.e. poor recovery potential) and/or the pressure can persist in the environment for a very long time, threat can be even higher and management potential lower. Full details on the categorisation of impact chains across five criteria are given in the latest ODEMM Pressure Assessment guidance document (Robinson et al., 2013)¹⁰. The confidence assessment undertaken to accompany this is also described therein.

4.3 Application of the ODEMM Pressure Assessment (PA) to Europe’s regional seas

The PA has been applied to each of Europe’s four regional seas and any impact chains identified as having the potential to exist from the 18 sectors, 24 pressures and 11 ecological components noted in the ODEMM linkage matrices assessed¹¹. Of a total of 5515 possible interactions, 3459 were found to have actual overlap (in space and time). A summary of some key findings is given below:

4.31 Types of Interactions

The majority of interactions between European sectors, their pressures and ecological components occurred at a site or local scale; only 15% of interactions were widespread in overlap with ecological components at the regional sea scale. Most interactions were rare or occasional, with only 18% of interactions classed as common and 3% as persistent i.e. where ecological components were thought to be exposed to the sector/pressure at all times where interactions occurred in space.

Where interactions occurred, the vast majority were classified as having a chronic severity, with only around 20% of interactions being either acute, or of low severity. The majority of pressures were categorised to persist for 0-2 years following cessation of activities causing them, but a core group of pressures

¹⁰ The ODEMM Pressure Assessment guidance document has been updated and the final version (Robinson et al., 2013) is available to download from www.odemm.com/content/pressure-assessment . A user-friendly walk through of the approach is also available at this site.

¹¹ The methodology is described in Robinson et al. (2013) and full results will be presented in Robinson et al. (in prep).

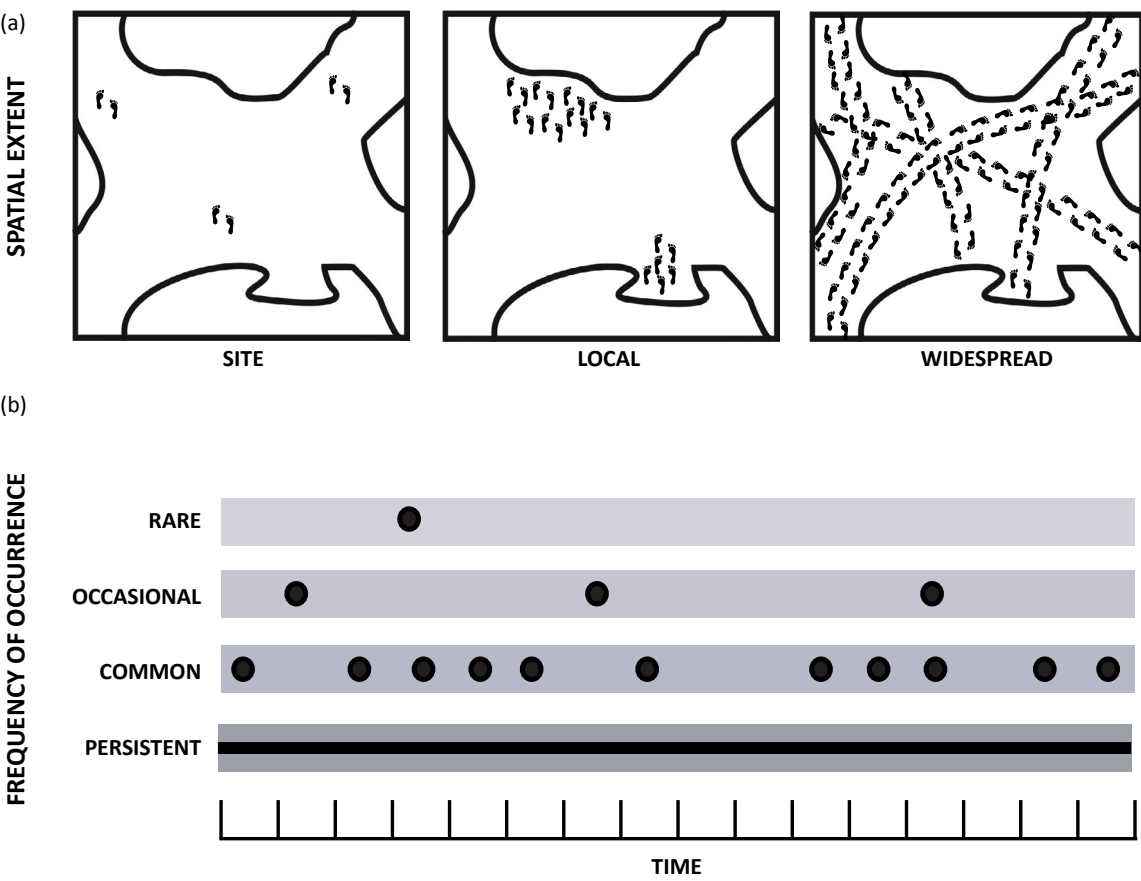


Figure 4.3 Footprint: (a) Categories of spatial extent, representing the overlap between a sector-pressure and an ecological component. (b) Categories of frequency of occurrence of overlap of a sector-pressure and ecological component. The timeline is broken into monthly increments, thus a rare overlap occurs ~once in an 18 month period, whilst an occasional overlap occurs 2-3 times a year. Dots (or line for ‘persistent’) illustrate the times at which both the ecological component and pressure overlap in space over time. (Nb - No overlap is not shown in either case).

were found to have the potential to persist in the ecosystem for more than 100 years. These pressures included radionuclides, non-indigenous species and also a number of pressures that would only ever be associated with activities that are unlikely to be removed (e.g. permanent coastal defences causing the pressure ‘emergence regime change’).

4.32 High Threat Interactions

Beyond simply analysing broad patterns in pressure distributions in regional sea ecosystems, the PA database provides a valuable resource to utilise for prioritising monitoring and management of human activities and their pressures. High threat issues can be extracted using criteria specified to represent issues of greatest concern. In Robinson et al (in prep) we extracted high threat issues across Europe’s regional seas using the following criteria (but users could modify this to be more or less precautionary):



- 1. We considered high threats to only include interactions that are **widespread** in extent of overlap at the scale of the assessment area (whole regional seas in the example here);
- 2. Where widespread interactions were found they were treated as high threat if they fulfilled the criteria shown in Table 4.1 below.
- 3. Low severity interactions were never considered to be high threat.

Based on these criteria (Table 4.1), 109 high threat interactions were identified within Europe’s regional seas; the majority of these occurred commonly throughout the year and had a long recovery lag due to low resilience of the component affected and/or high pressure persistence (Table 4.1). Littoral rock and sublittoral sediment habitats were exposed to the highest number of high threat interactions; by contrast, the deep sea bed was the only component not involved with any high threat interactions. High threat interactions were constrained to a limited number of pressures (11 of the 24 pressures) and a limited number of sectors (9 of 18) and most were concentrated in the Mediterranean – with more interactions found there than in the other three regions combined. Marine litter introduced by Shipping or Tourism and Recreation accounted for almost half of all high threat interactions, with high numbers also associated with Selective Extraction of Species from Fishing and Sealing caused by Coastal Infrastructure¹².

Table 4.1 High threat criteria based on the interaction of frequency of interactions, recovery lag and severity (degree of impact) of interactions. Blank cells indicate interactions that were not considered to be high threat regardless of the severity of the interaction. Recovery lag refers to the combined ecological component resilience and pressure persistence of the interaction as detailed in Table 3 of Robinson et al (in prep). The number of high threat interactions found in European regional seas per criteria set is given in parentheses.

		Recovery Lag			
		0 to 2	2 to 10	10 to 100	100+
Frequency	Rare				Acute (8)
	Occasional			Acute (5)	Acute (4)
	Common	Acute (3)	Acute or Chronic (17)	Acute or Chronic (41)	Acute or Chronic (22)
	Persistent	Acute or Chronic (2)	Acute or Chronic (2)	Acute or Chronic (5)	Acute or Chronic (0)

¹² For a full breakdown of results see Robinson et al. (in prep)

Table 4.2 Summary of high threat interactions by pressure type across the four regional seas: Baltic Sea, Black Sea, Mediterranean Sea (Med) and the Northeast Atlantic (NEA)

Pressure	Regional Sea				Total
	Baltic	Black	Med	NEA	
Abrasion	1		1	1	3
Changes in Siltation			6		6
Input of organic matter			7	2	9
Introduction of Non-Indigenous Species			4		4
Introduction of Non-synthetics				1	1
Marine Litter	9	9	16	9	43
Nitrogen and Phosphorus enrichment	2		5		7
Sealing	2	2	7	2	13
Selective extraction of species	6	2	8	5	21
Smothering			1		1
Underwater noise				1	1
Total	20	13	55	21	109

4.33 Confidence Assessment

Confidence assessments were also undertaken by the regional experts on the different criteria evaluated (see approach used in Robinson et al., 2013 and results in Robinson et al., in prep). These revealed the following broad issues: in terms of issues to do with overlap of sectors/pressures and ecological components, coverage and/or resolution of ecological components and sector activities is patchy, but best in the Northeast Atlantic; generally the understanding of how pressures are distributed around sectoral activities is good, as is the understanding of how these pressures persist in the environment once any activities causing them cease; there is also good understanding of whether pressures have acute, chronic or severe interactions with ecological components overall. Knowledge of the current status of ecological components was variable, but generally good enough to assign each broad ecological component a resilience score with high confidence. The confidence assessment results can be used to highlight research gaps for prioritisation, particularly where low confidence is associated with a potentially high threat interaction.



4.4 Utility of the approach and lessons learnt in its application

The PA database¹³ can be used to highlight priorities for monitoring and management in terms of high threat issues using combinations of criteria (see example in 4.32), or to examine issues to do with individual criteria, such as the number of high severity sector/pressure components currently affecting a particular ecological component in a given area. It can be adapted to different areas, or the same areas over different spatial scales or time frames or with different management criteria specified¹⁴.

Application of the PA highlighted very high numbers of chronic interactions, but there is currently no way of identifying at what level of activity these kinds of interaction would actually produce severe effects. Furthermore, even if a mechanism was built in to allow for this in the PA, there is currently little information available for most of these kinds of pressures (e.g. marine litter, contaminants, smothering) on the relationship between amount of activity and thresholds for severe effects; this highlights a clear research gap requiring attention, and the PA database can be used to extract all combinations of sector/pressure/ecological component where further research is required.

Only direct effects are considered in the PA approach; this allowed for identification of issues that can definitely be managed (i.e. we have a high degree of certainty that there is a link between managing a sector/pressure and reducing the threat to the interacting ecological components), and reduced complexity in application of the assessment (which is a resource-hungry exercise). Future work could explore how indirect effects might change priorities.

¹³ The project intends to make the database freely accessible following publication of the main outcomes (Robinson et al., in prep). Requests for use of the results have already been made by a number of related projects (e.g. DEVOTES, PERSEUS) and organisations

¹⁴ The time taken to complete a new assessment across all ecosystem components (even at the very coarse resolution described in Robinson et al., 2013) should not be underestimated and it is essential that expert teams have relevant experience and enough breadth in knowledge between them that they can confidently undertake all steps. Even where suitable time and expertise is assigned to the individual assessments, there is then a requirement for careful cross validation and checking, which again cannot be completed quickly. Adapting the existing assessment to new constraints (e.g. applying at the same spatial scale but considering future threats) would not be as time-consuming, but would still require suitable breadth of expertise.

4.5 Other uses of the ODEMM Pressure Assessment data

4.5.1 Risk Assessment and iMSE

As described, the PA is a categorical assessment and it is thus impossible to combine results across individual interactions. In subsequent work, ODEMM developed a risk assessment methodology that adds scores to the PA data, thus allowing for exploration of risks at the level of whole sectors or pressures (see Chapter 5). This approach has been further elaborated as a tool to evaluate management options, by adding in links to management measures and then evaluating how much risk is reduced in the ecosystem when specific measures are applied (see Chapter 6).

4.5.2 Combined Effects

ODEMM has also developed a spatially resolved combined assessment approach to start to explore the combined effects of multiple sectors, using the PA database to supply the underlying information (Goodsir et al., in prep). The approach uses broad spatial data from five sectors (Fishing, Aggregates, Oil & Gas, Renewable Energy and Telecommunications) and at this stage, only seeks to explore the propagation of high threat issues by combining pressure footprints for the *same pressure* where sectors overlap and the pressure interactions are individually categorised as chronic. Low severity interactions are not included because their definition is that irrespective of the frequency or magnitude of the pressure, no significant adverse effects on the ecosystem would occur. However, future work is required to consider cumulative effects of different pressure types, where it could be foreseen that interactions of different low severity pressures could together result in severe effects.



Chapter 5

Converting Individual Threats into Overall Risk: the ODEMM Ecological Risk Assessment

5.1 Introduction

In its assessment, the ODEMM project described a complex network of interactions, with over 3,000 impact chains in some regional sea areas (Knights et al. 2013a; White et al., 2013). The ODEMM pressure assessment (PA) methodology (Chapter 4) made significant strides towards assessing the threat from those impact chains and a valuable step in determining the importance of each impact chain. The vast number of impact chains can, however, make prioritisation for management problematic (Bottrill et al., 2008) and in Chapter 4, an approach for selecting the highest threat impact chains is described (also see Robinson et al., in prep). However, it is also possible to assign numerical scores to the categories of the PA such that impacts can be grouped across pressures, sectors and/or ecological components, allowing for further exploration of the information at a more aggregated level (Figure 5.1).

Risk assessment, in general, describes the likelihood and consequences of an event. There are several risk assessment approaches available using quantitative (e.g. Francis, 1992, Samhoury and Levin, 2012) or qualitative data (e.g. Fletcher, 2005, Fletcher et al., 2010, Breen et al., 2012). Many ecological risk assessments (e.g. Fletcher, 2005, Campbell and Gallagher, 2007, Astles et al., 2006) are based on a likelihood-consequence approach for estimating the risk of a rare or unpredictable event (Williams et al., 2011). However, when an assessment of on-going (current) pressure is needed – for example, when management measures to control threat and an improvement in ecosystem state is the objective – then an exposure-effect analysis is more suitable (Smith et al., 2007).

5.2 Summary of the ODEMM Ecological Risk Assessment Approach

The ODEMM risk assessment methodology is based on an exposure-effect analysis, but also bringing in recovery lag, which adds to the overall level of risk. The pressure assessment (PA) methodology was designed with the concept of risk assessment in mind. As such, the PA criteria can be directly related to the different aspects of risk (Figure 5.2), and the categorical assessments of the five criteria in the PA (see Robinson et al., 2013) each assigned a numerical score for

Chapter Highlights

- Summary of the ODEMM risk assessment method
- Regional overview of risk factors by sector
- Assessment Value and Limitations

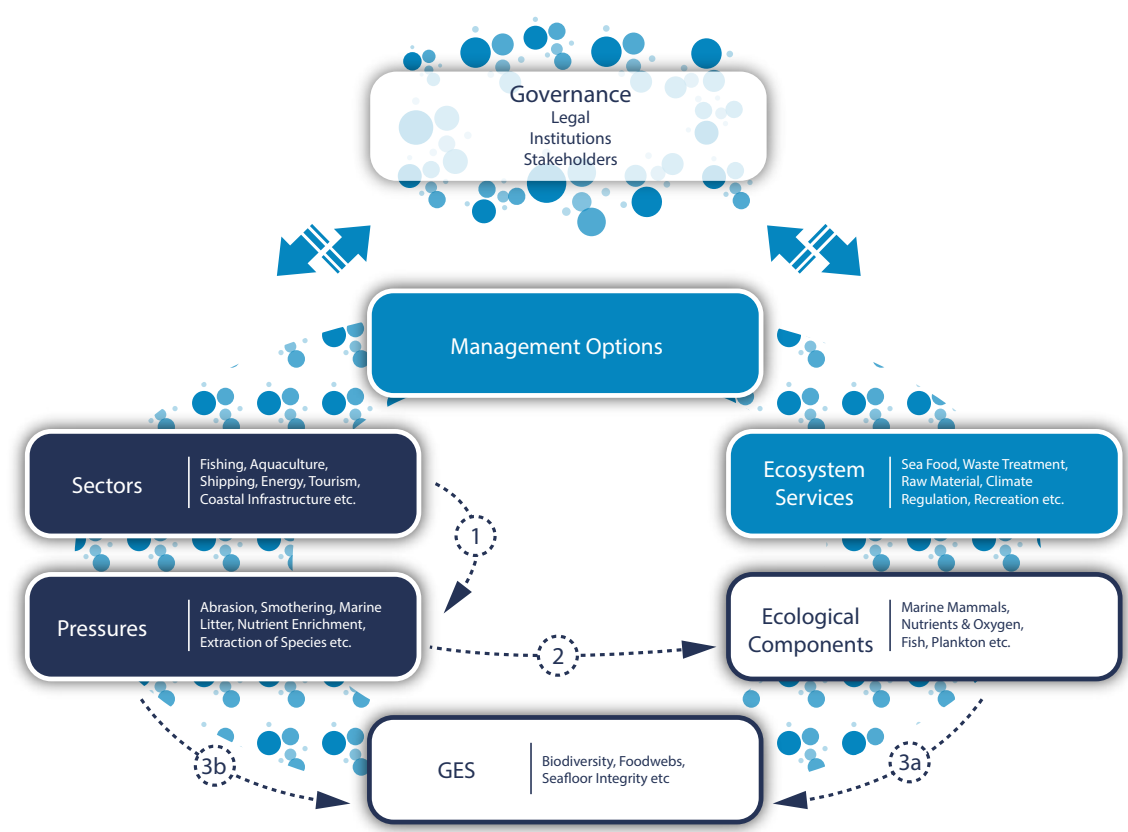


Figure 5.1 The ODEMM Ecological Risk Assessment builds on the ODEMM Pressure Assessment where (1) Sectors cause pressures through their activities, and (2) the interaction of these pressures with ecological components can then impact on the state of ecological components. The Ecological Risk Assessment is used to summarise risk about threats either at the level of individual ecological components, across the ecosystem (all ecological components), or in terms of risk to achieving GES high level objectives (descriptors from the MSFD) (3a) and (3b).

the risk assessment¹⁵. These scores were then combined to give:

- **Impact Risk**, which is the combination of scores from the spatial extent, frequency and severity criteria (Figure 5.2), and where the greater the Impact Risk score, the greater the threat to that component or combination of components, and
- **Recovery Lag**, described using a combination of the persistence of the pressure and the generic resilience (recovery time) of the ecological component. This aggregate criterion gives an indication of the time required for potential improvement in ecosystem state to be seen following the management of a specific impact chain, where the greater the recovery lag value, the longer time period required for an ecological component to recover back to its pre-impacted state.

¹⁵ For details of how each of the pressure assessment categories was numerically scored see Table 1 in ODEMM Deliverable 9, Knights et al., (2013b)

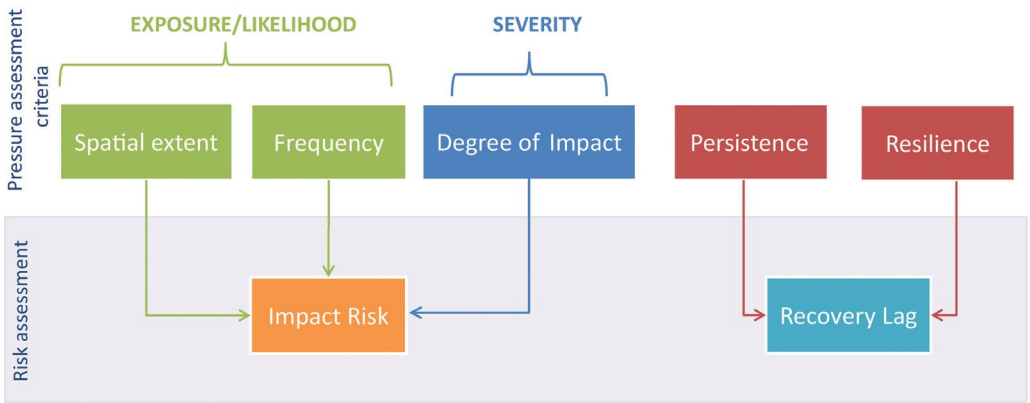


Figure 5.2 Pressure assessment criteria are grouped to assess *Impact Risk* and *Recovery Lag* under the risk assessment framework.

Impact risk and recovery lag can be calculated as the average or summation of all impact chains aggregated by sector, pressure or ecological component¹⁶. The assessment allows the ‘worst’ impact chain or chains to be identified (either in terms of impact risk and/or recovery lag) in isolation or grouped in combinations e.g. by sector or pressure.

5.3 Risks to Europe’s regional seas: A regional perspective

Using the PA described in Section 4.2, impact risk and recovery lag were scored for all impact chains found in each of the four regional seas of Europe (Figure 1.2). Full details of the application and results are described in Knights et al. (2013b) and here we summarise findings for Impact risk only.

The ranking of sectors by impact risk varied between regional seas, but the sectors posing the greatest impact risk were largely common across regions. Fishing was identified as the greatest risk sector in all regions (Figure 5.3); the risk at least two times greater than from any other sector and consistent with common perceptions of which are the greatest risk sectors. This risk score is the result of a relatively large number of impact chains being attributed to this sector, coupled with a high average risk score per impact chain driven by widespread, frequent and severe pressure assessment outcomes (Figure 5.4). We can contrast this sector with the relatively high average risk score of sectors such as aggregates and agriculture, but where the number of impact chains

¹⁶ See Piet et al (in prep) for an exploration of how scoring and summation method affects outcomes in the risk assessment approach

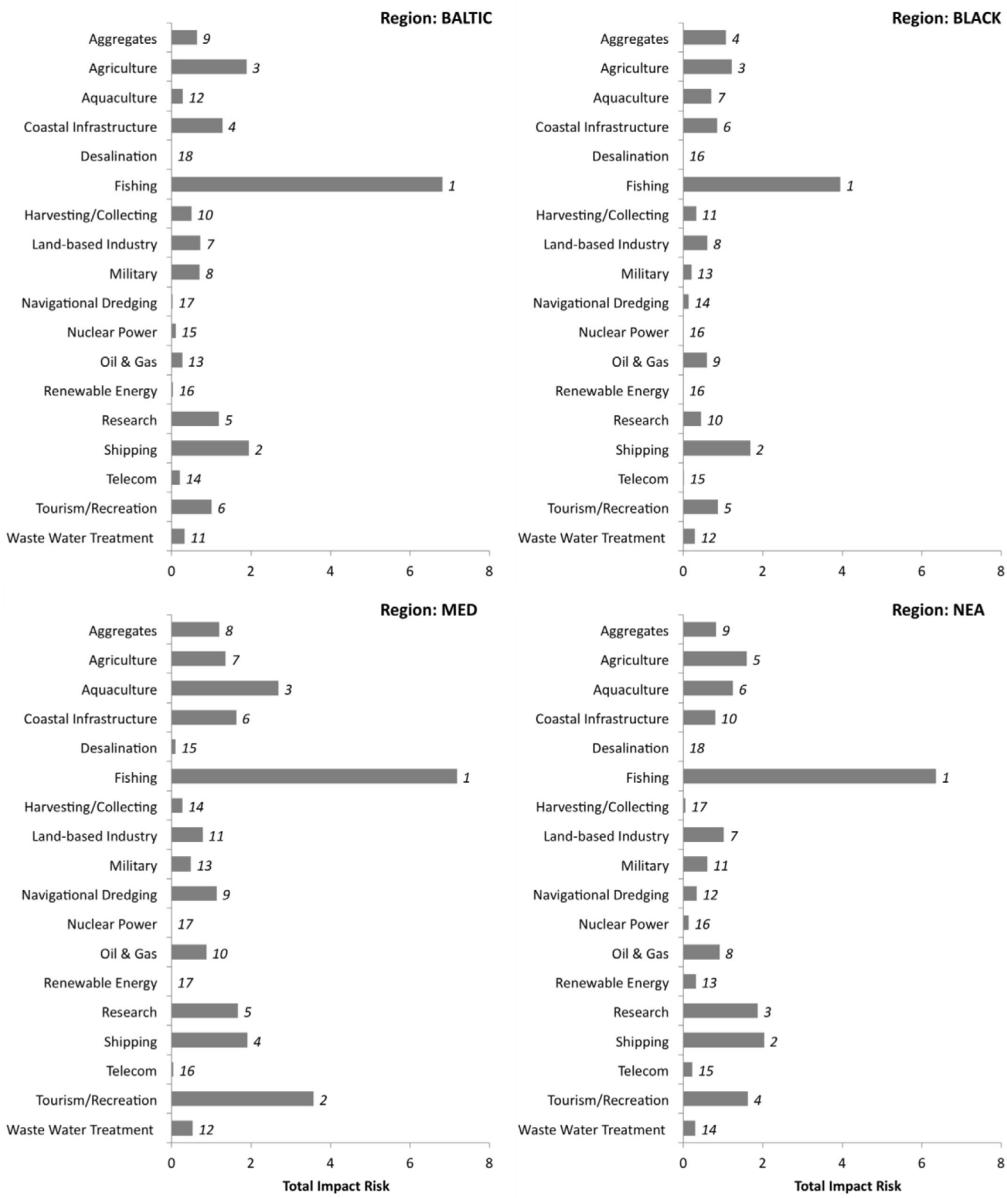


Figure 5.3 Total Impact Risk scores associated with each sector in each of Europe’s regional seas. The ranking of each sector is shown (*italics*) for each region for indicative purposes. NB Total impact risk is an addition of all impact chain risk scores associated with each sector and is therefore dependent on the number of impact chains

they generate has limited their total risk score (Figures 5.3 and 5.4). Notably, comparison of the maximum risk score associated with any one chain introduced by a particular sector indicates that the majority of sectors, despite often demonstrating relatively low total impact and average impact risk scores, introduce at least one chain of relatively high risk to the ecosystem (Figure 5.5).

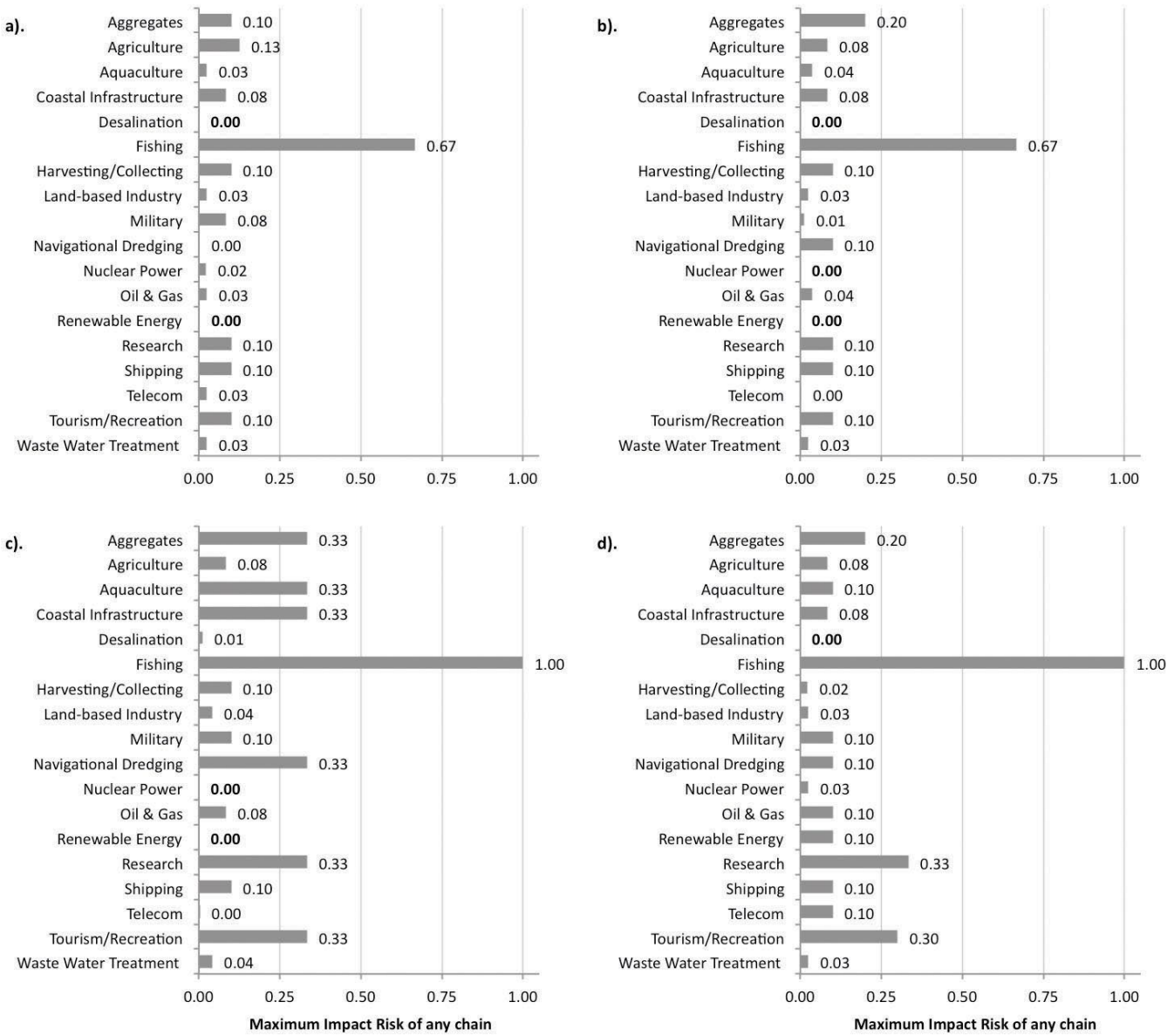


Figure 5.4 Average Impact Risk (\pm standard error) scores associated with each sector in each of Europe’s regional seas: (a) Baltic Sea, (b) Black Sea, (c) Mediterranean Sea, and (d) the North East Atlantic. NB Max impact risk score = 1.0. No bar present indicates the absence of the sector in the region

Regionally specific risks were also identified by the assessment. For example, agriculture and aquaculture were identified as high-risk sectors in the Baltic and Black Sea respectively (Figures 5.3 & 5.4), reflecting the challenges those regions face from Nitrogen and Phosphorus enrichment (N&P) and its contribution to eutrophication (HELCOM, 2010). In the Mediterranean Sea, tourism and recreation was identified as a higher risk sector (Figure 5.3).

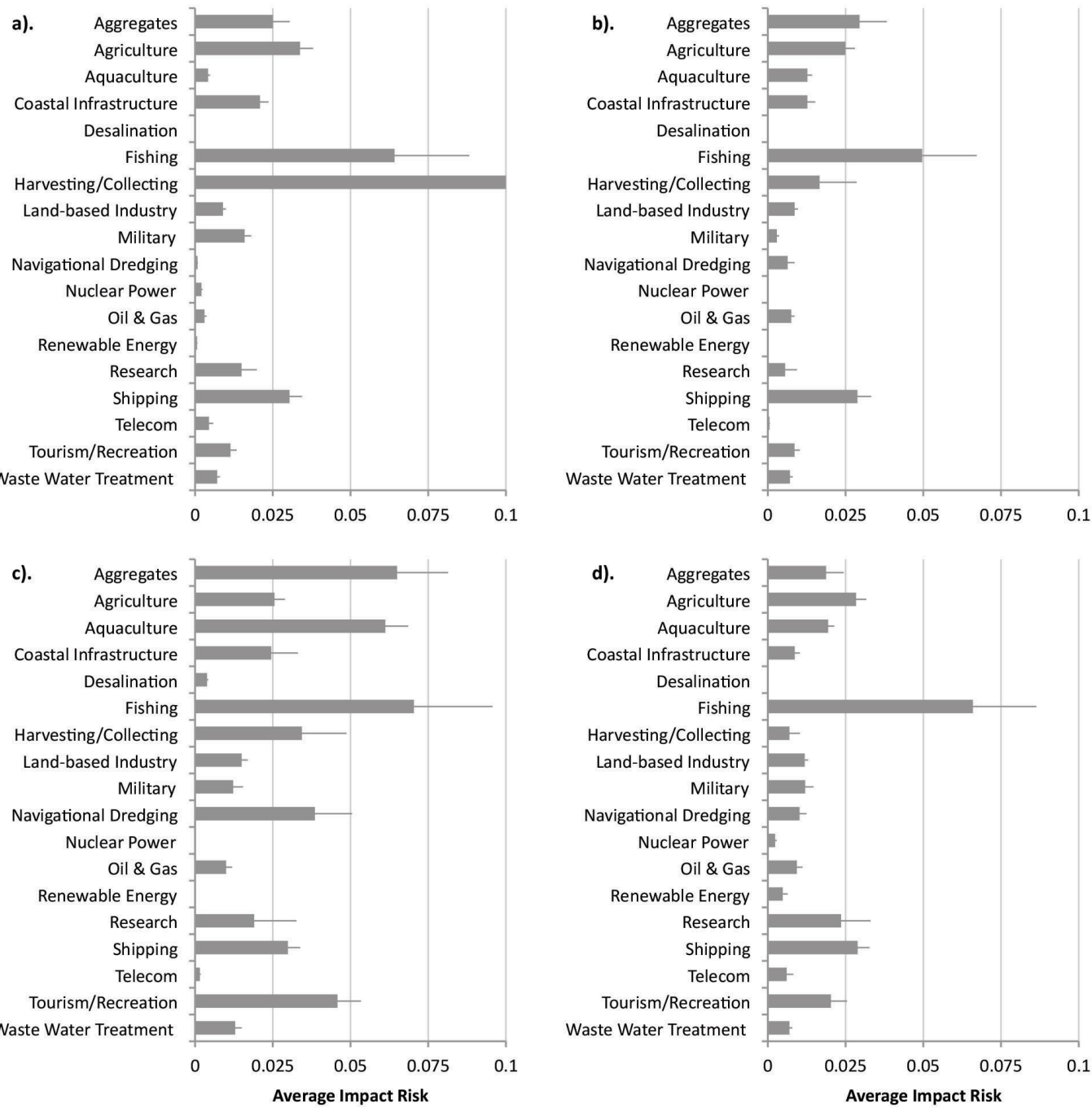


Figure 5.5 Maximum Impact Risk score of any chain introduced by a sector in each of Europe's regional seas. NB Values in bold indicate the sector is not present in the regional sea.

5.4 Assessment Value and Limitations

The ODEMM ecological risk assessment methodology allows users to identify risks at a broad level, such as that illustrated above for whole sectors. This allows high level prioritisation across and within regional sea ecosystems. As the approach links directly to the data generated by the ODEMM pressure assessment, any update or new application of the PA could then easily be converted into a risk output. In further work, we developed an integrated management strategy evaluation (iMSE) approach that allows users to select management options to target different aspects of risk in the ecosystem (see Chapter 6).

Where the number of risk impact chains is great, management may be challenging, as a range of issues have to be addressed although linkage pathways have been evaluated to identify efficient groupings of impact chains (Knights et al, 2013a). In this analysis, we have not considered situations when impact chains overlap (Knights et al, In press; Goodsir, In prep.). In such cases, non-linear effects may be seen resulting in greater risks than assessed under this methodology. The combined effects methodology briefly described under Section 4.52 starts to address this issue, although there is still more work required to deal with cumulative effects across pressures.



Chapter 6

Design and Evaluation of Management Options: the ODEMM iMSE

6.1 Introduction

Improving the state of the environment requires focussing on management of human activities. A key aspect of EBM is, therefore, the choice of management options (MOs) that can target the major threats to the different aspects of the ecosystem. The ODEMM pressure and risk assessments (Chapters 4 & 5) allow the main threats to be identified and indicate the links between components and human activities. The ODEMM integrated Management Strategy Evaluation (iMSE) tool can be used to link types of MOs with the categories of the PA, allowing different manageable aspects of human activities to be targeted to address the main threats in the system. Management options can focus on drivers, pressures, ecological components or combinations of these (see Figure 6.1).

There are different types of MO that can be applied to control human activities; these include spatial and temporal distribution controls, input and output controls, remediation and restoration (Figure 6.2). This allows several options to be produced which can achieve the same goal. For example, a management option could target how widespread an activity is through a spatial control; or how often the activity occurs through an input or output control.

The ODEMM integrated Management Strategy Evaluation (iMSE) tool is a comprehensive framework that aims to provide guidance for the identification and selection of consistently defined management options and allows an evaluation of these options in terms of their effectiveness to achieve policy objectives through their reduction of risk. Effectiveness is defined as the reduction in ecological risk associated with a specific MO. Management may target a sector or pressure directly and either remove the risk entirely or in part. We can also explore reduction in risk to Descriptors by understanding the links between ecological components, pressures and MSFD Descriptors (Fig. 6.1).

6.2 Summary of the iMSE Tool

The iMSE tool is based on the most extensive risk assessment framework to date (Knights et al. 2013b, Chapter 5), consisting of Driver-Pressure-State combinations (so-called “impact chains”, where in ODEMM Drivers are Sectors, and State refers to broad Ecological Components) that each contribute to the risk of not achieving policy objectives (Figure 6.2). The tool takes the different aspects

Chapter Highlights

- Summary of the ODEMM integrated Management Strategy Evaluation (iMSE) tool
- Applying the iMSE: an example
- Assessment Value and Limitations

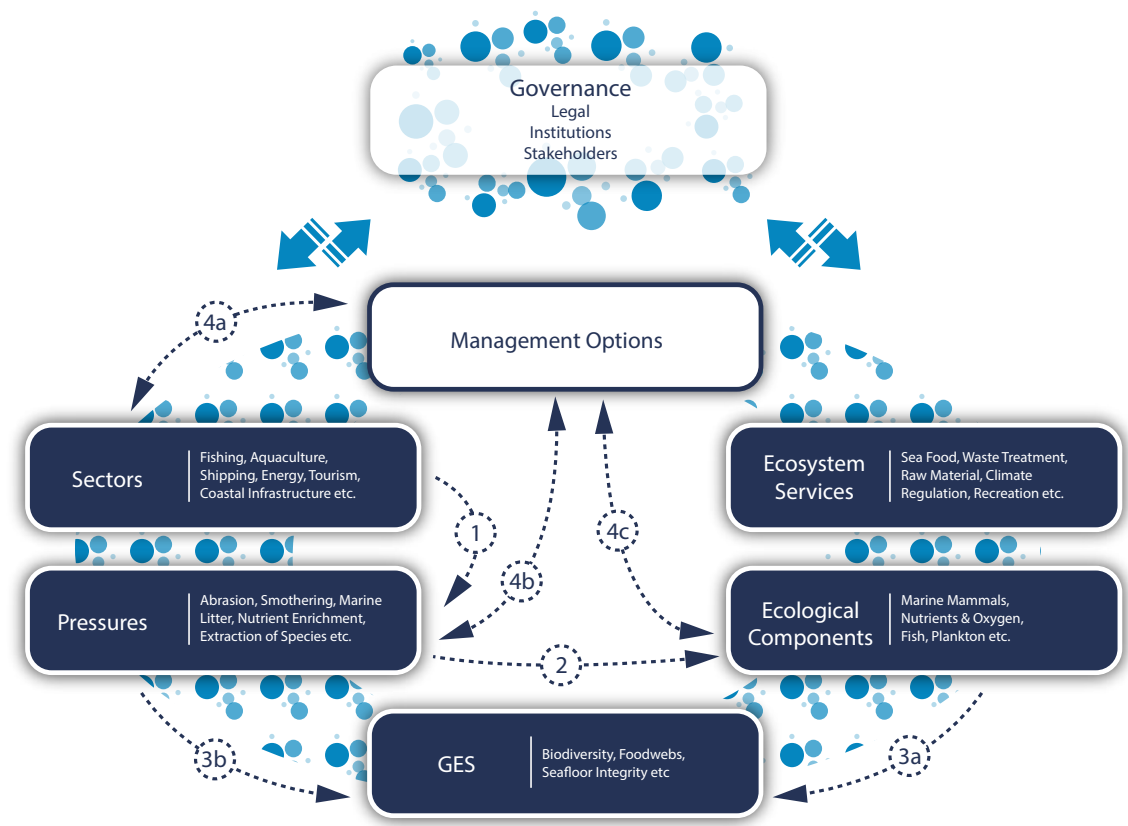


Figure 6.1 Using the ODEMM pressure assessment data, the ODEMM risk assessment relates sectors and their pressures (1) to ecological components (2) in terms of risk (see Chapter 5). In the ODEMM integrated Management Strategy Evaluation (iMSE) tool, management options can be selected to target drivers (sectors) (4a), pressures (4b), ecological components (4c) or a combination of these. The effectiveness of any management option can then be evaluated in terms of the reduction in risk of adverse impacts on individual ecological components, the ecosystem as a whole (across ecological components) and to the MSFD’s GES Descriptors (3).

of risk (based on the five pressure assessment criteria) and uses two distinct aspects of a measure, i.e. the “Focus” and the “Type” of measure, to select MOs that can reduce risk (see Table 6.1).

The “Focus” is determined by the part of the impact chain (Driver-Pressure-State) the measure is supposed to mitigate. A management measure may therefore involve only one single element in the impact chain (i.e. Driver, Pressure or State), the combination of two (i.e. Driver-Pressure or Pressure-State) or three which effectively implies it aims on one specific impact chain (i.e. Driver-Pressure-State) making the measure more specific as more elements are combined.

The “Type” represents the physical measure which affects the impact chain directly. We distinguish six types of measure loosely based on the MSFD (EC, 2008) that each link differently to the risk criteria (Figure 6.2). The options “Spatial distribution controls”, “Temporal distribution controls”, “Input control” and “Output control” each (or in combination) mitigate the Impact Risk, while “Remediation”, and “Restoration” mitigate the Recovery Lag.

The iMSE tool can analyse how risk is reduced when individual or combinations of MOs are applied, either in terms of a reduction in Impact Risk (IR), Recovery Lag (RL) or Total Risk (which is the product of RL and IR). Reduction in risk can be evaluated for single ecological components, the whole ecosystem or a GES Descriptor.

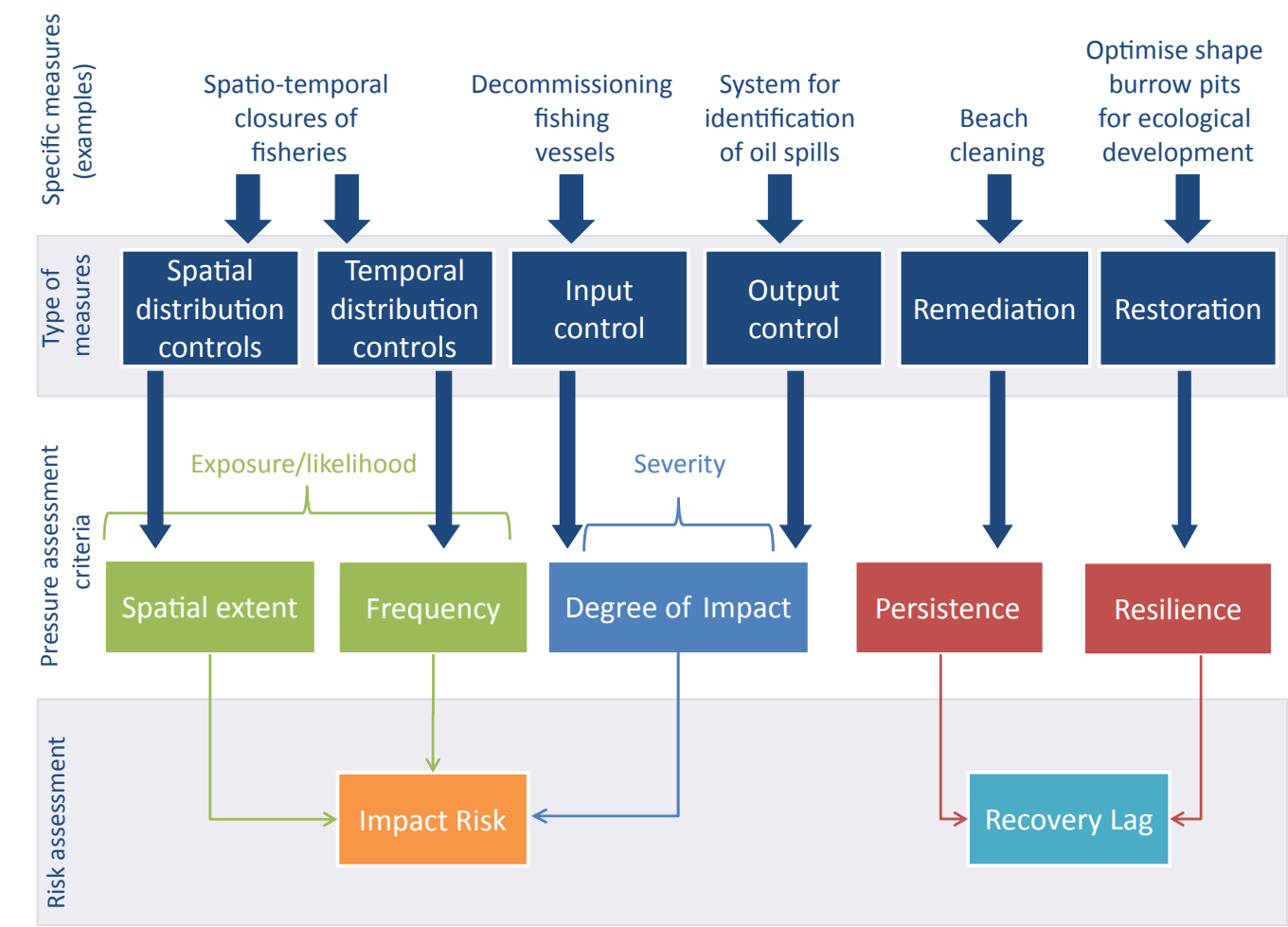


Figure 6.2 The iMSE tool which links potential Management Options through the Types of Measures to the Pressure Assessment criteria and ultimately to the two components of the Risk Assessment

Table 6.1 The possible combinations of “Focus” and “Type” of a measure. The numbers in the cells correspond to the management options in Table 6.2 that were considered in this evaluation. Measures can focus on either: a driver (D), driver-pressure combination (D-P), pressure (P), pressure-state combination (P-S), state issue (S), or a specific driver-pressure-state combination (D-P-S). See examples using numbers below from Table 6.2.

Focus	Type					
	Spatial distribution controls	Temporal distribution controls	Input control	Output control	Remediation	Restoration
D	1,2		6			
D-P	3			7,8		
P	4			9	13,14	
P-S	4			10	15	
S	5					17,18,19
D-P-S				11,12	16	20
Risk assessment criteria	Extent	Frequency	Degree of Impact		Persistence	Resilience
Aspects of risk	Impact Risk				Recovery Lag	

6.3 Application of the iMSE tool: an example

Using the risk assessment database (see Chapter 5), the iMSE tool was applied to explore effectiveness of a range of measures that varied in both ‘Type’ and ‘Focus’ (see full details in Piet et al., 2013, Deliverable 7 of ODEMM). A total of 20 management measures were selected for comparison, ranging from those that had a specific Focus on one set of impact chains (e.g. applying TACs (total allowable catch) to limit the pressure ‘selective extraction of species’ caused by the sector ‘fisheries’, acting on ‘fish’ specifically), through to those that had a broad Focus (e.g. Banning littering from any sector; i.e. a measure aimed to target the pressure ‘Marine Litter’ regardless of sector or impacts associated). A full range of Types of measure were compared, although there were less options available for Input Control measures (see summary of distribution of Type and Focus of measures in Table 6.1).

In the application of the iMSE tool illustrated here, the performance of a management measure, in terms of its reduction of risk, depended on (a) the num-

ber of impact chain(s) and (b) the risk criteria associated with that measure. The performance was assessed based on an explicit consideration of three time horizons for management:

- **Past:** management aimed at reducing existing adverse impacts from past activities
- **Present:** management aimed at current activities based on preventing/reducing the likelihood they will cause an adverse impact
- **Future:** management aimed at current activities but considering both the likelihood of an adverse impact as well as the time it takes to return to pre-impacted condition after the implementation management

Outcomes were explored in terms of change in risk for the three time horizons as follows: “Past” was based on the Recovery Lag (RL), “Present” on the Impact Risk (IR), while “Future” was based on the Total Risk (TR). These “Time Horizon” perspectives are explicitly considered in our evaluation of the management options. For the evaluation of the options we assumed a full implementation of the measure (i.e. a 100% reduction of the risk criteria linked to the Type of measure).

From a “Present” perspective we only considered options that affect the likelihood of current activities to cause an adverse impact (MOs1-12 where RL is not affected) and do not consider the remaining management options (MOs13-20 where IR is not affected) which are specifically intended to reduce existing adverse impacts and hence only relevant for the “Past” perspective. All management options are relevant for the “Future” perspective for which TR applies.

The “Past” perspective shows that the best Recovery measure (MO18) targeting the most impacted ecosystem component (i.e. fish, a combination of pelagic-, demersal- and deep sea fish) performs better in terms of a reduction of the RL than the best Remediation measure (MO13) targeting the second most important pressure (i.e. Marine litter after Sealing for which management is unlikely).

The “Present” perspective shows that options targeting what is currently the main driver causing adverse impacts (i.e. fisheries), either through a Spatio-temporal closure (MO2) or through an Input control (MO6), cause the largest reductions in IR and that the performance of the options increased as more impact chains are targeted by the measure. For example, MO2 targeting 70 impact chains, outperformed MO1 targeting only 30 impact chains.

The “Future” perspective shows that the Output control (MO9) performs best because it is preventing a pressure (i.e. marine litter) that has a high likelihood

No.	Management option	Focus	# Impact Chains	Potential reduction (%)		
				RL	IR	TR
1	Spatio-temporal closures of the pelagic fishery	D (Fisheries) P (All pressures related to this type of fishery) S (Pelagic fish)	30	-	13	7
2	Spatio-temporal closures of the demersal fishery	D (Fisheries) P (All pressures related to this type of fishery) S (Demersal fish and all seafloor habitats)	70	-	30	11
3	Spatio-temporal restrictions to the discharge of ballast water	D (Shipping, Military) P (Non-indigenous species)	38	-	5	11
4	No take zone(s)	P (Selective extraction of species and non-living resources) S (may be applied, e.g. a specific seafloor habitat but was not in this assessment)	38	-	29	1
5	Closed areas for deepwater coral or seamounts	S (Deep sea bed)	28	-	3	3
6	Decommissioning fishing vessels	D (Fisheries)	81	-	31	14
7	System for identification of oil spills from offshore installations	D (Oil & Gas) P (Non-synthetic compounds)	11	-	1	1
8	Biodegradable fishing gear	D (Fisheries) P (Marine Litter)	12	-	2	7
9	Ban on littering	P (Marine Litter)	84	-	10	33
10	Fish guide	P (Selective extraction of species) S (Fish)	11	-	19	1
11	MSC	D (Fisheries) P (Selective extraction of species)	9	-	21	1
12	TAC/Quota	D (Fisheries) P (Selective extraction of species) S (Fish)	3	-	12	1
13	Retrieval of lost or abandoned fishing gear	P (Marine Litter)	12	2	-	7
14	Collection of fished litter (fishing for litter scheme)	P (Marine Litter)	57	9	-	22
15	Additional beach cleaning	P (Marine Litter) S (Seabirds, Littoral habitats)	21	6	-	14
16	Cleaning pollution from offshore drilling operations, e.g. drilling muds and cuttings	D (Oil & Gas) P (Synthetic and Non-synthetic compounds) S (Seafloor habitats)	12	<1	-	<1
17	Breeding program Seabirds	S (Seabirds)	79	11	-	6
18	Breeding program Fish	S (Pelagic fish)	138	15	-	15
19	Breeding program Marine mammals	S (Marine mammals)	110	14	-	9
20	Optimise shape burrow pits for ecological development	D (Aggregates) P (Abrasion, Selective extraction of non-living resources) S (Seafloor habitats)	6	<1	-	<1

Table 6.2 (opposite page) Non-exhaustive list of potential management options, the number of impact chains affected and the maximum potential reduction that can be achieved if the options are fully implemented. The Nr.Number (No.) corresponds to those in Table 6.1 RL=Recovery Lag, IR=Impact Risk and TR=Total Risk

of causing an adverse impact as it is caused by many different drivers together with a long RL due to its persistence.

6.4 Assessment Value and Limitations

The iMSE tool provides a powerful means for exploring the effectiveness in MOs, which can then be used as one aspect in the consideration of tradeoffs between different MOs when choosing programmes of measures to help reduce threats to the different aspects of the ecosystem, and in particular here, to reduce risk to the Descriptors of GES. However, whilst the iMSE tool assesses the performance of the potential management options quantitatively in terms of their relative reduction of the risk of an adverse impact, we caution that the results should be used qualitatively (i.e. providing a ranked order of the management options).

Moreover, the final choice of the actual options requires an interpretation of the feasibility of the guidance coming from this tool in a real-world context. The instruments to initiate the MOs, i.e. regulatory, economic and social (van Vliet, 1999), should be based on the outcome of this process considered in the appropriate governance and socio-economic context. In the following two chapters, we explore the work undertaken by ODEMM to evaluate two of the key aspects that influence feasibility (see exploration of this in Knights et al., in press): (1) the costs and benefits of MOs (Chapter 7), and (2) the complexity and arrangements of governance operating in the relevant decision-making context (Chapter 8).



Chapter 7

Evaluation of Management Options: ODEMM's Costs-Benefits Analyses



7.1 Introduction

In ODEMM, a number of approaches were explored that can be used in trade-off analysis of management options (MOs), in terms of cost-benefit analysis (Hussain et al., 2013). On the benefits side, an ecosystem services approach was assumed, where ecosystem services have been defined as “the direct and indirect contributions of ecosystems to human well-being” (de Groot et al., 2010 ; Böhnke-Henrichs et al., 2013). ODEMM set out to use ecosystem services as a unit-of-account for assessing the incremental changes that arise when the state of the ecosystem changes. The approach considers each ecosystem service in turn and assesses, where possible, whether the supply of a particular ecosystem service will be higher or lower (and the extent of change) when comparing one management option with another.

Early in the project it was noted that there were many gaps in terms of the tools and understanding required to complete assessments for benefits arising from application of MOs, in particular when these are based on an ecosystem services approach. There were also gaps in terms of guiding comprehensive cost assessment of any MOs. Effort was therefore placed in furthering these two areas of research independently, rather than on carrying out cost-benefit analysis per se. Emphasis was placed on development of typologies of ecosystem services (section 7.21) and costs (section 7.24), to ensure that an appropriate structure is in place for full evaluation of trade-offs in terms of social and economic outcomes of MOs. On the benefits side, work was also undertaken to explore what is possible in terms of estimating change in supply of ecosystem services where data (and knowledge) is lacking (section 7.22), as well as furthering data available for monetary valuation of those services (section 7.23).

7.2 Summary of ODEMM costs and benefits analyses

7.21 Typology of Marine Ecosystem Services

The need for a typology of ecosystem services arises so as to ensure that all benefits are made explicit as any omission of benefit categories leads to a systemic under-representation of the benefits arising from measures aimed at

Chapter Highlights

- Description of the ODEMM Ecosystem Service Typology
- Linking management options to changes in ecosystem service supply
- Choice Experiments for the assessment of cultural services
- Typologies for assessment of costs

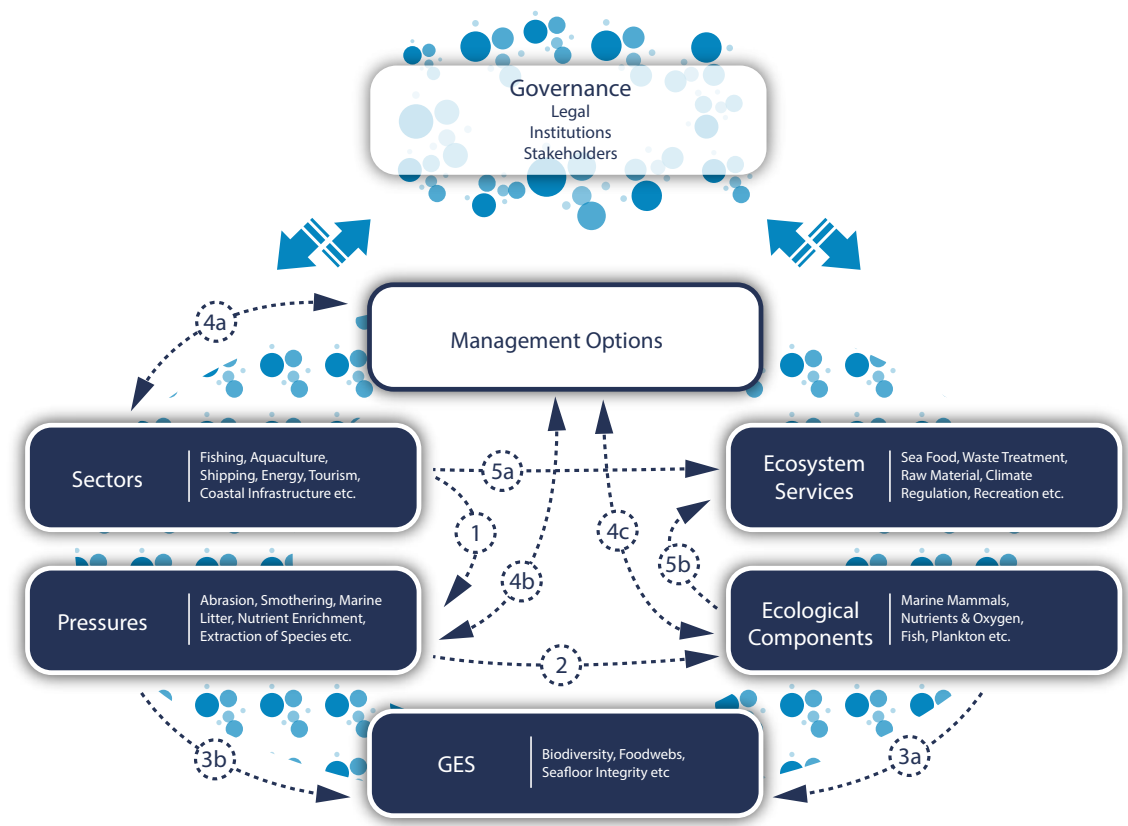


Figure 7.1 The ODEMM Cost and Benefits analyses consider how the appraisal of management options can take into consideration both associated costs and benefits (where benefits are described by the supply of ecosystem services). Here, the supply of ecosystem services can be altered when management options are instigated (4 a-c), either through controls on sectors that supply key ecosystem services (5a) (e.g. instigating catch control on Fisheries can alter supply of Seafood directly), or through the alteration in state of ecological components that contribute to the supply of ESs (5b). [State of ecological components may change due to management options acting directly on ecological components (4c) or acting on pressures (4b) and/or sectors (4a) that impact ecological components (2)]. Costs associated with management options may arise at both the level of the sector and/or at institutes involved in the governance of those management options.

conserving nature. The core principle is to make the benefits visible, to remove what is otherwise a pro-extractive, contra-conservation bias in decision-making. But there is also a corollary to this argument in that the typology must be designed so as to avoid double-counting.

The ODEMM ecosystem service typology built on and adapted extant terrestrial typologies (TEEB, 2010; MA 2005) which have four main categories of services (1) provisioning services such as sea fish for human consumption; (2) regulating services such as gas and climate regulation; (3) supporting/habitat services (e.g. sea grass beds providing a nursery habitat for juvenile fish); and (4) cultural/

amenity services such as leisure and recreation. The scientific rationale for the categorisation of ecosystem services in the ODEMM typology is set out in Böhnke-Henrichs et al. (2013) and a set of ecosystem service cards which summarise and illustrate the full typology (see examples in Figures 7.2) is freely available. Using these cards (and Böhnke-Henrichs et al., 2013) allows decision-makers to begin to identify those ecosystem services that are likely to be priorities in their particular decision-making context.

7.22 Linking Management Options to Change in the Supply of Individual Ecosystem Services

The ODEMM approach links up MOs with Sectors, Pressures, Ecological Components and Ecosystem Services (Figure 7.1; Chapter 3). Detailed one-to-one linkages have been specified between most aspects of this framework, including between the different ecological components (seabirds, habitat types, demersal fish etc.) and the full list of ecosystem services presented in the Böhnke-Henrichs et al. (2013) typology (see example in Figure 3.2). This means that it is possible to extract the relevant links for any scenario and to see which ecosystem services have the potential to be affected by that scenario.

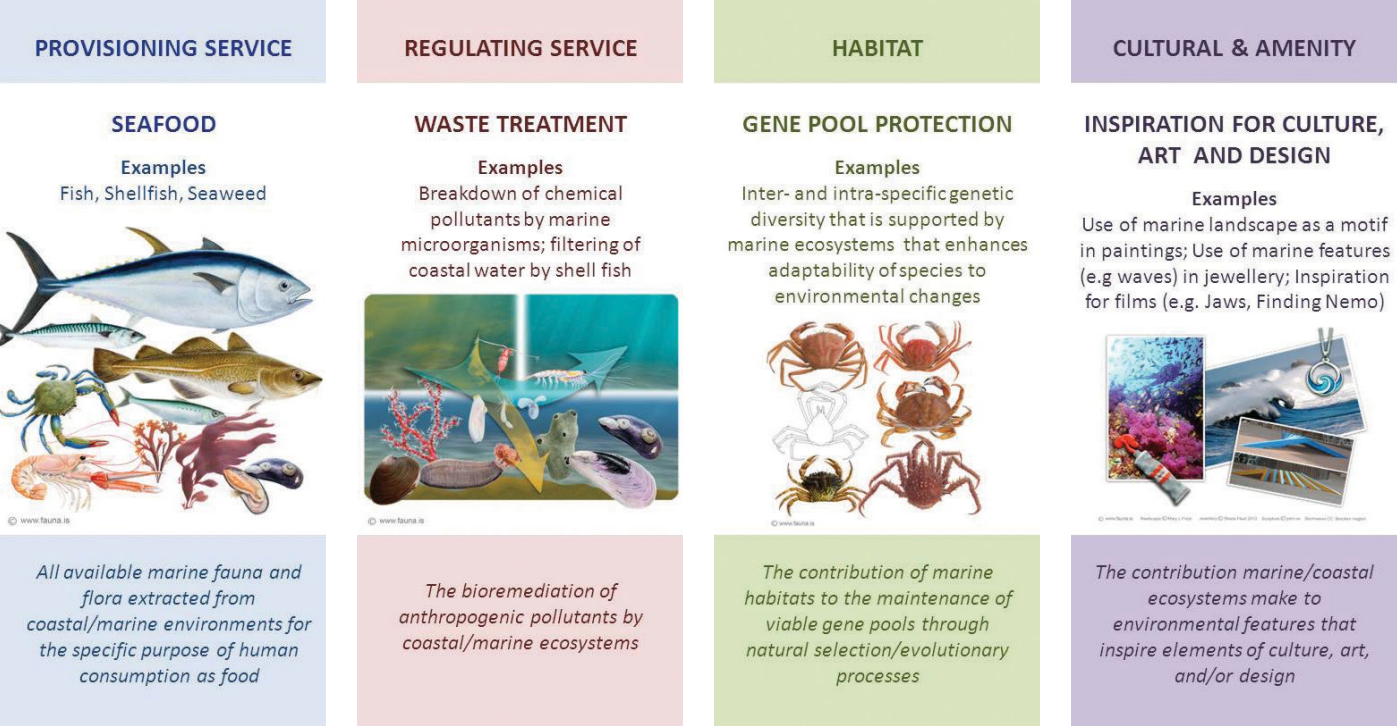


Figure 7.2 Examples of marine ecosystem service typology cards. The ODEMM ecosystem services cards are available to download for use from www.odemm.com/content/cost-and-benefits-analyses



Knowing the qualitative links between these different aspects of the ecosystem provides the structure within which management options can be explored. ODEMM went on to examine the ways in which change in ecosystem service supply (resulting from application of MOs) could be estimated and these are described below.

Exploring the potential to quantify change in ecosystem service supply as a result of applying management options

In a series of regional sea case studies, the effects of applying a range of MOs were compared in ODEMM with the do nothing scenario in terms of any resultant change in the state of ecological components over a set time period (Akoğlu, 2013; Baltic Sea Case Study, 2013; Bloomfield et al., 2013; Papadopoulou et al., 2013; for a summary of results across case studies see Paijmans et al., (2013)). These case studies were framed around the potential to improve the state of particular objectives of the MSFD. ODEMM ecologists and economists then worked together to explore the potential to quantify how the effects of applying MOs in each case study translated into any change in the supply of linked ecosystem services. In all cases it was assumed that change in ecosystem services supply could arise either as a direct effect of a change in ecosystem state and/or as a direct consequence of the management applied (see explanation with Figure 7.1)¹⁷.

The main findings¹⁸ from the ecosystem services case study work in ODEMM showed that there are many data and/or knowledge gaps in terms of the ability to undertake quantitative analysis of the likely change in ecosystem service supply resulting from application of management options. There is generally poor understanding of how the change in state of specific ecological components would result in a change of supply of specific ecosystem services. However, there are cases where experts are confident that there would be no effect of the management option applied on the supply of particular ecosystem services. This helps to narrow down the scope of assessments still required to conduct a full ecosystem services trade off analysis.

Further investment in this area of research is clearly required, but given the current absence of understanding and/or data, ODEMM went on to develop a more qualitative approach to predict the relative change in ecosystem service

supply following application of MOs, to facilitate exploring consequences across all ecosystem services (see below). This was deemed important because otherwise decisions made about the selection of management options are based on assessments of the few relatively well studied ecosystem services (Seafood, Tourism and Recreation) which leaves the likelihood that full trade-off analysis of benefits cannot be achieved.

Relative change in Ecosystem Service supply due to reduction in Ecological Risk

The ecological consequences of marine management were explored with the concept of ecological risk (Chapters 5 and 6). In theory, the adoption of new management should lead to a reduction in risk, and reductions in risk should be reflected in changes in the identified ecological components. As the linkages between state of ecological components and supply of ecosystem services have been established in ODEMM (Chapter 3) it was thus possible to then examine how change in risk to the ecosystem would lead to change in supply of ecosystem services (Figure 7.3).

In order to translate risk reduction to change in supply of ecosystem services, it was necessary to categorise the relative contribution made by each identified ecological component to the supply of each identified ecosystem service. The analysis of the relative contributions of ecological components to ecosystem services is conducted using expert judgment, scoring the contributions on a categorical scale from none, low, moderate or high¹⁹. This then allows

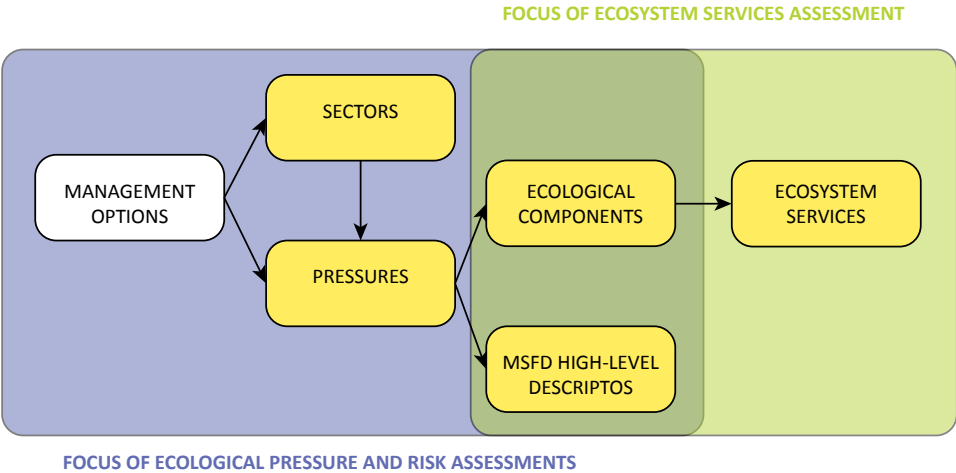


Figure 7.3 Visualising the connection between the ODEMM ecological risk assessment and the analysis of ecosystem services

¹⁷ Full details of these assessments are given in individual regional case study reports available on www.liv.ac.uk/odemm/data/, and a tabulated cross-regional overview of the findings, in terms of the ability to quantify change in ecosystem services supply under each scenario, can be found in Annex I of Hussain et al 2013.

¹⁸ A full discussion is given in Hussain et al 2013

¹⁹ Details of expert judgement approaches can be found in Hussain et al 2013

a formal link to be assigned between changes in ecosystem services supply to changes in marine management. This is achieved by multiplying the reductions in the ecological risk associated with each ecological component (the output of the ecological risk assessment, Chapter 5) by the relative contribution linking each ecological component to each ecosystem service (the categorical score). As the results are based on the best available information, when better information becomes available scores should be reviewed and updated where necessary (as part of an adaptive management process). Thus, the outcomes are indicative and should be viewed as a mechanism for sign-posting research and management options. Despite any inherent subjectivity in the approach, the ODEMM framework captures ecosystem complexity and translates this into a simple metric (i.e. a single figure in each cell of a matrix) that allows comparison across management options.

7.23 Valuation of changes in Ecosystem Service supply

The ODEMM project has contributed to the evidence base on the valuation of marine ecosystem services in two significant ways: (i) conducting primary valuation studies using a methodology termed ‘choice experiments’ to assess marine cultural ecosystem services; and (ii) the development of a database of marine ecosystem service valuations, structured so as to facilitate the process of ‘benefits transfer’ wherein the cost of conducting a site-specific primary valuation study is avoided by relying instead on transferring a value estimate from a previously published study (or studies).

Notwithstanding the shift towards management at a regional (and therefore trans-national) scale in marine management internationally, the vast majority of marine and coastal ecosystem valuation literature refers to study sites at a much smaller spatial scale (e.g. individual strips of coastline and adjacent marine ecosystems). The most frequently applied methodologies in such primary valuation studies fall under the category of ‘stated preference techniques,’ wherein the respondents’ willingness-to-pay for a defined change in the natural environment (quality, access or both) is elicited through a structured, survey-based approach²⁰. ODEMM investigated willingness-to-pay through choice experiment surveys, with one in each of Poland, Romania, and Turkey. The methodology employed across these case studies was novel in that it focused on the monetary valuation of cultural ecosystem services other than ‘Recreation and Leisure.’

²⁰ See Hanley and Barbier (2009) for an introduction.

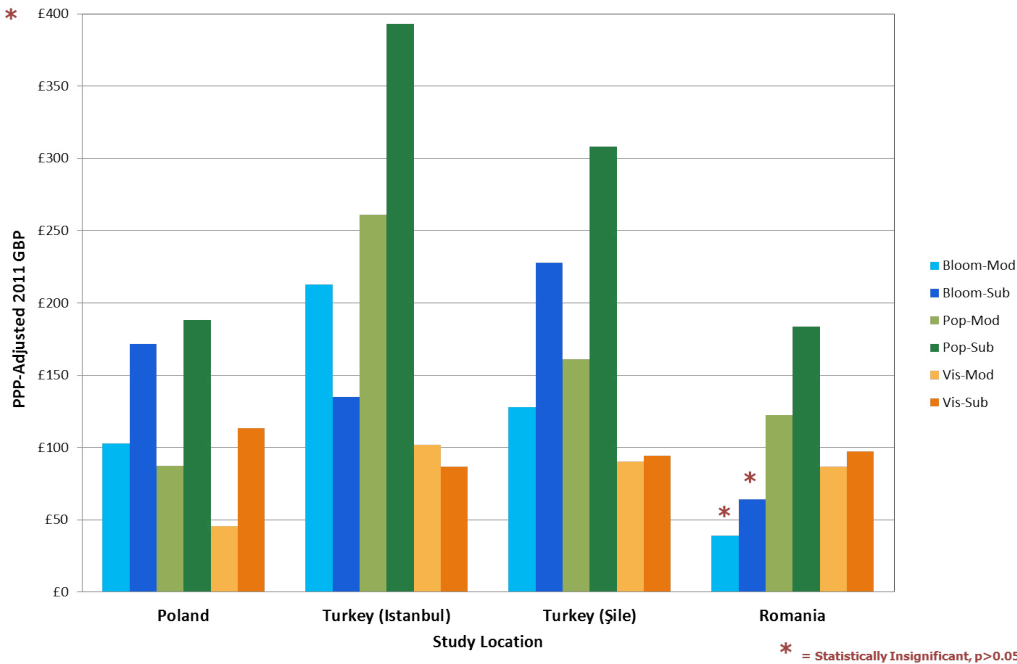


Figure 7.4 Annual mean valuation of common attributes across ODEMM choice experiments

In each choice experiment study, a cultural scoping study was carried out prior to the workshops that allowed for the finalisation of the attributes included in the survey design. As it turned out, there were attribute categories that were common across sites (though their cultural relevance differed between sites), and one attribute unique to each site. In Turkey for instance this attribute was the availability and quality of locally-sourced anchovy for traditional meals, and in Poland it was the protection of local artisanal fishing communities. Figure 7.4 presents a selection of initial results for prevalence of blooms (‘Bloom’), population size of key species (‘Pop’), and the visibility of key species (‘Vis’) under both a moderate (‘Mod’) and a substantial amount of new marine management interventions (‘Sub’).

As well as conducting primary valuation studies, ODEMM also developed a database of valuation studies. In total 590 studies were reviewed²¹. What is perhaps the most interesting outcome from this comprehensive review is the extent to which data gaps apply in the valuation of marine and coastal ecosystem services, with the exception of ‘Recreation and Leisure’.

²¹ A synopsis of results is provided in Table 5 in Hussain et al 2013

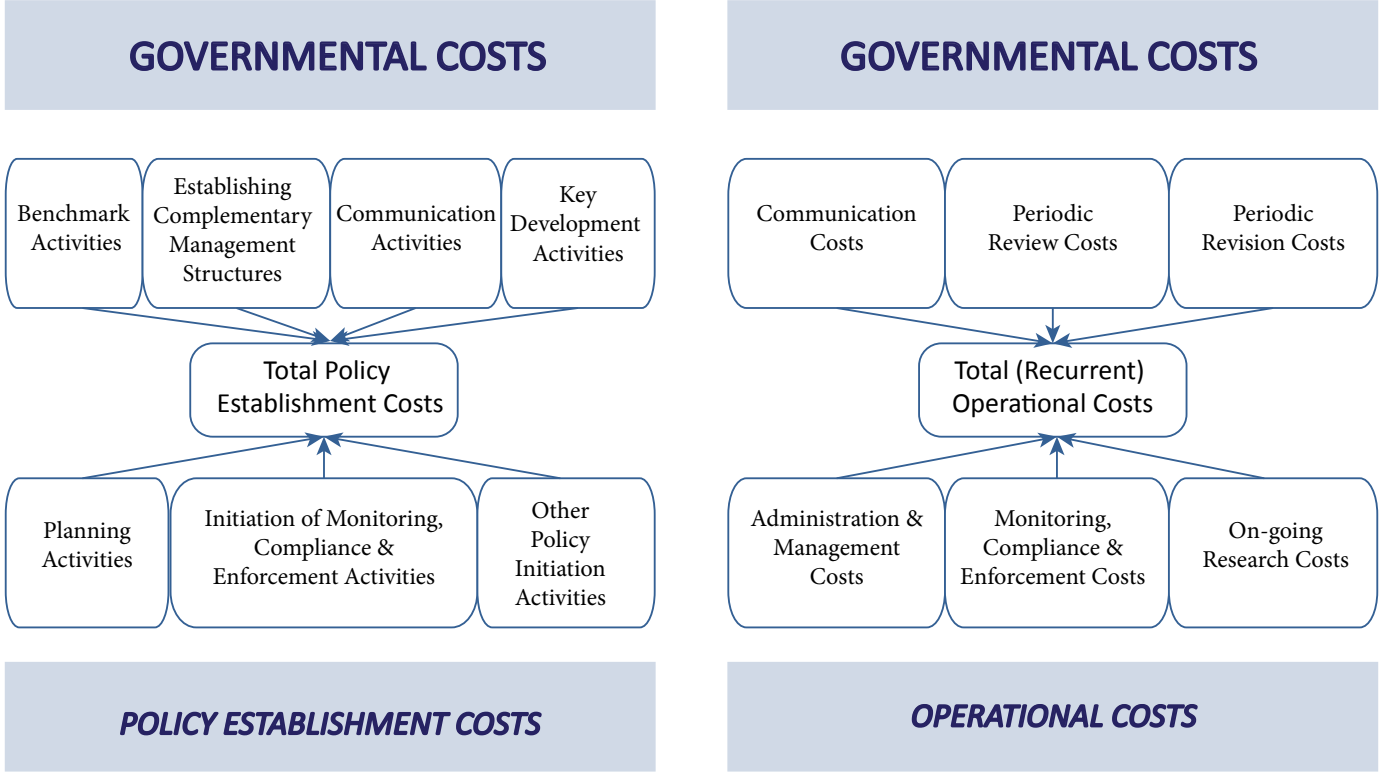


Figure 7.5 Typology of governmental costs incurred before and during implementation of the Management Option

7.24 The assessment of costs

ODEMM has developed a typology of costs, adapted from existing typologies, associated with the implementation of management options. This highlights the range of cost categories that should be considered when pursuing a full cost assessment of marine policy.

In general it is possible to split the assessment of costs across two domains: (i) the affected agents incurring the costs; and (ii) when the costs are incurred – before, during or after the application of the management option.

It is noteworthy that these cost categories are incurred not only by the regulator (as shown in Figure 7.5), but also the affected industries (as well as other stakeholders such as the Third Sector and civil society). For instance, the regulator is likely to have to set up the platform for communication but non-governmental organisations (NGOs) may need to carry out Planning Activities in preparation for a consultation phase and Communication Activities once the

consultation phase is on-going. ODEMM carried out a review of costs for Marine Protected Area (MPA) designation and found that only a sub-set of these cost categories have been estimated, and even then the range of value estimates is large, and dependent on a wide number of key variables²².

There are some substantive issues in terms of assessing costs, particularly when appraising management options that are linked to a regional initiative such as the MSFD. Costs to the regulator are typically borne at Member State level, but the designation of one particular Member State’s share of this regulatory burden can be unclear in regional management. This issue of cost-sharing across Member States applies to costs incurred by industry sectors as well, e.g. the costs borne by one Member State’s trawling fleet versus another Member State’s.

A second issue is that any before application cost assessment is likely to be applied under conditions where the management option is not fully specified. For instance, knowing that the management option is the designation of MPAs in the NE Atlantic is insufficient to facilitate an accurate cost assessment. Rather, it is also necessary to know where exactly the MPAs would be located, and what restrictions on activities and pressures would be applied. It is rarely the case that such a complete specification is available, but in its absence, cost estimate ranges are so large as to be near useless in terms of informing policy.

7.3 Key Lessons learnt and the way forward

A failure to apply EBM (with its focus on the supply of ecosystem services) will mean that policy choices may not be economically efficient, and can easily miss key trade-offs. Although a management option is likely to be specified with a particular target in mind - for instance achieving GES for one MSFD descriptor, the management option is likely to have impacts on *other descriptors* and also impact on specific ecosystem services. The management option that is best in terms of reducing the risk of failing to meet GES for that particular descriptor may not be the best choice in economic terms. This could result from *co-benefits* in terms of enhanced ecosystem service supply, or indeed *inadvertent losses* in ecosystem service supply.

²² A detailed typology of costs for the assessment of management options to implement MPAs has been developed. Data on these cost categories is often difficult to obtain and/or confidential. For a review of what information is publicly available, see the associated report on MPA costs that was created for ODEMM (Baulcomb, 2013).



This links to the *cost-effectiveness analysis* (CEA) approach. CEA differs from cost-benefit analysis in that benefits are not measured. The premise of CEA is that a state change is required irrespective of the benefits accruing, and thus an assessment of benefits is superfluous. We would argue caution here owing to the issue of co-benefits. Even if management option A reduces the risk of failing to achieve GES for one descriptor *as much* as management option B and is cheaper to implement, it may be the case that option A increases the risk of failing to achieve GES for *other descriptors* and/or that option B provides *co-benefits* in terms of ecosystem service provision that are missed when a cost effectiveness approach is taken.

A cost-benefit analysis must be based on a specific management option, and in so far as is possible, that management option should be assessed using an approach which focusses on ecosystem services. Approaches developed within ODEMM help to facilitate this need.

The economic analysis of management options at a regional scale requires the attribution of costs and benefits across different nation states, and the constituency of winners and losers may differ. Although the appropriate spatial scale for the specification of management options (and the ecological modelling that tests the impacts of such interventions) may be at the regional scale, it is challenging for economic valuation to be applied at such a large scale when considering some ecosystem services. For instance, the regulating service of ‘Disturbance Prevention and Moderation’ has been estimated as being extremely valuable (see de Groot et al., 2012; Barbier et al., 2008) but the supply of the ecosystem services depends on highly localised conditions such as the typography of marine habitats and the proximity (and value) of developed land near the shoreline. Consequently, there can be a divergence between the appropriate spatial scale for economic analysis versus ecological analysis. There is also a significant research cost associated with up-scaling high-resolution economic analyses to a regional scale in order to be scale-matched with regional-scale ecological analyses. The scale at which actual marine management occurs also depends on governance regimes which can add a third layer to the mapping problem.

There are very few re-usable data points for the valuation of marine ecosystem services, and primary valuation is both possible and should be prioritised.

In the review of 590 extant studies for the ODEMM database, there are very few studies that can be used for benefits transfer (i.e. to transfer value estimates from one or more study site(s) to a policy site). Only three studies on cultural ecosystem services were found (if we exclude ‘Recreation and Leisure’). The total for most individual ecosystem services was <5. ODEMM has carried out primary valuation and generated usable values. Such work should be prioritised if we are required to place monetary values across the full range of ecosystem services. At the same time, it may not be appropriate to assign monetary values to all services, and even if it were, there is still a need to link change in state of the ecosystem arising from management interventions to change in supply of the full range of ecosystem services. ODEMM has developed a qualitative method to complete such an assessment²³.



²³ See Hussain et al., (2013) and www.odemm.com/content/cost-and-benefits-analyses

Chapter 8

Evaluation of Management Options: Governance Complexity



8.1 Introduction

In ODEMM, another focus of the research was on the exploration of the governance complexity around implementation of policies such as the MSFD. **Governance complexity can be defined as the likelihood of adoption and implementation of a management option, given the complexity of the governance system (legislation, institutions and stakeholders) and (lack of) institutional interaction.**

The focus of the MSFD is on marine regions (regional seas; Figure 1.2). Member States (MSs) sharing a regional sea are supposed to cooperate and coordinate their activities. To achieve this coordination it is suggested they make use of existing regional institutional cooperation structures, such as the Regional Sea Conventions (Commission of the European Communities 2005). Despite this recognition for the need to organise regional cooperation and coordination between MSs and with efforts undertaken by the Regional Sea Conventions (RSCs), the MSFD itself does not provide any specific legal framework nor specify governing structures to ensure cooperation and coordination at the regional sea level between MSs (Long, 2012; van Leeuwen et al., 2012).

Early work in ODEMM identified high levels of ambiguity in terms of understanding of the MSFD and how it would be implemented at all levels of governance around Europe (van Leeuwen et al., 2012; Ounanian et al., 2012). Novel work going forward in ODEMM was thus focused on addressing two key challenges in implementation of the MSFD: the development of (1) governance models that would help facilitate thinking about the options and possibilities of stakeholder involvement and regional cooperation and collaboration (Section 8.2), and (2) a nested hierarchical structure for linking emerging regional governance requirements with existing sectoral governance arrangements (Section 8.3).

8.2 Governance Models

Based on the building blocks participation/stakeholder involvement and decision-making power (binding or non-binding decisions) we developed four governance models for regional cooperation:

Chapter Highlights

- ODEMM's Regional Governance Models
- ODEMM's Nested Governance Structure
- The Way Forward, Towards Governance to Support EBM for Regional Seas

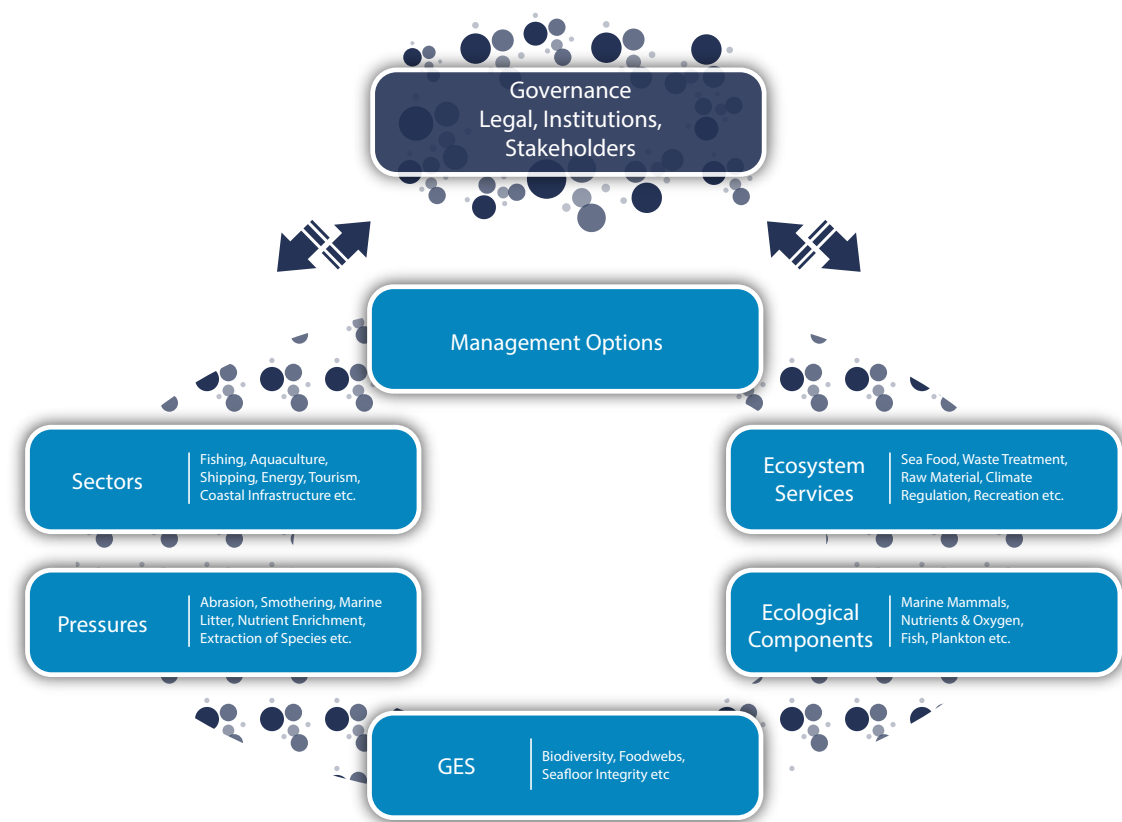


Figure 8.1 The ODEMM Governance work has focused on how information from policies (legal), institutions and stakeholders informs the context of any evaluation of the system and of potential effects of management on the system. Information from the evaluation feeds back to the governance system to inform decision making within this system.

(1) Cross-border platforms; (2) Regional Sea Convention-PLUS; (3) Advisory Alliance and (4) Regional Sea Assembly (see Table 8.1) (van Tatenhove et al., in press). These are described below:

Cross-border platforms

Cross border platforms consist of neighbouring MSs working together on an ad hoc basis and coordinating their initiatives in implementing the MSFD through information sharing. Typically cooperation takes place between two or three MSs at the sub-regional level. Participation of representatives of marine sectors and NGOs is mostly through consultation (asked for comments) at the national level. This mode of governance emulates the present way of involving stakeholders in the MSFD process and will not provide stakeholders with formal influence on the outcome of decision-making processes (although they can still

Table 8.1 Alternative governance models for regional cooperation as designed and tested by ODEMM (van Tatenhove et al., in press)

	Non-binding decisions	Binding decisions
Low Stakeholders involvement	1. Cross-border Platforms	2. Regional Sea Convention-PLUS
High Stakeholder involvement	3. Advisory Alliance	4. Regional Sea Assembly

exercise informal influence). Furthermore, the cross-border platforms will not have binding decision-making power. Each individual member state remains responsible for the implementation of the MSFD and use of shared information. Cross-border platforms are temporary, because no formal cross-border institutional arrangements are developed. Participating MSs themselves take the initiative to organise bilateral or trilateral meetings on an ad-hoc basis or will agree on more formal procedures for coordination and collaboration.

Regional Sea Convention-PLUS (RSC+)

The Regional Sea Convention-PLUS governance model takes the existing structures between the EU, RSC and MSs a step further by providing the Regional Sea Convention with a stronger role and mandate in implementing and coordinating the regional aspects of the MSFD. This model replaces the nationally-oriented implementation process with a regional implementation process coordinated by the RSC+. At the level of the marine region or sub-region, MSs negotiate assessment work to define GES, programmes of measures, implementation procedures and policies that shall direct the implementation of MSFD and monitoring programmes at the regional rather than at the national level. In this model, MSs still play a key role, but the difference with the existing situation is that binding decisions to which the MSs adhere, are taken in the RSC+. MSs have to implement these decisions and follow implementation guidelines as formulated by the RSC+. Stakeholder involvement will remain to be implemented at the national level in accordance with MS procedures for stakeholder consultation.

Advisory Alliance

The governance model of the Advisory Alliance is comparable to the Regional Advisory Councils (RACs) known from fisheries under the Common Fisheries Policy (CFP). The RACs are bodies providing advice to the EU Directorate-General for Maritime Affairs and Fisheries (DG MARE) and to national authorities of involved MSs on request. The Advisory Alliance proposed here would consist of representatives of all maritime stakeholders; industry (fisheries, oil and gas industry, shipping, off shore wind energy, coastal tourism), societal groups (eNGOs), and relevant national administrations. An Advisory Alliance would be installed for each marine region or sub-region. The Advisory Alliance formulates non-binding advice to the EU and the MSs and leave the implementation of decisions to the individual MSs. However, and in contrast to how RACs operate at present, it is envisaged that MSs would take on the role of coordination and facilitate collaboration both between MSs and between MSs and stakeholders at the regional sea level. Although this governance model is advisory in nature, and hence has no formal implementing authority in MSFD measures, the platform is intended to stimulate coordination and collaboration through soft modes of governance e.g. best practises and peer pressure.

Regional Sea Assembly

The Regional Sea Assembly (RSA) governance model proposes the establishment of a new institution. The RSA is given the exclusive competence of management of marine regions (regional sea), its natural resources, habitats and its uses. Hence an important responsibility of the RSA is to implement the MSFD, yet also to decide about other marine policies for a specific regional sea. The assembly is an entirely new governance arrangement at the level of the regional sea, with sovereign decision-making power and an elected representative body. Through elections all citizens and hence all stakeholders of the regional sea can be involved. The Members of the RSA are elected by a voting system and represent the Member States, ideally including neighbouring states (but likely impossible in practise) and the maritime sectors. The RSA has decision-making power on both operationalising and implementing maritime policies. There is a clear demarcation of the RSA from its bureaucracy responsible for the implementation processes. Decisions are taken by all the members of the RSA. The RSA will adopt binding policies for all Member States, industry and other users of the marine environment in a particular regional sea. Because the RSA is responsible for the implementation, it will also have enforcement mechanisms at hand, such as sanctioning in case of non-implementation. Consultation and advice procedures will be set up for those stakeholders who do not participate in the RSA directly.



Assessment of the governance performance

For each of the models we assessed the governance performance. Governance performance of a model is the effective and legitimate implementation of the MSFD, given the costs (in setting up and running the model and the capacity to cooperate of public and private actors) needed and the benefits achieved (in terms of cooperation, institutional ambiguity and implementation drift). The models were also evaluated by stakeholders in four regional Round Table Discussions (RTDs) (in the Baltic, the Mediterranean, the Black Sea and the Greater North Sea). When we compare the different governance models, the Advisory Alliance scores the lowest on performance. The high costs to organise participation are not rewarded by the outcome of the decision-making structure. While increased participation is strived for by many stakeholder groups, the associated governance performance is low as costs of running a model on high stakeholder involvement are high and these costs are not offset by a reduction in other governance performance criteria. The role of stakeholders is only advisory. This makes this model effective in giving insight into stakeholder preferences, but the legitimacy of implementation is low. Furthermore, the participants of the RTDs came to the same conclusion: the effectiveness of the Advisory Alliance is not guaranteed and this model could only function successfully in combination with (elements of) other governance models.

The performance of the other governance models is medium to high, with the highest governance performance for the Cross Border Platforms. An important reason for this is that the way stakeholders are involved in these models is clearly coupled to institutionalized decision-making settings. Yet even though the overall performance is comparable across the three models, the ratio between costs and benefits differs. For example, the Regional Sea Assemblies have the highest score on the benefits (high policy coordination and low degrees of ambiguity and implementation drift), but at the same time, score worst on the costs involved in creating a new decision making structure. Although there is low stakeholder involvement in the Cross Border Platforms and RSC+, these models score high on governance performance because the costs (for setting up and running the model and the capacity to cooperate) are low to medium, while the overall benefits are also medium.

Despite differences for the regional seas, the stakeholders in the RTDs perceived the Cross Border Platforms as a useful starting point for regional cooperation and the Regional Sea Assembly as the most unrealistic governance model. Stakeholders liked the general structure of the RSC+ model, because of its possibilities to contribute to integrated management of the European seas but criticised the lack of stakeholder involvement and the lack of precision of



the enforcement of decisions made of this model. The preference of the RTDs was therefore to combine the Advisory Alliance with the RSC+ to ensure both stakeholder involvement and binding decision making.

Based on the research undertaken by ODEMM in this area, we draw two important conclusions. First, stakeholder involvement at the regional level is costly and does not necessarily bring many benefits, unless it is combined with decision making power. A second conclusion is that an effective and legitimate implementation of the MSFD can only be realised by a combination of the suggested models. In addition, we have to bear in mind that because of the institutional differences of the four regional seas there is no “one size fits all” solution. Depending on the regional sea as well as the phase of implementation (e.g. defining GES, formulating programmes of measures) different hybrid models are desired.

8.3 Nested Governance Structures

The implementation of ecosystem-based management (EBM) requires the development of governance structures and coordination mechanisms at the level of the regional seas. The governance challenges to implement EBM are on the one hand to create platform(s) and hybrid governance models, which facilitate regional collaboration and coordination in relation to implementation of EBM (section 8.2), and on the other hand, to allow for coordination and to create synergies between the various sector policies and any relevant institutional setting at the broad policy level (discussed here).

The process of regionalisation of governance arrangements requires the nesting of individual sectoral governance arrangements. This nested (polycentric) governance system has to deal with the existing multi-level governance arrangements that have emerged and evolved over the last decades to govern activities such as shipping and fisheries or that focus on marine environmental protection more generally. By developing institutional linkages with these governance arrangements it could be possible to ensure a common discourse, policy objectives and decision making and implementation of sectoral measures supporting EBM objectives at the regional sea level. ODEMM developed a nested governance structure that can be used to explore how the institutional setting of the EU (as laid down in the Treaties) at the regional level (top part of Figure 8.2), can/should be connected with existing sectoral governance arrangements (lower part of Figure 8.2) for any policy or management issue (Raakjaer et al., in press).

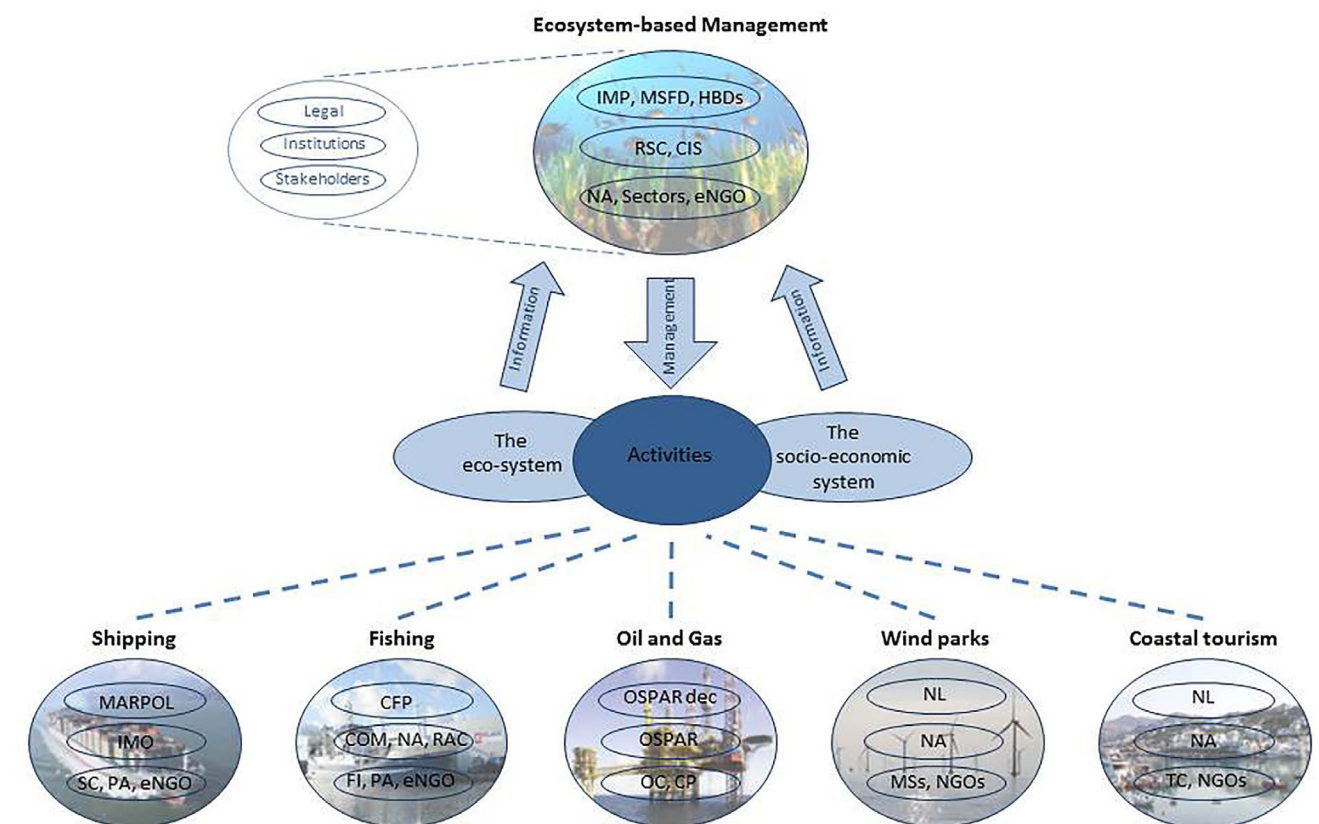


Figure 8.2 Governance system for ecosystem-based management in European seas from Raakjaer et al., in press.

Abbreviations used in Figure 8.2

CFP Common Fisheries Policy, **CIS** Common Implementation Structure, **COM** Commission, **CP** Chemical Producers, **eNGO** environmental Non-Governmental Organisation, **FI** Fishing Industry, **HBDs** Habitats and Birds Directives, **IMO** International Maritime Organization, **IMP** Integrated Maritime Policy, **MARPOL** International Convention for the Prevention of Pollution from Ships, **MSFD** Marine Strategy Framework Directive, **MSs** Member States, **NA** National Authorities, **NGOs** Non-Governmental Organisation, **NL** National Laws, **OC** Oil Companies, **OSPAR dec** OSPAR Decision, **PA** Port Authorities, **RAC** Regional Advisory Council, **RSC** Regional Sea Convention, **SC** Shipping Community, **TC** Tourism companies



To create constitutional rules and principles within this nested governance system, soft modes of governance are of vital importance. Soft modes of governance (such as the Open Method of Coordination (OMC), peer pressure voluntary agreements, etc. Diedrichs, 2008; Peters, 2006; Simpson, 2013) in the nested governance system at the regional sea levels can prove to be a useful tool for steering policy implementation, because the non-binding nature leaves room for innovative practices, the capacity for policy learning, deliberation, as well as policy coordination. For the four European regional seas (Baltic, Black, Mediterranean and the North East Atlantic Ocean) we analysed the fragmented governance situation and the challenges to realise institutional interaction and linkages. A corresponding lack of collaborative institutional interaction, between the coordinating top part of Figure 8.2 and the relevant sectoral governance arrangements in the lower part of the figure, was found across seas and sectors. For example, the RSCs which exist in each region have variable levels of interaction with certain sectors such as fishing, shipping or agriculture, limiting their influence on decision making and the potential for coordination in EBM.

8.4 The Way Forward, Towards Governance to Support EBM for Regional Seas

Our main concern is that the present governance structures (European, regional, international or national) cannot fully deal with the foreseen challenges of EBM implementation, in particular that of ensuring coordination and collaboration in a multi-governance setting with a dynamic policy environment and various stakeholder groups and interests (national authorities, economic sectors and NGOs).

Clearly EBM calls for regionalisation of the governance system to match the (sub) ecosystem (e.g. regional sea). In this process, institutional ambiguity should be eliminated where possible and regionalisation, in the sense of developing institutional interactions in a nested governance system at the level of the regional sea, should occur knowing that (in an EU context) such an approach lacks legal support from EU treaties. The reformed CFP might show a way forward for regionalisation in European marine governance drawing on soft modes of governance. We emphasise the importance of understanding the nested governance system. This could be implemented through RSCs or similar institutions (different alternative governance models explained above) serving as a coordination body. Through this, institutional interactions could be encouraged, thus avoiding duplication of activities and benefitting from institutional coexistence, while applying Open Methods of Coordination.

Another important conclusion is that governance structures need to be context dependent (as they to some degree already are) and should avoid a “one size fits all” approach, which tries to create an embroiling umbrella without taking sectoral and regional, national and sub national policy dynamics into account. Because the implementation of EBM takes place in a policy environment of nested institutions, the way forward is to mobilise and allow specific forms of institutional networking and interaction for each of the regional seas to secure collaboration and policy coordination.

To secure tailor-made regional cooperation, policy coordination and collaboration between private and public actors at the level of the regional sea, research is needed to understand a regionalised nested governance system. ODEMM has made a first step to develop governance models, and a first understanding of hybrid models for the different seas and the policy and stakeholder dynamics within the sectors in a nested governance structure.

The next research step should be the development of nested governance systems, based on in depth studies of institutional interactions and inter-linkages and a thorough investigation of how institutional interaction and soft modes of governance are emerging between the Regional Sea Conventions and sectoral governance arrangements in the implementation of the MSFD in the four regional seas. To what extent is institutional interaction facilitating the translation of the objectives of GES into management options for individual sectors? This research can focus on each individual European sea to support policy development, but can also have a comparative element in which lessons across the European seas and even across continents are investigated. The research can focus on successful examples of institutional interaction and soft modes of governance, but also on existing gaps that hamper the translation of the objectives of GES into management options for specific sectors. In addition, research can focus on how institutional interaction and soft modes of governance enhance or constrain stakeholder involvement of different sectors, industry groups and other interest groups in the different European seas. Or on how decision making authority is dispersed across European Institutions, Parties to the Regional Sea Conventions, EU member States, industry groups and other interest groups, and how institutional interaction and soft modes of governance reinforce or change decision making authority of these actors.



Chapter 9

Reflection on the ODEMM approach, how it can aid decision-making, and next steps

8.1 The purpose of the research conducted in ODEMM

The ODEMM project started with some key bounding presumptions:

“(i) the setting of high level objectives is a societal decision, (ii) science (natural and social) should provide data and interpretations so that society makes informed decisions, (iii) science (natural and social) should advise on the selection of management tools to deliver the objectives, and monitor the effectiveness of the management regime in delivering them, and (iv) it is through an informed democratic process that decisions on management regimes should be developed.” (ODEMM Description of work).

While the overall aim of the project was to provide managers and decision-makers with procedures that could help to integrate management and move away from the current fragmented system, it was recognised that environmental objectives and management decisions are ultimately societal and that the role of science is to provide data and advice to the decision making process.

The project had clear objectives of developing approaches that could fulfil this provision of data, advice and options for management and these have been presented in the previous chapters. We consider that the tools and approaches developed in ODEMM can meet key needs in implementing Ecosystem Based Management (Box 9.1). In utilising the suite of tools developed it is possible to identify (environmental) priorities and relevant potential management options to address these priorities and to then explore their effectiveness (ecological), the wider effects of the management options on ecosystem services and the complexity of their implementation (see earlier chapters for details).

Box 9.1 Value of the ODEMM approach. In a nutshell

- 1. Formalise and structure information gathered as part of initial assessments or other monitoring and assessment programmes
- 2. Prioritise the sectors and pressures for management
- 3. Prioritise the ecological components where threats to them pose the greatest risks to failing to achieve high-level policy objectives (such as the MSFD’s Descriptors of Good Environmental Status)
- 4. Generate management options (based on 2 and 3 above)
- 5. valuate management options in terms of:
 - a) Evidence of effectiveness
 - b) Evidence of costs and benefits
 - c) Governance complexity
- 6. Provide frameworks for better governance models for effective EBM implementation in different regional contexts

However, decision makers need to incorporate known information and scientific advice with other pertinent factors which may arise in a given context. In Knights et al. (2014) we presented a stepwise process that can be undertaken in decision-making around environmental policies (see Figure 9.1 below), but we also described the various uncertainties that can arise within the process of providing advice for the different steps and commented on other factors that might influence the decisions that are ultimately made, such as political will. The broader criteria that influence decision-making on choice of management measures to implement were then explored further in a high-level thematic workshop described below (Section 9.2).

9.2 ODEMM stakeholder workshop on decision making

The ODEMM thematic workshop on decision making included stakeholders involved in providing evidence for, or weighing up the evidence around, decision-making for ecosystem-based marine management policies across Europe(-see full details in Culhane et al., 2013).

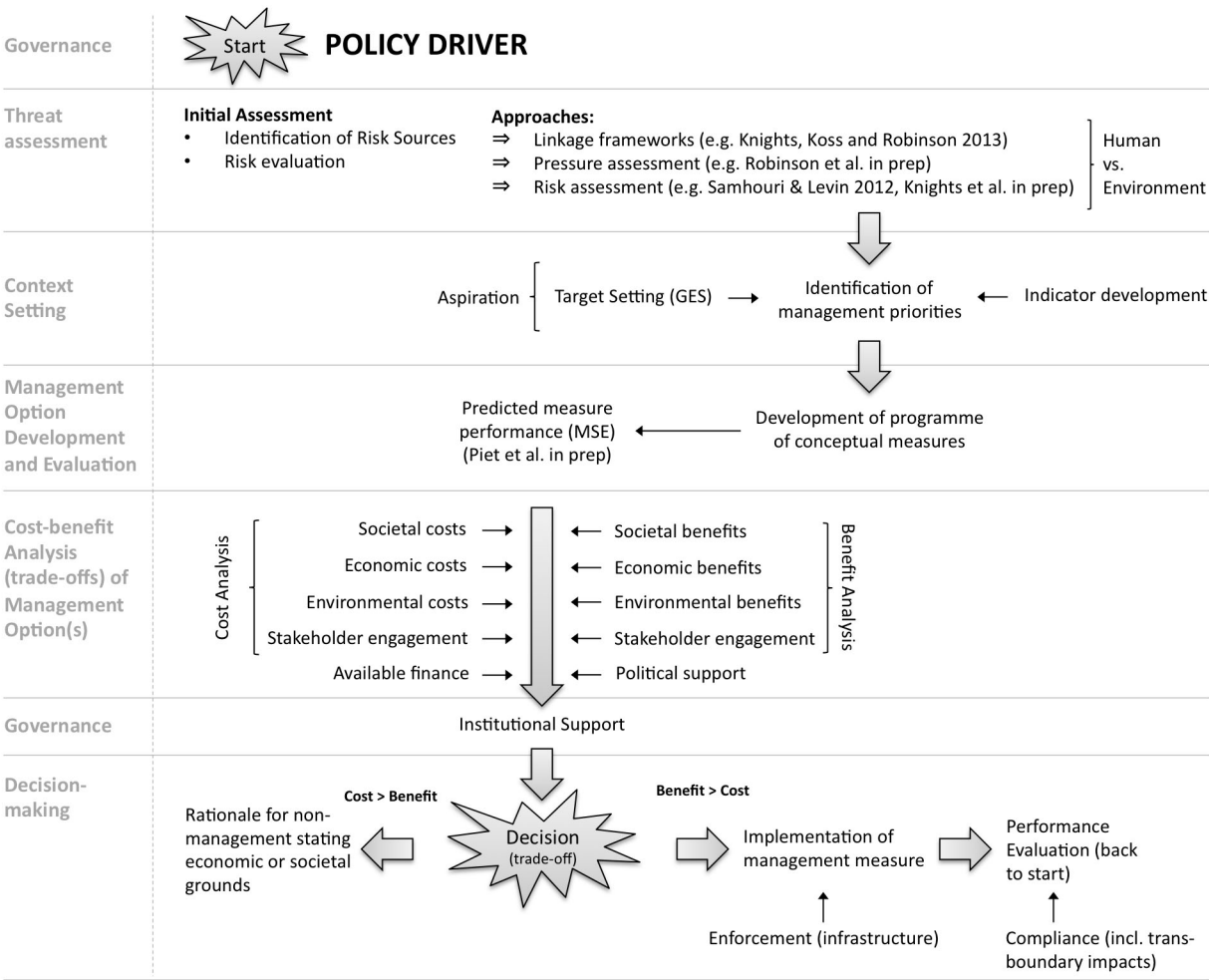


Figure 9.1 A step-wise approach to decision-making on environmental policies that utilises information from the various tools developed in ODEMM, and places these in a broader context (taken from Knights et al., 2014)

In this workshop, a list of broad criteria that may influence decision making was used as a starting point and was further developed with the participants. The decision-making criteria discussed (see Annex I in Culhane et al., 2013) can be summarised to fall under the following broad types: scientific evidence, economic evidence, stakeholder acceptance, governance organisation, coordination and cooperation, commitments to policies, timeliness of response and perceived effort of implementation. Workshop participants considered a large number of factors that may play a role in decision making in this context, however, there were some key criteria and trade-offs identified through the workshop which may be particularly relevant in practice.

It was apparent that generally, criteria prioritised in decision making are related to the scientific evidence that a management measure can achieve specific ecological objectives and that the measure will be acceptable to stakeholders. Much of the work undertaken in ODEMM has been to provide approaches that can be used to provide appropriate scientific evidence for EBM (Chapters 2-7) but we also focused on the development and appraisal of Alternative Governance Models (Chapter 8) which offer different means of how to involve stakeholders in the decision making process.

The outcomes of the workshop also highlighted that decision making is context dependent and the particular context may cause even the most important criteria to be outweighed by other factors; for example, where coordination and cooperation between neighbouring states would preclude several measures from being adopted, regardless of how they may fulfil other criteria such as improvements in ecological state. This again highlights the importance of needing to understand and provide clarity around the governance context surrounding any decision-making undertaken (see next steps under Section 9.4).

In further work, Rockmann et al (submitted) described the ‘interaction triangle’ (Fig 9.2), which presents a framework to direct stakeholders to identify their place in the interaction process. The appropriate level of interaction in a given

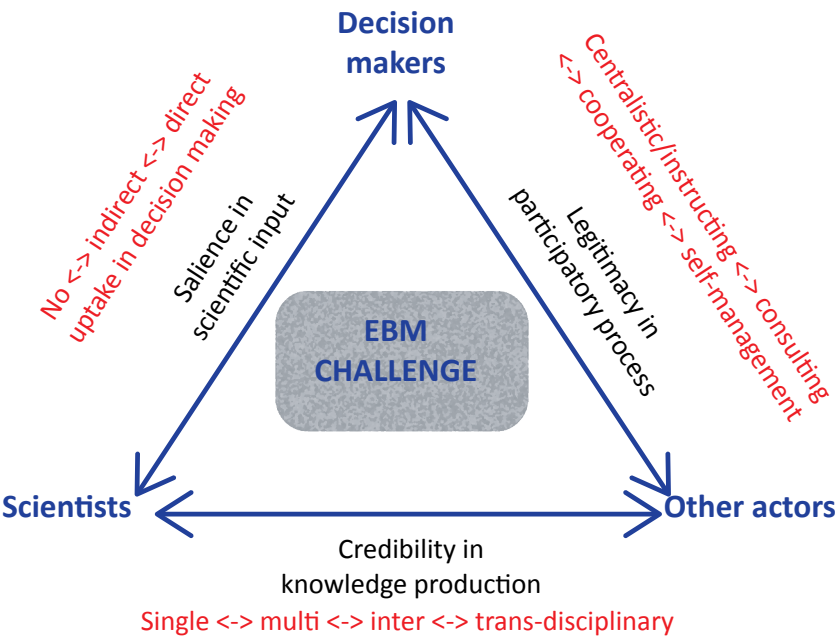


Figure 9.2 The Ecosystem Based Management triangle of interaction specifying an interaction spectrum (red) for each of the three dimensions (black) from Rockmann et al (submitted)

situation can improve implementation of EBM in terms of salience or relevance of knowledge; legitimacy or how fair and open the process is to all relevant stakeholders; and credibility or how reliable the knowledge is. Each of these contributes to how effective the EBM process can be.

The discussion surrounding stakeholder acceptance by participants was a complex issue which involved several different aspects of the process of EBM. This included having scientific and economic evidence to convince stakeholders; equitability and fairness in terms of spreading a burden across several sectors rather than targeting one sector (even if evidence suggested this one sector posed the greatest threat to achieving a policy objective, e.g. GES); perceived differences in stakeholder acceptance across states within a region; and time to gain stakeholder acceptance of desired measures. There was always a trade-off between achieving ecological objectives and gaining stakeholder acceptance and the perceived level of acceptance of measures would often automatically limit the measures that could be considered.

Overall, where stakeholder conflict may be high, it was felt that alternative management options will be required. This reflects the strong recognition that good stakeholder relationships are crucial for achieving marine environmental objectives since the stakeholders themselves are the means for change (Pomeroy and Douvere, 2008; Ehler, 2008), as well as the provisions in the MSFD for the need to consult with stakeholders (EC, 2008), and that decision-makers, such as governments, are reluctant to act without a solid evidence base to both achieve results and to defend proposed measures.

9.3 Insights from ODEMM’s regional roadshows

Building on the experience taken from the thematic decision-making workshop, we designed four regional roadshows to showcase the approaches developed in ODEMM that we felt could be most readily taken up in practice to aid decision-making around choice of management measures to implement. Specifically we asked participants to explore the types of information that would be available to consider trade-offs that might need to be made when selecting and implementing ecosystem-based management options. Participants were presented with evidence on ecological effectiveness, economic benefits and governance complexity associated with a number of management options for comparison (see Box 9.2).



Box 9.2 ODEMM’s regional roadshows

The aim of the roadshows was to present and illustrate the overall approach of ODEMM and to then focus on three different areas developed within ODEMM (‘ecological effectiveness’, ‘economic benefits’ and ‘governance complexity’) that can be used to help weigh up options for management measures against MSFD ecological descriptors. Participants were presented with three example management options (MOs) which could be implemented to lead to improvements in the MSFD descriptors Seafloor Integrity and Foodwebs and following each of the three sessions described below, participants ranked the MOs. The participants’ experience of the approaches during the roadshow was then used to further inform us of how our approaches can be used in practical decision making going forward (see Section 9.4).

Ecological Effectiveness Session

In order to achieve its main objective of Good Environmental Status (GES), the MSFD requires each Member State to “develop a marine strategy for its marine waters” while recognising that “programmes of measures executed under marine strategies will be effective only if they are devised on the basis of a sound knowledge of the state of the marine environment”. As the basis for such a marine strategy “Member states should undertake an analysis of the features or characteristics of, and pressures and impacts on, their marine waters, identifying the predominant pressures and impacts on those waters”. To that end, the session demonstrated a series of tools (covered in Chapters 3-6) that are compiled into a holistic risk-based integrated **Management Strategy Evaluation (iMSE)** tool which combines the Driver-Pressure-State concept through a risk assessment to the MSFD Annex VI “Programmes of measures”. This tool allowed participants to evaluate the potential for the three example management options to reduce the risk to the ecosystem, its component parts and the two MSFD descriptors, Seafloor Integrity and Foodwebs. Participants evaluated which sectors, pressures, ecological components and GES descriptors were affected by each example management option and determined the reduction in risk associated with each option. They then ranked the MOs based on what they experienced in this session.

Economic Benefits Session

Implementing an ecosystem approach to management involves consideration of changes in Ecosystem Service benefits related to this management. Ecosystem Services can be defined as the direct and indirect contributions of (marine and coastal) ecosystems to human well-being. The aim of this session was to demonstrate how marine Ecosystem Services can be assessed and how those results can be taken into account when comparing different management options (see Chapter 7). Management options affect the state of marine ecosystems and therefore their capacity to provide Ecosystem Services. During

Box 9.2 continued

this session, these effects were assessed in a stepwise approach: the ecological effectiveness session was taken as the starting point with the reduction in risk to each ecological component that is associated with the three example MOs provided. It was argued that a reduction in risk to an ecological component translates into an improvement in state of that ecological component and, thus, into an increased capacity for the provision of Ecosystem Services. An approach to identify which ecological components contribute to the provision of which Ecosystem Services was then explained and participants were also given the opportunity to estimate how strong these links were. These two steps were then brought together in order to identify (for each Ecosystem Service) which MO has the highest potential to increase Ecosystem Service provisioning. In this session, participants experienced and applied this stepwise approach for each of the three example management options in order to estimate how management options can cause changes in human well-being. Results were then used to inform a second ranking of the MOs based on what had been experienced in this session.

Governance Complexity Session

The objective of this session was to take into account the complexity of the governance system and (lack of) institutional interaction when comparing the likelihood of adoption and implementation of the three example MOs. To achieve GES in 2020, national programmes of measures consisting of a variety of MOs will be adopted in 2015. The governance system facilitating implementation of the MSFD and the adoption of these MOs should not only be about coordinating MSFD implementation at the EU and regional levels. It is important to also consider how to create institutional interaction with existing sectoral governance arrangements such as those for shipping, fishing, oil and gas production, offshore wind park development and coastal tourism. Thus, governance structures to accommodate MSFD implementation easily become complex due to the need to account for sectoral laws and policies, existing institutional structures and stakeholders that will be influenced by the adoption of MOs. This session aimed to identify the complicated governance system associated with each MO. ODEMM’s nested governance system (described in Chapter 8) was used to help structure the session, and following completion of the mapping of the governance structures for each MO, participants completed a final ranking of the MOs based on what had been experienced in this session.

On completion of all sessions an open discussion was held on the experience of the participants, in particular covering whether the original perceptions of participants, on how relevant and useful MOs might be, had changed following their experiences of the approaches described above.

On completion of the four regional roadshows, some broad themes emerged in terms of the experience of the participants in trying out the ODEMM approaches:

1. The ODEMM approach has a pragmatic aspect for real-world implementation in the current political and economic climate.

“can envisage using this roadshow info to look at approaches and to prioritise what areas of MSFD we need to concentrate on especially with limited budgets in mind”

“proposed scheme is very practical”

“practical approach to link management options with potential changes in the provision of ecosystem services”

“concept definitions and systematic approach are in line with the Plan Bleu work and experience on ECAP/Indicators/Participative approach”

2. The ODEMM approach can facilitate the provision of evidence which can be used to both inform decision makers and present to other stakeholders. Participants at the ODEMM roadshows felt that the approaches laid out by ODEMM achieved a rationale for prioritisation of management options that can be upheld by policy-makers.

“Achieving a logic for priorities that can be defended by policy-makers”

“Provides a formalised structure against which to test decisions and may lead to questioning of assumptions”

“More structured vision of ecosystem services”

3. The holistic perspective incorporated in this approach offered improved understanding of the system and the process of assessing options.

“improved understanding in evaluation of alternative [Management Options] MOs”

“the perception on how the sea ‘works’ and the need to challenge that”

“...to reconsider my personal perspective on certain issues”

“Gaps (data gaps or other) are revealed using these tools”



“an approach to classify and visualise the governance landscape”

4. It was also noted that the approach provides a practical way of linking management options with potential changes in the ecosystem and ecosystem services and focus on those options which may be the most successful.

“enables managers to focus actions on options most likely to have an impact”

“the approach is helpful to structure available information and identify where there may be the highest impacts of management options”

9.4 The way forward, where to from here

The role of the ODEMM approach is to provide a solid evidence base to inform decision makers and allow them to make trade-offs with the necessary information available. The tools and approaches do not give the ‘right’ answer but allow decision-makers to consider trade-offs and likelihood of management success. Despite any inherent subjectivity in the approach, the ODEMM framework captures ecosystem complexity and translates this into simple metrics (i.e. single figures in each cell of a matrix) that allow comparison across management options. We consider this to be a starting point for EBM implementation and a flexible approach which can adapt to changing needs.

The approaches we have developed to date are what we consider to be best practice with the available knowledge and techniques that we currently have at our disposal, but naturally, these can be improved and built on. The following section is a reflection on how we can move forward with improving EBM, based on feedback from our roadshow participants on the ODEMM tools and approach, as well as feedback from our Advisory Committee and lessons learnt by the project team. We believe that moving forward with implementation of EBM requires both advances in research and in the practical organisation of how management of the marine environment takes place (see summary in Box 9.3 and detail following).

Box 9.3 Ten steps to moving forward with successful implementation of EBM, where numbers do not indicate any order of importance, but link to the numbered points made in Section 9.4 below

1. Making use of what we have now in practice
2. Using ODEMM tools to identify gaps and priorities for research
3. From governance complexity to governance clarity
4. Working at multiple spatial and temporal scales
5. Moving forward with Cost-benefit analysis
6. Environmental drivers and indirect effects
7. Holistic assessment, expert judgement and confidence
8. A fully linked up ecosystem approach in EBM
9. Interdisciplinary working and benefits for EBM
10. Need for adaptive and responsive management to meet expectations of EBM

1. Making use of what we have now in practice

Successful trialling of the ODEMM approach through the series of regional roadshows revealed that the resources available (www.odemm.com) can already be of use to those working in practice. There is a particular relevance to implemen-

tation of the next stage of the MSFD process in Europe in terms of selection of suitable programmes of (management) measures. However, it is clear that the level of expertise required to make use of the tools should not be underestimated, and at this stage, ODEMM experts would still be needed to guide users through any applications. It is important that the analyses undertaken are not oversimplified, nor applied to objectives for which they have no suitable purpose. ODEMM experts will work with those interested in application of the approaches directly and initiatives are underway to work with agencies and government departments in a number of countries, as well as with regional sea conventions and through collaborations with ongoing research projects.

In further development of this work, time will need to be committed to making the resources more accessible and user-friendly, such that it will be possible for suitably qualified individuals to apply the approach without direct use of ODEMM partners. However, it was clear from the experience of the project team, the advisory committee and all stakeholders who experienced the ODEMM approach that for any institution to really engage with EBM, a truly interdisciplinary team needs to be put together. Different departments working separately to advise on different aspects of evidence required to inform EBM will be flawed (e.g. economics teams working separately to those preparing the advice on state of the ecosystem) (see point 9 below).

2. Using ODEMM tools to identify gaps and priorities for research

There is already a substantial amount of information that can be taken from the application of the ODEMM tools to date, on knowledge gaps and data limitations. As one example, the confidence assessments that accompany the ODEMM pressure assessment database (see Chapter 4) reveal that there are particular pressures that are amongst the most widespread in terms of the potential to affect our regional seas, but that are actually still very poorly understood in terms of the thresholds at which they start to really cause noticeable detrimental impacts to the different components of our ecosystems (e.g. marine litter). A useful standalone exercise will be to analyse the various ODEMM resources for gaps to draw up a list of priorities for research.

3. From governance complexity to governance clarity

A significant concern emerging from the research undertaken in ODEMM is that the present governance structures (European, regional, international or national) cannot fully deal with the foreseen challenges of EBM implementation, in particular that of ensuring coordination and collaboration in a multi-governance setting with a dynamic policy environment and various stakeholder groups and



interests. This issue clearly requires further attention, as a lack of governance clarity will continue to undermine any implementation of policies such as the MSFD.

ODEMM has made a first step to develop governance models, and a first understanding of hybrid models for the different seas and the policy and stakeholder dynamics within the sectors in a nested governance structure. The understanding of governance complexity needs to be taken further to bind this to systematic decision making (see suggestions on next research steps in Chapter 8) and the need for the approaches developed to provide governance clarity has also been emphasized by both the advisory committee and participants of ODEMM's roadshows.

As with all aspects of the ODEMM approach, we believe it is the holistic understanding of complexity that can ultimately be used to highlight clarity. In this context this may be by indicating governance settings and modes that allow certain policy objectives (e.g. elements of ecosystem integrity and health) to always be retained. We foresee a key part of our ongoing research to be to develop further the understanding of the linkages within the ecosystem, where this ultimately can also highlight governance structures that are most relevant to particular issues in EBM (see point 8 below).

4. Working at multiple spatial and temporal scales

We set out in ODEMM to develop and test methods that could provide evidence for regional-sea scale EBM with a focus on the current situation and future scenarios for comparison of management options. However, all of our approaches can be applied over different spatial scales and time horizons, and there is a clear need to pursue this further. Many of the participants of our roadshows and workshops felt uncomfortable with results presented at the scale of regional seas (even if policies may require such assessments) and there is an obvious need to apply the analyses across multiple scales (regional, sub-regional, national and local) to explore how priorities might change and how they can be related to those that are relevant at different scales (and different policies). Furthermore, we can learn from history in terms of exploring how our ecosystems differed under historic policy commitments, human drivers and environmental conditions. This is an area that can be developed further in the application of the ODEMM approach.

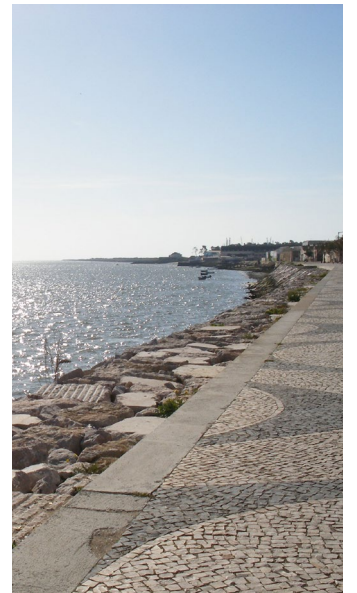
In addition, we found that the interdisciplinary work required by EBM presented its own challenges in terms of selection of the appropriate scales at which to

work. For example, there is a significant research cost associated with up-scaling high-resolution economic analyses to match with regional-scale ecological analyses, and the scale at which actual marine management occurs also depends on governance regimes that may operate over various scales. Consideration of the appropriate scales and time horizons of analysis for the various disciplines required to provide the advice for EBM, is an obvious next step in progressing the interdisciplinary research required here (see Point 9).

5. Moving forward with Cost-Benefit Analysis

We had originally set out in ODEMM with the objective of completing full cost-benefit analysis (CBA) on management options for every case study explored. This would be based on an ecosystem services approach where benefits were described in terms of change in value of ecosystem services following change in state of the ecosystem under management scenarios, and costs of implementation and operation would be weighed up against these. Ultimately this was not possible given the gaps in both understanding and methodology discovered, but advances were made on how to account for changes in ecosystem services and costs in a holistic manner. Work undertaken clearly illustrated that without an overall and complete assessment of change in supply of ecosystem services and costs arising from implementation of different management options, policy choices may not be economically efficient, and will easily miss key trade-offs (see examples described in Chapter 7).

We would therefore argue that CBA based on an ecosystem services approach should still be pursued as the appropriate methodology for incorporating economic and social trade-offs into EBM, and the feedback we received from our roadshow participants and advisory committee was that they were indeed pleased that progress was at least being made in this area. We caution against the use of cost-effectiveness analysis (CEA) on its own, because it is likely to miss co-benefits arising under particular management scenarios, and thus will more likely favour management options where costs are limited regardless of the potential long-term gain in economic and social benefits. We do, however, acknowledge there is a still much progress to be made on an ecosystem service type approach to CBA, but have developed suitable typologies and approaches to move this forward (Chapter 7) and will continue to work in this area.



6. Environmental drivers and indirect effects

Our initial premise in ODEMM was to focus on issues that can be managed (i.e. identifying human drivers and activities whose threats are manageable), and as such less consideration was given to the role of indirect effects, nor was there explicit consideration of environmental drivers (although these were of course reflected in the setting of the context for any scenario covered). In future work, we will explore these aspects further, for example using decision trees or Bayesian networks to identify critical pathways in management response that are limited by the proliferation of indirect effects and/or environmental drivers under particular conditions. We will also consider how the uncertainty associated with stochastic responses in ecosystems (see examples in Knights et al., 2014) can be expressed and clearly communicated in our confidence assessments. As discussed with our roadshow participants, the need for clear communication of confidence in evidence provided is critical, particularly where the approaches used utilise expert judgement for some aspects of the assessment (see Point 7 following).

7. Holistic assessment, expert judgement and confidence

ODEMM tools do not provide concrete answers but good quality and unbiased information to allow managers to reach a decision. There are aspects of expert judgement used with all approaches, but as has recently been pointed out by Barnard & Boyes (2013), the move from single species/single issue advice to the ecosystem-level advice required by EBM is simply not possible without elements of expert judgement. Yet the use of expert judgement is met with some resistance still in the field of marine ecosystem science, advice and policy despite the fact that it is used widely across disciplines including public health assessment, structural engineering, nuclear safety and air traffic control (see review in Barnard & Boyes, 2013). It is essential that it is recognised that factors which cannot be quantified, may be just as, if not more important, than those that can.

As described in Chapter 1 of this report, ODEMM had five key principles around which our work was based; principles II and III describe the need for holistic assessment, where analyses must thus be able to work in both data-poor and data-rich situations, and must thus be structured, transparent and repeatable. These principles will in most situations lead to the need for expert judgement and our advisory committee and roadshow participants commented on the benefits of being presented with approaches that allow the complete picture to be represented when weighing up management options, whilst cautioning the

need for transparency, particular in terms of the communication of uncertainty/confidence. We still defend our key principles as being central to EBM implementation, but will look to moving forward and learning from best practice in the use of expert judgement and communication of uncertainty from other disciplines. Barnard & Boyes (2013) provide an excellent introduction to this area.

8. A fully linked-up ecosystem approach in EBM

A key aspect of the ODEMM approach is the linkage framework and detailed linkages described between human drivers (sectors), pressures, ecosystem components, policy objectives and ecosystem services (see Chapter 3). We also developed other approaches that help to structure the view of the ecosystem; for example, the nested governance model that helps to identify the relevant actors around any management option (see Chapter 8) and the typologies defined to capture the full cost and benefit landscape associated with full trade-off analysis. We argue that classification and visualisation of the landscape within which advice is presented for EBM is absolutely key and the provision of clear definitions for pressures and ecosystem services and the identification of relevant management scales, institutions, stakeholders, laws, and policy objectives has been a major achievement of the project.

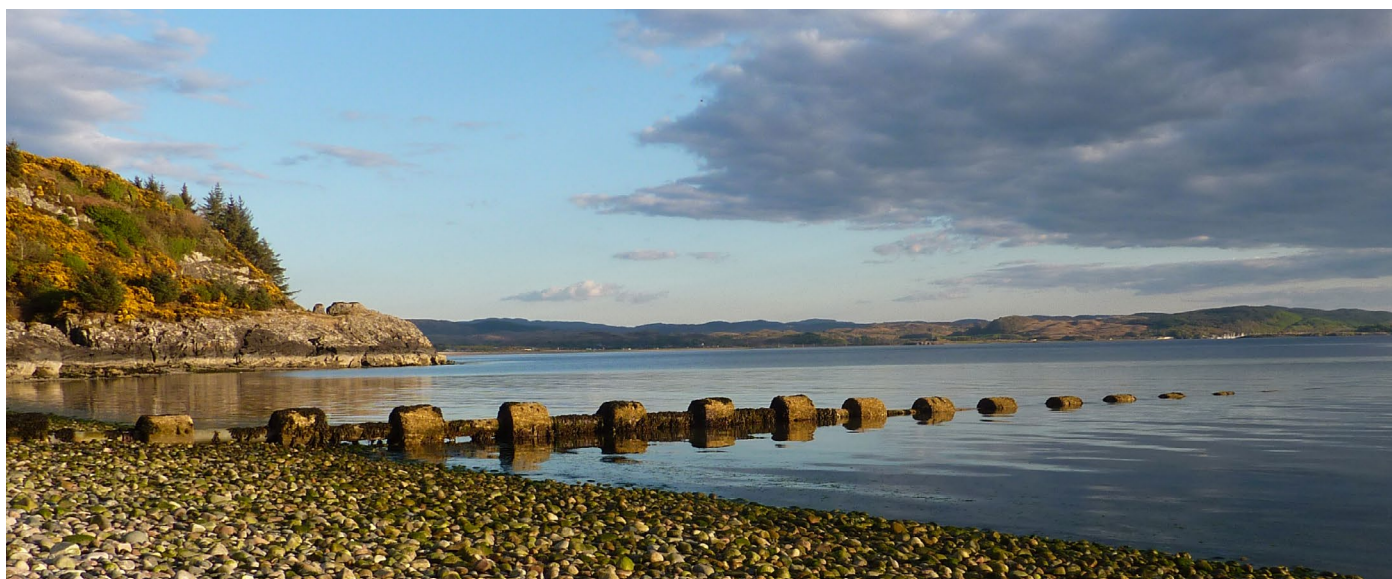
There is much more that can be done here, however, including the potential to compare across/examine relatedness and conflict between policies through linkages into the different components already described in our linkage frame-



work, and the potential to extend linkages through management options into the different levels of governance hierarchy for some clear test examples. An approach is described in Chapter 6 whereby the type and focus of management options can be used to link to relevant aspects within the broader linkage framework (e.g. joining up MOs with relevant sectors, pressures and/or ecological components). It is also recognised that future work could expand on this to include linkages between relevant laws, policies, institutes, and stakeholders (the governance setting) and the aspects already included in the ODEMM linkage matrices (e.g. from stakeholder groups or policies to sectors or ecological components).

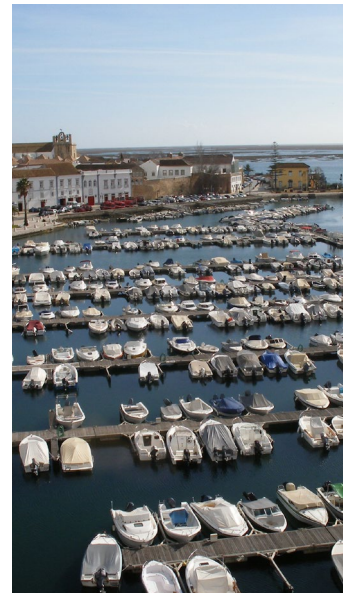
9. Interdisciplinary working and benefits for EBM

The ODEMM experience highlighted that implementation of EBM will always require teams that are truly interdisciplinary in nature. At the same time, the efforts required to move forward the understanding and methodology within each individual discipline, meant that there was less time available to fully develop the interdisciplinary aspects of the project. The advisory committee and participants of our roadshows were impressed by the level of cohesion in the project across disciplines, and the project team felt a great deal of satisfaction future work should have designated milestones and deliverables that focus entirely on moving forward interdisciplinary working (e.g. sabbaticals and exchanges for project team members to experience working amongst teams from the different disciplines on core aspects of work). In addition, we have highlighted above a number of aspects of work that would help to build up the interdisciplinary nature of our work (see points 4 and 8).



10. Need for adaptive and responsive management to meet expectations of EBM

Finally, we emphasise the importance of adaptive management in responding to the outcomes from approaches such as those developed under ODEMM; to be holistic in approach (as EBM demands) we are working in a data-poor environment with many uncertainties and as more information becomes available (e.g. better information on the state of our ecosystems, or the value given to particular ecosystem services) results should be reviewed and advice to management updated. If it is not possible for management to respond to this evolving evidence base, then the whole process of EBM will be undermined. Furthermore there must be mechanisms in place whereby management options can be appropriately enforced; without this, efforts to implement EBM are rendered futile; yet a review by Long (2012) highlighted that there are currently many gaps in terms of legal mechanisms to ensure compliance with management implemented under EBM. This suggests a need for change at the level of operational management and legal policy but another important step forward in the research environment will be the consideration of how soft modes of governance might be associated with different response levels to management where legally binding enforcement is perhaps missing.



Above we have highlighted a number of clear avenues for furthering the research to underpin advice for successful implementation of ecosystem-based management of marine ecosystems. ODEMM provides some very useful starting points for delivering EBM (resources at www.odemm.com) and we look forward to moving forward in this area.

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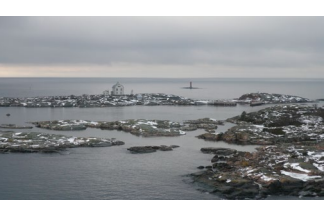
PHOTOGRAPH ACKNOWLEDGEMENTS



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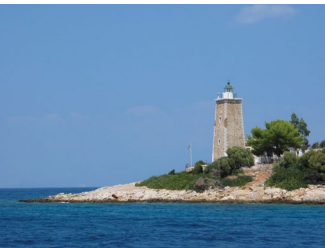
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ODEMM is funded by the EC under FP7

ISBN Number: 978-0-906370-89-6