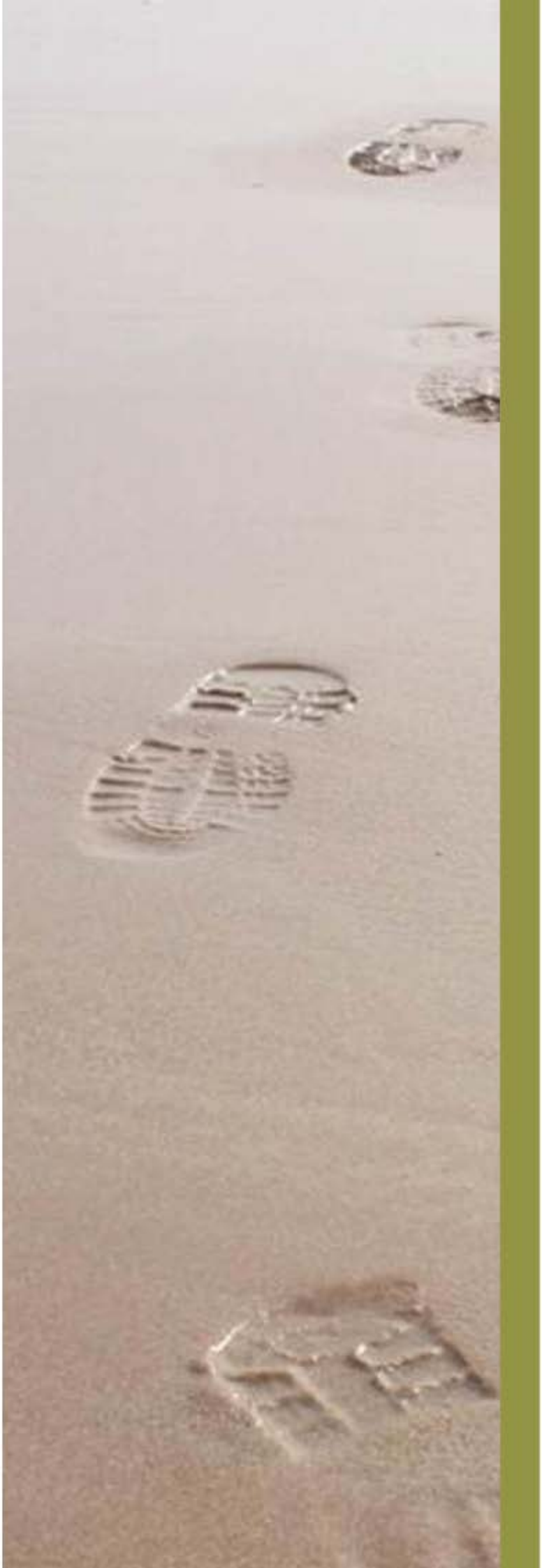
Marine Management Organisation

Practical Framework for Outlining the Integration of the Ecosystem Approach into Marine Planning in England

MMO Project No: 1048



Practical Framework for Outlining the Integration of the Ecosystem Approach into Marine Planning in England

MMO Project No: 1048

Project funded by: The Marine Management Organisation

Report prepared by: eftec and ABPmer

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List of Acronyms

AA	Appropriate Assessment
BALANCE	Baltic Sea Management — Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning
BAU	Business-as-Usual
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CEA	Cumulative Effects Analysis
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
DECC	Department of Energy and Climate Change
Defra	Department of the Environment and Rural Affairs
DFO	Fisheries and Oceans Canada
DPSIR	Drivers, Pressures, State, Impact, Response
DPSWR	Drivers, Pressures, State, Welfare, Response
DSS	Decision Support System
EcoQos	Ecological Quality objectives
EA	Environment Agency
EBM	Ecosystem Based Management
EGS	Ecosystem Goods and Services
EIA	Environmental Impact Assessment
ES	Ecosystem Services
ESIA	Environmental and Social Impact Assessment
ESSIM	Eastern Scotian Shelf Integrated Management
EU	European Union
GES	Good Environmental Status
GIS	Geographical Information System
HBDSEG	Healthy and Biologically Diverse Seas Evidence Group
HLMOs	High Level Marine Objectives
HRA	Habitats Regulations Assessment
IA	Impact Assessment
ICES	International Council for the Exploration of the Seas
IMP	Implementation and Monitoring Plan
JNCC	Joint Nature Conservation Committee

km	Kilometre(s)
MCA	Multi Criteria Analysis
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MEA	Millennium Ecosystem Assessment
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
MRV	Marginal Resilience Value
NCC	National Capital Committee
NEA	National Ecosystem Assessment
NGO	Non-Governmental Organisation
NOC	US National Ocean Council
NPS	National Policy Statement
PA	Pressure Assessment
ODEMM	Options for Delivering Ecosystem-Based Marine Management
ONS	Office of National Statistics
OSPAR	Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
PISCES	Partnerships Involving Stakeholders in the Celtic Sea Ecosystem
SA	Sustainability Appraisal
SAC	Stakeholder Advisory Council
SEA	Strategic Environmental Assessment
SEP	Strategic Evidence Plan
SIC	Standard Industrial Classification of Economic Activity
SPP	Statement of Public Participation
TESSA	Toolkit for Ecosystem Service Site-based Assessment
TraC-MImAs	Transitional and Coastal Waters Morphological Impact Assessment System
UKMMAS	UK Marine Monitoring and Assessment Strategy
VMS	Vessel Monitoring System
WFD	Water Framework Directive

Executive Summary

In undertaking marine planning, the Marine Management Organisation (MMO) is required by the Marine Policy Statement (MPS) to use the ecosystem approach, in particular to ensure that human pressures are kept within levels compatible with the achievement of environmental objectives. The aim of this study is to outline an operational framework that demonstrates how MMO can improve the implementation of the principles of the ecosystem approach in marine planning. The need to manage crowded usage of sea waters involving activities with the potential for significant impacts on marine ecosystems (both positive and negative) is increasing. Equally, experience with the development and implementation of marine plans is also growing. It is expected that marine plan policies will become more specific and directional in order to account for the important goods and services derived from marine ecosystems and the multiple and cumulative impacts of human activities in these systems. Application of the ecosystem approach within marine planning will therefore become increasingly important in supporting sustainable development.

The proposed framework for improving the use of the ecosystem approach is intended to help with preparation of marine plans, and aims to amalgamate ecosystem approach principles with MMO's marine planning process. This work is a resource for a range of stakeholders interested in marine planning: MMO, policy makers (e.g. Defra), other planning and licensing bodies (e.g. local planners), and those with interests in the marine environment, both commercial (e.g. businesses, The Crown Estate), and non-commercial (e.g. Non-Government Organisations).

This study has reviewed the ecosystem approach principles outlined through the Convention on Biological Diversity (CBD) (the 12 Malawi Principles, Figure 1 page 13). It suggests a slightly modified set of ten principles (below) that are suitable for application in marine planning.

1. Clear long-term ecosystem objectives, targets and indicators against which progress can be monitored.
2. Integration of social and economic factors.
3. Establishing a robust dynamic baseline.
4. Considering all forms of information.
5. Engaging with all relevant sectors.
6. Monitoring, review and adaptive management.
7. Conserving ecosystem structure and function and managing within functional limits.
8. Adopting a co-ordinated and integrated approach to management of human activities.
9. Using appropriate spatial and temporal scales.
10. Planning and management should be decentralized to the lowest appropriate level.

These ten principles highlight several key issues for marine management:

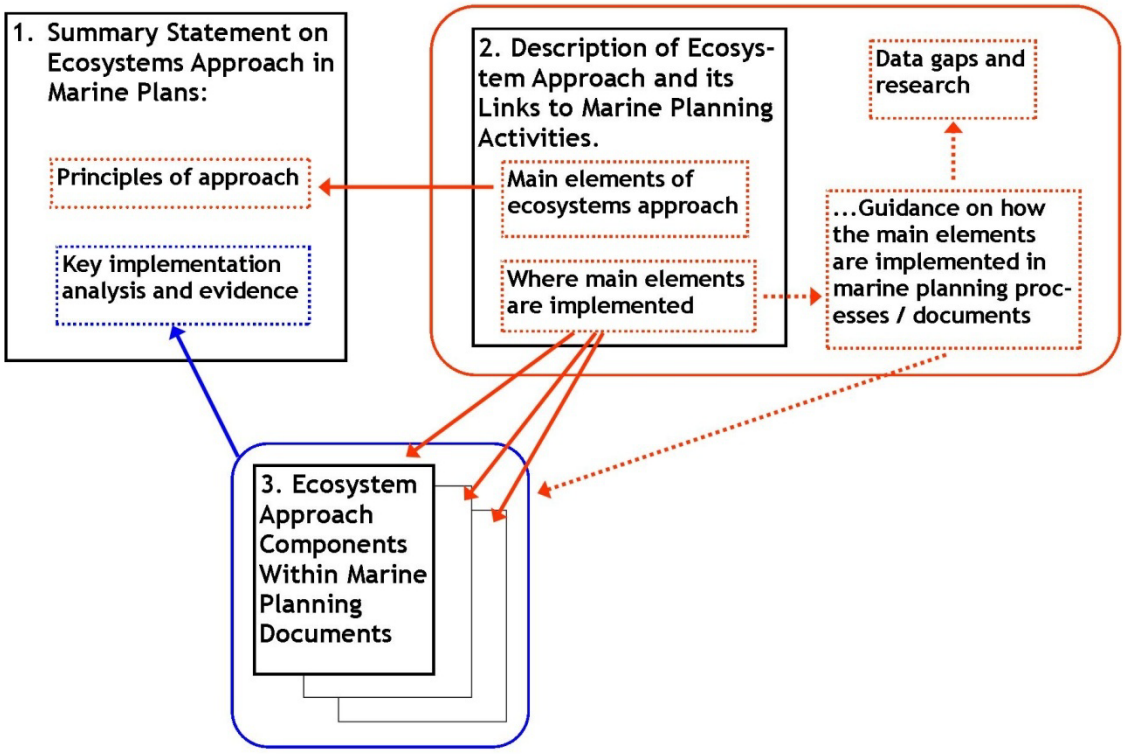
1. Emphasis is placed on the importance of setting clear ecosystem objectives as a fundamental part of the management system to deliver the ecosystem approach.
2. Building on recognition that change is inevitable, importance is placed on monitoring and adaptive management.
3. The importance of having a robust baseline against which to measure and manage change is emphasised.
4. The economic context within which the ecosystem approach is applied is explicitly defined as including social analysis.
5. Recognition is also given to the consideration of cumulative effects and thresholds, and on the requirement for co-ordination and integration across marine sectors.

The report then describes a framework through which to record and demonstrate implementation of the ecosystem approach in marine plans and identify actions to make improvements. The framework involves:

- A summary statement in the marine plan, summarising the extent to which the ecosystem approach is incorporated in the plan and how it is implemented.
- A more detailed description in the plan of how the ecosystem approach is defined (i.e. through the ten principles defined in this report), and reflected in the marine planning process and related sustainability appraisal tools.
- Supporting plan guidance that outlines where detailed information and analysis that contribute to implementing the ecosystem approach are expected to be within other marine planning documents (e.g. if ecosystem services analysis is used in the Sustainability Appraisal (SA) of the marine plan).

This framework is illustrated in Figure S1.

Figure S1: Outline of Framework for Implementing the Ecosystem Approach in MMO's Marine Planning.



To develop this framework, the project held two workshops: one at the outset of the project with MMO to understand requirements and the marine planning process; and one in November 2013 with stakeholders to gain views on the draft findings from the project, draw on their expertise and influence the framework development. The second workshop reviewed the framework and a draft assessment of whether, and to what extent, existing marine planning activities led by MMO implement the ten revised principles. This assessment looked at current marine management practices and evidence, and also at a case study of the East Marine Plans.

The assessment positively identifies that contributory work is underway to implement the ecosystem approach in marine planning, particularly in terms of the participatory process used. However, other aspects of the ecosystem approach are not being fully implemented due to lack of evidence. Some elements of this can be taken forward through existing processes, which will contribute evidence and analysis, in particular, the development of Marine Strategy Framework Directive (MSFD) evidence, sustainability appraisals and potentially Impact Assessments (IAs).

Some implementation gaps can be filled through improved practices, led by MMO and other organisations. However, a number of key gaps require better evidence and assessment tools before meaningful progress can be made. In particular, better spatial data are required on important ecosystem elements, together with improved information on the spatial distribution and intensity of human pressures to facilitate spatial assessment of cumulative impacts.

The other marine management processes and authorities that marine planning will interact with in implementing the ecosystem approach reflect the prevailing

institutional and legal arrangements applying to the planning areas. International experience highlights few examples of practical application. Where application occurs there has been a struggle to achieve practical or detailed implementation owing to a lack of political will, the lack of a supporting legal framework and/or a lack of data and suitable assessment tools. These are likely to be barriers to implementation by MMO. Of the examples considered, most of those that have been applied in practice have tended to focus on the achievement of environmental ecosystem objectives rather than integration with economic and social objectives. However, the production of both an SA and an IA to accompany each marine plan offer opportunities to address this challenge in future in English waters.

Recommendations are made throughout this report on how to develop implementation of the ecosystem approach in marine planning. These are collated in Section 6, and summarised below.

Summary of Recommendations

This report identifies that while relevant structures and processes are in place within the MMO marine planning process to implement much of the ecosystem approach, further work is needed to ensure its full implementation. Many requirements are identified mainly in relation to evidence and assessment tools. Realistically, it will only be possible to address some of the data gaps in the medium to long term, and in the meantime risk-based approaches incorporating expert judgement will be necessary to deal with uncertainty. It is recognised that full application of the proposed framework for applying the ecosystem approach is potentially costly and time consuming. It is therefore important that any effort applied to more detailed assessments of impacts is done in a proportionate manner.

Detailed recommendations are provided in Section 6 of this report, where they are linked to both the implementation of the ten principles defined in this report and to MMO's planning process. Key recommendations relate to improving the availability of data to support implementation of the ecosystem approach, such as:

- Informing marine decision-making and management with better understanding and analysis of ecosystem thresholds and limits (e.g. by applying concepts of natural capital, and analysis of the resilience value of marine ecosystems).
- In the absence of quantified social and/or economic values, undertaking qualitative analysis of the impacts of marine planning on human activities and of human activities on marine Ecosystem Services (ES).
- Better developed analysis of the cumulative impacts of human activities on the marine environment is required. This is dependent on the availability of good quality spatial data on ecosystem elements and human pressures to facilitate meaningful spatial analysis.
- Developing knowledge of marine ES and how these will change in response to marine management, particularly marine planning. A broad effort across the marine research community will be needed to address this gap, through long-term iterations of evidence on the significance of different marine ES and mapping of the extent and condition of marine features supporting these services. In the meantime, MMO should focus on making best use of existing data and information, supported by expert judgement.

It is recommended that links to processes that generate information used in marine planning are developed further. In particular, MSFD implementation will clarify information for descriptors related to ecosystem structure and function. Marine plans will benefit from input from supporting economic analysis, for example assessing changes in ES and the distribution of impacts amongst social groups.

Further recommendations for actions by MMO in stakeholder engagement are identified across different time scales and can be applied by others.

- Integrate socio-economic factors, and discuss the key trade-offs presented by marine plan options, moving towards co-decision making.
- Use social media or other options for outreach to those groups that have been less successfully engaged through traditional routes.
- Standardise use of well-developed and consistently applied future scenarios and data products with other marine organisations.
- Transparently assess the suitability of information inputted by stakeholders for use in marine planning.
- Demonstrate to stakeholders how their views have been taken into account.

Finally, it should be noted that implementing the ecosystem approach in marine planning is an ongoing process, aiming to achieve sustainable development, which will continue after a marine plan is produced. MMO should continue to work with stakeholders in plan areas following plan adoption to monitor and review the effectiveness of policies, and to revise plan policies where necessary. The marine planning framework established by Marine and Coastal Access Act (MCAA) provides the opportunity for more local plans to be produced, and MMO should consider the merits of developing these where they might support decentralized management.

1. Introduction

The aim of the study is to outline an operational framework that demonstrates how the Marine Management Organisation (MMO) can improve the implementation of the ecosystem approach in marine planning. The Marine and Coastal Access Act[1] 2009 (MCAA) introduced, among other things, a statutory system of marine planning. The marine planning system comprises a UK wide Marine Policy Statement (MPS) and provisions for the preparation and adoption of a series of regional marine plans. Within English inshore and offshore waters, MMO has responsibility for marine plan making (S.50 MCAA). The Act requires that decisions should be made in accordance with the MPS and plan policies unless material considerations indicate otherwise.

The MPS requires marine planning to use the ecosystem approach, in particular to ensure that human pressures are kept within levels compatible with the achievement of good environmental status; that does not compromise the capacity of marine ecosystems to respond to human-induced changes; and that enables sustainable use of marine goods and services. Relevant environmental objectives include those established by the Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD) and other European legislation, as well as broader environmental targets.

To meet these environmental objectives, the concept of Ecosystem Services (ES) which are defined by the Millennium Ecosystem Assessment at provisioning, regulating, supporting and cultural (discussed further in Section 5.7), and of maintaining and enhancing natural capital, become relevant considerations for marine planning. Marine planning will influence the organisation, location and timing of marine human activities. The extent of these activities may be in line with existing policy objectives, but in making them more explicit, marine planning has the ability to influence the condition of marine ecosystems and the levels of goods and services society obtains from them. In addition, given the ongoing changes in the marine environment (in line with the ecosystem approach's recognition that change in inevitable, for example due to climate change), even if marine planning results in maintaining the status quo its consequences may still be that ES are changed. ES should therefore be taken into account within marine planning, building on existing work.

The proposed framework for improving the use of the ecosystem approach is intended to be used to prepare marine plans. It aims to amalgamate ecosystem approach principles with MMO's current marine planning process.

This work is aimed at the range of stakeholders involved in marine planning:

- MMO
- Policy makers such as Government departments
- Other planning and licensing bodies (e.g. local planners), and environmental bodies (e.g. Natural England, Joint Nature Conservation Committee (JNCC))

[1] http://www.legislation.gov.uk/ukpga/2009/23/pdfs/ukpga_20090023_en.pdf accessed 09/05/14.

- Those individuals and organisations with interests in the marine environment, both commercial (e.g. businesses, The Crown Estate), and non-commercial (e.g. Non-Governmental Organisations (NGOs)).

It can inform these audiences in different ways:

- Shaping actions taken by MMO and its partners in undertaking marine planning, such as to:
    - Generate the necessary evidence on which to base plans
    - Monitor compliance with particular environmental and ecosystem objectives, to avoid duplication of effort and to ensure that the information collected is fit for purpose
    - Communicate with stakeholders.
- Helping all stakeholders understand MMO's actions in implementing the ecosystem approach
- Providing a framework through which other organisations (e.g. NGOs) can follow MMO's implementation of the ecosystem approach

Part of the purpose of this study is to examine how MMO is currently applying the ecosystem approach and the strengths and weaknesses of current implementation. In applying the ecosystem approach, MMO needs to ensure it is compatible with the requirements of MSFD and national level MSFD implementation. It can also take into account other objectives like those for developing sources of renewable energy from the marine environment, economic growth, the European Blue Growth Strategy and the proposed Marine Spatial Planning Directive. The marine planning process balances these requirements.

Impact Assessments (IAs) may be produced for other marine policy decisions (e.g. related to ongoing MSFD implementation). These sources of economic evidence are referred to as 'supporting economic analyses' and their role in improving the implementation of the ecosystem approach in marine plans is discussed in relevant sections of the remainder of this report. There was no Impact Assessment (IA) required of the East Marine Plans. At the time of writing this report, Better Regulations Executive guidance now advises that an IA will be required for individual marine plans and will be subject to the Reducing Regulation Committee clearance. Marine plans can improve their implementation of the ecosystem approach by drawing on the ongoing development of economic analyses of related marine policies, such as of MSFD targets and management measures, Sustainability Appraisal (SA) and other marine economic analyses for example from OSPAR.

One of the purposes of the ecosystem approach framework should be to explicitly explain and demonstrate how the ecosystem approach is delivered through marine planning. This includes the methods used, and the way that these methods and their results are reported in a marine plan (or its associated documentation). This can be based on the outline contents for a specific marine plan section on the ecosystem approach. This section can be short, summarising information from, and linking to, the relevant analyses where specific aspects of the ecosystem approach are being delivered in marine plan documents (e.g. where a cumulative effects assessment is covered in the SA). Guidance needs to be given on the questions to answer in relevant parts of marine plan documents in order to ensure that they include the

relevant information and analysis to implement the ecosystem approach as outlined later in this document.

The ecosystem approach also applies to plan options (scenarios) that are given consideration as part of the process of establishing a marine plan's vision. So far, analyses of options have been limited to thinking separately about the main sectors in a plan area. There may be questions or discussions throughout the plan process during stakeholder engagement that can help gather the opinions and information necessary to deliver the ecosystem approach.

Following this introduction, the report summarises a review of the requirements of the ecosystem approach (Section 2) – the full review is in Annex 1. It then describes a proposed framework for delivering the ecosystem approach and tools that can support its implementation (Section 3). A case study in Section 4 applies the framework to the East Marine Plans. Section 5 provides guidance on implementing the ecosystem approach principles identified for marine planning. Section 6 provides conclusions and recommendations for actions by marine planners and for further research.

1.1 Methodology

The approach to undertaking this study is based on a thorough review of the relevant literature, an understanding of the context of marine management and planning, and two one-day workshops. The first workshop (held on 19/09/13) was internal to the project team and MMO, and scoped the requirements of the framework. The second workshop was held on 19th November, and involved a group of over 20 stakeholders, as well as MMO and project staff. It presented draft proposals for the framework and analysis, allowing them to be scrutinised by stakeholders.

The study is organised around five objectives:

Objective 1 – Developing a practical framework, to deliver the ecosystem approach requirements within marine planning, recognising that this will require a broad scope to incorporate MSFD indicators and targets for the eleven descriptors of 'Good Environmental Status' (GES) under the MSFD and other Regulations and Directives such as the WFD, Marine Protected Areas (MPAs) established under the Habitats and Wild Birds Directives or national legislation, Bathing Waters Directive, Shellfish Hygiene Regulation and maintenance and enhancement of natural capital in terms of the provision of marine ES.

Objective 2 – Outlining the required evidence and data, based on experience of previous work in this area, and recognising the challenges in seeking to undertake spatial assessments of the state of the marine environment to evaluate implementation of the ecosystem approach.

Objective 3 - Highlighting evidence and data gaps, and making recommendations on how to fill evidence and data gaps, which gaps are priorities, and how to use improved evidence.

Objective 4 - Recommending methods for spatial analysis of trade-offs, based on tools that can facilitate comparison of options and inform rational choices between options for delivering the ecosystem approach.

Objective 5 - Applying the framework to the East Inshore and Offshore Marine Plans, using the Department of the Environment and Rural Affairs (Defra) MSFD 'Business-as-Usual' (BAU) study data layers, to validate the framework in relation to a limited number of ecological receptors.

1.2 First workshop with MMO

The first project workshop explored and established MMO's requirements for a framework to support implementation of the ecosystem approach within marine planning. It considered:

- Opportunities and constraints
- Information requirements to inform decision-making under the framework
- Possible components of the framework
- Existing evidence and data
- Existing tools to support spatial analysis of trade-offs.

1.3 Results of second workshop with stakeholders

The workshop's objective was to present and scrutinise an operational decision-support framework that demonstrates how MMO will ***improve*** the integration of the ecosystem approach in marine planning going forwards. A draft report was shared with participants prior to the workshop, reflecting work in progress. Over 20 stakeholders participated in the workshop, representing mainly environmental NGOs and public bodies, but also businesses, as well as MMO and project staff

The project team presented the principles of the ecosystem approach as adapted for marine planning, linking to the MPS and other European Union (EU) and global policy contexts. eftec presented the proposed framework for MMO to apply the ecosystem approach in marine planning.

Group discussion and feedback were undertaken with respect to the proposed marine planning ecosystem approach principles and approach (the framework) developed during this project. Discussions covered why different marine principles had been developed from the Malawi Principles (table 1 on page 12) and the pros and cons of existing processes for their implementation, such as stakeholder consultation obligations and Cost-Benefit Analysis (CBA).

The project team presented a case study applying existing data to aspects of the East Inshore and Offshore Marine Plans. It linked the Statement of Public Participation (SPP) for the East marine plans to the required co-ordination and engagement of stakeholders in consultations. There was then group discussion of the ten principles for the ecosystem framework applied to the East Inshore and Offshore Marine Plans. This provided a useful way to consider the extent to which they had been implemented.

Points that were highlighted include:

- How the ten marine principles were identified was a big discussion point, and subsequently further effort has been devoted to explaining this within this report.
- How to ensure principles are represented across the many aspects of marine planning.
- While some of the principles have already been applied there is room for improvement, and care is needed not to lose cross-cutting issues.
- Whether the right capacity, data and tools to implement the ecosystem approach in marine planning are available.

A record of the agenda and workshop attendees is included in Annex 6.

2. Principles and requirements for implementing the Ecosystem Approach in marine planning — review of relevant experiences and application

This section presents the context for applying the ecosystem approach in marine planning. It summarises the findings of a literature review that examined relevant examples of the application of the ecosystem approach to the marine environment (presented in full in Annex 1). It describes how MMO's existing marine planning process takes account of the requirement to adopt the ecosystem approach. This context is then built on in Section 3 to develop a proposed framework for improving the implementation of the ecosystem approach in marine planning.

2.1 Review of definitions, principles and relevant experience

Annex 1 presents a detailed review of the potential requirements of an ecosystem approach and relevant examples of recommended/adopted approaches from the literature. The key findings from the review are summarised below.

2.1.1 Definitions of the ecosystem approach

There are a number of definitions of the ecosystem approach including in the Convention on Biological Diversity (CBD, 2000), Laffoley *et al*. (2004), JNCC (Atkins *et al.,* 2013) and the MPS (HM Government, 2011a). All of these definitions have a number of common characteristics including integrated management, conservation of ecosystems and sustainable use of ecosystem goods and services. For the purposes of this study, the MPS definition has been used as the basis for defining the requirements of the ecosystem approach, as it particularly highlights linkages to the achievement of GES under MSFD, which is a key driver for UK policy:

> "*an approach which ensures the collective pressure of human activities is kept within the levels compatible with the achievement of good environmental status; that does not compromise the capacity of marine ecosystems to respond to human-induced changes; and that enables sustainable use of marine goods and services*".

The MPS states that marine planning will take an ecosystem approach in order to manage competing demands on the marine environment as well as achieving environmental objectives established by relevant directives and legislation. Whether this is achieved is currently addressed in the marine plans and the SA, based on expert judgement owing to the limitations of existing data and tools.

2.1.2 Principles for applying the ecosystem approach

Key principles for applying the ecosystem approach to marine planning were reviewed (see Annex 1). The review included the Convention on biological diversity's (CBD) 'Malawi Principles'[2], Defra's five ecosystem approach principles (Defra, 2007)

[2] http://www.cbd.int/ecosystem/principles.shtml

and the Australian Government's '*Guidelines for Applying an Ecosystem Approach in the Oceans*' (Department of Environment and Heritage, 2006).

A report published by Defra (2007) promoted a generic ecosystem approach for application in a wide range of policy areas and decision-making contexts. The approach advocated by Defra was based on five broad key principles that encompassed aspects of the Malawi Principles rather than imposing a single, rigid definition of the ecosystem approach. The report noted that not all of the principles may be relevant in all contexts and to all stakeholders. Marine planning is considered to have greater focus on implementing policies for managing the natural environment, rather than policy development itself. Defra (2007) suggested that such implementation processes should consider all principles regarding conservation issues and land management.

Figure 1 below lists the 12 Malawi Principles through which the CBD defines the ecosystem approach, and describes suggested adjustments to them resulting in a list of ten marine planning ecosystem approach principles. These are not presented in the same order as the original 12. Further details of these adjustments are contained in Annex 1. The final set of ten principles identified for applying the ecosystem approach in marine planning are shown in Figure 1.

Many of the suggested principles reflect requirements for the process which should be followed when implementing the ecosystem approach (Principles 1, 3, 4, 5, 6, 8 and 10). These principles can therefore be fairly readily accommodated through process design. However, there are particular challenges when seeking to apply principles that require some level of assessment or analysis across particular spatial and temporal scales (Principles 2, 7 and 9) owing to the lack of suitable tools to undertake such analyses.

Figure 1: Malawi Principles for the ecosystem approach, recommended adjustments and revised marine ecosystem approach principles for marine planning.

Malawi Principle	Adjustment
1. The objectives of management of land, water and living resources are a matter of societal choices	While this remains true in the UK at the largest scale of policy implementation, in practice for many of the processes linked to marine planning, marine management objectives are relatively fixed. There remain choices to be made on marine management within narrow boundaries established by legislation (e.g. application of exemptions such as disproportionate costs under MSFD and WFD). Objective 1 underplays the importance of setting clear ecosystem objectives. Reflected in revised Principle 1.
2. Management should be decentralized to the lowest appropriate level	Copied in revised Principle 10.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems	Reflected in revised Principle 8. The marine environment is considered a single ecosystem, and marine management can influence terrestrial ecosystems. Terrestrial ecosystems and their management can influence the marine environment.
4. Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context	Reflected in revised Principle 2. Omits social context alongside economic context, which is now an explicit part of marine management policies in general (e.g. MSFD) and marine planning specifically. This is reflected in revised Principle 2.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach	Copied into revised Principle 7
6. Ecosystems must be managed within the limits of their functioning	Copied into revised Principle 7

Revised Marine Ecosystem Approach Principles
1. There should be clear long-term ecosystem objectives, ideally linked to targets and indicators, against which progress can be monitored.
2. Integration of social and economic factors is necessary to support sustainable development.
3. A robust dynamic baseline, which acknowledges that change is inevitable, should be established against which progress towards achievement of objectives can be measured.
4. All forms of relevant information should be considered including scientific and local knowledge.
5. All relevant sectors of society and scientific disciplines should be involved.

7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales	Reflected in revised Principle 9
8. Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set in the long term	Objective 8 underplays the importance of setting clear long-term ecosystem objectives. Reflected in adjusted Principle 1. Ecosystem processes and lag effects reflected in revised Principle 7.
9. Management must recognise that change is inevitable	Reflected in revised Principle 3 which recognises the importance of ensuring that the baseline takes account of ongoing change (dynamic baseline). Omits importance of adaptive management in response to this factor, which is reflected in revised Principle 6.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity	Reflected in revised Principles 2, 7 and 8.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices	Copied into Principle 4, also reflected in Principle 5. Omits importance of having a baseline against which data can reflect impacts, which is reflected in revised Principle 3.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines	Copied into revised Principle 5.
	There is no specific reference to thresholds or cumulative effects assessment within the principles, although Principles 5 and 6 might be seen as inherently requiring the consideration of cumulative effects; reflected in revised Principle 8.
	None of the principles recognise the requirement for co-ordination and integration across marine sectors; reflected in revised Principle 8.

6. Monitoring, review and adaptive management are important elements of the planning and management cycle.
7. Conservation of ecosystem structure and function to provide ecosystem services should be a priority and ecosystems must be managed within limits of their functioning and with consideration for lag effects that characterise ecosystem processes.
8. A coordinated and integrated approach should be adopted when considering effects of human activity, particularly taking account of cumulative effects and thresholds, to support sustainable development.
9. Appropriate spatial and temporal scales should be applied.
10. Planning and management should be decentralized to the lowest appropriate level.

2.1.3 Case studies of recommended/adopted approaches

Nine case studies of recommended/adopted approaches for the implementation of the ecosystem approach were reviewed in detail (Annex 1) and are summarised in Table 2. The case studies were chosen to reflect examples of:

- Theoretical frameworks based on academic research e.g.
  - Options for Delivering Ecosystem-Based Marine Management (ODEMM)[3]
  - Partnerships Involving Stakeholders in the Celtic Sea Ecosystem (PISCES)[4]
  - Drivers, Pressures, State, Impact, Response (DPSIR) Framework.
- National guidelines based on reviews of research and good practice, e.g.
  - US National Ocean Council Marine Planning Handbook
  - Australian Government Guidelines for Applying Ecosystem Approach in the Oceans
- Attempts at practical application in the marine environment e.g.
  - Eastern Scotian Shelf Integrated Management (ESSIM) initiative
  - Norwegian Ecosystem-Based Management (EBM)
  - UK MSFD Implementation
  - Baltic Sea Management — Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning (BALANCE)[5].

The various initiatives reflect the prevailing institutional and legal arrangements applying to the planning areas. Few of these initiatives have been applied in practice and those that are have struggled to achieve practical or detailed implementation owing to a lack of political will, the lack of a supporting legal framework and/or a lack of data. Of the initiatives considered, most of those that have been applied in practice have tended to focus on the achievement of ecosystem objectives rather than integration with economic and social objectives. A summary of this analysis is presented in Table 1.

As a result, these case studies are considered to be of limited benefit in helping to define an operational framework for applying the ecosystem approach through the marine planning process. Therefore the most pertinent elements as judged by the project team of each initiative were carried forward into the development of the ten principles and are summarised in Table 2.

[3] www.liv.ac.uk/odemm accessed on 16th January 2015
[4] www.projectpisces.eu accessed on 16th January 2015
[5] www.balance-eu.org accessed on 16th January 2015

Table 1: Summary of case studies of recommended/adopted approaches to implementation of the ecosystem approach.

Initiative	Applied in Practice / Theoretical	Strengths	Weaknesses	Comments on Applicability in UK
ESSIM: Canadian government initiative for ecosystem-based management in the Eastern Scotian Shelf in Canadian Waters (first presented to stakeholders in 2005)	Yes	• Comprehensive ecosystem approach • Strengthens stakeholder communication • Promotes networking and interdependency between stakeholders	• Top-down impetus • Essentially a sectoral approach to planning • Sectoral collaboration on production of main planning goals but not on measures to achieve such goals • Data limitations - poor consideration given to baseline information	Includes broad, widely applicable concept of ecosystem approach, although developed within the context of Canadian waters and legal/socio-economic/governmental context by Fisheries and Oceans Canada (DFO).
US National Ocean Council: Marine Planning Handbook (July 2013)	Theoretical guidelines	• Comprehensive ecosystem approach	• Untested in practice	Includes broad, widely applicable concept of ecosystem approach, although developed in the context of US waters and legal/socio-economic/governmental context by the US National Ocean Council.
Norwegian EBM (June 2006, updated every 4 years)	Yes	• Strong ecosystem approach • Ensures cooperation among government institutions • EcoQOs provide clear objectives for monitoring progress, covering various system components • Updates on progress and identification of knowledge gaps	• Does not cover entire ecosystem due to political boundaries • Depends on good cooperation with Russia • Limited in its economic and societal scope • No monitoring programme as of yet	Includes broad, widely applicable concept of ecosystem approach, although developed by the Norwegian Ministry of Environment in response to a Norwegian government White Paper. Designed for implementation within the Baltic Sea and Lofoten Islands and Norwegian legal/socio-economic/governmental context
The PISCES Project: Stakeholder-Developed Guide to Implementing Ecosystem Approach in the Celtic Sea (2012)	Theoretical guide for MSFD implementation	• Comprehensive ecosystem approach • Promotes stakeholder involvement and communication	• No real consideration for integrated management of human activities – sole focus on MSFD • Does not take socio-economic factors into	Specifically focused on implementation of MSFD in UK waters. Involved relevant stakeholders and legislation, although lacks a holistic approach that considers the integration of human activities and socio-economic factors necessary to support

Initiative	Applied in Practice / Theoretical	Strengths	Weaknesses	Comments on Applicability in UK
			account • Data limitations	sustainable development.
Australian Government Guidelines for Applying Ecosystem Approach in the Oceans (2006)	Theoretical guidelines	• Strong ecosystem approach	• No specific examples of practical application	Includes broad, widely applicable concept of ecosystem approach, although guidelines were developed in the context of Australia's oceans and socio-economic/governmental context.
The DPSIR Framework: 'Driver-Pressure-State-Impact-Response' Management Framework (2002)	Largely theoretical although has been utilised in a number of studies	• Potentially useful in application of the ecosystem approach and marine management • Recognises the interconnection between social and ecological systems • Aims to comprehensively include human causes of change, the nature of that change and its consequences	• Definitional uncertainty • Lack of clear conceptual underpinning • Data limitations	Potentially useful tool for marine management and applicable anywhere where relevant data/information exists. Has previously been used in UK assessments (ABPmer and eftec, 2012), although has limitations; the DPSWR[6] framework advocated by Cooper *et al*. (2012) may overcome some of its uncertainties.
UK MSFD Implementation (2008 onwards)	Currently in development and remains largely theoretical	• Comprehensive ecosystem approach • Development of future scenarios and evidence base to inform the Initial Assessment • Strong buy-in by UK government agencies and devolved administrations	• Work in progress • Untested in practice • Needs to ensure consideration of social and economic factors • Data limitations	MSFD taken forward within the UK by a collaboration of UK devolved administrations and the relevant government agencies. Represents the best model for application of MSFD and assessment of the broad-scale impacts of policy measures. Easily applicable to other broad-scale, marine planning assessments.
The ODEMM Project (2010–2014)	Currently in development and	• Comprehensive ecosystem approach	• Work in progress • Data limitations	Developed in the context of European legislation applicable within the UK. Work

[6] DPSWR is a variation on the DPSIR framework which emphasises that the impact (I) of concern is that on human welfare (W).

Initiative	Applied in Practice / Theoretical	Strengths	Weaknesses	Comments on Applicability in UK
	remains largely theoretical	• Builds on DPSIR model by integrating aspects of MSFD		completed contributes to knowledge base and outlines objectives. Next phase will develop tools and recommendations for governance from stakeholder consultation. Will be relevant to UK government agencies and administrations and can contribute to MSFD implementation.
BALANCE Project: Towards Marine Spatial Planning in the Baltic Sea (2005–2007)	Theoretical guidelines	• Comprehensive ecosystem approach • Operates over a multinational area • Introduces a zoning template as a management tool • Outlines relevant tools	• Data limitations • No specific examples of practical application	Includes broad, widely applicable concept of ecosystem approach, although developed in the context of the multinational Baltic Sea. Planning framework developed in the context of MSFD implementation and may therefore be relevant to UK.

Table 2: Elements of ecosystem approach from each case study drawn out and incorporated into the ten principles.

Initiative	Elements of ecosystem approach taken forward
ESSIM: Canadian government initiative for ecosystem-based management in the Eastern Scotian Shelf in Canadian Waters	• Collaborative, multi-stakeholder approach to plan development and implementation • Objective-based approach with system of indicators and evaluation
US National Ocean Council: Marine Planning Handbook	• Goals and objectives • Plan implementation, monitoring, evaluation and adaptation
Norwegian EBM	• High-level goals, detailed aims and regulations – established Ecological Quality Objectives[7] • Considered environmental, social and economic factors • Utilised Cost-Effectiveness Analysis
The PISCES Project: stakeholder-developed guide to implementing ecosystem approach in the Celtic Sea	• Initial assessment of ecosystem condition • Monitoring programmes for ongoing assessment • Programme of management measures • Large focus on stakeholder involvement
Australian Government Guidelines for Applying Ecosystem Approach in the Oceans	• Define the ecosystem in which the plan is operating • Assessment of activity/ecosystem interactions and knock-on effects • Consideration of social, economic and cultural factors
The DPSIR Framework: 'Driver-Pressure-State-Impact-Response' management framework	• Theoretical framework for the assessment of human pressures on the environment
UK MSFD Implementation	• Modelling of environmental state under 'BAU' scenario • Development of supporting economic analysis tools • Development of evidence base
The ODEMM Project	• Numerous outputs regarding current knowledge base, existing governance structures, operational objectives, management options and their evaluation, risk analysis, CBA implementation plan and dissemination.
BALANCE Project: Towards Marine Spatial Planning in the Baltic Sea	• Importance of Geographical Information Systems (GIS) and spatial information • Identification and mapping of marine landscapes and habitats • Cyclic structure of marine spatial planning

2.2 Application of the ecosystem approach within MMO's marine planning process

Figure 1 shows the marine planning process as an iterative cycle, aspects of which may be repeated when marine plans are reviewed every 6 years for marine plan

[7] EcoQOs – developed within OSPAR requirements.

areas. Table 4 maps the ten principles onto parts of MMO's existing marine planning process and highlights that the planning process and ecosystem approach feed into each other. It is of note that some principles are relevant to several stages in the process. This section describes the actions that MMO currently take to apply the ten principles within their marine planning process and options for more detailed application of these principles.

Figure 2: Marine planning process.

Table 3: Application of the ten adapted ecosystem approach principles for this project within MMO's marine planning process (adapted from Defra (2011)).

Marine Planning Process	Principles	Recommendations
1. Plan area selection decision	5, 9 ⟺	Clear definition of the plan area is required, taking distribution of human activities, ecosystem features and physical and administrative boundaries into account. Public consultation on marine plan area boundaries, allowing stakeholders to comment on the spatial areas they consider appropriate for planning.
2. SPP and stakeholder engagement	5 ⟺	Gives explicit means of stakeholder involvement within planning process. Local knowledge may be helpful in identifying additional evidence needs, particularly if local knowledge contradicts more formal evidence. Stakeholder engagement should be implemented throughout the planning process. Evidence and data gathered through the requirements of the SPP.
3. Identifying issues	5 ⟺	Gather evidence from a range of stakeholders to help identify issues within marine planning. Evidence and data gathered through the requirements of the SPP.
4. Gathering evidence	2, 3, 4, 5 ⟺	Evidence is required to establish a robust baseline against which progress can be measured. All forms of information should be considered. Evidence and data gathered through the requirements of the SPP.
5. Vision and Objectives	1, 2, 5, 7, 8 ⟺	The plan should outline a clear vision and objectives from the outset. High level objectives are presented by key Government policy and a range of legislation. Objectives should integrate economic, social and environmental objectives drawn from the SPP and should aim to conserve ecosystem function through a multi-sectoral approach. Outputs from the SPP, IA and SA can provide the necessary evidence and data.
6. Options development	2, 5, 7, 8 ⟺	Plan options should be developed with consideration for all available information using an integrated approach. Outputs from the SA and from relevant economic analysis can inform the development of plan options.
7. Plan policy development	2, 5, 7, 8, 10 ⟺	Consideration should be given for all forms of information during the development of plan policies and all relevant sectors of society should be engaged with during the process. The SPP can provide evidence and data to inform the development of plan policies. Plan development should be carried out in parallel with the SA.
8. Representation period on draft plans	5 ⟺	Public consultation on draft plans can be facilitated through the SPP in order to gather evidence and opinion from stakeholders. Draft plans will be accompanied by the SA Report.
9. Review plan proposals	5 ⟺	Plan proposals should be reviewed with consideration for the responses gathered from the representation of the draft plans through the SPP.
10. Independent investigation	5 ⟺	After public consultation of the plan proposals, the MCAA requires the Secretary of State to consider whether there is a need for an independent investigation, from recommendations from MMO. Appropriate stakeholder engagement throughout the development process through the SPP and public consultation should help avoid the need for an independent investigation.
11. Plan adopted and published		The plan may be amended in light of the results of an independent investigation. A plan is adopted when its publication is agreed upon by MMO, in agreement with the Secretary of State.
12. Implement, monitor and review	5, 6 ⟺	Monitoring is vital for testing the effectiveness of plan policies and informing decisions on requirements for changes to plan policies (adaptive management). Planners and stakeholders must be involved in the monitoring and review process in order to improve future plans. The SPP can facilitate stakeholder involvement in the process.

2.2.1 Principle 1: Clear long-term ecosystem objectives, targets and indicators against which progress can be monitored.

Establishing clear objectives for marine plans is a key element of MMO's marine planning process (Defra, 2011). High level marine objectives are provided by the MPS (HM Government, 2011a) and are used as the basis for establishing overall marine plan objectives (for example, see MMO, 2013a). In turn, these objectives are supported by a large number of other environmental objectives, particularly stemming from international commitments and European Directives as well as from national legislation. Key sources that establish ecosystem objectives include:

- The EU Marine Strategy Framework Directive
- The EU Water Framework Directive (2000/60/EC)
- The Habitats and Wild Birds Directives (92/43EC and 2009/147/EC)
- The Common Fisheries Policy (CFP) [8]
- The Marine and Coastal Access Act (2009) (in relation to Marine Conservation Zones (MCZs)).

The SA is a key mechanism that can be used to evaluate the extent to which draft plan policies may support achievement of ecosystem and wider environmental objectives. Good practice in Strategic Environmental Assessment (SEA) recognises the benefits of closely integrating such assessments with the plan-making process and using appraisal in an iterative manner to test and refine draft policies (Department for Communities and Local Government, 2006). MMO (2013b) identifies a wide range of environmental and ecosystem objectives for the East Marine Plan areas. The SA of the East Marine Plans includes a high level assessment of the potential impacts of the plan policies on some of these objectives (MMO, 2013c).

Defra (2011) provides guidance on how the MCAA requires the impacts of marine plan policies to be monitored. This includes impacts in relation to environmental and ecosystem objectives. As marine planning processes mature, it is possible that marine plan policies could become increasingly influential and monitoring requirements may increase accordingly. It is recognised that MMO will need to work closely with other public bodies that have specific responsibilities for monitoring compliance with particular environmental and ecosystem objectives to avoid duplication of effort and to ensure that the information collected is fit for purpose. Details of the monitoring data that will be used to inform assessments of progress towards achieving environmental and ecosystem objectives will be included in plan-specific implementation and monitoring plans (e.g. MMO, 2013d). Further discussion of monitoring arrangements is provided under Principle 6.

There is a very wide range of environmental and ecosystem objectives that potentially need to be taken into account within marine planning (for example, see SA for East Marine Plans (MMO, 2013b)). However, for many of the requirements, planning for the objectives is taken forward through separate initiatives, for example, the implementation processes for MSFD, WFD and the Habitats and Wild Birds Directives (see further discussion under Principle 7).

[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0022:0061:EN:PDF accessed 09/05/14

A further variable in long term planning is the uncertain impact of climate change on the marine environment. Marine plans can integrate this thinking, building on how MSFD implementation takes account of prevailing conditions, including climate change, such as through assessment of the impacts of climate change in analysis of the costs of degradation.

2.2.2 Principle 2: Integration of social and economic factors

The Marine Policy Statement (HM Government, 2011a) requires that marine planning integrates environmental, economic and social factors in developing plan policies in order to support sustainable development. Within MMO's marine planning process, the SA is an important mechanism for assessing the potential impacts of draft plan policies on human use activities and for evaluating potential social impacts. For example, the SA for the East Marine Plans (MMO, 2013c) presents qualitative information on the potential social and economic impacts of the draft plan policies alongside information on potential environmental impacts.

The consultation on the East Marine Plans was accompanied by an analysis of the potential impacts of plan policies (MMO, 2013e), but this did not estimate monetary impacts and no formal IA was required. Plans to undertake IAs as part of future marine planning are being developed.

The IA for the marine planning process[9] took the view that the services and benefits from ecosystems and other environmental resources depend to a very great extent on being able to stay within certain thresholds and limits. Enabling marine decision-making and management that is informed by better understanding of where those limits are should facilitate increased productive use of marine resources at the same time as reducing the instances where thresholds and limits are breached. This approach is in line with the ecosystem approach, although in both cases they are constrained by the available evidence base.

This IA also recognised that the scales of the environmental benefits are difficult to predict at present. However, improved capacity for monitoring environmental outcomes, including for the MSFD, should help inform evaluation of the impact of marine planning. Overall, in the future the IAs could potentially be a tool for documenting aspects of marine ecosystem approach principles, such as with respect to integrating socio-economic data, and managing ecosystems within their limits (See Section 5 and Annex 3).

The MMO Strategic Evidence Plan (SEP) (MMO, 2011a) recognises the importance of taking forward economic and social research to support marine planning. MMO has also prepared a separate social research strategy (MMO, 2011b). The purpose of the strategy is to enable MMO to develop its social research capacity and capability, so that it can fully integrate social considerations into not only marine planning but also licensing, fisheries management and conservation.

[9] http://archive.defra.gov.uk/environment/marine/documents/interim2/20110221mps-ia.pdf

In order to improve the integration of social and economic factors into marine planning, MMO could apply more quantitative methods for assessing social and economic impacts and to seek to monetise such impacts through the use of CBA. A number of recent IAs undertaken for the marine environment have sought to estimate socio-economic impacts of proposed policies, and there is an emerging body of learning that can inform the development of a methodology that could be applied by MMO (e.g. Finding Sanctuary *et al*., 2012; Marine Scotland, 2013a; 2013b).

The Natural Capital Committee (NCC) (2013) has recently highlighted the usefulness of CBA as a tool for decision-makers in helping to identify options delivering best value for money. However, its use in relation to marine policy decisions is limited due to uncertainty in the scientific evidence on the changes expected and a paucity of primary environmental-economics research on society's preferences for those changes. The nature of the economic values involved is discussed further in Section 3.3 and Annex 3.

In the absence of quantified social and or economic values, qualitative analysis of the impacts of marine planning on human activities can be undertaken. This may use Multi-Criteria Analysis (MCA) techniques, such as the qualitative scoring of social impacts that was applied in Marine Scotland's socio-economic analysis of impacts of proposed MPAs (Marine Scotland, 2013b) based on a framework developed by the Social Impacts Taskforce (Harper and Price, 2011). The depth of such analysis needs to be proportionate to the severity of impacts. For example, comparing the recent Scottish IAs of offshore renewables and MPAs, on a range of social issues the offshore renewables work looked at impacts in greater detail (Marine Scotland, 2013a). However, the MPA work was able to identify communities where impacts would be sufficiently concentrated to be noticeable, and focussed analysis on these specific locations.

2.2.3 Principle 3: Establishing a robust dynamic baseline

The gathering of evidence at an appropriate scale is a key task within MMO's marine planning process (Defra, 2011).

MMO has an ongoing programme of evidence collection both in relation to specific marine plan areas and also in relation to wider marine planning issues, guided by its SEP (MMO, 2011a). For each marine plan area, MMO publishes a report during the early stages of each marine planning process presenting the evidence and issues (e.g. MMO, 2012a, 2013f), which includes a collation and analysis of existing information. Stakeholders are invited to identify and provide additional information that they consider should be taken into account in the marine planning process. The SPP also supports engagement by stakeholders and members of the public in the process of gathering evidence (for example, see MMO, 2013g).

In identifying evidence requirements, MMO needs to consider the appropriate spatial and temporal scales for data collection and its spatial resolution. Temporal aspects of the baseline are important in understanding how the baseline will change in the future (reflecting the ecosystem approach's recognition that change is inevitable) in response to the full range of existing environmental, economic and social drivers and

policies. In developing the baseline, the uncertainties inherent in the data should be recognised.

The lack of available data at suitable resolution and temporal and spatial scales is acknowledged as being a significant constraint in implementing marine planning at the present time. Key data gaps identified in MMO (2012a) and MMO (2013f) include:

- Spatial and temporal representation of the distribution of ecological features (e.g. marine habitat maps, mobile features (fish, birds, marine mammals))
- Spatial representation of cultural heritage features
- The lack of comprehensive coverage for seascape assessments
- Spatial and temporal distribution of some existing human activities (e.g. commercial fisheries, commercial navigation, marine recreation)
- Future (e.g. business as usual) baseline for many human activities.

2.2.4 Principle 4: Considering all forms of information

The SPP encourages stakeholders and members of the public to contribute to evidence gathering (for example, MMO, 2013g) as part of the overall marine planning process. This is in recognition of the value of collective evidence gathering by all parties, to feed into a planning system that is owned and progressed by all. MMO applies a quality assurance process to all the evidence it collects and uses in marine planning[10]. This process seeks to ensure that data used to support marine planning are robust and that any limitations of evidence are transparent and taken into account in decision-making. This process also seeks to ensure that there is no contradiction in the available data from different sources and that the best available information is used to inform marine planning.

MMO's process provides opportunity for stakeholders and members of the public to contribute evidence and data to the marine planning process. While it may be possible to apply more systematic processes for collecting evidence and data from stakeholders and members of the public, this may not be cost effective. MMO should consider whether there is a need for more systematic data collection, for example in relation to inshore fisheries or recreational users, similar to the Fishermap[11] and Stakmap[12] initiatives developed and implemented by the MCZ Regional Projects.

2.2.5 Principle 5: Engaging with all relevant sectors of society and scientific disciplines

Stakeholder engagement is recognised as a fundamental component of MMO's marine planning process (Defra, 2011). Stakeholders have an important role in the identification of key issues and their resolution, and guidelines have been published to facilitate their engagement in the planning process (UNEP, 2005; Maguire *et al*., 2012).

[10] http://www.marinemanagement.org.uk/marineplanning/evidence/qa.htm
[11] Fishermap was an initiative carried out by the English Regional MCZ Projects to map the relative importance of fishing grounds in English waters through consultation with local fishermen.
[12] Stakmap was an initiative carried out by the English Regional MCZ Projects to map the spatial distribution and intensity of recreational activities in English waters through consultation with local stakeholders.

Marine plans fall within the definition of public 'plans' for the purposes of the EU Public Participation Directive (2003/35/EC) and the EU SEA Directive (2001/42/EC). Together with requirements under the MCAA 2009, these Directives impose legal obligations on MMO to involve stakeholders and the public in the process of developing and environmentally appraising marine plans. In line with these requirements, MMO issues a SPP at the commencement of the planning process for each marine region. This sets out the timetable for preparing the plan(s) and the opportunities for engagement that will be provided at different stages of plan preparation.

For example, for the South Inshore and Offshore Marine Plan Areas, the SPP identifies a number of points in the planning process at which engagement with stakeholders and the general public will be sought (MMO, 2013g), including:

- Evidence and data for the plan areas
- Plan area issues and matters to be included in marine plans
- Scoping of the SA (including requirements of the SEA Directive)
- Plan area vision and objectives
- Plan options and policies (including findings of the SA)
- Public consultation on the plan and SA Report
- Independent investigation on plan (if required)
- Public notification of plan adoption.

The SPP also identifies specific stakeholder groups with whom MMO will seek to engage, including mechanisms for engaging with the general public, for example, through local authorities and local representatives as well as through social media such as Twitter and Facebook. The SPP also identifies opportunities to consult with stakeholders who have interests adjacent to the marine plan areas for which plans are being developed, including other member states and Crown dependencies.

2.2.6 Principle 6: Monitoring, review and adaptive management

Monitoring, review and adaptive management are fundamental components of MMO's marine planning process (Defra, 2011).

The process of monitoring and periodical reporting on the implementation of the marine plans and any need for review is a requirement under Section 61 of the MCAA 2009. MMO (under the functions delegated to it by the Secretary of State) has a duty to:

- Report, at intervals not more than three years after each marine plan is adopted, on the effects of policies, the effectiveness of those policies in securing marine plan objectives and the progress towards achieving the objectives set out for that region in the MPS. After each report, the marine planning authority should decide whether or not the marine plan needs to be amended or replaced. MMO, with the input of Government and stakeholders, may choose to report to Government more frequently.
- In addition, no more than six years after the passing of the MCAA, and until 2030, report to Government on any marine plans it has prepared and

adopted, its intentions for their amendment, and its intentions for the preparation and adoption of further marine plans

To support implementation of marine plans, MMO prepares an Implementation and Monitoring Plan (IMP) alongside each marine plan. The IMPs are to be informed by, amongst other things, recommendations from the SA including the SEA and Habitats Regulations Assessment (HRA). At the time of writing the detailed format and content of IMPs is being progressed by MMO.

A particular challenge in preparing the IMPs will be the need to ensure that MMO has fit for purpose information to inform its assessment of the impact of plan policies on the achievement of environmental and ecosystem objectives as well as wider influences on the achievement of such objectives. This will require MMO to work closely with other public bodies that have specific responsibilities for monitoring compliance with particular objectives to avoid duplication of effort and to ensure that monitoring data is fit for purpose.

For example, while a large amount of monitoring data is collected by various public bodies, this may be for specific purposes and may not provide the information required to assess the impact of plan policies. By way of illustration, in relation to air quality, the SA recognises the potential contribution that ship emissions may make to ambient air quality, particularly in the vicinity of ports. However, there is very little data on the relative contribution of ship emissions to ambient air quality. The SA considered that potential increases in shipping activity that may occur over the plan period would not give rise to significant air quality impacts. Although local authorities carry out some monitoring of local air quality, such information would not readily inform assessments of the contribution made by ships emissions. Where specific new port developments are proposed, assessments of the potential impact of such developments on air quality during the operational phase would be made. However, for existing facilities, increasing the numbers of vessels would not necessarily trigger any requirement for environmental approval.

Acquisition of evidence is an on-going process and the actions will be implemented through the delivery of MMO's SEP (MMO, 2011a) as well as through collaboration with other organisations with a duty or interest in developing the marine evidence base as a whole. Their success will be monitored by MMO with new evidence incorporated into future marine plans formulation and decision making as it becomes available (MMO, 2013d). MMO has undertaken a research project seeking to develop a method and data to monitor implementation of social objectives and policies of marine plans and overall plan derived social outcomes (MMO, 2014c).

2.2.7 Principle 7: Conserving ecosystem structure and function and managing within functional limits

The High Level Marine Objectives (HLMOs) set out in the MPS (HM Government, 2011a) recognise the importance of conserving the marine ecosystem. For example in relation to 'Living within environmental limits' the MPS identifies the following key HLMOs:

- Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.

- Healthy marine and coastal habitats occur across their natural range and are able to support strong, bio-diverse biological communities and the functioning of a healthy, resilient and adaptable marine ecosystem.
- Our oceans support viable populations of representative, rare, vulnerable, and/or valued species.

These HLMOs are therefore important in shaping the nature and content of marine plans. Within the East marine plans (MMO, 2013a), these HLMOs are translated into objectives 6,7 and 8 and accompanying policies supporting the conserving of marine ecosystem and are repeated here:

- To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.
- To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.
- To support the objectives of MPAs (and other designated sites around the coast that overlap, or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.

The potential effects of policies within the East marine plans on marine ecosystem are primarily addressed within the 'marine ecology', 'geology, substrates and coastal processes' and 'water environment' topics of the East marine plan SA. Separate consideration is also given to potentially significant cumulative effects. The SA provides a high level qualitative description of potential impacts. No spatial assessment of potential changes in ecosystem structure or function was attempted, on the grounds that many of the plan policies were not spatially specific and the changes in the baseline (in the absence of the plan) were also uncertain.

The East marine plans HRA also considered the potential impacts on Natura 2000 sites in relation to those plan policies for which there was a clear spatial dimension. However, owing to uncertainties surrounding potential impacts to features within designated sites that are attributable to the East marine plans, the assessment was mostly focused on identifying potential mitigation measures that could be applied at project level to avoid adverse effect, together with an overall process for iteratively developing the plan in the light of any new evidence obtained (ABPmer, 2013).

Objective 6 of the East marine plans recognises that a healthy, resilient marine ecosystem extends beyond specific biodiversity interests and includes the functioning of biological communities, such as: the interaction between species; nutrient and carbon cycling; water quality characteristics critical to supporting a healthy ecosystem, and pollutants (from marine as well as riverine and terrestrial sources) that may affect these; coastal processes; the interaction between various pressures acting on the environment as a whole; and the benefits to people from marine ecosystem services (MMO, 2013a - discussed further in Section 5.7).

Strong linkages are identified with the requirements of the MSFD. It is stated in the East marine plans that the plans will, "…make a contribution to implementing the MSFD alongside a range of other measures", though it is noted that the nature of this contribution will only become clear as measures for achieving GES and the East Marine Plans develop (MMO, 2013a, paragraph 151). Given that the aim to achieve

GES is likely to be undertaken at UK/devolved administration level, the clarification of the relationship with marine planning is particularly important.

All the MSFD's descriptors of GES are relevant to the ecosystem approach. They all characterise some aspect of marine ecosystem services and/or marine human activities and are therefore relevant to Ecosystem Approach Principles 2 and/or 8. Some MSFD descriptors (e.g. 4: Food Webs, and 6: Sea Floor Integrity) are particularly relevant to Principle 7 as they reflect aspects of ecosystem structure and function.

It is currently unclear how detailed the UK/devolved administration process might be for determining the measures required to aim to achieve GES. If such work is considered to be robust, there would be no particular benefit in marine plans seeking to repeat this work and the plans might therefore simply signpost MSFD measures. However, if UK/devolved administration planning for MSFD measures is only undertaken at a high level, the marine planning process could provide added value through assessments of the specific available measures that might need to be implemented to make an appropriate contribution to the achievement of GES within the relevant marine planning regions. However, the timetable for producing a full suite of marine plans for English waters extends to 2021, whereas MSFD management measures for all English waters need to be identified by the end of 2015 and implemented by the end of 2016. Therefore, it will not be possible to link the development of marine plans process with the timetable for developing measures. In this context it should also be noted that it is not the responsibility of MMO to develop MSFD measures. It would therefore seem more likely that MSFD measures will need to be determined centrally, but with the potential for regional marine plans to contribute to the implementation of measures where this can add value.

The concept of ecosystem goods and services – the recognition of the multiple ways in which humans derive benefits from ecosystems (UK National Ecosystem Assessment (NEA), 2011) – also has a potentially important role to play in helping to shape policies and actions to conserve ecosystem structure and function. While current understanding of marine ecosystem service provision and the benefits humans derived from many of these services is quite limited (Austen *et al.*, 2011), considerable progress is being made. This topic is already recognised as a priority evidence gap to support marine planning (MMO, 2011a). In line with the thinking in the Natural Environment White Paper (HM Government, 2011b), the concept of valuing natural capital is likely to become a major driver of policy over the next five to ten years. As the evidence base improves and assessment tools become available, it will become increasingly possible to apply ecosystem services concepts within marine decision-making. Ecosystem services are discussed further in Section 5.7.

The approach currently adopted within marine planning to assessing compliance with ecosystem objectives is acknowledged as being limited (MMO, 2013c), largely being based on expert judgement. This makes it difficult to robustly demonstrate delivery of Principle 7. The approach that will be applied to MSFD implementation is likely to adopt a best practice approach given current limitations in data and scientific knowledge.

2.2.8 Principle 8: Adopting a co-ordinated and integrated approach to management of human activities

A fundamental aspect of marine planning is that it seeks to adopt an integrated and co-ordinated approach to the management of human activities (Gilliland and Laffoley, 2008). This is supported by the Marine Policy Statement (HM Government, 2011a) which requires an integrated approach across all sectors. This includes interaction with land-based activities (in particular discharges to water courses that enter the marine environment).

In practice, MMO's marine planning process achieves this in two main ways. Firstly, the SPP supports multiple activities occurring within the plan area and encourages extensive engagement with those interested in the development of marine plans and identifies the specific marine sectors that need to be involved in plan development. Secondly, by way of example, Objective 10 of the East Marine Plans seeks to 'Ensure integration with other plans and regulation and management of key activities and issues in the East Marine Plan and adjacent areas'. In addition, marine plan policies may support co-ordination and integration. For example, within the East Marine Plans a number of policies contribute to this, including policy ECO1 on cumulative effects and draft GOV2 on co-existence. In addition the SA provides a mechanism for assessing the effects of plan policies and evaluating the combined impacts of multiple activities occurring within the plan areas.

While the approach adopted by MMO within current marine planning seeks to facilitate co-ordination and integration, the limitations of data and available tools mean that it remains difficult to achieve the desired level of integration (see commentary on Principles 2 and 7 above). In particular, the SA provides a largely qualitative assessment of environmental, economic and social impacts and in the absence of more detailed cost-benefit information, it is difficult to reliably compare options in an integrated manner.

The use of ecosystem services analysis to identify the impacts of changes in the marine environment on human activity, could help to improve the level of integration that is achieved between marine plans, and increasingly so, as better data and evidence become available. This will not, however, be the case for terrestrial plans that are not subject to IA in many cases. Recent work on co-location and co-existence (MMO, 2013h; 2014a) and ongoing work by MMO to develop a strategic approach to cumulative effects assessments (MMO1055 'A Strategic Level Approach to Cumulative Effects') may also examine ways to secure more integrated management.

Interactions with land-based activities are mainly managed through linkages with the terrestrial planning/development management system (both through marine planning and marine licensing). In addition environmental interactions are also managed by the requirements of the WFD, which is overseen by the Environment Agency (EA). WFD objectives for coastal water complement MSFD objectives and should be reflected in the long-term planning that underpins the ecosystem approach.

2.2.9 Principle 9: Using appropriate spatial and temporal scales

Defra (2011) established a 20 year time period for the duration of marine plans. Where plans have been produced, they will be reviewed every 3 years.

The marine plan areas have been determined largely on the basis of physical and administrative boundaries, but have also taken account of the distribution of human activities and biogeographic factors. Defra undertook a public consultation on proposed marine plan areas (Defra, 2009). As a result of this public consultation a number of amendments were made to the proposed plan area boundaries (Defra, 2010). In particular, it was recognised that the boundary between inshore and offshore plan areas is artificial and could mitigate against the delivery of an ecosystem approach. To minimise this risk it has been agreed that 'the approach to developing Inshore and Offshore marine plans at the same time through a 'single process' as proposed for the North West should be followed wherever appropriate' (Defra, 2010).

When developing plans for particular marine regions, MMO also takes account of adjacent areas and interests. For example, the SPP prepared by MMO at the outset of the marine planning process identifies transboundary stakeholders that may have an interest in the marine plan area(s) (for example, see MMO, 2013a).

The 20 year time period provides for a long-term view to be taken on how plan regions might change. It does not preclude taking account of the influence of longer-term factors such as climate change as projections of climate change impacts beyond 20 years can be taken into account within plan policies.

2.2.10 Principle 10: Planning and management should be decentralized to the lowest appropriate level

As noted above, the marine plan areas have been determined largely on the basis of physical and administrative boundaries but have also taken account of the distribution of human activities and biogeographic factors. Objective 10 of the East Marine Plans, for example, seeks to 'Ensure integration with other plans and regulation and management of key activities and issues in the East Marine Plan and adjacent areas':

In developing marine plans, MMO has to have regard to existing policies which may be set at national regional or local levels. There are thus limits to the extent to which planning and management can be fully devolved to plan area or sub-plan area levels. However, within marine plan areas, MMO has given consideration to how sub-regional and local engagement can be facilitated. For example, the SPP for the South Inshore and Offshore Marine Plan Areas establishes a role for existing coastal fora in facilitating local engagement (MMO, 2013g). The SPP also highlights the role of local authorities and local councillors in helping to engage with members of the public.

The approach supports implementation of the ecosystem approach by decentralising planning and management where possible. It is suggested that the SPP might usefully make specific reference to how it contributes to decentralization.

2.3 Conclusions

Many of the suggested principles reflect requirements for the process which should be followed when implementing the ecosystem approach (Principles 1, 3, 4, 5, 6, 8

and 10). These principles can be (and largely already are) readily accommodated through the design of the marine planning process. However, there are particular challenges when seeking to apply principles that require some level of assessment or analysis across particular spatial and temporal scales (Principles 2, 7 and 9) owing to the relative lack of suitable data and tools to undertake such analyses.

A further issue that requires exploration is the extent to which marine planning might add value to separate initiatives such as MSFD and WFD implementation, which are seeking to apply the ecosystem approach. This could have particular implications for the level of effort that MMO might need to apply in implementing the ecosystem approach to marine planning.

A more detailed consideration of the issues and challenges in adopting the ecosystem approach for marine planning is presented in Section 4 which trials the application of a proposed framework for improving the implementation of the ecosystem approach drawing on information from the East Inshore and Offshore Marine Plans.

3. Proposed framework for implementing the Ecosystem Approach within marine planning

This section builds on the evidence in Section 2 to give a draft proposal for a framework for improving the implementation of the ecosystem approach in marine planning. Further detailed information on development of the framework is in the annexes.

3.1 Scope of framework

The scope of the proposed framework for implementing the ecosystem approach in marine planning encompasses all the marine planning process overseen directly by MMO and also takes account of the linkages to other relevant planning and implementation processes such as river basin management plans.

Some key points in determining the scope of the framework are:

- Timescales considered: in general these can match the timescales in existing marine planning processes, but need to be open to longer-term considerations, such as in analysing cumulative effects.

- Geographical scale – this should take account of ecosystem issues that extend beyond planning regions and/or beyond UK waters. As the evidence base builds, issues across marine planning regions in UK waters should be picked up in analysis of cumulative effects. International impacts on ecosystems will be more difficult to consider. The MSFD's requirement to coordinate analysis in regional seas (the Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (OSPAR) is working to plan implementation of this), provides a starting point for such analysis, but is unlikely to fully meet requirements of the ecosystem approach in the first round of MSFD implementation (it is not explicitly set up to do so).

- An ability to implicitly take account of the combined impacts of human pressures at different spatial scales, for example, the recent review of cumulative effects of offshore wind farms (MMO, 2013i), work to develop a high level approach to cumulative effects assessment (MMO1055: 'A Strategic Level Approach to Cumulative Effects') and work being taken forward by the JNCC and Centre for Environment, Fisheries and Aquaculture Science (Cefas) to develop standardised pressure layers.

- To consider spatial overlaps between activities, both in terms of human activities (co-location) and identification of ecosystem service 'hot spots', allowing policies to focus on protecting areas that provide greatest value.

- Support links to other aspects of marine analysis, in particular:
    - Spatial and scientific classifications of biotopes and ecosystem services, recognising the range of factors determining levels of marine

ecosystem services (described as contributing factors in current work on benthic ecosystem services (eftec and ABPmer, 2013).

- Supporting links to sectors, linking to where economic information is integrated into marine plans, and supporting disaggregation of data to appropriate spatial scales (e.g. to examine social impacts on marine-dependent communities, as being taken forward by MMO 1060 'Social Impacts and Interactions' (MMO (2014b)), and between different human activities subject to different management measures (e.g. to distinguish between different forms of marine recreation, or different fishing gears).

3.2 Overview of framework

The proposed framework for improving the implementation of the ecosystem approach in marine planning has three parts. These are illustrated in Figure 2 and described below and in Table 5.

Figure 3: Outline of framework for implementing the ecosystem approach in the MMO's marine planning.

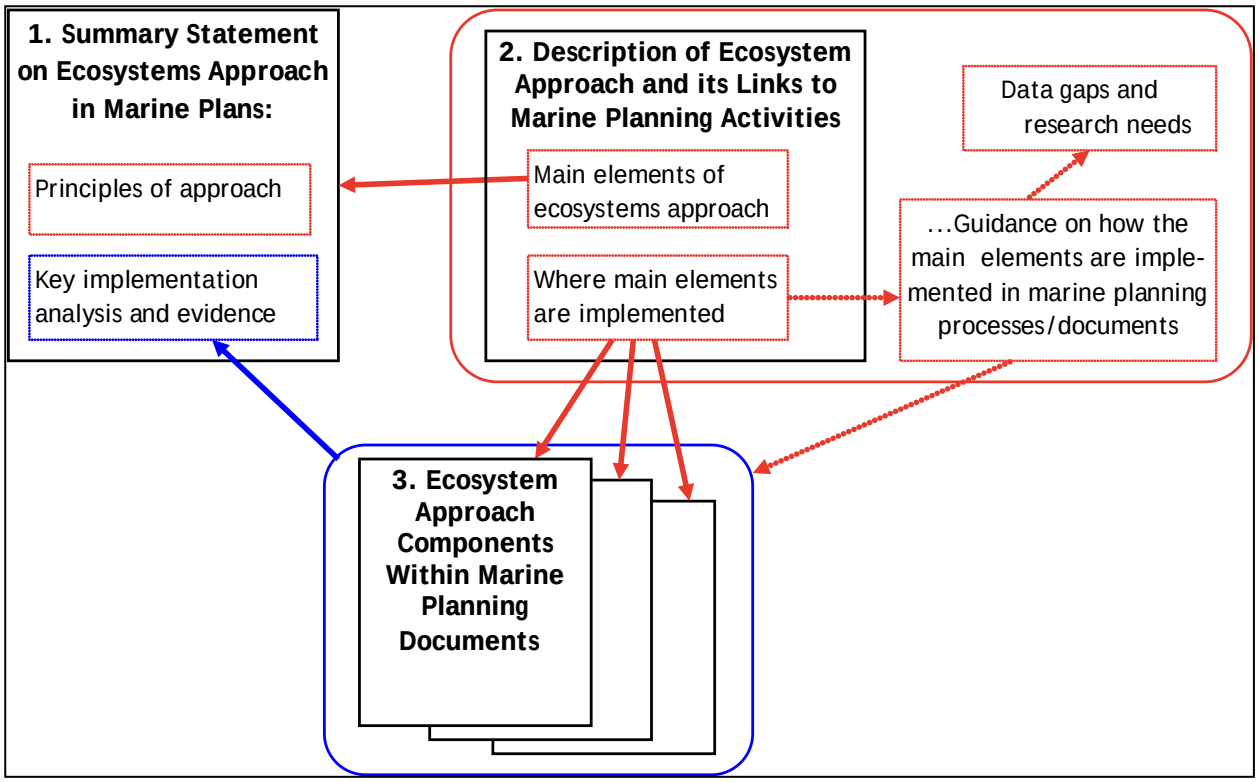


Table 4: Elements of framework for implementing the ecosystem approach in marine planning.

Part	Element	Proposed location in marine planning documents	Purpose and links
1	Statement on Ecosystem Approach in marine plans	Short section within headline marine planning documents (e.g. in marine region plan).	Summary of method linking to Part 2; Summary of and cross-reference to ecosystem approach analysis contained elsewhere in marine planning documents.
2	Description of Ecosystem Approach and its links to marine planning activities	Annex to marine plan or in other supporting documentation describing how marine plans implement ecosystem approach - based on ten principles in Box 1	Clear description of ecosystem approach within MMO's marine planning process. Supports summary statement on ecosystem approach in Part 1.
3	Linkages to Ecosystem Approach components Within marine planning documents	Elements of ecosystem approach throughout marine planning documents (e.g. IA, SA) remain *in situ*, but are flagged as contributing to ecosystem approach. Any additional analysis required to implement ecosystem approach added as subsections of relevant documents. See guidance in Section 5.	Cross-reference to ecosystem approach summary (Part 1) from main elements identified.

3.2.1 Part 1: Statement on ecosystem approach in marine plans

This part of the proposed framework would be the focal point for implementation of the ecosystem approach in marine plans. It is intended as the first information on the ecosystem approach encountered by stakeholders in marine plans. It is envisaged as a short section (1 – 2 pages), summarising and signposting all the relevant information and analysis making up the ecosystem approach throughout marine plans and associated documents.

This statement could be structured as follows:

- Summary statement on the ecosystem approach in marine planning (what is it, how is it being implemented) taking key points from, and cross referenced to, an annex (containing Part 2 of the framework).

- An evidence summary, possibly in the form of a table, of the key analysis/information in marine plans that make up elements of the ecosystem approach. Evidence in this summary is likely to include:
    - Headline points from the evidence/analysis, including its geographical and temporal scale
    - The elements of the ecosystem approach it relates to (based on the ten principles in Box 1)
    - The information source (with links to material where this evidence is generated).
- Conclusions on the extent to which the marine plan implements the ecosystem approach, identifying key aspects of marine management for the ecosystem approach, and acknowledgement of uncertainties and gaps in knowledge that impair implementation of the ecosystem approach.

3.2.2 Part 2: Description of ecosystem approach and its links to marine planning activities

This part of the proposed framework is intended as a standalone Annex to marine planning documentation, containing:

- A definition of the ecosystem approach, with reference to its implementation in marine planning.
- The requirements of the ecosystem approach identified from relevant literature (cross-referenced to this report).
- A description of how MMO is implementing the ecosystem approach in marine planning (based on the outputs of, and cross-referenced to, the final report of this study), including a diagram showing implementation (based on Figure 1).
- A collation of key evidence from elsewhere in marine planning documents (e.g. SA, supporting economic analysis) that implement the ecosystem approach in marine planning. This is effectively a longer version of the summary evidence table described in Part 1, containing the same information, but providing more detail of the analysis involved, including descriptions of ranges and uncertainties in data.
- A checklist on how different parts of existing marine planning documentation implement different parts of the requirements of the ecosystem approach, and how they relate to each other. This checklist can also act as guidance to those compiling the relevant documentation to ensure that it includes the necessary information.
- Where the requirements of the ecosystem approach in marine planning are not fulfilled by existing documentation (identified by comparing the checklist and collation of key evidence, described above), guidance on further analysis/ evidence required. It will identify where further analysis can most efficiently be carried out (e.g. further subsections of existing documents, methods for completing them), and how to address data gaps (see below).
- A conclusion on the extent to which the marine plan implements the ecosystem approach, identifying key aspects of marine management in the relevant plan area for the ecosystem approach, and acknowledgement of uncertainties and gaps in knowledge that impair implementation of the ecosystem approach (linking to the conclusion in Part 1).

This part of the ecosystem approach framework is intended to work alongside other elements of marine planning, such as analysis of co-existence or cumulative effects, and marine economic valuation studies, as they develop.

Where a marine plan identifies data gaps that inhibit implementation of the ecosystem approach:

- Some judgement will need to be made about the importance of the gaps to the implementation of the ecosystem approach in marine planning
- Consideration should be given to the feasibility/effort/timescales of gathering the relevant data (including whether they can be obtained at all)
- The best methods to use to collect the data, given the requirements of the ecosystem approach in marine planning
- Suggestions on who is best placed to gather the relevant information, including recommendations on methods of how to handle links to GIS, and where MMO is not best placed to lead the work, how MMO could engage in its development.

These observations on data gaps will be addressed to all the stakeholders in the marine planning process, in particular other agencies with statutory roles (e.g. JNCC) to encourage consideration of how the current roles of different agencies fit together to implement the ecosystem approach.

3.2.3 Part 3: Linkages from marine planning documents to ecosystem approach components

This element of the ecosystem approach in marine planning is not intended to exist in a standalone form, but exists conceptually with the documentation that makes up the marine planning process. It reflects the spread of the information highlighted in the checklist on how different parts of existing marine planning documentation implement different parts of the requirements of the ecosystem approach (see Part 2). These linkages will reflect the structure of marine planning documents used in any regional plan: while the structure of the documents may evolve over time, the relevant elements of analysis and evidence required to implement the ecosystem approach will still need to be present.

The different parts of marine planning documents that contain the analysis/evidence implementing the ecosystem approach should explicitly recognise this. Some standard text should be developed for them, making reference to:

- The overall requirements of the ecosystem approach (described in Part 1)
- Which parts of these requirements they contribute to, and that they have used appropriate approaches to do so (linking to the checklist described in Part 2).

3.3 Economic and social analysis

An important link identified at several points in the preceding analysis is the connection between the ecosystem approach and social and economic analysis. Economic and some aspects of social analysis will be available through supporting economic analyses. This links to the ecosystem approach in a number of ways which

are described more in 5.6). Firstly, it should capture socio-economic analysis of marine activities and of the implications of marine plans. This covers distribution of impacts both positive and negative, wellbeing, health, employment and resources. This links to several of the principles, particularly Principle 2, from Figure 1. Data for these socio-economic analyses are relatively well captured in current analysis based on market data and in statistics for economic sectors.

Secondly, there is a need for socio-economic analysis (such as under Principle 2 in Figure 1) to reflect the other principles (such as Principle 7 on ecosystem structure and function). This need results from recognition that socio-economic analysis dominates information provided to decision-makers. Approaches for reflecting the ecosystem approach in socio-economic analysis are discussed in Section 5.6.

Socio-economic analysis should capture changes in human welfare. Changes in the state of the marine ecosystem can be linked to human welfare using the ecosystem services framework. This is described further in Section 5.7 and Annex 3.

3.4 Tools to support the implementation of the ecosystem approach

The literature review presented in Annex 1 established the definitions and principles for delivering the ecosystem approach and explored its current and past applications in the marine environment. From this review it is apparent that the overall concept of the ecosystem approach is widely understood and the overall process for its implementation and delivery is well established. However, there remains a requirement for effective tools and data to support implementation of the ecosystem approach. Robust tools are needed in order to predict and model future changes to the provision of ecosystem services and ecosystem health under varying management scenarios and levels of human pressure, and to evaluate economic and social impacts.

There are currently a number of such tools designed to aid the implementation of the ecosystem approach that range from spatial management tools to complex computer software, requiring large amounts of social and economic data. A review of these tools is presented in Annex 2 which also drew on a previous wider review of spatial, social and economic data and tools (MMO, 2012b; Stelzenmuller *et al*., 2013). A summary of the strengths and weaknesses of each tool is presented in Table 6.

Based on the review, many of the tools would have some potential for application within UK waters but none are comprehensive or suitable for immediate application. The most useful tools are likely to be those developed by Defra and Marine Scotland to support implementation of MSFD, and the approach developed by Marine Scotland to undertake socio-economic assessment in its marine waters. This is particularly because these tools are consistent with the institutional and legal frameworks applied in the UK and are based on relevant UK spatial data. While these tools are still under development and suffer from data limitations and a weak evidence base, over time, they are likely to be increasingly useful in providing quantitative assessments of potential change. A key strength of the tools is that, because they are inherently spatial and temporal, they can be used to consider potential cumulative effects. A recent report prepared by MMO (2014a) explored the requirements of MMO functions including planning, licensing and conservation for an

approach to the assessment of the co-existence potential of marine sectors. The work proposed a draft framework and scoped the feasibility of fully developing the framework to would deliver such an approach considering environmental, economic and social factors.

Two particular components of MSFD tools have potential application within marine planning:

- A tool to project the future state of the marine environment in relation to indicators and targets for GES descriptors (the business as usual (BAU) model) which uses the DPSIR framework (ABPmer and eftec, 2012). Further development of this tool and human pressure layers is being taken forward by Cefas and JNCC on behalf of Defra.
- The development of the evidence base on marine ecosystem services (eftec and ABPmer, 2013.) which has included the development of a spatial model of benthic marine ecosystem service provision.

While the tools have been developed to inform UK implementation of MSFD, they also have wider application within marine planning. Firstly, marine planning will need to ensure that environmental targets established under MSFD are not compromised by human activity pressures, particularly associated with increasing economic development within the sea. The tools can also be used to explore wider changes in ecosystem structure and function. As the tools are further developed and their reliability and accuracy improves, they are therefore likely to be more useful for testing marine plan options and draft policies which might give rise to significant environmental effects and which therefore may require more detailed assessment.

The Marine Scotland socio-economic assessment tools (Marine Scotland, 2013a, b) use an interactions approach to identify potential social and economic impacts. The tools use spatial analysis together with stakeholder consultation to identify the potential significance of interactions. Economic impacts are quantified and monetised, where possible, using HM Treasury Green Book methods (HM Treasury, 2011). The tools provide a qualitative assessment of social impacts based on a social capitals approach (Harper and Price, 2011) and using a distributional analysis based on the economic assessment. A limitation of the methodology is that the evidence base on interactions and consequential impacts is currently weak (MMO, 2014a). This can be accommodated to some extent by using scenarios and sensitivity testing. Stakeholder consultation is also important in seeking to build consensus around impact estimates. Some further work to document how interactions give rise to social impacts is has been undertaken (MMO, 2014b).

Table 5: Summary of the strengths and weaknesses of existing tools to support the implementation of the ecosystem approach and their applicability in the UK drawing on MMO 2012b.

Tool	Used in practice?	Strengths	Weaknesses	Comments on applicability in the UK
EcoQOs	Yes	• Provide detailed coverage of many elements of the ecosystem and pressures acting upon it • Clear objectives are easily measurable/enforceable	• Do not cover all ecosystem components and processes • Requires long-term data series	Defined clear indicators for the North Sea ecosystem, although future work aims to align current EcoQOs with MSFD descriptors, as well as developing further EcoQOs. Development of EcoQOs for UK waters a possibility.
ODEMM Pressure Assessment	Yes	• Gives weights to ecosystem interactions • Takes account of sensitivity of ecological characteristics • Uses expert judgement to assess spatial overlap with pressure and the temporal persistence of the pressure • Can be used to assess cumulative effects	• Relies heavily on expert judgement • Applied to broad-scale EUNIS level 2 habitats; subject to high variation in sensitivity and spatial extent	Has been applied for EUNIS level 2 habitats around Europe but broad-scale habitats are therefore subject to high variation in sensitivity and extent of overlap. Potential for UK application although with limitations and as yet no review of its practical use.
TraC-MImAs (Transitional and Coastal Waters Morphological Impact Assessment System)	Yes	• Calculates risk posed to ecosystem capacity by new developments • Scoring system allows an 'impact rating' • Can be used to produce risk-based status maps • Can be used to assess cumulative effects	• Unable to take into account complex ecological relationships or specific biotopes and their sensitivity/resilience	Developed for use in assessing the risk of not delivering GES under WFD. Possible potential for modification for use in MSFD assessment as part of the ecosystem approach.
ARIES	Yes	• Can be used without complete data, gives an indication of uncertainty • Can build a simple or complex model as the user intends • Potential to apply in screening or scoping process • Ability to compare scenarios and	• Currently no data for UK, although possible to input your own • No 'off the shelf' model • Need for long-term funding and maintenance plan for	User can input data. May provide useful modelling tool if relevant UK data is available.

Tool	Used in practice?	Strengths	Weaknesses	Comments on applicability in the UK
		potential ripple effects • Depiction of bundled ecosystem services on spatial map • Relatively low level of effort required for basic models	both the tool and database • Modelling methods not transparent	
InVEST	Yes	• Compares outcomes of multiple scenarios • Can be run at multiple geographic scales • Provides biophysical or economic outputs • Modular, tiered approach • Can be used to assess cumulative effects	• Lack of availability of suitable spatial data limits application of tool • Requires proficiency in GIS • Limited modelling of feedbacks between ecosystem services • Changes in human behaviour generally not modelled	User can input data. May provide useful modelling tool if relevant UK data is available.
POLCOMS-ERSEM	Yes	• Represents aspects of the hydrodynamics and ecosystem behaviour of the region • Can be used to assess cumulative effects	• Poor data availability • Good modelling of sea surface temperature • Poor modelling of nutrient cycling	Developed for NE Atlantic region and shown to successfully model hydrodynamics and ecosystem function of NW European continental shelf.
Ecopath with Ecosim	Yes	• Allows user to explore models temporally and spatially • Allows user to add in different variables affecting system e.g. temperature, fishing effort etc. • User friendly and free • Can be used to assess cumulative effects	• Data intense beyond simplistic models • Developed specifically for fisheries with limited scope for integration of other human activities/ pressures	Developed for use in fisheries modelling and therefore relatively specialised. Limited integration of other human pressures so limited scope for its use in the ecosystem approach to holistic MSP.
Cumulative Effects Analysis (CEA)	Yes	• Provides assessment of effects of multiple activities • Allows assessment of impacts in wider context with broader scope,	• Lack of suitable data to populate CEA models; • Inadequate understanding of many	The SEA Directive requires cumulative effects of a plan or programme to be considered. Legislation relevant to UK and presents a useful tool when implementing the ecosystem approach.

Tool	Used in practice?	Strengths	Weaknesses	Comments on applicability in the UK
		incorporating qualitative data • Allows broader cumulative effects to be considered at an appropriate level of decision making	cumulative interactions and impacts	
ESR for IA	No specific examples of its application	• Identify unexpected social impacts and operational risks • Increase understanding of socio-economic aspects of environmental impacts and the operational implications of ecosystem change • Identify additional mitigation measures for social impacts and management measures	• No information on its practical applications	Methodology complements standard Environmental Impact Assessment (EIA) methodology to incorporate ecosystem services into assessment. Concept of identifying and prioritising relevant ecosystem services may be incorporated into initial assessment.
Toolkit for Ecosystem Service Site-based Assessment (TESSA)	Yes	• Identifies priority ecosystem services and how to measure them • Identifies consequences of a given activity or development • Adaptable for local conditions	• Lack of detail of all ecosystem services • Difficult to derive monetary value for water-based activities • Does not address sustainability or resilience of ecosystem or temporal variation • Does not consider non-linearities or disproportionate effects/tipping points • No consideration of climate change projections	Methods to measure and quantify ecosystem services can provide valuable data for use in tools such as InVEST and ARIES. Provides methodological framework for identifying and measuring ecosystem services at “current state” and “plausible alternative states”.
MSFD Modelling	Currently under development	• Combines environmental features and human activity pressures along with sensitivity information to produce vulnerability assessment in relation to achieving GES • Assess marginal change in	• Lack of suitable spatial data of feature distributions and human pressures • Lack of understanding of impact of human	In development specifically for the implementation of MSFD in the UK by UK and Scottish government agencies. Draws on current best information of UK habitats, species and levels of human activity and pressures.

Tool	Used in practice?	Strengths	Weaknesses	Comments on applicability in the UK
		ecosystem service provision • Tools can be used to assess cumulative effects • CBA of implementation of mitigation measures	pressures on ES provision	
Marine Scotland Socio-economic Assessment Tools	Yes	• Adopt readily understood interactions approach • Draw on available evidence of potential social and economic impacts, informed by stakeholder consultation • Provide quantitative assessment of potential economic impacts to human activities • Provide qualitative assessment of potential social impact based on distributional analysis • Tools can be used to assess cumulative effects	• Limited data on human activities, particularly future human activity • Limited evidence on social and economic impacts associated with interactions • Lack of quantification of social impacts	Directly applicable within UK and successful experience of doing so.

3.5 Outlining the required evidence and data

As part of the current marine planning process, MMO seeks to collate and present readily available existing baseline information on environmental, social and economic factors early on in the process and to engage stakeholders in identifying additional baseline data. This provides an opportunity to identify evidence gaps and to seek to address them where appropriate, either to inform initial plan preparation or subsequent iterations of the plan. This baseline evidence is then used in the SA to assess draft plan options and draft plan policies to help to identify preferred options and policies.

The evidence and data requirements are a function of the scope of the framework used to implement the ecosystem approach and the types of tools that are used to undertake any supporting assessments. Given that the ecosystem approach explicitly seeks to integrate environmental, economic and social factors, the evidence requirements to inform the relevant underpinning assessments are potentially very substantial.

As noted in Section 3.4, a range of tools is being developed which could support integrated assessment. Figures 3 and 4 present illustrative frameworks which set out the broad process that might be followed to facilitate integrated assessments using the relevant tools, together with the associated information requirements. These frameworks effectively provide a ‘UK model’ for undertaking integrated assessment together with a list of information requirements. It may be helpful to formalise these frameworks and supporting data requirements at a UK level, and to develop controlled data lists, to promote consistency of their application between these frameworks and the ecosystem approach and to help focus the further development of data and information requirements.

In broad terms, the core information requirements to support implementation of the frameworks in Figures 3 and 4 and the ecosystem approach include:

- Spatial data layers
    - Current and future distribution and condition of ecological features.
    - Current and future distribution of human activities and pressures.
    - Current and future distribution of ecosystem services provision.
- Non-spatial data.
    - Sensitivity data on ecological features.
    - Understanding of social impacts.
    - Understanding of social and economic outcomes of interactions between human activities.
    - Costs of management measures.
    - Market and non-market data for activities.
    - Information on employment linked to marine activities.
    - Understanding of marine natural capital (capacity of ecosystem to produce ecosystem services).
    - Valuation data for marginal changes in ES provision.

The MMO Master Data Register[13] includes a listing of all spatial datasets used by MMO to inform marine planning. These largely relate to the current/historic distribution of ecological features and human activities, although some information on the possible future distribution of activities is available, for example proposed areas for future offshore wind development. The gaps in spatial baseline data to support marine planning are relatively well understood based on previous marine planning activity (MMO, 2012a; 2013f; Marine Scotland, 2013a). Table 7 describes the current availability of data in relation to the suggested requirements and identifies key gaps together with current actions to address those gaps. These gaps include:

- Inaccurate and inadequately resolved habitat maps
- Varying spatial quality and confidence in habitat and species maps
- Incomplete spatial coverage for protected habitats and species
- Habitats and species maps represent a snapshot in time and do not reflect the temporal variability demonstrated in the marine environment
- Lack of information on habitat and species condition
- Inadequate information on the spatial distribution of highly mobile species (e.g. marine mammals, birds and fish) and their functional use of areas in which they occur
- Distribution and intensity of commercial fishing activity, particularly for the under 15m fleet
- Distribution and intensity of commercial shipping
- Distribution and intensity of recreational activities
- Absence of spatial data on social impacts
- Lack of adequate spatial data to inform future baseline maps;
- Absence of suitable information (e.g. GIS layers) on the spatial distribution of pressures
- Absence of current and future baseline layers for ecosystem services provision.

Table 8 provides a summary of the current availability of non-spatial data and highlights current gaps and actions to address these gaps. The table highlights that there are gaps in all areas and to a significant degree.

[13] https://www.gov.uk/government/publications/master-data-register

Table 6: Spatial data requirements and data gaps.

Requirement	Current availability	Data gaps and current initiatives
Current and future distribution and condition of ecological features	EU SeaMap provides comprehensive coverage of sea bed habitats using a combination of observed and modelled data; MESH Atlantic Habitat Map is based purely on survey data. The geographical coverage is patchy across UK waters. This data is being enhanced by ongoing surveys undertaken to support designation of UK MPAs. JNCC Annex 1 habitat layers. Cetacean Atlas and European Seabirds at Sea Atlas provide coarse resolution data for mammals and birds. These information sources are supplemented by information provided under the Joint Cetacean Protocol, industry data and ongoing data collection by and on behalf of the statutory nature conservation bodies. Special Committee on Seals information on seal colonies and pup production MB0102 data layers provide information on distribution of fish and fish spawning and nursery grounds (Ellis *et al.*, 2010)	Inaccurate and inadequately resolved habitat maps; incomplete information on distribution of protected habitats and species. General lack of good spatial information on habitat condition. MAREMAP project continues to develop improved data and methods for preparing broad scale habitat maps. Data for marine mammals and seabirds are generally not sufficiently spatially resolved to facilitate planning and information on functional use is weak. Some information on condition available from Statutory Nature Conservation Bodies status reports (e.g. Article 17 Reports for cetaceans). Information on movements of migratory species inadequate to inform planning.
Current and future distribution of human activities and pressures	The MMO Master Data Register identifies wide range of data sources for the existing distribution of activities. Some of these data sources are becoming dated (e.g. Stakmap data collected by MCZ Regional Projects).	Some weaknesses in data layers for existing activities (e.g. commercial fisheries <15m fleet; commercial navigation, recreation). MMO 1066 (MMO, 2014d) has developed national shipping data layers. General lack of future data layers General lack of pressure layers. Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) has prioritised production of pressure layers and JNCC/Cefas are working together to prepare some of these, although issues remain with spatial resolution of layers. The confidence in the quality of both pressure and feature maps is

Requirement	Current availability	Data gaps and current initiatives
		spatially variable. For example, offshore mapping of broadscale habitats is probably of a similar data quality and level of resolution as fishing activity (abrasion pressure). In contrast mapping of inshore fisheries data and smaller scale features is not typically as well resolved generating spatial incompatibilities when overlapping these datasets.
Current and future distribution of ecosystem service provision	Limited information available from UK NEA (Austen *et al.*, 2011) and NEA Follow-On work (in prep). Initial spatial model of marine ecosystem service provision in UK seas (eftec and ABPmer, 2013)	Low confidence in current maps of ES provision, affected by confidence in underlying data (e.g. weaknesses in existing habitat maps)

Table 7: Non-spatial data requirements and data gaps.

Requirement	Current Availability	Data Gaps and Current Initiatives
Sensitivity data for ecological features	MB0102 sensitivity matrix provides information for benthic MPA features (Tillin *et al.*, 2010); Scottish MPA project has added to this (FEAST). This is being updated by JNCC, and Natural England have commissioned some work on sensitivity of birds (Bradbury et al. 2014).	Lack of coverage for non-MPA benthic features; limited information on mobile species. Natural England commissioning work to develop evidence base on sensitivity of mobile features.
Understanding of social impacts	MMO 1035 (MMO, 2013k) has collated information on social impacts for five key MPS activities.	Incomplete coverage of all MPS activities. MMO (2014b) will extend coverage to all MPS activities.
Understanding impacts of interactions between human activities	A number of generic interaction matrices exist (e.g. MMO, 2013h). More detailed interaction tables exist for some sectors (e.g. Marine Scotland, 2013a)	Lack of comprehensive understanding of environmental, economic and social impacts of interactions between human activities. MMO (2014b) will collate information on social impacts and interactions.
Costs of management measures	Some information available from existing impact assessments (e.g. Finding Sanctuary *et al.*, 2012; Marine Scotland, 2013a, b)	Lack of comprehensive information on costs of management measures; information not collated in a single place
Market and non-market data for activities	Charting Progress 2 compiled information on economic values of marine activities. Some subsequent sectoral economic reports have also been published. MMO 1050 (MMO, 2013m) has compiled economic baseline for South Marine Plan areas	Difficult to establish market data for some sectors e.g. cables and pipelines. Need to develop methods for applying non-market data e.g. replacement cost.
Information on employment	Office of National Statistics (ONS) provides breakdown by Standard Industrial Classification of Economic Activity (SIC)codes and geographically	SIC codes do not adequately define marine-related activities (e.g. see Pugh, 2008)
Understanding of marine natural capital	UK National Ecosystem Assessment (UKNEA) provides some information on marine ES values (Austen *et al.,* 2011); some additional work has been completed by NEA follow-on project (e.g. on benefits of MPAs to divers and recreational anglers; Kenter *et al.*, 2013)	Lack of good data for some services, particularly cultural services. Defra and ONS taking forward work to scope marine natural capital accounts. NEA Follow-on reports will be available in spring 2014.
Valuing marginal changes in ES provision	UKNEA provides some information on marine ES values (Austen *et al.,* 2011);	Eftec and ABPmer (2013) are developing the evidence base for marine ecosystem services but many gaps remain.

Figure 4: Indicative environmental assessment model.

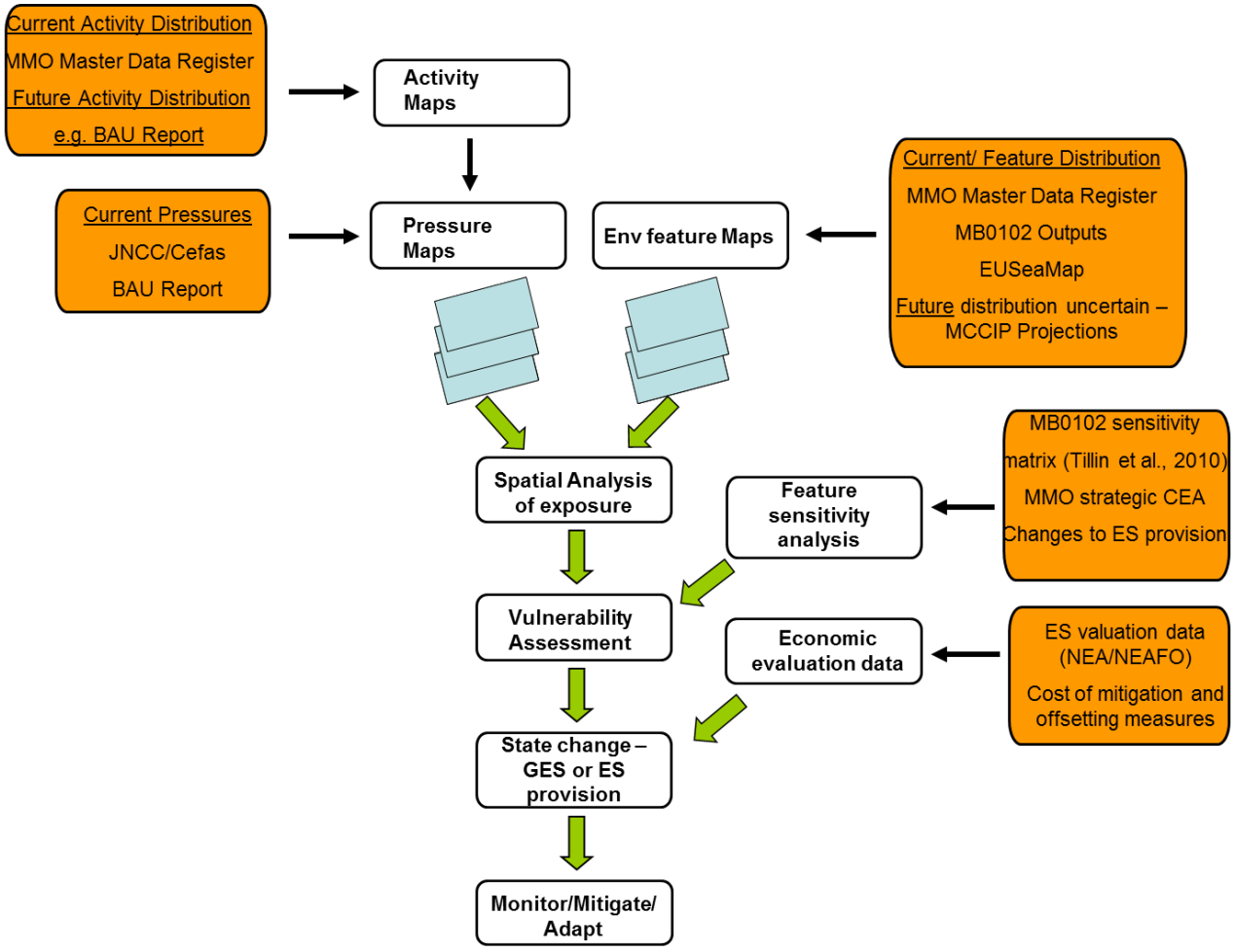
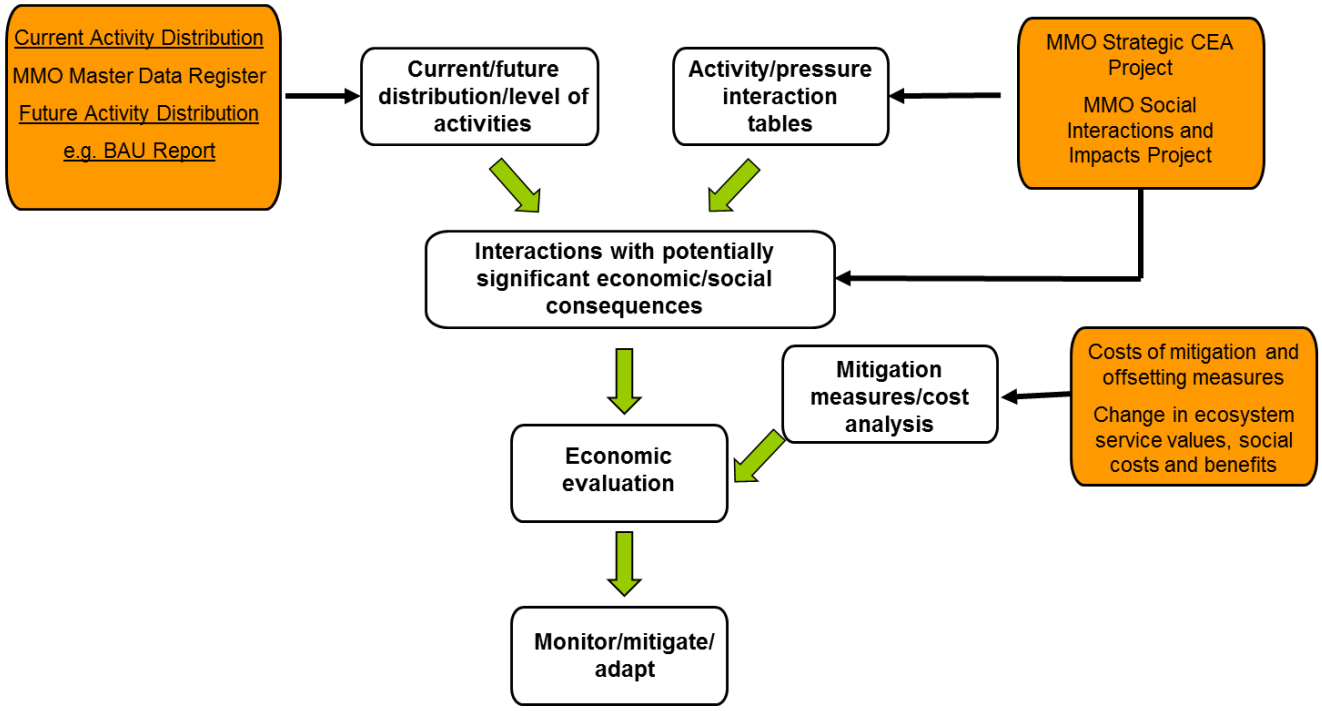


Figure 5: Indicative socio-economic assessment model.



4. Case study on draft East marine plans

4.1 Introduction

To further explore the application of ecosystem approach principles within marine planning, the principles were reviewed against the process followed to develop the East Marine Plans.

In addition, a trial application of some of the tools developed for UK implementation of MSFD was undertaken (see Annex 4). This included application of the BAU tool to the East Marine Plan area to explore potential future changes in abrasion pressure from commercial fishing on selected sea bed habitats and the use of an ecosystem services model to assess potential changes in secondary productivity as a result of changes in abrasion pressure from commercial fishing. The trial was undertaken because a key current limitation in applying the ecosystem approach is the difficulty in reliably quantifying potential changes in ecosystem structure and function in response to policy interventions. It is thus important that such approaches are explored if the current barriers are to be overcome. The findings from the trial are incorporated into the case study at appropriate points, primarily in relation to Principle 3 (establishing a robust baseline) and Principle 7 (conserving ecosystem structure and function).

4.2 Current application of ecosystem approach and potential improvement opportunities

4.2.1 Principle 1: Clear long-term ecosystem objectives, targets and indicators against which progress can be monitored

Within the East Marine Plans (MMO, 2013a), the HLMOs set out in the MPS are translated into three key objectives and accompanying policies to conserve the marine ecosystem:

- Objective 6: To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas:
    - ECO1: Cumulative impacts affecting the ecosystem of the East Marine Plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation
    - ECO 2: The risk of release of hazardous substances as a result of any increased collision risk should be taken account of in proposals that require an authorisation.
- Objective 7: To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East Marine Plan areas:
    - BIO1: Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence including on habitats and species that are protected or of conservation concern in the East Marine Plans and adjacent areas.
    - BIO 2: Where appropriate, proposals for development should incorporate features that enhance biodiversity and geological interests.
- Objective 8: To support the objectives of MPAs (and other designated sites around the coast that overlap, or are adjacent to the East Marine Plan areas), individually and as part of an ecologically coherent network.
    - MPA1: Any impacts on the overall MPA network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network.

The objectives were based on the MPS HLMOs because marine plans need to be consistent with the MPS. Initial drafts of objectives and policies were prepared by MMO and then refined through formal and informal consultation. No specific ecosystem targets or indicators have been established within the draft East Marine Plans. Rather, the plan signposts the numerous of other environmental objectives, targets and indicators particularly stemming from international commitments and European Directives as well as from national legislation, including:

- The EU Marine Strategy Framework Directive (2008/58/EC).
- The EU Water Framework Directive (2000/60/EC).
- The Habitats and Wild Birds Directives (92/43/EC and 2009/147/EC).
- The Common Fisheries Policy.
- The Marine and Coastal Access Act (2009) (in relation to MCZs).

The SA for the draft East Marine Plans (MMO, 2013c) identifies a very wide range of ecosystem and environmental objectives, targets and indicators which marine

planning needs to take account. Responsibility for planning for and monitoring achievement of these objectives, targets and indicators is very fragmented across a range of organisations with responsibilities relating to the marine environment. Furthermore, many of the policies lack specific objectives or targets. Thus while the draft East Marine Plans provide some clear overarching ecosystem objectives, the linkages between plan objectives and the existing policies, objectives, targets and indicators is much less clear.

For future marine plans, it is likely that ecosystem objectives, targets and indicators will continue to be largely driven by statutory requirements stemming from European legislation and the need to ensure consistency with the MPS. While this approach provides many objectives, targets and indicators, their very number and the overlapping nature of requirements, means that they are not particularly clear. However, this is considered unavoidable as the objectives, targets and indicators are largely statutory.

Within its IMPs, MMO should consider how it can make clear linkages between the detailed objectives, targets and indicators and the achievement of its marine plan objectives.

4.2.2 Principle 2: Integration of social and economic factors

Within the planning process for the Marine Plans, the policies in the plan were developed in the context of the available evidence on social and economic factors. The options available for consideration in the marine plan are then taken into account within the SA (e.g. MMO, 2013c) and an analysis of potential impacts of plan policies (e.g. MMO, 2013e).

A range of supporting economic analyses can be drawn on here. The Evidence and Issues Report (MMO, 2012a) for the East Marine Plans included a significant amount of information on the economic value of human activities in the plan areas. Separately, some information on social factors relevant to the plan areas was documented in Roger Tym and Partners (2011). There is further evidence on recreational activities in MMO1013 (MMO, 2012b) and social impacts in MMO1035 (MMO, 2013k), plus methods and tools are reviewed in MMO1012 (MMO, 2012c), MMO1060 (MMO, 2014b), MMO1061 (MMO, 2014c) and MMO1075 (2014e).

In broad terms most plan policies will have either a direct or indirect effect on socio-economic objectives. The draft East Marine Plans developed two key social and cultural objectives, accompanied by a number of policies that aim to realise social benefits of the plan and improve people's well-being:

- Objective 4: To reduce deprivation and support vibrant, sustainable communities through improving health and social well-being
    - SOC1: Proposals that provide health and social well-being benefits including through maintaining, or enhancing, access to the coast and marine area should be supported
- Objective 5: To conserve heritage assets and ensure that decisions consider the character of the local area
    - SOC2: Proposals that may affect heritage assets should demonstrate, in order of preference:

    a) that they will not compromise or harm elements which contribute to the significance of the heritage asset
    b) how, if there is compromise or harm to a heritage asset, this will be minimised
    c) how, where compromise or harm to a heritage asset cannot be minimised it will be mitigated against, or
    d) the public benefits for proceeding with the proposal if it is not possible to minimise or mitigate compromise or harm to the heritage asset.
  - SOC3: Proposals that may affect the terrestrial and marine character of an area should demonstrate, in order of preference:
    a) that they will not adversely impact the terrestrial and marine character of an area
    b) how, if there are adverse impacts on the terrestrial and marine character of an area, they will minimise them
    c) how, where these adverse impacts on the terrestrial and marine character of an area cannot be minimised they will be mitigated against
    d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts.

Social benefits and community effects will result from economic growth stimulated by the introduction of the draft East Marine Plans. Economic objectives and policies were developed for the plan to support economic growth that would contribute to both the national and local economies:

- Objective 1: To promote the sustainable development of economically productive activities, while taking account of spatial requirements of other activities of importance to the East Marine Plan areas:
  - EC1: Proposals that provide sustainable economic productivity benefits which are additional to Gross Value Added generated by existing activities should be supported
- Objective 2: To support activities that create employment at all skill levels, taking account of the spatial and other requirements of activities in the East Marine Plan areas.
  - EC2: Proposals that provide additional sustainable employment benefits should be supported, particularly where those benefits have the potential to meet employment needs in localities close to the marine plan areas.
- Objective 3: To realise sustainably the potential of renewable energy, particularly offshore wind, which is likely to be the most significant transformational economic activity over the next 20 years in the East Marine Plan areas, helping to achieve the UK's energy security and carbon reduction objectives.
  - EC3: Proposals that will help the East Marine Plan areas to contribute substantially to offshore wind energy generation should be supported

In addition to the plan-specific policies, the Evidence and Issues paper outlines other relevant economic and social policy and guidance at the European, national and local levels, together with signposting in the draft East Marine Plans. The objectives

were developed by MMO to be consistent with the MPS. The initial plan policies were also drafted by MMO and further developed through formal and informal consultation.

Chapter 6 of the Evidence and Issues Report (MMO, 2012a) provides detailed baseline information on social and economic factors of communities in the East Plan Areas. Issues regarding these social and economic factors are then discussed with regards to plan implementation, along with opportunities for the plan to promote investment in the area and increase economic growth, leading to increased employment and other social benefits. MMO consulted on the Evidence and Issues Report with all stakeholders.

The SA (MMO, 2013c) considers impacts of the plans on economic interests and communities along the coastline and in inland areas corresponding to the East Marine Plan areas. The scoping process for the SA investigated whether an Equalities Impact Assessment would be appropriate to determine impacts of the plans on issues of equality and discrimination, although it was determined that such issues would be taken into account within the SA where appropriate.

An analysis of the impacts of plan policies (MMO, 2013e) considered economic impacts of the plans by sector, and social impacts that would arise from such economic benefits.

A lack of data and appropriate tools presents significant challenges for the quantitative assessment of the economic and social impacts of the policies of the East Marine Plans. The large volume of information and the multiplicity of issues also presented challenges in effectively engaging stakeholders in the discussion of economic and social factors and potential impacts and integrating these considerations with environmental factors in line with the requirements of the ecosystem approach.

Understanding the extent to which sustainable development is being achieved is difficult due to the multiplicity of drivers. Supporting economic analysis could be carried out that would seek to better quantify such impacts and wider changes in the marine plan area (see discussion in Section 5 and Annex 3). This could build on the approaches to plan level socio-economic assessment developed by Marine Scotland (2013a, b) – see Section 3.4 on tools.

MMO could also refine the marine planning process and seek to ensure that it structures the information it provides to stakeholders to facilitate discussion and the integration of environmental, economic and social factors. This might also include greater targeting of particular groups of stakeholders to focus on identifying solutions to key issues.

4.2.3 Principle 3: Establishing a robust dynamic baseline

The Evidence and Issues Report (MMO, 2012a) collated evidence for use in the East Marine Plan areas in order to highlight the relevant issues to be addressed within the planning process. The methods for evidence gathering drew on four main sources of information: national policy, stakeholder engagement, technical data collation and GIS analysis and sub-national plans and policies.

The MPS and other national policy was assessed in order to translate high level policy into detailed policy and spatial guidance within the plan area. Stakeholder engagement was conducted by the Marine Planning Team that included a liaison officer based in Lowestoft. This planning officer attended local, national and international meetings and events in order to gather stakeholder views and information, to ensure that plans meet the needs and expectations of stakeholders. A wide range of datasets were collated while working with a range of partners and stakeholders that were used to develop maps and statistics related to activities and the environment, in order to assess levels of interaction and current and future scenarios. Attention was also paid to existing sub-national plans and particularly terrestrial plans, through the development of an assessment framework for local plans.

MMO's stakeholder engagement during the development of the draft plans included:

- Five series of stakeholder workshops attended by over 300 people in total
- Over 350 one-to-one meetings with marine sector representatives from industries such as offshore wind, fishing, recreation, aggregates and cabling
- Local liaison officers based in Lowestoft and Grimsby met with very many local stakeholders, attended their meetings and events
- 12 public drop-in sessions across the East for over 600 people before the vision and objectives stage
- Specific groups or fora, e.g. Local Authority elected members, Local Government Association, Inshore Fisheries and Conservation Authorities, etc.
- International workshops involving France, Belgium, Netherlands, Germany, Denmark, Norway (Scotland and European Commission)
- Informal consultations on plan stages- evidence and issues, vision and objectives and options - more than 2,000 comments from 70 different organisations in 2012
- Formal consultation on the draft East Inshore and Offshore Marine Plans for 12 weeks. 107 responses received through email responses and via an online consultation tool. Nine public drop in sessions held during this period along the East coast
- Three decision-making workshops with public authorities and regulators to explore approaches to implementation of the marine plans
- An SA Advisory Group made up of statutory nature conservation bodies, industry representatives and environmental NGOs. The group met at key points in the process to shape the development of the SA and provide input and feedback on the different stages of the SA.

The Evidence and Issues Report (MMO, 2012a) outlined current and projected future levels of key marine activities in the plan area and assessed interactions between multiple activities and between activities and the environment. Baseline information on environmental, social and economic issues was also presented, and key issues and opportunities for progress identified.

The SA appendices (MMO, 2013b) also present policy context and baseline information for specific topics, and outline data gaps. Data gaps identified include:

- Understanding of where air quality as a result of marine activity is a problem
- Certain equality characteristics such as sexual orientation and non-spatial determinants of community well-being
- Lack of spatial data regarding underwater archaeological sites
- Uncertainty regarding the extent and detail of undiscovered archaeological remains
- Numerous data gaps on the topic of marine ecology, notably with regards to: species distribution; reproductive biology; effects of climate change; causes of declines in diadramous fish; migratory and foraging patterns; basic marine mammal ecology and reaction to noise; and understanding of pressures on waterbirds
- Insufficient detail in the British Geological Survey sediment map, a lack of coordination in bathymetry studies, a lack of understanding of the impacts of tidal energy on coastal processes and poor consideration of sea-level variability in climate projections
- Lack of a comprehensive seascape assessment for all marine plan areas
- Lack of data related to coastal flood mapping

Table 6 (see Section 3.5) identifies a list of specific baseline evidence and data gaps on which progress should be made, including improving the quality of existing habitat maps, distributions of mobile species and location and intensity of some MPS activities.

One particular area of weakness in the establishment of a robust baseline is information on future scenarios. Future levels of activity and distribution are difficult to predict for many sectors, and notably, understanding of the effects of climate change is limited. This weakness has been addressed to some extent in the South Marine Plan Areas planning process through the preparation of a South Marine Plan Areas Futures Analysis (MMO, 2013j) which was incorporated into the South Plans Analytical Report (MMO, 2013f). MMO should seek to work collaboratively with other marine organisations to develop standardised approaches for future scenarios and the development of standard data products.

A robust baseline is also important for informing work to define the spatial distribution of pressures and the potential impacts on sensitive receptors, in line with the DPSIR framework. Detailed information on pressure relationships is required, however, in order to properly understand the nature of the effects of human activities on the environment. More detailed information is also required on the baseline provision of ecosystem services in order to assess how plans will affect this. MMO should work with other marine organisations that are involved in developing such information, for example, JNCC and Cefas and with the wider UK Marine Monitoring and Assessment Strategy (UKMMAS) community.

MMO published and consulted upon its Evidence and Issues Report (MMO, 2012a) and held a number of public and specific stakeholder events as part of the development of the plan. Stakeholders were invited to provide evidence over the time of plan development directly to the team and indeed following plan publication to the planning portal where evidence can still be uploaded. There is a varying scale of resources available to sectors and stakeholder groups to supply evidence that is

appropriate and relevant for plan development and finalisation. This necessitates further work to be carried out by and with some stakeholders to improve the evidence on their activity. All the results of MMO evidence improvements work have been published on the archive MMO and gov.uk websites including data catalogues. MMO will continue to encourage, guide and assist stakeholders who provide evidence for marine planning to improve the evidence base and document its decisions transparently.

4.2.4 Principle 4: Considering all forms of information

The East Marine Plan SPP (MMO, 2013g), as required under the MCAA, set out how stakeholders could be involved in the planning process. The SPP outlines MMO's core principles in stakeholder engagement throughout the planning process and therefore seeks to collect information from as wide a range of sources as possible. Those principles focused on early involvement of people during the planning process and at timely intervals, with proper consultation and the development of locally specific policies. MMO pledged to remain adaptable during the planning process and to respect diversity, recognising that best consultation methods varied between groups. In this way the SPP contributed to the gathering of numerous forms of information from a range of stakeholders with various interests and requirements in the development of the plan.

As outlined in the above section, the Evidence and Issues Report (MMO, 2012a) brought together many forms of information to inform the planning process, sourced from national policy, stakeholder engagement, technical data collation and GIS analysis and sub-national plans and policies (see above for details).

Development of the East Marine Plans therefore considered a wide range of data from a number of sources, much of which was at the local scale drawn from stakeholder meetings attended by MMO's Marine Planning Team. The Marine Planning Team includes a number of people specifically responsible for stakeholder engagement and implementation officers that represent the first point of contact for stakeholders. The East Marine Plan demonstrated good engagement with stakeholders and considered all forms of information in its planning process.

A challenge for MMO is ensuring that it achieves broad engagement sufficiently early in the planning process to ensure that anecdotal evidence can be considered alongside more formal evidence when considering additional evidence requirements and priorities. This might be achieved through better engagement with local communities through local authorities and with local organisations (fishermen's associations, recreational interests etc.) and through the use of social media as well as methods developed by social scientists.

4.2.5 Principle 5: Engaging with all relevant sections of society and scientific disciplines

As discussed above, the East Marine Plans SPP (MMO, 2013g) outlined MMO's commitments to proper engagement with all relevant stakeholders early and throughout the planning process. The SPP also highlights MMO's appreciation for the various needs of the numerous stakeholders and their interests in the plan, and the need for a number of methods of engagement to suit such requirements. It is

therefore considered that this principle was effectively applied to the planning process.

The SPP also highlights the role of MMO's statutory partners and other government bodies. Partnership working, particularly with members of the UKMMAS community is likely to be particularly important in seeking to improve data availability and in developing suitable assessment tools. It may be useful to highlight how this will be taken forward within future SPP's.

MMO has been innovative in exploring the use of social media to seek to engage stakeholders that might not be reached by more traditional communication methods. MMO may wish to consider what else it might do to engage in specific outreach to those sectors that may not be able to engage through traditional routes.

4.2.6 Principle 6: Monitoring, review and adaptive management

MMO's 'Draft approach to marine plan implementation, monitoring and review' (MMO, 2013d) outlines proposals for an IMP, in line with the requirements of the MCAA. Under the MCAA, MMO has a duty to report:

- at intervals not more than three years after each marine plan is adopted, on the effects of policies, the effectiveness of those policies in securing objectives and the progress towards achieving the MPS objectives set out for that region in a marine plan and the MPS – after each report, the marine planning authority should decide whether or not the marine plan needs to be amended or replaced.
- at intervals not more than six years after the passing of the MCAA until 2030, on any plans it has prepared and adopted, its intentions for their amendment, and its intentions for the preparation and adoption of further plans.

The draft approach to the IMP states that implementation and monitoring should be limited to that necessary to fulfil objectives, and to be targeted via a risk-based approach i.e. high-risk areas receive more monitoring and support. Monitoring will be focussed on legislative requirements, and activities should work towards the achievement of objectives of the MPS.

The IMP will outline the monitoring process for assessing the effectiveness of the plans and determine which indicators will be monitored. The document acknowledges that existing initiatives such as those carried out for WFD, local authorities and the UKMMAS will contribute to achieving objectives and existing monitoring programmes will already collect relevant data and information in relation to established indicators. The IMP will therefore need to establish relevant gaps in current monitoring and establish appropriate indicators based on a review of existing monitoring datasets, and implement the collection of relevant data. Where gaps are identified MMO will assess whether or not there is a need to fill these gaps based on time and resources.

The outline approach to the IMP notes that indicators may not be useful for measuring some aspects of plan effectiveness, and effects of policy may be hard to predict or disentangle from other drivers. Monitoring must therefore evaluate wider

trends alongside indicators such as overall changes to biodiversity, climate and environmental trends.

With regard to adaptive management, the results of monitoring will inform the regular review process. This will identify areas where plan policies are not achieving objectives from which adaptive measures to plan policies can be identified.

There is currently little practical experience of preparing and implementing an IMP and therefore the process is likely to need to evolve over time. For example, as highlighted above, it is currently unclear whether existing monitoring programmes might provide sufficient information on the impact or effectiveness of marine plan policies. MMO should ensure that there are strong linkages and transparency between the process by which evidence needs to support marine plans are identified, the SEP and wider research initiatives in the UK and elsewhere.

4.2.7 Principle 7: Conserving ecosystem structure and function and managing within functional limits

The Evidence and Issues Report (MMO, 2012a) included information on the natural environment within the East Marine Plan areas and identified a range of potential issues relating to elements of the marine ecosystem, including climate change, habitat loss and disturbance, litter, marine noise, pollution and non-native species. MMO consulted stakeholders on this report.

The draft East Marine Plans included a number of objectives which seek to conserve ecosystem structure and function (see Principle 1 above) which were developed through consultation with stakeholders.

The SA of the draft East Marine Plans (MMO, 2013c) includes an assessment of the impacts of the plans on marine ecology. This assessment identified potentially sensitive aspects of marine ecology (receptors) such as species and habitats, along with plan policies that may impact upon them. Details of the current baseline conditions of these features and the future baseline in the absence of the East Marine Plans were also provided. The SA then assessed the likely changes in these baseline conditions as a result of the implementation of the East Marine Plans, including the significance of the change, the reversibility of the change and the level of certainty applied. This was done for three timescales: to 2019, 2033 and after 2033, with positive changes in baseline conditions anticipated from 2019 onwards. Stakeholders were engaged during the SA process and formally consulted on the draft SA.

An HRA was also undertaken to identify whether the East marine plans are likely to have a significant effect on any European protected sites, and whether they may have an adverse effect on the integrity of such sites (ABPmer, 2013). The HRA process followed guidance for plan-level HRA work and included a pre-screening review, screening study and an Appropriate Assessment (AA). The HRA and AA processes concluded that the plans would have no adverse effects on the integrity of any European sites.

Despite these assessments of impacts of plan policies and developments on the marine ecosystem, results are largely qualitative reflecting the lack of appropriate

data and tools with which to carry out a more quantitative analysis. Nor does the SA provide an assessment of impacts to ecosystem services. These are critical gaps in being able to apply the ecosystem approach.

Section 3.4 identifies the potential for marine planning to make use of spatial analysis tools that are being developed for MSFD implementation. These tools have the potential to estimate changes in extent and condition of benthic habitats, mobile features and ecosystem services provision as a result of human pressures, in response to marine plan and wider marine policies. However, the tools are limited by current availability and quality of data.

Annex 4 presents a trial application of two spatial analysis tools using data from the East Marine Plan areas. Based on assumptions, these provide indicative assessments of potential changes in the extent and condition of broad scale habitats and some biogenic habitat features in the period 2010 to 2030 as a result of seabed abrasion pressure from commercial fishing and in relation to infrastructure and dredging activity. Information on potential changes in secondary productivity is also presented, which can help to inform changes in ES provision. While confidence in many aspects of the assessments is low owing to data limitations, the analysis is potentially useful to MMO in clarifying issues within the plan areas and providing a high level quantitative analysis of potential changes over time. As the tools are inherently spatial and temporal, they have good potential to be used to inform cumulative effects assessments of marine plan policies in combination with other marine policies (e.g. MPA designation, MSFD implementation, and offshore renewables planning) though still limited by data availability.

As the quality of information improves, the tools should be increasingly useful in providing quantitative assessments to inform decision-making. MMO should work with other organisations within the UKMMAS community to develop these tools and the supporting evidence base.

4.2.8 Principle 8: Adopting a co-ordinated and integrated approach to management of human activities

The SPP (MMO, 2013g) was inclusive of all stakeholders with an interest in the East Marine Plans, but identified a number of sectors that were recognised as particularly key in the marine planning process:

- Aquaculture
- Defence and national security
- Energy production and infrastructure development
- Fisheries
- Local communities and elected members
- Local authorities
- Marine aggregates
- Marine conservation
- Marine dredging and disposal
- Ports and shipping
- Telecommunications and cabling
- Tourism and recreation

- Waste water treatment and disposal.

It was noted that this list was likely to expand throughout the planning process. A number of groups and organisations were also identified to contribute to the planning process such as coastal partnerships and fora, stakeholders previously engaged with the regional MCZ projects, local authorities and other regulators, bordering nations, NGOs, industry representatives, general public, local communities and local interest groups, statutory partnerships and government bodies. The engagement of local authorities was recognised as being particularly important in promoting integration across the land-sea interface.

Stakeholder engagement was a thorough process throughout the development of the East Marine Plans and was coordinated across all relevant sectors. The SA also allowed an assessment of the effects of plan policies and an evaluation of combined effects of multiple activities within the plan areas as well as external influences.

The main impediment to integration between MPS activities relates to the availability of data and the consequent difficulty in preparing a meaningful integrated assessment. This necessarily limits the scope for evidence-led discussion on options and draft plan policies.

Integration across plan boundaries was also limited. While consultation and engagement occurred with local authorities and other marine plan-making authorities, the draft plan policies generally do not have significant implications for management across the land-sea interface. The draft plans did not identify new initiatives that would create employment and thus might contribute to addressing issues of deprivation in coastal communities.

In the future, improvements in data availability and greater use of appropriate assessment tools could help facilitate a more integrated and coordinated approach to management across MPS activities (see Principles 2 and 7). Better engagement with coastal local authorities and a clearer focus on key plan issues (such as deprivation) and the development of options to address these issues may also help to improve integration across the land-sea interface.

4.2.9 Principle 9: Using appropriate spatial and temporal scales

The spatial scale of the East Marine Plans was determined by Defra based on physical and administrative boundaries, and the distribution of human activities and bio-geographical features. Public consultation on the proposed areas also influenced the extent of the plan boundaries and resulted in a number of amendments (Defra, 2009). The SPP (MMO, 2013g) outlines the requirements for stakeholder consultation when determining plan boundaries in order to assess any limitations in spatial and temporal scales. Specifically the SPP states that engagement with transboundary stakeholders that have an interest in or may be affected by marine plans should be sought, and identifies such stakeholders.

When developing marine plans, further specific consideration might be given to the spatial scale at which evidence should be collected for each plan area, to ensure that interactions which span plan boundaries are not missed through too rigid a focus on activities and interests within the plan boundaries. For example, within the planning

process for the East Plans, important interests such as the Port of Felixstowe were recognised within the plans, as the port is close to the southern boundary of the East Inshore Marine Plan area. As the evidence base improves this might be extended to consider aspects of ecosystem function and the dependencies of MPS activities, for example, the dependency of a fishing vessel on specific fishing grounds.

The 20 year time period for the plans was also set by Defra (2011), who specified requirements for plans to be reviewed every 3 years, in order to assess long-term changes to plan areas. This timescale may not be appropriate for longer-term factors that may influence plan policies, such as climate change, although future projections of climate change scenarios can be taken into account within plan policies.

4.2.10 Principle 10: Planning and management should be decentralized to the lowest appropriate level

The Evidence and Issues Report (MMO, 2012a) reviewed existing policies relating to marine planning that have been set at international, national, regional or local levels. MMO must consider such policies during plan development, and the decentralisation of the planning and management processes is therefore limited.

Despite this, the SPP (MMO, 2013g) established a role for stakeholders in contributing to the development of the plans through consultation and engagement with MMO staff, and while plan making is led by MMO, feedback from this consultation process is taken into account during the process. Furthermore, the SPP specifically highlights the role of local coastal partnerships and fora and local authorities and regulators, ensuring that wherever possible marine plans are integrated into existing local development frameworks. MMO is committed to ongoing dialogue with local authorities throughout duration of the plan and recognise that community interests may be communicated in this way.

The actual planning and management process of the East Marine Plans was largely MMO-led and relatively high level. This reflected some of the challenges in developing the first marine plans.

MMO compiled a large amount of evidence and identified a large number of issues on the basis of this evidence. Further rationalisation of this information would have been helpful to make it accessible to stakeholders and to enable them to focus on identifying solutions to the key issues. MMO should consider carefully how to structure and present information to stakeholders through the planning process: successful communication should increasingly help stakeholders to focus discussions on the key trade-offs presented by different plan options and policies and to move towards co-decision making. This would support decentralized planning.

MMO should continue to work with stakeholders in plan areas following plan adoption and consider the merits of developing more local marine plans where these might support decentralized management.

4.3 Summary

Table 9 summarises current implementation of the ecosystem approach principles within marine planning and identifies key improvement opportunities.

Table 8: Summary of current implementation of principles and key improvement opportunities.

Principle	Extent of Current Implementation in Draft East Marine Plans	Improvement Opportunities
1	Ecosystem objectives included in draft Plans but linkages to existing statutory objectives, targets and indicators is unclear	Consider how to improve clarity of linkages between plan objectives and the more detailed statutory objectives, targets and indicators
2	Social and economic baseline reviewed and specific objectives and policies developed. Social/economic effects of policies assessed qualitatively in SA	Improve consideration of social and economic effects with quantitative assessment of impacts, including through IAs, and wider changes within plan area. Rationalise and structure the evidence to help stakeholders to engage and focus on the key issues
3	Collation of data from a range of sources on a variety of issues within the plan area	Improve evidence base, particularly knowledge of future scenarios and ES provision (see Section 5.7)
4	Many forms of information considered along with stakeholder engagement to solicit local knowledge	Continue to engage with stakeholders through local planning and implementation officers and use a range of information sources. Ensure an effective process is in place to make best use of informal evidence
5	Thorough stakeholder engagement and public consultation	Continue to engage with all relevant stakeholders to solicit their views and relevant information. Improve partnerships with key stakeholders particularly to support data and tool development
6	Draft plans for monitoring and review process outlined in IMP	Review effectiveness of monitoring and how management adapts as plan implementation progresses. Engage stakeholders in determining evidence requirements for IMP and work with others to maximise use of existing information
7	Impacts of plans on marine ecology features qualitatively assessed in SA and HRA process	Improve baseline data and utilise tools for quantitative assessment. Increase understanding of pressure relationships, limits of ecosystem functioning and ES provision
8	Stakeholder engagement carried out and a number of key sectors related to plans identified within SPP	Improve data and tools to support integrated framework. Improve engagement with local authorities, focusing on key shared issues
9	Spatial extent took account of physical and administrative boundaries and considered human activities and bio-geographical features. Transboundary stakeholder engagement and consideration of wider issues. Time-scale set with requirements for regular review	Ensure continued engagement with transboundary stakeholders and consideration of relevant issues spanning the plan area boundaries. Consider long-term factors when defining temporal scale. Take account of ecosystem functional requirements and socio-economic dependencies across plan boundaries
10	Attempts to devolve planning and management to local authorities and partnerships where possible, but must simultaneously adhere to high-level policies	Rationalise and structure evidence to help stakeholders engage and focus on resolving key plan issues. Continue working with local authorities and coastal planning partnerships to translate plan policies into local frameworks and consider the merits of more local plans to support decentralized management. Solicit local community interests through this process

5. Guidance on implementing principles

5.1 Introduction

This section provides guidance on how MMO might seek to further implement ecosystem approach principles within its marine planning process. The guidance draws on previous sections of this report, on discussion of environmental-economic analysis in Annex 3, and on an analysis of the key points relating to implementation of each principle presented in Annex 5. The guidance considers possible improvements to the marine planning process, improvements in data and improvements in the application of assessment tools.

The guidance covers the key parts of MMO's marine planning work through which the ecosystem approach can be implemented. However, it should be noted that the interactions with MMO's functions are not restricted to these areas. The issues noted are also relevant (although less significantly) to other MMO activities such as marine licensing. In implementing them, MMO needs to be mindful not to impose an excessive burden on the economic activities impacted by marine management.

5.2 Process

The nature of marine planning in England, which requires the preparation of statutory plans by MMO, necessarily entails compliance with a wide range of formal process requirements. In particular, marine plans constitute 'public plans and policies' within the meaning of the Public Participation and SEA Directives which establish minimum requirements for stakeholder engagement and consultation. The MCAA 2009 also establishes elements of process to be followed in preparing marine plans, for example, the requirement to prepare a SPP at the inception of each marine planning process. All of these requirements positively support the implementation of many of the ecosystem approach principles which encourage early and meaningful stakeholder engagement. Thus, when considering how MMO might improve processes to implement the ecosystem approach within marine planning, the focus should be on improving on existing good practice rather than requiring wholesale change.

Based on the suggested requirements of the ten principles for implementing the ecosystem approach (Section 2.2), the case study application of the principles to the East Marine Plan areas (Section 4) and the key points relating to the implementation of the principles (Annex 5), the following suggestions are provided for refining the marine planning process to better deliver the ecosystem approach:

- Improving the clarity of the linkages between marine plan ecosystem objectives and the detailed supporting objectives stemming from international, European and national commitments (Principle 1)
- Improving the use of data and tools to facilitate quantitative assessment of social and economic impacts alongside environmental impacts – see Data and Tools below (Principle 2)

- Engaging stakeholders in identifying and prioritising evidence requirements and marine plan issues and clearly communicating decisions on priorities, recognising that this needs to be an iterative process (Principle 3);
- Engaging with local stakeholders early in the planning process to make best use of local knowledge (Principle 4)
- Engaging in specific outreach to those sectors that may not be able to engage through traditional routes to promote breadth of engagement. Strengthening relationships with key stakeholders, particularly to support data and tool development (Principle 5)
- Working closely with other organisations with responsibilities for marine monitoring to maximise use of existing data and to identify monitoring gaps and ways of addressing them. Recognising that the IMP process will need to evolve over time in the light of experience, particularly to ensure that the plans (and policies) can be adapted in the light of monitoring data. Engaging stakeholders in determining evidence requirements for IMP (Principle 6)
- Improving the use of data and tools to facilitate quantitative assessment of ecosystem impacts – see Data and Tools below (Principle 7)
- Ensuring adequate cross-sectoral engagement and engagement across plan boundaries to achieve adequate co-ordination and integrated management (Principle 8)
- Consider the appropriate spatial and temporal scales for data collection for marine plans, recognising that data requirements may span plan spatial and temporal boundaries (Principle 9)
- Rationalise marine plan issues and work to build consensus around a manageable number of key issues. Structure the evidence to facilitate discussion by stakeholders of key issues and to focus on key trade-offs. This will support decentralized planning. Consider merits of developing more local plans where this can support decentralized management (Principle 10).

5.3 Tools

Owing in part to a lack of suitable data and tools, the SA for the East Marine Plans was largely a qualitative assessment, based on expert judgement. For future marine plans, which may include more directional policies and thus have greater potential for significant effects, better data and tools will be required to enable more quantitative assessments to be made, such as within the SA. Adopting this structure of analysis is feasible with existing approaches, although its implications will be restricted by a lack of data on ES in the short-term.

The most suitable tools to support more quantitative assessment within the SA and IA are the tools that are currently being developed to support UK implementation of MSFD and socio-economic impact assessment tools developed by Marine Scotland.

While these tools currently have significant limitations, owing to data availability (see next section), it is expected that over the next five years they will become increasingly useful in quantifying impacts. The application of the BAU and ecosystem services tools to the East Marine Plan areas has demonstrated their potential to provide useful management information in relation to MSFD indicators and targets (with which marine plans will need to contribute) and in relation to ecosystem services provision (see Section 5.7 below).

The tools should be applied in a proportionate and transparent manner, both to evaluate the potential impact of marine plan policies and the cumulative impact of plan policies in combination with other marine policies such as offshore renewables policies, establishment of an MPA network and implementation of European Directives such as MSFD and WFD. The limitations of the tools and current data should be acknowledged.

Work is ongoing to develop ecosystem services analysis tools that can be applied in the management of UK ecosystems (UK NEA Follow-On)[14]. These tools do not focus on marine planning but provide detailed examples of how ecosystems-based approaches can be applied in approaches regularly used by decision-makers, including terrestrial planners for example the eat me tree available at the following link (http://www.eatmetree.org.uk/pdfs/cba_mcda_ecosystem_proofed_tool.pdf).

5.4 Data

The application of the MSFD and Marine Scotland assessment tools described above has important implications for the information required to apply them. In broad terms, the core information requirements to support implementation of these frameworks include:

- Spatial data layers
    - Current and future distribution and condition of ecological features
    - Current and future distribution of human activities and pressures
    - Current and future distribution of ecosystem services provision.

- Non-spatial data[15]
    - Sensitivity data on ecological features
    - Understanding of types and magnitude of social impacts
    - Understanding of social and economic outcomes of interactions between human activities
    - Costs of management measures
    - Market and non-market data for activities
    - Information on employment linked to marine activities
    - Understanding and indicators of marine natural capital (capacity of the ecosystem to produce ecosystem services)
    - Valuation data for marginal changes in ES provision.

Section 3.5 has identified a large number of data gaps which will need to be addressed, at least in part, in order to effectively apply the assessment tools.

Key gaps for spatial data include:

- Inaccurate and inadequately resolved habitat maps

[14] See: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx
[15] Defined as the parameters that would combine with spatial data in order to ascertain the relevant information.

- Varying spatial quality and confidence in habitat and species maps
- Incomplete spatial coverage for protected habitats and species
- Habitats and species maps represent a snapshot of ecosystem structure in time (as proxies for ecosystem processes/functions underlying ES) and do not reflect the temporal variability demonstrated in the marine environment
- Lack of information on habitat and species condition
- Inadequate information on the spatial distribution of mobile species (marine mammals, birds and fish) and their functional use of areas in which they occur
- Distribution and intensity of commercial fishing activity, particularly for the under 15m fleet
- Distribution and intensity of commercial shipping
- Distribution and intensity of recreational activities
- Absence of spatial data on social impacts
- Lack of adequate spatial data to inform future baseline maps
- Absence of suitable pressure layers
- Absence of current or future baseline layers for ecosystem services provision
- Lack of understanding/demonstration of the flow of ES and the location of key beneficiaries and demand.

Key gaps for non-spatial data include:

- Sensitivity information for ecological features - lack of coverage of non-MPA benthic features; limited information on mobile species
- Understanding of type and magnitude of social impacts - incomplete coverage of all MPS activities
- Understanding of impacts associated with activity interactions - lack of comprehensive understanding of environmental, economic and social impacts of interactions between human activities
- Costs of management measures - lack of comprehensive information on costs of management measures; information not collated in a single place
- Market and non-market data for activities - difficult to establish market data for some sectors e.g. cables and pipelines. Need to develop methods for applying non-market data
- Employment data –SIC codes do not adequately define many marine-related activities
- Natural capital - lack of good data for some services, particularly cultural services
- Value of marginal changes in ES provision – lack of understanding concerning how ES values change in response to changes in human pressure.

While the analysis has identified many significant data gaps, progress is being made in a number of areas. MMO should seek to work in collaboration with other organisations with responsibilities in the marine environment. For example, JNCC and Cefas are collaborating under the auspices of the HBDSEG to create pressure layers from an agreed and prioritised list. MMO has also recently commissioned (in collaboration with its devolved administration partners) a series of UK-wide spatial data layers for commercial shipping based on Automatic Identification System data.

It would be helpful to standardise and control the assessment frameworks and associated data and information requirements to facilitate ongoing collaboration and continual development of the information necessary to improve application of the assessment tools. This will help to avoid duplication and ensure that new work builds on existing outputs.

MMO may wish to consider its priorities within the overall list of data gaps and to promote those priorities within relevant fora (HBDSEG, Productive Seas Evidence Group and inter-Agency meetings). The prioritisation of data gaps with respect to marine planning can be informed by developing analysis on marine ecosystem services (e.g. Turner *et al.*, 2014), which can highlight which marine ecosystem services are most vulnerable to pressure from human activities. This can inform judgements about to the extent they might be impacted by marine plans, and therefore what level of detail is proportionate in filling data gaps.

5.5 Sustainability appraisal

As highlighted above, there will be significant benefits in the future if the SA can include quantitative assessments of the environmental, economic and social impacts of plan policies, particularly as, in future, plan policies may be more directional and thus have greater potential to give rise to significant effects. In addition quantification of impacts will assist understanding of the cumulative effects of marine plan policies in combination with other policy interventions in the marine area.

Annex 4 demonstrates the application of existing MSFD assessment tools to the East Marine Plan areas and highlights the types of quantitative information that can be derived for environmental impacts using these tools. While current information limits the application of these tools to a small number of parameters, the outputs can still usefully indicate the potential environmental impacts relative to MSFD indicators and targets and wider ecological objectives. The Marine Scotland socio-economic impact assessment tools can similarly be used to generate spatially resolved estimates of socio-economic impacts. Because these tools are inherently spatial and temporal they can be used to inform assessments of cumulative impacts.

In addition to these processes, the SA has other interactions with the marine planning cycle (shown in Figure 1) which support the implementation of the ecosystem approach. These include the involvement of stakeholders (e.g. in defining its scope) and informing the analysis of plan options. For this analysis, the SA is the main mechanism for evaluating the extent to which plan policies may support achievement of ecosystem and wider environmental objectives. MMO (2013b) identifies a wide range of environmental and ecosystem objectives for the East Marine Plan areas (see Appendix 2 of that document). The SA of the East Marine Plans includes a high level assessment of the impact of the plan policies on some of these objectives.

It is recommended that future SAs of marine plans provide evidence to support the statement in the marine plan on the extent to which it is implementing the ecosystem approach. This could give links to where different elements of the ecosystem approach are implemented (e.g. in supporting economic analysis), making reference to this report, particularly the principles defined in Box 1. It should make reference to

the extent to which implementation is feasible given the data and tools available for the task (see Sections 5.3 and 5.4).

5.6 Socio-economic analysis

Economic analysis plays a major role in environmental management in the UK, and marine planning is no exception. In addition, social analysis that helps reflect these factors is needed to fully understand effects on human activity, and hence inform adaptive management and thereby support sustainable development.

Economic approaches that reflect these factors, and therefore could be utilised in support of the ecosystem approach are:

- Analysis of option and quasi-option value
- Analysis of resilience value
- Assessment of cumulative effects, including ecological network benefits.

Option, quasi-option and resilience values can potentially be significant, in particular when there is a risk of irreversible losses of natural capital, but they can also be very hard to quantify. In general, the processes for incorporating the appraisal of these values into analysis require a baseline, a quantification of change, then valuation of change. Change against the baseline may be quantified based on observed or modelled data, or developed for one or more future scenarios. It should be noted that the way economic evidence for non-market values is often derived, using stated preference valuation techniques[16], generally identifies total economic value but does not break this down into different components of value. The issues surrounding incorporation of these non-market economic values into analysis supporting the ecosystem approach are discussed further in Annex 3.

Social impacts are not always as well documented in available evidence, nor as well reflected in IAs even when evidence is available. This can be because IAs are set up to capture the main impacts at a national level, and are less concerned with the distribution of impacts. Although they will capture some distributional issues (e.g. concentration of impacts in particular sectors) they will not necessarily focus on impacts within particular social groups or communities. Further work on this has been published by MMO (MMO, 2014b, c and e), and this work provides an opportunity to explicitly consider what social information could be included in various processes (SA or IA), and what further information needs to be gathered and reported to ensure sufficient monitoring of social outcomes to enable implementation of the ecosystem approach in marine planning. The potential future contribution of

[16] Stated preference techniques are described, for example, in Fujiwara and Campbell (2011). This evidence can sometimes be transferred, with appropriate adjustments, allowing existing economic valuation evidence to be applied in a new context, such as estimating the monetary value of environmental benefits associated with a proposed policy. This process is known as value transfer (See: http://archive.defra.gov.uk/environment/policy/natural-environ/using/valuation/documents/non-tech-summary.pdf) and is in line with HM Treasury appraisal requirements (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf)

IAs of marine plans to implementing the ecosystem approach is discussed further in Section 5.8 and Annex 3.

Data limitations with respect to these factors may be a limitation on effective appraisal and communication of the ecosystem approach for decision-makers, and therefore are an evidence gap in fully implementing the approach. Nevertheless, efforts are required to incorporate these economic valuation issues into supporting economic analyses as these are developed.

5.7 Ecosystem services

As discussed in Section 2.2 with respect to Principle 8, information on ecosystem services changes connected to changes in the state of the marine ecosystem is a gap in being able to apply the ecosystem approach in marine planning. This gap was highlighted as important by stakeholders during the development of this report. Ecosystem services are described in more detail in Annex 3.

Decision-making requires a better understanding of how changes in the integrity (the amount and condition) of parts of the marine ecosystem influence its productivity, in terms of the delivery of each ecosystem service. In considering productivity of ecosystem services, the marine environment is framed as a natural capital asset. In many cases the basic link between the integrity of the capital and the ecosystem services needs to be adequately identified and understood.

Where this link is established, thinking about the underlying relationship between the flow of ecosystem services and the natural capital stock highlights the importance of: i.) the risks of threshold effects connected to the unsustainable use of some assets (indicators of when these risks are unacceptable are also called ‘red flags’), ii.) identifying where the integrity of natural capital is a limiting factor on human welfare, and iii.) the overall understanding of resilience as an asset attribute (see Annex 3). Empirical data is urgently needed to quantify the underlying functional relationships, including when thresholds are likely to be approached and quantification of the consequences of crossing thresholds.

These research questions present major challenges, which are likely to be beyond the extent of MMO’s research responsibilities. However, parts of them are within the scope of the research interests of a number of other UK (and non-UK) marine bodies. In the UK these include relevant public bodies (such as JNCC, Natural England) and research organisations (such as NERC and Defra-commissioned research).

5.8 Supporting economic analyses

The requirement to undertake IAs of marine plans creates a challenge for MMO. At the time of writing, Better Regulations Executive guidance advises that an IA will be required for individual marine plans and will be subject to the Reducing Regulation Committee clearance. Therefore, in this context the current use of an IA is not to evaluate marine plan options. However, IA as a tool offers the opportunity to undertake some of the socio-economic analysis required by the ecosystem approach. As IAs can be developed iteratively alongside policy options, the IA can

both be informed by, and inform the development of marine plans. Current plans are for IAs of marine plans to focus, amongst other considerations, on impacts on businesses of a preferred option. In future, marine plans will also be able to draw on other sources of economic analysis to support their development (e.g. IAs of MSFD implementation decisions).

The use of supporting economic analyses, particularly linked to ecosystem services frameworks, could help to improve the level of integration that is achieved, increasingly so as better data and evidence become available. This is reflected in the prioritisation given to ecosystem services research to fill evidence gaps (see Section 5.7). Integrating ecosystem services into IAs results in a more comprehensive and realistic assessment of a project's immediate and long-term impacts (Landsberg *et al.,* 2013).

The IA can be informed by the marine spatial planning process, for example through social information gathered from stakeholders that may not be obtained through national data. Detailed consideration of the opportunity for the IA to input to the implementation of the ecosystem approach in marine plans is described in Annex 3. It provides some guidance on the ways that future IAs of marine plans can use socio-economic concepts to reflect the ecosystems approach. This is supported by technical consideration to non-market economic value concepts.

In developing the supporting economic evidence base, it should be recognised that quantitative marine data will be unavailable in some areas. However, qualitative measures of impact can be acceptable, and can, especially when collected in a consistent manner, also be useful to inform other appraisals, such as Cost-Effectiveness Analysis or MCA. These tools may be suitable for stakeholder engagement discussion on marine plan options in the face of missing and/or uncertain information. Also it may be efficient for evidence collection to ensure proportionate measurement of local socio-economic distributional impacts, even though these cannot always be included in the UK impacts calculated by an IA (as they may not be additional effects at a national scale). Guidance on the use of CBA and MCA when assessing impacts during the decision-making process is provided as part of Work Package 10 of the NEA Follow-On[17].

The six conceptual steps and four process steps to undertaking an IA are described in Annex 3. Opportunities for integrating the ecosystem approach into these are identified and summarised to inform those undertaking future IAs of marine plans. Many of the suggested actions are already in line with standard IA practices (e.g. establishing a baseline), whereas others are less regularly applied in IAs (e.g. objectives for ecosystem structure and function).

5.9 Marine planning and MSFD implementation

It is recognised that there are strong linkages between marine planning and aspects of the implementation of the MSFD with both interventions seeking to contribute to the achievement of marine environmental objectives and to support sustainable

[17] http://www.eatme-tree.org.uk/pdfs/cba_mcda_ecosystem_proofed_tool.pdf

development through the application of the ecosystem approach. While MSFD is focused on delivering environmental objectives, the outputs from the MSFD implementation process provide a potentially useful contribution to the implementation of the ecosystem approach alongside wider social and economic information.

Within English waters, marine planning will occur progressively with the intention of adopting regional marine plans for all waters by 2022. The MSFD sets an ambitious timetable for achieving GES by 2020, with a requirement to identify management measures which aim to achieve GES by the end of 2015 and to implement those measures by the end of 2016 working in a co-ordinated manner with other Member States within Marine Regions/sub-regions.

As noted in Section 2.2, it is currently unclear how detailed the UK/devolved administration process might be for determining the measures required to aim to achieve GES. If such work is considered to be robust, there would be no particular benefit in marine plans seeking to repeat, this work and the plans might therefore simply signpost MSFD measures. However, if UK/devolved administration planning for MSFD measures is only undertaken at a high level, the marine planning process could provide significant added value. For example, it could undertake more detailed assessments of the specific measures that might need to be implemented to make an appropriate contribution to the achievement of GES within the relevant marine planning regions, and/or do so at a smaller spatial scale where implementation can be decentralised to a lower appropriate level (in line with the ecosystem approach: see Principle 10 from Box 1).

Nevertheless, given that the timetable for producing a full suite of marine plans for English waters extends to 2021, it will not be possible to rely on the marine planning process to implement any MSFD management measures for all English waters, as the measures need to be identified by the end of 2015 and implemented by the end of 2016. On this basis, it would seem more likely that MSFD measures will need to be determined centrally, but with the potential for marine plans to refine and/or help to deliver measures within regional marine plans if and where they can add value.

5.10 Summary

The guidance for implementing the principles of ecosystem approach into marine planning is summarised in a step-by-step format in Table 10 below, according to MMO’s planning process.

Table 9: Summary of step-by-step guidance on the implementation of the ecosystem approach framework in marine planning.

Steps of marine planning process	Principles of Ecosystem Approach	Marine planning documents	Short-term improvements	Long-term improvements	Required evidence and data	Gaps	Priorities	Required stakeholder engagement (who and how)	Required institutional Integration
1. Plan area selection decision	5, 9	SPP SA	Targeted engagement with local communities affected by plan regarding relevant issues.	Continue to engage with stakeholders at the most appropriate level (e.g. local engagement officers). Better information on ecosystem function and economic and social dependencies.	Spatial data layers: distribution of ecological features and human activities; administrative boundaries; ecosystem function; economic and social dependencies	Inaccurate spatial data, variable confidence in data due to temporal variations, lack of information on habitat/species condition. Information of ecosystem functional linkages, and economic and social dependencies.	-	Industry sectors, national and foreign government institutions, through the SPP issued at outset of planning process.	Better partnership with local authorities, local communities and coastal fora.
2. SPP and stakeholder engagement	5	SA SEP SPP	Targeted engagement with local communities; better use of social media to aid communication and develop stakeholder capacity to engage in marine planning. Engage all relevant stakeholders early in the planning process to solicit views and relevant information.	Ongoing engagement with stakeholders throughout the timescale of the plan.	Stakeholder contact details. Information on stakeholder requirements, interests and values and other relevant issues.	-	Need to ensure engagement is carried out early and at a broad scale to collect relevant data from the outset.	Industry sectors, general public, and other relevant stakeholders affected by the plan through the SPP. May be through Local Authorities and other means (e.g. social media	Better partnership with local authorities, local communities and coastal fora.
3. Identifying issues	5	SPP SA EIR	More structured engagement with stakeholders to tease out key issues and build consensus. Engage all relevant stakeholders early in the planning process to solicit views and	Better information on future trends (many plan issues arise as a result of potential future changes). Better baseline	Baseline evidence: historical trends; anticipated future changes; uncertainties relating to future changes.	Better evidence and data, particularly of future trends.	More structured process for identifying key issues.	Engage all stakeholders when identifying issues. Review and prioritise issues.	Better working with key stakeholders; shared evidence base, build consensus on issues.

Steps of marine planning process	Principles of Ecosystem Approach	Marine planning documents	Short-term improvements	Long-term improvements	Required evidence and data	Gaps	Priorities	Required stakeholder engagement (who and how)	Required institutional Integration
			relevant information.	evidence – MMO should work with public bodies responsible for monitoring/data collection.					
4. Gathering evidence	3, 4, 5	SPP SEP	Work with stakeholders to agree baseline evidence requirements and indicators. Consider all forms of information. Early stakeholder engagement to solicit required information.	Better baseline evidence - work with public bodies. Better information on future trends.	Spatial data of the current/future distribution and condition of ecological features, current/future distribution of human activities and pressures and ES levels. Economic and social quantitative data and understanding of marine natural capital.	Gaps regarding spatial distribution and condition of: benthic habitats and species, mobile features and their functional use of areas, ES provision (and human benefits), spatial distribution and intensity of human activities and pressures, projections of future baseline. Variable confidence.	Consider need for more systematic data and evidence collection.	Stakeholder engagement through the SPP. Evidence gathering process guided by the SEP. Encourage collection of informal evidence.	Develop partnerships with more data collection bodies e.g. collaboration through UKMMAS.
5. Vision and objectives	1, 2, 5, 7, 8	SA IA SEP	Working to develop a shared vision and objectives early in process, including commitments to monitor progress towards achievement of objectives while considering stakeholder needs. Developing stakeholder capacity to engage in marine planning (local engagement officers/social media	As short term improvements.	Existing objectives and relevant national and international legislation. Current state and distribution of ecological features. Understanding of stakeholder views and requirements and social/economic factors.	Issues regarding reliability of data that inform objective development.	-	Consultation with Government departments that set objectives through Government policy documents. Relevant industry stakeholders affected by plans and objectives.	Working with key partners to develop shared vision and objectives, particularly with local authorities.

Steps of marine planning process	Principles of Ecosystem Approach	Marine planning documents	Short-term improvements	Long-term improvements	Required evidence and data	Gaps	Priorities	Required stakeholder engagement (who and how)	Required institutional Integration
			etc.)						
6. Options development	2, 5, 7, 8	Future IA if current requirement swifts SA	Rationalize and structure evidence to facilitate stakeholder engagement, focusing on key issues. Qualitative assessment of environmental changes in SA. IA with partial mapping of ES (subject to prioritisation) and qualitative assessment.	IA with economic analysis of ES. Qualitative social impact assessment also feeding into assessment of ES. Engagement of relevant stakeholders who could be affected by the plan options.	Understanding of social impacts. Mapping of ES, elicitation of economic values, knowledge of change of services.	Mapping of ES, economic evaluation, ecosystem condition and distribution. Confidence in habitat distribution data.	Ensure information is fit for purpose.	Engage relevant stakeholders in developing options to address key issues; iterative process informed by appraisal.	Working with other bodies with marine responsibilities to develop assessment tools and data.
7. Plan policy development	2, 5, 7, 8, 10	SPP SA IA	As for 6	As for 6	As for 6	As for 6	-	As for 6	As for 6
8. Representation period on draft plan	5	SPP	Clearer description of plan policy impacts in order to facilitate consultation on draft plan, accompanied by SA report and IA.	As for short-term	n/a	-	Clear description of plan policy impacts.	All interested persons and parties to allow public representation on plan.	-
9. Review plan proposals	5	SPP SA IA	Establish point processes for resolution of comments e.g. multiple party meetings.	As for short-term	Consultation responses	-	Joint problem solving	Engage with stakeholders that have made representations and keep wider stakeholders informed of progress.	Work with other marine bodies to resolve issues
10. Independent investigation	5	-	Take account of stakeholder views on need for independent investigation.	As for short-term	-	-	-	Engage with stakeholders on requirement for independent investigation.	-
11. Plan adopted and published	-	SA	Statement of changes and reasons behind changes to plan to meet requirements of	-	-	-	-	Notify stakeholders of plan publication.	-

Steps of marine planning process	Principles of Ecosystem Approach	Marine planning documents	Short-term improvements	Long-term improvements	Required evidence and data	Gaps	Priorities	Required stakeholder engagement (who and how)	Required institutional Integration
			SEA Directive.						
12. Implement, monitor and review	5, 6	SPP IMP SA	Develop indicators and objectives with consideration for the monitoring requirements for the plan. Develop dissemination mechanisms and review processes. Consider benefit of more local plans to support decentralized management.	Outline plan for monitoring and adaptive management clearly through IMP	Data relevant to plan policies to assess their effectiveness in meeting targets and objectives	Information requirements for monitoring of social impacts. Indicators for monitoring plan.	Review process for monitoring data and mechanisms for disseminating results.	Relevant public bodies and stakeholders with monitoring responsibilities. Keep stakeholders informed of progress.	Working with other marine bodies to streamline monitoring and make best use of existing data.
Key: SPP: Statement of Public Participation; SEP: Strategic Evidence Plan; SA: Sustainability Appraisal; IA: Impact Assessment; IMP: Implementation and Monitoring Plan; EIR: Evidence and Issues Report.									

6. Conclusions

A literature review (presented in Annex 1) has established the definitions and principles for delivering the ecosystem approach and explored its current and past applications in the marine environment. The ecosystem approach is captured in the CBD's 12 Malawi Principles, but these were considered to need minor adjustments in order to enable the approach to be applied to marine plans.

From this review it is apparent that the overall concept of the ecosystem approach is widely understood by stakeholders and the overall process for its implementation and delivery is well established. For several of the principles (e.g. that all relevant sectors of society and scientific disciplines should be involved) the right structures and processes are in place and these need to be used effectively to deliver the ecosystem approach going forward. For other principles (e.g. integration of social and economic factors and conservation of ecosystem structure and function) further development of structures/ processes is needed, and there are significant questions over whether appropriate data and tools are feasible or available.

This assessment has been further tested in a case study of the East Marine Plans. This shows existing processes are well suited to implementing many aspects of the ecosystem approach, but there remains a requirement for effective tools and data to support implementation of the ecosystem approach.

Robust tools are needed in order to predict and model future changes to the provision of ecosystem services and ecosystem health under varying management scenarios and levels of human pressure, and to systematically appraise the consequences of this for human welfare. Tools for doing so can be developed in conjunction with the ongoing development of other marine management tools, such as the use of SA. The use of these tools should aim in future to incorporate a broad evidence base, covering social, local and cumulative impacts that IA guidance suggests should be excluded from assessments of national economic impacts. This should aim to support implementation of the ecosystem approach through adaptive management implemented at a variety of scales.

6.1 Recommendations

This report identifies how the ecosystem approach is highly relevant to many aspects of marine planning. Relevant structures and processes are in place to implement many aspects of the ecosystem approach, but ongoing development and coordination of marine planning can continue to improve its delivery. As part of this, further work is needed to ensure its full implementation.

In some areas the data gaps that need to be filled will only be addressed in the medium to long term and therefore, improvements in implementation of the ecosystem approach will be ongoing beyond the completion of the first round of England's regional marine plans in 2022 and may need to be fully incorporated as part of the review cycle for plans. Recommendations are presented for three areas which may improve application of the ecosystem approach: ecosystem research, the involvement of stakeholders and actions to help fill gaps in its implementation.

The ecosystem approach can be a useful principle for marine planning in providing a common objective to guide actions in these three areas. This can help shape the purpose of activities to deliver them, and a framework to coordinate use of their outputs.

6.2 Ecosystem research

The IA of the MCAA Act (2009) took the view that the services and benefits from ecosystems and other environmental resources depend to a very great extent on being able to stay within certain thresholds and limits. Enabling marine decision-making and management that is informed by better understanding of where those limits are, should facilitate increased productive use of marine resources at the same time as reducing the instances where thresholds and limits are breached. This is in line with the ecosystem approach, although in both cases they are constrained by the available evidence base.

Options for taking forward research in this area relate to applying concepts of natural capital to consider the future capacity to support flows of ecosystem services, and analysis of the resilience value of marine ecosystems. Both are described in Section 5 and discussed in more detail in Annex 3. MMO should follow the ongoing work of the Natural Capital Committee (NCC), which is developing approaches to identifying and assessing the implications of unsustainable use of natural capital for society.

In the absence of quantified social and/or economic values, qualitative analysis of the impacts of marine planning on human activities can be undertaken. This may use MCA techniques, such as the qualitative scoring of social impacts that was applied in Marine Scotland's socio-economic analysis of impacts of proposed MPAs. The depth of such analysis needs to be proportionate to the severity of impacts considered.

Better developed analysis of the cumulative impacts of human activities on the marine environment is required to inform ecosystem approach implementation in marine planning. MMO has ongoing research on this, and in responding to this research it should aim to support the implementation of the ecosystem approach.

A key evidence gap relates to knowledge of marine ES, and how these will change in response to changes in the condition of the marine management. A broad effort across the marine research community, in which networks are developing[18], will be needed to address this gap, and MMO should aim both to contribute to this where possible, and to encourage this by looking to make use of emerging research, thereby encouraging researchers to appreciate the practical implications of their work. Further work is needed to define and prioritise these questions, taking into account which ES are believed to be most valuable to society now and in the future, and the scale of spatial resolution that is needed to identify features providing these ES. A cost-effective research strategy will involve iterations between estimating the significance of different marine ES to society (such as that emerging through work on benthic ES by eftec and ABPmer (2013)) and development of more accurate maps of the extent of marine features supporting these services.

[18] e.g. http://marineecosystemservices.org/

It is recommended that existing processes that generate information used in marine planning are further developed so that in future they contribute as much as possible to implementation of the ecosystem approach. Key processes in this respect are:

- MSFD implementation. This provides the main route through which marine environmental objectives will be set and monitored, and therefore is a key source of information for implementing the ecosystem approach. In particular, descriptors related to ecosystem structure and function (such as on food webs) directly contribute to implementation of ecosystem approach principles.
- Sustainability appraisal. While it is not a formal requirement of SEA or SA to take account of ecosystem services, such information, where available, could usefully inform such assessments.
- Development of supporting economic analysis, such as potentially in future IAs of marine plans. These provide an opportunity in the future to develop the evidence base for the ecosystem approach in marine planning beyond the statutory requirements of plans. For example, they can identify the distribution of impacts amongst social groups that will aid implementation of the ecosystem approach. However, this is not usually a focus of IA analysis which concentrates on national level costs and benefits. Six conceptual steps and four process steps to undertaking an IA are described in Annex 3. Opportunities for integrating the ecosystem approach into these in future are identified and summarised to act as guidance for the future development of IAs of marine plans, if the requirement and therefore scope of current IAs change.
- Monitoring mechanisms. Existing monitoring mechanisms such as those implemented under WFD and MSFD may provide information that can be used to track the implementation of the ecosystem approach, for example as proxies to monitor changes to the provision of ES.

All of these processes can use ES analysis. Some consistency in the typology of marine ES is desirable. It is suggested that the typology developed in the UKNEA follow-on project (Turner *et al*., 2014), is used because it is most likely to be the basis for further research (e.g. sponsored by other public bodies and undertaken by academic institutions in the UK), the results of which will be needed to inform marine planning. However, use of this typology should bear in mind two factors. Firstly, definition of ES, particularly in marine environments, is an ongoing area of research in which further developments are expected. Secondly, alternative ES frameworks have been proposed to meet the needs of marine planning, and their features should be borne in mind as typologies develop.

The descriptions in Annex 5 are recommended for use by MMO as a reference point for planning the implementation of the ecosystem approach in future marine plans. A summary of recommendations for the implementation of ecosystem approach principles to MMO's planning process is provided in Table 11. If these recommendations are implemented then more of the principles will be achievable as listed in the final column.

Table 10: Summary of suggestions and opportunities for improvement when implementing the principles of the ecosystem approach in MMO's marine planning process.

Marine Planning Process	Principles	Suggestions/Opportunities for Improvement	Principles 'updated'
1. Plan area selection decision	5, 9	Continue to develop inshore/offshore marine plans simultaneously through a single process wherever appropriate. Ensure continued engagement with all relevant stakeholders, including trans-boundary ones, and consideration of relevant issues from outside the plan area. Ensure targeted engagement with local communities. Incorporate better information on ecosystem function and social/economic dependencies.	2, 5, 9
2. SPP and stakeholder engagement	5	Timely issue of SPP to outline opportunities for engagement during planning process and to help identify all relevant stakeholders that MMO will require engagement with to solicit their views and relevant information. Targeted engagement with local communities; better use of social media. Developing stakeholder capacity to engage in marine planning. Engage all relevant stakeholders early in the planning process to solicit views and relevant information.	2, 5
3. Identifying issues	5	More structured engagement with stakeholders to tease out key issues and build consensus. Engage all relevant stakeholders early in the planning process to solicit views and relevant information. Improve baseline evidence and knowledge on future trends (many plan issues arise as a result of potential future changes).	2, 3, 5
4. Gathering evidence	3, 4, 5	Consider all forms of information through coordinated efforts to engage stakeholders and members of the public through local planning and implementation officers and a range of sources. Work with stakeholders to agree baseline evidence requirements and indicators. Early stakeholder engagement to solicit required information. Improve knowledge on future.	2, 3, 4, 5
5. Vision and objectives	1, 2, 5, 7, 8	Develop plan objectives with consideration of all the available information and a shared vision and objectives. Consider how to improve clarity of linkages between plan objectives and the more detailed statutory objectives, targets and indicators. Developing stakeholder capacity to engage in marine planning.	1, 2, 4, 5, 7, 8
6. Options development	2, 5, 7, 8	Qualitative assessment of environmental changes in SA. Consider in future using IA with partial mapping of ES (subject to prioritisation) and qualitative assessment. Qualitative social impact assessment also feeding into assessment of ES. Engagement of relevant stakeholders who could be affected by the plan options.	2, 4, 5, 7, 8
7. Plan policy development	2, 5, 7, 8, 10	As above.	2, 4, 5, 7, 8, 10
8. Representation period on draft plan	5	Clearer description of plan policy impacts. Facilitate consultation on draft plan, accompanied by SA report and IA.	5
9. Review plan proposals	5	Establish point processes for resolution of comments e.g. multiple party meetings.	5
10. Independent Investigation	5	Take account of stakeholder views on need for Independent Investigation.	5
11. Plan adopted and published	5	Statement of changes and reasons behind changes to plan to meet requirements of SEA Directive.	5
12. Implement, monitor and review	5, 6	Develop indicators and objectives with consideration for the monitoring requirements for the plan. Develop dissemination mechanisms and review processes. Consider benefit of local plans to support decentralized management.	5, 6

6.3 Involvement of stakeholders

Further recommendations for actions by MMO in stakeholder engagement are identified in Section 4.2. They are summarised here based on the activities that MMO is currently undertaking and those actions that it should implement and carry out to fulfil its duties, and to improve for the future. The suggestions below have been identified across different time scales.

Short-term current activities:
In the short-term, MMO's current activities can continue to develop the stakeholder engagement process required to implement the ecosystem approach through marine spatial planning. MMO should encourage other organisations undertaking marine stakeholder engagement to be mindful of the requirements of the ecosystem approach. It should remain adaptable during the planning process, and use a range of stakeholder engagement activities, recognising that best consultation methods vary between groups. Stakeholders should provide information on their dependence to or benefits they derive from ES and how these benefits are accessed or obtained. Such information can inform assessments of impacts and trade-offs, allowing relevant ES to be prioritised through plan policies.

MMO should also aim to maintain ongoing dialogue with local authorities (and local coastal partnerships; regulators), allowing an ongoing role for these stakeholders throughout the duration of the plan. This should be done to ensure that marine plans are integrated into existing local development frameworks. It should aim to make clear linkages between detailed marine objectives, targets and indicators, and the achievement of its marine plan objectives (through implementation and monitoring plans).

Short-term next steps
The following are suggestions for actions that MMO is currently not undertaking, but that can be implemented and acted upon in the shorter term:

1. Adjust the marine planning process to ensure that it structures information to stakeholders to facilitate discussion and integration of socio-economic factors. An example would be to include greater targeting of particular groups to focus on identifying solutions to key issues. Continued engagement of stakeholders through social media or other options may enable outreach to those groups that have been less successfully engaged through traditional routes.
2. Work with IMPs and existing initiatives (e.g. WFD) to help provide an assessment of whether or not there is a need to fill the existing gaps - identified by the IMP - based on time and resources.
3. Ensure strong linkages between the evidence needed to support development of marine plans and evidence used to develop existing policies (identified in MMO, 2012a).

Long-term
Further actions for MMO will take a longer time period to decide on and trial different options that will appeal to stakeholders. To improve the process of stakeholder engagement and marine planning, MMO can work to:

1. Develop standardised approaches for future scenarios and the development of standard data products in collaboration with other marine organisations.
2. Develop detailed information on pressure relationships; and on the baseline provision of ecosystem services in order to assess how plans will affect the environment with other marine organisations (e.g. JNCC and Cefas; UKMMAS).
3. Continue to be transparent about the assessment of suitability of information inputted by stakeholders for use in marine planning and for how stakeholder information (and views) are disseminated.
4. Demonstrate to stakeholders how their views have been taken into account by ensuring transparency in how evidence needs are identified.
5. Incorporate into stakeholder engagement (organised by MMO or other bodies) discussions on the key trade-offs presented by different marine plan options, in order to move towards co-decision making.

The challenge for the planning process is to ensure that both anecdotal and formal evidence is incorporated. This might be achieved through better engagement with local communities through local authorities and with local organisations (fishermen's associations, recreational interests etc.), and through the use of social media.

6.4 Actions to fill gaps in ecosystem approach implementation

Key actions for the marine planning process and other marine management activities are presented in Table 12 against the ten principles defined in Section 2.

Table 11: Key marine planning actions for the ten ecosystem approach principles.

Principles	Actions
Principle 1: Clear, long-term ecosystem objectives, ideally linked to targets and indicators, against which progress can be monitored	Stakeholder engagement by other marine bodies to include consideration of clear long-term ecosystem objectives and discuss long-term adaptive management. Monitoring and management structure to enable adaptive management.
Principle 2: Integration of social and economic factors is necessary to support sustainable development	Development of understanding of importance of ecosystem services to stakeholders, and analysis of potential changes. Social analysis to be applied at marine plan, or where necessary smaller, scales.
Principle 3: A robust dynamic baseline should be established against which progress towards achievement of objectives can be measured	Stakeholder engagement by other marine bodies to include consideration of clear long-term ecosystem objectives (which recognise that change is inevitable).
Principle 4: All forms of relevant information should be considered including scientific and local knowledge	See Principle 2. Marine stakeholder engagement processes by all marine bodies should aim to demonstrate to stakeholders how their views will be utilised (including judging the suitability of information inputted and its dissemination), and cover discussions on the key trade-offs in marine plan options.
Principle 5: All relevant sectors of society and scientific disciplines should be involved	All of the above, plus outreach through social media of less well engaged sectors/groups.
Principle 6: Monitoring, review and adaptive management are important elements of the planning and management cycle	See Principle 1. Engage with Defra/UKMMAS on importance of monitoring linked to ecosystem objectives and to informing adaptive management.
Principle 7: Conservation of ecosystem structure and function to provide ecosystem services should be a priority and ecosystems must be managed within limits of their functioning	Development of analysis of changes to ecosystem services, natural capital and the value of ecosystem resilience. See Principle 6 regarding adaptive management.
Principle 8: A co-ordinated and integrated approach should be adopted when considering effects of human activity, particularly taking account of cumulative effects	See Principle 2 regarding socio-economic analysis. Explicitly include cumulative analysis in SA of marine plans.
Principle 9: Appropriate spatial and temporal scales should be applied	These should inform actions under other principles. MMO should continue engagement in marine plan areas after plan publication, and consider refining plans to smaller areas where appropriate.
Principle 10: Planning and management should be decentralized to the lowest appropriate level	

The overall concept of the ecosystem approach and the process by which it can be implemented within the marine planning process is generally well understood and established. The majority of the principles of the ecosystem approach are already incorporated into the existing planning process, although some require further development, while gaps in the available data, evidence and appropriate tools must also be addressed. The above recommended actions may improve the current planning process by helping to fill these gaps and contribute to the achievement of the ecosystem approach within marine planning.

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Annex 1: Literature review of attempts to operationalise the Ecosystem Approach

Introduction

This annex provides a review of definitions and principles for delivering the ecosystem approach and explores relevant applications of the ecosystem approach in the marine environment.

Ecosystem approach definitions

The Convention on Biological Diversity (CBD) considers the ecosystem approach to be the primary framework for achieving sustainable development, based on maintaining fully functioning ecosystems. This concept has been given a number of definitions (see below) but the core of the approach aims to integrate and manage the range of demands that are placed on the marine environment, in order to support essential needs and provide benefits to all, without the cost of degradation.

The failure of the world's governments to achieve the biodiversity targets set out by the CBD was described by the United Nations Secretary-General in the foreword to the third Global Biodiversity Outlook. It was noted that "current trends are bringing us closer to a number of potential tipping points that would catastrophically reduce the capacity of ecosystems to provide essential services" (Long, 2012).

Long (2012) reviewed legal aspects of ecosystem-based management and recognised that the question "what is the ecosystem approach?" is very much an open-ended one, from both scientific and legal perspectives. The implementation of the ecosystem approach, at both global and regional levels, is constantly evolving as the science at the core of the approach develops. Much of the science that informs the ecosystem approach is multidisciplinary and involves a range of physical and life sciences. The lack of a global definition of the ecosystem approach or ecosystem-based management has not, however, stopped the adoption of a clear definition by a number of international organisations.

The CBD is the most well-known exponent of the ecosystem approach, and defines it as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". The CBD states that ecosystem-based management will "help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources" (CBD, 2000).

The International Council for the Exploration of the Seas (ICES) have adopted a working definition that describes the ecosystem approach as "the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of the marine ecosystem, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity".

At an EU Marine Strategy Stakeholder Workshop held in Denmark in December 2002 the ecosystem approach was defined as "the comprehensive integrated management of human activities, based on best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of the marine ecosystem, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity" (Laffoley *et al*., 2004).

The Joint Nature Conservation Committee (JNCC) website[19] describes the ecosystem approach as a framework rather than a formula, which can be adapted to suit various issues and situations. The approach is described as a concept that integrates the management of land, water and living resources and aims to reach a balance between three objectives: conservation of biodiversity; its sustainable use; and equitable sharing of benefits arising from the utilisation of natural resources. The ecosystem approach should not be considered as an all-encompassing solution as its application depends on local, provincial, national, regional or global conditions, and existing strategies and methodologies should be used in conjunction. JNCC provides operational guidance[20] based on the 12 Malawi Principles promoted by the CBD.

The Marine Policy Statement (MPS) (HM Government, 2011a) defines the ecosystem approach as that stated within the Marine Strategy Regulations 2010[21]: "an approach which ensures the collective pressure of human activities is kept within the levels compatible with the achievement of GES; that does not compromise the capacity of the marine ecosystem to respond to human-induced changes". The MPS, however, has added the condition that an ecosystem approach is one that also "enables sustainable use of marine goods and services".

The MPS definition makes reference to both Good Environmental Status (GES), a concept promoted by the Marine Strategy Framework Directive (MSFD), and also the sustainable use of goods and services as goals of ecosystem-based management. The concept of Ecosystem Services (ES) and maintaining and enhancing natural capital are important considerations for marine planning which must be taken into account within the framework (see below).

Drivers for implementing the ecosystem approach

Marine biodiversity is under pressure from a number of sources that require action. Pressures to the marine environment include habitat destruction, fragmentation and degradation, unsustainable practices and overexploitation of resources, invasive species, ocean acidification, pollution and climate change. Due to the range of pressure sources an integrated approach to management of pressures is necessary and in recent years a host of legislation has been passed to encourage the use of the ecosystem approach and to create a legal requirement for its implementation.

[19] http://jncc.defra.gov.uk/default.aspx?page=6276
[20] http://jncc.defra.gov.uk/page-6241
[21] http://www.legislation.gov.uk/uksi/2010/1627/pdfs/uksi_20101627_en.pdf

The Conference of the Parties is the governing body of the CBD and promotes implementation of the Convention through the decisions made at periodical meetings. The seventh Conference of the Parties, held in Kuala Lumpur, 2004, agreed that facilitating the implementation of the ecosystem approach should be a priority.

Ministerial declarations of the OSPAR[22] Convention in 2002 recognised the need for an ecosystem approach in the North Sea in order to conserve biodiversity and ensure sustainable development. Ministers agreed to implement the ecosystem approach through research efforts, policy decisions, coordinated monitoring and the use of Ecological Quality objectives (EcoQOs).

The UK Government's Natural Environment White Paper, published in 2011 (HM Government, 2011b), advocated action to put natural capital at the heart of economic planning and the movement to a green economy. The report laid out measures to create an independent Natural Capital Committee (NCC) that reports to the Economic Affairs Cabinet Committee, chaired by the Chancellor of the Exchequer. The NCC was created in May 2012 and focuses on providing advice to the UK government on the state and value of natural capital and ES in England and when, where and how natural assets are being used sustainably. This aims to put the value of nature at the heart of the government's economic policy by advising Government on how to prioritise private and public activity on the protection and improvement of natural capital.

In April 2013 the NCC published "The State of Natural Capital: Towards a framework for measurement and valuation" (NCC, 2013). The report is the first from the NCC and sets out its aim to develop a framework to define and measure natural capital and incorporate it into economic decision making in the UK. The report also recommends the development of a 'risk register' for natural capital assets to identify the implications of further depletion or lack of restoration.

An ecosystem-based approach is at the heart of the MSFD. The Directive has been transposed into UK law through the Marine Strategy Regulations in July 2010. Regulation 5 of the Marine Strategy Regulations states "the marine strategy must apply an ecosystem-based approach to the management of human activities within the marine strategy area". The MSFD aims to achieve GES across Europe's marine environment by 2020 and outlines eleven high-level descriptors of GES:

- Biological diversity
- Non-indigenous species
- Population of commercial fish/shellfish
- Elements of marine food webs
- Eutrophication
- Sea floor integrity
- Alteration of hydrographical conditions
- Contaminants
- Contaminants in fish and seafood for human consumption

[22] Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic

- Marine litter
- Introduction of energy, including underwater noise.

The characteristics of each GES descriptor are established and underpinned by more detailed indicators and targets that are used to assess and measure progress towards GES. GES is considered to be the most important measure by which ecosystem health will be determined when implementing ecosystem-based management.

A number of high-level environmental objectives are also outlined in other European legislation. The EU Water Framework Directive (WFD) (200/60EC) aims to promote long-term sustainable management of the aquatic environment based on a high level of protection. Under the Directive, all surface and groundwater bodies, including coastal waters, are expected to achieve 'good ecological status' and 'good chemical status' by 2015. In the marine environment, good status is achieved when a coastal water body meets relevant Environmental Quality Standards that set limits for the quantities of substances present in European coastal waters. While the WFD doesn't explicitly require application of an ecosystem-based approach, such an approach is increasingly being applied to support effective delivery of WFD objectives.

Various other European Directives support implementation of an ecosystem-based approach, for example the Habitats and Wild Birds Directives, the Urban Wastewater Treatment Directive and the Nitrates Directive.

In the UK the MPS is the framework for the marine planning laid out in the Marine and Coastal Access Act (MCAA) 2009, which aims to produce a series of regional marine plans that utilise information about spatial uses, conflicts and specific needs of marine planning in those areas. The MPS sets out both short and long-term objectives for the sustainable use of the marine environment by both UK government and devolved administrations. The MPS requires marine planning to use the ecosystem approach in order to manage competing demand on the marine environment, and in particular to ensure that human pressures are kept within levels compatible with the achievement of environmental objectives such as those established by relevant directives and legislation.

Principles for implementing the ecosystem approach

The last thirty years have seen the ecosystem approach increasingly incorporated into policy, aimed at promoting long-term sustainable use of resources and the environment. Aspects of planning already exist that incorporate the principles of the ecosystem approach such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA) and Sustainability Appraisal (SA), all of which assess the environmental impacts of a proposed project, plan or policy. The ecosystem approach will bring a broader scope and compliment such tools in assessing both individual and cumulative effects (Potts *et al.*, 2013). The ecosystem approach has many advantages regarding the management of natural resources. A single framework is used to consider ecological, economic and social factors, which enables potential conflicts and interactions to be identified. In this way it considers humans and the diversity of human activities within the environment as an integral component of the marine ecosystem. Stakeholder involvement and flexible, adaptive management methods are therefore integral to the ecosystem approach.

The CBD recommends 12 principles, known as the ‘Malawi Principles’ for delivering the ecosystem approach listed below.

1. The objectives of management of land, water and living resources are a matter of societal choices.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set in the long term.
9. Management must recognise that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

The Malawi Principles make it clear that the implementation of the ecosystem approach will require the consolidation of ecological, economic and social considerations regarding marine planning, with stakeholder involvement at all stages. An assessment of the current ecological state and spatial and temporal boundary of the marine ecosystem is required, as well as baseline information on the nature of human pressures. The marine ecosystem is less easily defined than terrestrial ones and boundaries may be subtle; defined by temperature, salinity, depth, ocean currents and stratification (Laffoley *et al*., 2004). Marine systems operate at a range of spatial and temporal scales and are often overlapping and interconnected (Farmer *et al*., 2012). Biophysical data is necessary in order to define the boundaries of an ecosystem and its features, along with an understanding of the key ecosystem factors that contribute to ES such as seabed habitats and abiotic factors.

A 2007 report published by Defra, “Securing a healthy natural environment: An action plan for embedding an ecosystems approach”, also known as the Ecosystems Approach Action Plan promoted a generic ecosystem approach for application in a wide range of policy areas and decision-making contexts. The approach advocated by Defra was based on five broad key principles that encompassed aspects of the Malawi Principles rather than imposing a single, rigid definition of the ecosystem approach (see Table 14). The report noted that not all of these principles may be relevant in all contexts and to all stakeholders, depending on their agenda. For

example, local and regional government departments and policy-makers will have more of an interest in the valuation of ES and how to respect environmental limits compared to those with a focus on managing the natural environment, who would likely consider all principles regarding conservation issues and land management.

Table A1: The five principles of ecosystem approach outlined by Defra (2007).

The Five Principles of Ecosystem Approach
1. Taking a more holistic approach to policy-making and delivery, with the focus on maintaining healthy ecosystems and ecosystem services
2. Ensuring that the value of ecosystem services is fully reflected in decision-making
3. Ensuring environmental limits are respected in the context of sustainable development, taking into account ecosystem functioning
4. Taking decisions at the appropriate spatial scale while recognising the cumulative impacts of decisions
5. Promoting adaptive management of the natural environment to respond to changing pressures, including climate change

In 2006 the Australian government published its *Guidelines for Applying an Ecosystem Approach in the Oceans*, aimed at policy makers, managers, NGOs and stakeholder groups (Department of Environment and Heritage, 2006). The guidelines promoted the ecosystem approach to management as one that considers human activities in the context of ecosystem boundaries rather than those based on government, putting ecosystems at the centre of planning and management. The guidelines state that ecosystem objectives, health and integrity and the continued provision of ecosystem goods and services should be taken into account in planning and management. The guidelines state that the approach should recognise the uncertainty in our knowledge of the marine ecosystem and the relationship with human activities. The precautionary approach should therefore be applied during decision making. Management should be integrated and coordinated across all sectors, jurisdictions, industry and the community, and assess the cumulative effects of all human uses of the ecosystem. Finally, the guidelines promote the use of adaptive management as a fundamental feature of ecosystem-based management, with the modification of management of human activities with results of monitoring.

Suggested key principles for applying the ecosystem approach to marine planning in English waters

While there are a number of definitions of the ecosystem approach, the definitions all have many common characteristics including integrated management, conservation of ecosystems and sustainable use of ecosystem goods and services. The MPS (HM Government, 2011a) definition particularly highlights linkages to the achievement of GES under MSFD as a key driver for UK policy (HM Government, 2011a).

Various reports have sought to define sets of principles that can be applied to deliver the ecosystem approach. While the CBD Malawi Principles are upheld as a model to follow in applying the ecosystem approach, this review has identified that there are some principles that would benefit from amplification and strengthening, particularly when considering the ecosystem approach in the context of marine planning:

- Principles 1 and 8 mention management objectives, but only in fairly narrow contexts and thus they tend to underplay the importance of setting clear ecosystem objectives as a fundamental part of the management system to deliver the ecosystem approach (e.g. Department of the Environment and Heritage, 2006; Department of Fisheries and Oceans, 2007; Olsen *et al.*, 2007; PISCES, 2012; National Ocean Council, 2013).
- Principle 9 recognises that change is inevitable. However, there is no recognition of the importance of monitoring and adaptive management which are recognised elsewhere as being fundamental to the successful delivery of the ecosystem approach (e.g. Department of the Environment and Heritage, 2006; Olsen *et al.*, 2007; PISCES, 2012; National Ocean Council, 2013).
- Principle 11 recognises the need to consider all forms of relevant information. However the importance of having a robust baseline against which to manage change is underplayed (e.g. Olsen *et al.*, 2007; Ekebom *et al.*, 2008; PISCES, 2012; National Ocean Council, 2013).
- Principle 4 recognises the importance of the economic context within which ecosystem approach is applied as this is essential when considering the requirements for sustainable development. However, the principle might also usefully encompass the social context as well.
- There is no specific reference to cumulative effects assessment within the principles, although Principles 5 and 6 might be seen as inherently requiring the consideration of cumulative effects.
- None of the principles recognise the requirement for co-ordination and integration across marine sectors.

Based on the above considerations, the following set of consolidated principles is proposed in applying the ecosystem approach to marine planning:

1. There should be clear long-term objectives, ideally linked to targets and indicators, against which progress can be monitored.
2. Integration of social and economic factors is necessary to support sustainable development.
3. A robust dynamic baseline should be established against which progress towards achievement of objectives can be measured.
4. All forms of relevant information should be considered including scientific and local knowledge.
5. All relevant sectors of society and scientific disciplines should be involved.
6. Monitoring, review and adaptive management are important elements of the planning and management cycle.
7. Conservation of ecosystem structure and function to provide ES should be a priority and ecosystems must be managed within limits of their functioning.
8. A co-ordinated and integrated approach should be adopted when considering effects of human activity, particularly taking account of cumulative effects.
9. Appropriate spatial and temporal scales should be applied.
10. Planning and management should be decentralized to the lowest appropriate level

Many of the suggested principles reflect requirements for the process which should be followed when implementing the ecosystem approach (Principles 1, 3, 4, 5, 6, 8 and 10). These principles can therefore be fairly readily accommodated through

process design. However, there are particular challenges when seeking to apply principles that require some level of assessment or analysis across particular spatial and temporal scales (Principles 2, 7 and 9) owing to the lack of suitable tools to undertake such analyses.

The ecosystem approach and ecosystem services

Ecosystem services can be defined as "the outcomes from ecosystems that directly lead to good(s) that are valued by people" (Austen *et al.,* 2010). Thus protection and enhancement of the provision of marine ES can directly contribute to delivering the ecosystem approach. The MPS (HM Government, 2011a) requires that marine planning should seek to ensure the continued provision and sustainable use of ES for human benefit together with the achievement of GES.

There is no single accepted method of categorising ES, although the Millennium Ecosystem Assessment (MEA) (2005) identified four broad categories that lead to different human benefits. The MEA separated ES provided by the marine environment into: provisioning services (harvesting of fish, shellfish and algae); regulating services (climate, waste and water quality regulation); cultural services (recreational, cultural and spiritual benefits); and supporting services (nutrient cycling, supporting habitats) (Defra, 2010).

The MEA carried out a scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, with a focus on fisheries in the marine environment. The results of the MEA showed that marine biodiversity is continuing to decline and that humans have altered the marine ecosystem more extensively in the last 50 years than any other period in human history. Douvere (2008) refers to the conclusion that the loss of marine biodiversity impairs the ability of the marine ecosystem to produce seafood, filter pollutants, resist disease, maintain water quality, recover from over-fishing and resist climate change.

A National Ecosystem Assessment (NEA) was completed in the UK in 2011 and provided a detailed appraisal of ES derived from UK waters, demonstrating the strong economic reasons for safeguarding and enhancing the natural environment. The NEA set out a framework for considering the role of biodiversity in the provision of ES and recognised its importance for: supporting ecosystem processes and dynamics e.g. nutrient cycling and decomposition; providing genes and species that contribute directly to goods e.g. genetic diversity contributing to disease resistance; and its value to people in their appreciation of wildlife, scenery and in a spiritual or religious sense (Table 15).

Table A2: Ecosystem goods and services provided by UK ecosystems (adapted from NEA framework, Defra (2010)).

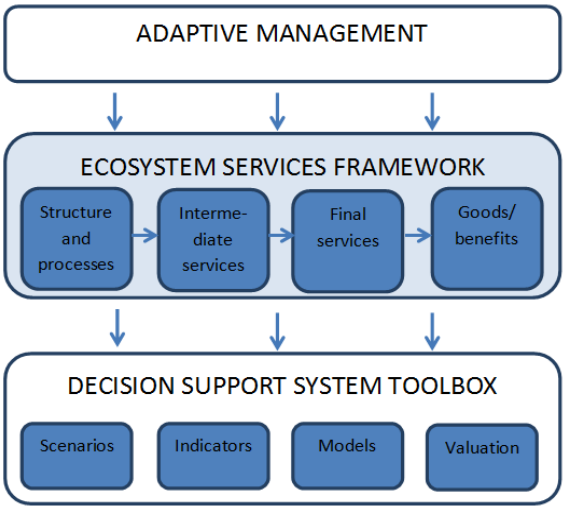
Ecosystem Service Type	Primary and Intermediate Ecosystem Services and Processes	Goods and Ecosystem Services
Provisioning		Food and fertiliser: crops, plants, livestock, fish etc. (wild and domesticated) Water: quantity for potable and

		industrial use Timber, avoidance of climate stress: trees Natural medicine: wild species diversity (including microbes)
Cultural		Aesthetics, recreation, tourism: meaningful places, socially valued landscapes, waterscapes and wildlife
Regulating	Climate regulation Pollination	Avoidance of climate stress: climate regulation Pollution control, waste removal: waste breakdown and detoxification Flood protection: hazard regulation (vegetation and other habitats), storm buffering, water quantity Clean air, water and soils: purification Disease and pest control: wild species diversity (including microbes)
Supporting	Weathering Primary production Decomposition Soil formation Nutrient cycling Water cycling Ecological interactions	

The NEA framework has been extended further by the NEA follow-on project. The draft WP3b report (Turner *et al*., in draft) presents a modified ES framework and particularly emphasises the need for adaptive management to manage the rate of change in ecosystems as the economy, society and the environment co-evolve over time (Figure 5). The draft WP3b report and final WP4 (Turner *et al.*, 2014) advocate the use of a Decision Support System (DSS) in order to assess the economic value and social significance of the flow of ecosystem services over time. The report suggests the DSS should be composed of a number of sequential components:

- A scoping exercise to establish baseline conditions, together with a focused attempt to identify 'key' policy contexts/issues
- A futures assessment through the use of DPSWR framework for scenario analysis
- The selection and development of appropriate functionally related indicators of ecosystem state (the stock position) and changes in services (the flow position) supply over time
- The deployment of 'tools' (including models) to enable a scientific, economic and social appraisal of policy options, including distributional concerns
- Setting up adequate monitoring and review procedures.

Figure A1: Ecosystem services conceptual framework advocated by the UK NEA (Turner *et al*., in draft).



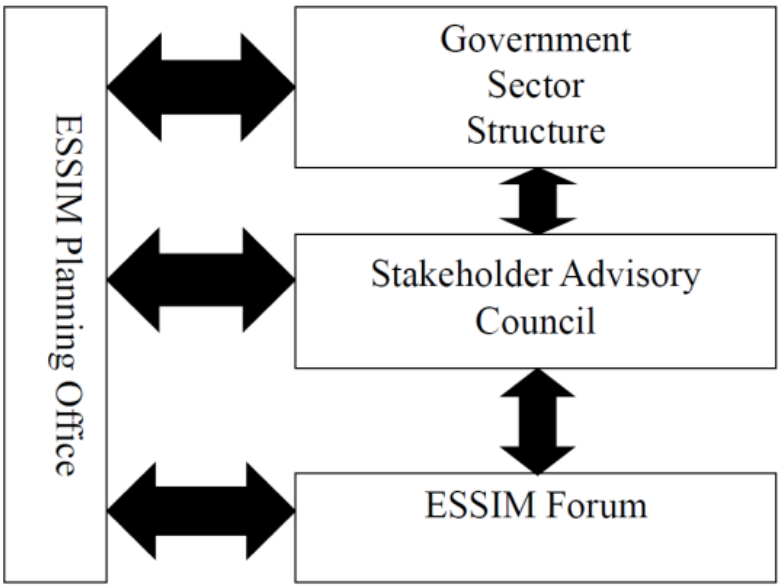
Review of examples applying the ecosystem approach

A literature review has been undertaken to identify examples of the practical application of the ecosystem approach that could inform this study. Full details of all literature reviewed are presented in Annex 1. Key examples have been reviewed below in order to highlight the key principles of ecosystem-based management and potential limitations.

The Eastern Scotian Shelf Integrated Ocean Management Plan

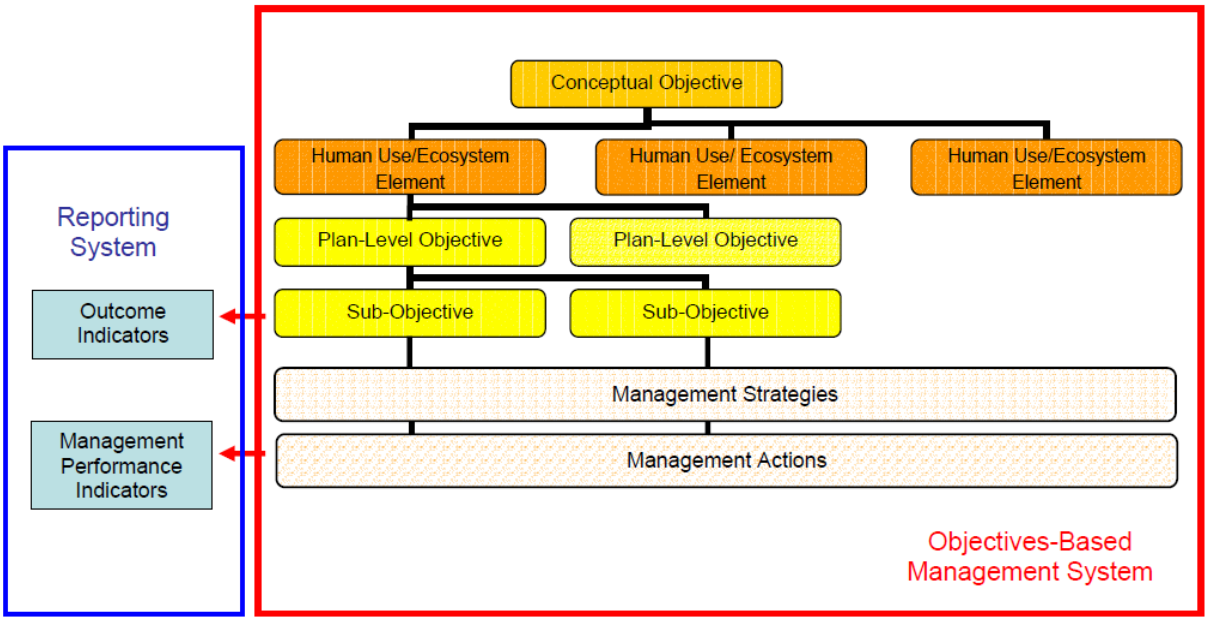
The Eastern Scotian Shelf Integrated Ocean Management Plan (ESSIM) is a long-term strategic plan to provide direction and commitment for integrated and adaptive ecosystem-based management of all activities in the marine environment in or affecting the Eastern Scotian Shelf in Canadian Waters. The ESSIM initiative was first presented to stakeholders in 2005, in contrast to the traditional 'sector-based' management that operates on a case-by-case basis. The ESSIM model uses a collaborative, multi-stakeholder approach, with all sectors and stakeholders contributing to the development and implementation of the plan, with an objectives-based approach to integrated management. The collaborative planning group is made up of a number of components: the ESSIM forum made up of stakeholders and interested individuals; a Stakeholder Advisory Council (SAC) made up of sector representatives; a government sector structure of federal and provincial government representatives; and an ESSIM planning office based within the Canadian government's Department of Fisheries and Oceans. Cross-communication between member groups of the collaborative planning model ensures the development of shared goals throughout all stages of the management process (see Figure 6).

Figure A2: The ESSIM collaborative planning model (from DFO, 2007).



The objective-based approach adopted by the plan involves the development of a hierarchy of goals, comprised of elements that are given strategic-level and operational objectives. The three major goals of the plan are: collaborative governance and integrated management; sustainable human use; and healthy ecosystems. The objectives of each goal are aligned with relevant management strategies and actions in order to achieve each objective, with a reporting system in place to evaluate implementation of the management strategies and measure progress towards meeting the objectives. The reporting system is based on 'outcome indicators' and 'management performance indicators' (see Figure 7).

Figure A3: Objectives-based management framework for the ESSIM initiative (from Walmsley, 2005).



The objectives developed for ESSIM are split into ecosystem objectives and human use objectives.

Ecosystem Objectives

The ecosystem objectives were developed through a national workshop in 2001. The national Fisheries and Oceans Canada (DFO) ESSIM framework contains two overarching conceptual objectives that arose from the workshop:

- The sustainability of human usage of environmental resources
- The conservation of species and habitats, including those other ecosystem components that may not be utilised by humans.

The second of these objectives is broken down into three more specific sub-objectives:

- To conserve enough components so as to maintain the natural resilience of the ecosystem
- To conserve each component so that it can play its historic role in the food web
- To conserve the physical and chemical properties of the ecosystem.

In order to define more practical objectives that can be judged using specific indicators of individual elements, ESSIM breaks down these objectives further into specific ecosystem elements, issues affecting those elements and plan-level objectives (e.g. maintain/restore benthic genetic diversity.

Human Use Objectives

The human use objectives were developed through a collaborative process involving a range of stakeholders. Objectives were expressed as goals for four human use elements: community well-being; economic well-being; industrial capacity and assets; and integrated management process. These elements each have a number of sub-objectives and indicators in order to assess progress in achieving human use objectives (Walmsley, 2005).

The ESSIM plan has received both praise and criticism from stakeholders since its inception. Flannery and Cinneide (no date) presented a case-study of the ESSIM initiative and critically examined the process, observing one SAC and one subcommittee meeting and carrying out interviews with SAC members. Critics of the plan viewed the process as ineffective and cited a top-down impetus to the management. Under the plan, sectors are asked to develop their own action plans to implement management strategies, which is described by some as simply a sectoral approach with no real focus on integrated management. Other critics have stated that sectors collaborate on main goals of the plan but not how to achieve the goals.

The plan has also drawn praise from stakeholders, however, who feel that the process “makes existing communications stronger” and gives stakeholders the opportunity to meet other stakeholders who they normally would not. One SAC member commented that the networks formed with other SAC members help to carry out their own work away from SAC. Flannery and Cinneide (no date)

summarised that ecosystem-based management is about recognising connections and to be successful it should foster a sense of interdependency between stakeholders. The issue of fragmented governance must be addressed and lead agencies must be empowered to implement plans.

It was noted that a lack of federal support has made implementation of the management plans difficult. There are mixed views as to the success of the plan, which is viewed by some as “all intent, not commitment but intent, but it still represents the beginning of a new way of doing business”. Frustration at the lack of federal support is recognised and gives rise to questions over whether resources should further be expended on the initiative if it is never to be signed off by the federal government (Flannery and Cinneide, no date). Any plan that aims to bring together stakeholders to implement an effective ecosystem approach must have strong government support.

US National Ocean Council Marine Planning Handbook

The National Ocean Council (NOC) of the US government published its Marine Planning Handbook in July 2013 that provided information and guidance for regions that aim to establish marine plans and ‘regional planning bodies’. Regional planning bodies are groups composed of representatives from different levels of government in a region, such as state, tribal, federal, fishery management council or local government. Regional planning bodies aim to coordinate with stakeholders, scientists, business and technical experts and members of the public to identify and address issues of importance to the region through collaborative decision-making.

The handbook states that marine plans should incorporate ecosystem-based management and that the planning process provides an opportunity for scientists, managers and stakeholders to work together in regions to develop and test applications of ecosystem-based management incrementally and transparently as knowledge, scientific data and information and experience increase.

The handbook describes a planning framework that allows all interested parties to clearly understand the issues involved and the planning process. Consistent with the scope and scale of a region’s work, the handbook states that a marine plan should include:

- Goals and objectives
- A regional assessment that describes the marine environment and human activities using maps and information
- The regulatory context relevant to the subject matter of the plan
- A description of the planning process, materials, analyses and information and guidance that make up the plan
- A description of where and how the plan intersects with Federal authorities
- A description of how the results of the plan will enhance coordination/promote consistency in Federal agencies interpretation and application of laws/regulations
- Ongoing monitoring and evaluation mechanisms
- A dispute resolution process developed by the NOC for Federal agencies.

Furthermore, the NOC advocates the following steps that must be completed by regional planning bodies when developing a marine plan:

- Assess regional capacity for planning
- Host discussions with stakeholders, members and public
- Agree a shared vision
- Identify goals and objectives
- Develop a work plan
- Analyse data, uses, services and impacts
- Develop and evaluate options for achieving goals and objectives
- Provide a draft plan for public comment
- Provide a final plan for NOC review
- Implement, monitor, evaluate and adapt plan over time.

Announced in July 2013, the planning approach outlined in the NOC Handbook is in the early stages of implementation. A National Ocean Policy Implementation Plan was released by the US government in April 2013 that details “on-the-ground actions” for the implementation of the plan, including those that: support economic growth; improve coastal and ocean resilience by reducing adverse conditions, preparing for change and recovering and sustaining ocean health; provide and enhance maritime and port safety and security; support regional action and provide tools to do so; and enhance scientific understanding and the ability to acquire marine data (NOC, 2013).

The planning approach and implementation plan outline the NOC’s intentions to implement the ecosystem approach to marine planning while considering social, environmental and economic factors, although is currently at the early stages of its implementation and its practical effectiveness remains to be seen.

Norwegian Ecosystem-Based Management (EBM)

The Norwegian government passed an integrated ecosystem approach-based management plan for the Barents Sea and the seas around the Lofoten Islands in June 2006 (Olsen *et al*., 2007). In addition to high-level goals the plan contained detailed aims and regulations, with major revisions to the plan planned for every 4 years. Development of the management plan was carried out in a three-step process. During step one status reports were prepared by governmental management and research institutions and consultants that outlined the current state of the marine environment, the coastal zone, fisheries and aquaculture activities, particularly valuable fishing grounds and shipping. The reports thereby covered environmental, social and economic factors within the plan region. To allow the evaluation of new knowledge as it became available the plan had to be dynamic and adaptable, and gave consideration to the ecosystem, economics, politics and discussions with ICES and other organisations when determining the boundaries of the plan.

Step two of the development involved the production of four EIAs based on the information provided in step one. These EIAs assessed the impacts of commercial fishing, shipping, hydrocarbon extraction and external pressures such as pollution on the environment, resources and local communities. Impacts were assessed in

relation to the starting situation (i.e. 2003 baseline) and based on future projections up to 2020.

Results of the EIAs were brought together and analysed in more detail during step three that focused on:

- The total combined impacts (cumulative effects) of human activities, both for the current situation and future scenarios
- Area conflicts among human activities and between human use and ecologically valuable areas
- The definition of high-level management goals required for implementation
- Identification of gaps in current knowledge.

A set of operational Ecological Quality Objectives (EcoQOs) was developed in parallel with steps two and three that was based on high-level management goals. These EcoQOs covered climate, ice edge extent, plankton, commercial and non-commercial fish species, benthos, marine mammals, seabirds, invasive species, threatened species and pollutants. It was proposed that annual monitoring of these EcoQOs is carried out.

Olsen *et al*., (2007) recognised that the main challenge of management is achieving measurable improvements in the numerous industries that utilise the marine environment. The plan identified ecologically valuable areas and requires strict regulation of activities within those areas. A limitation of the plan is that it fails to cover the entire Barents Sea ecosystem due to Russian jurisdiction of part of it, and future revisions of the plan must seek to extend the area through improved cooperation between the countries.

In 2011 the Norwegian government announced an update on the management plan for the Barents Sea-Lofoten. The Ministry of the Environment announced that a “good balance between environmental concerns” and marine industry has been found, that allows access to areas for activities within an environmentally sustainable framework. Since the presentation of the plan in 2006, work has been focused on increasing the knowledge base of the state of species, habitats and the ecosystem as a whole and the services it provides. The importance of the Barents Sea area and its socio-economic aspects have been given a more prominent place within management. The plan aims to strengthen this ecosystem-based management, including socio-economic considerations, and a monitoring programme is currently under development. A requirement for more knowledge on the effects of ocean acidification, climate change and the factors that affect ecosystem resilience has been identified, along with synergistic effects with other human activities. This update demonstrates the Norwegian government’s commitment to complying with the proposals laid out within the initial 2006 management plan (Norwegian Ministry of Environment website).

Australian Government: Guidelines for Applying an Ecosystem Approach in the Oceans

The 2006 guidelines published by the Australian Government provide an 8-point guide in order to guide policy makers when focusing on the key concepts of the ecosystem approach. These 8-points are suggested as a checklist for use when

agencies wish to implement a comprehensive ecosystem approach and questions are posed that should be considered. The 8 steps are:

1. Define the ecosystem in which you are operating
2. Determine if the activity has the potential to interact with the ecosystem
3. Understand the flow-on effects of the activity at the ecosystem level
4. Determine if the activity will affect, or be affected by, other users of the ecosystem
5. Uncertainty and the precautionary approach
6. Determine the social, economic and cultural benefits of the activity
7. Balance social, economic, cultural and ecosystem objectives for the ecosystem
8. Monitoring and feedback.

The guidelines state that the ecosystem definition should be logical and practical relative to the management of an activity, although the links between operationally defined ecosystems should be considered. The definition should be based on key biological and physical features, spatial and temporal scales, ecological models and uncertainty.

Indicators are outlined in the guidelines that are proposed for use in determining ecosystem health and integrity. These indicators focus on biological, ecological, genetic and physical components of the ecosystem. It is stated that indicators should be simple and quantifiable. Unlike the ESSIM initiative, no actual objectives are outlined, and ecosystem health is simply measured against these indicators.

The PISCES Project

The PISCES (Partnerships Involving Stakeholders in the Celtic Sea Ecosystem) project (2012) was a WWF-led project that sought to introduce the ecosystem approach to marine management across a number of countries, sectors and cultures around the Celtic Sea. The project brought together stakeholders from the Celtic Sea to a forum in order to develop a practical guide to the implementation of the ecosystem approach through MSFD requirements and identified five key steps. Step one involves fulfilment of the requirements of the MSFD by 2012 through: an initial assessment of the condition of marine waters, including an economic and social analysis of the uses and costs of degradation; the definition of GES; and a determination of targets and indicators. The MSFD requires mandatory public consultation at the end of this initial step. Step two requires the development and implementation of monitoring programmes for the ongoing assessment of environmental status by 2014, as is required within the MSFD.

The third step identified by PISCES is the development of a programme of measures to reach or maintain GES by 2020. Current measures may be identified such as the WFD, Birds and Habitats Directives, Bathing Waters Directive etc., as well as additional measures. By 2013, countries are expected to report on “designated spatial protection measures” such as marine protected areas. The European Commission will assess the proposed measures on their ability to meet GES and if necessary, will provide guidance on any changes required.

In the UK, OSPAR is expected to play an important role in coordinating programmes of measures across political and national boundaries. Step four is the implementation of the programmes of measures, which under MSFD must be in place by 2016. If failure to achieve GES within the MSFD timetable is justifiable, measures must be put in place to prevent further deterioration and to ensure GES is not permanently compromised. Stakeholders should be encouraged to develop voluntary measures in order to meet targets sooner and alleviate future need for regulation. Governments should gain support and encourage two-way exchanges with stakeholders. The key components will be reviewed every six years under the MSFD as a cyclical process (Figure 8). Step five therefore involves evaluation and adaptation with a focus on stakeholder involvement. Under MSFD each Member State must submit an interim review of the outputs of Step 1 by July 2018.

Figure A4: Process and timeline for the implementation of MSFD as identified by the PISCES project (2012).

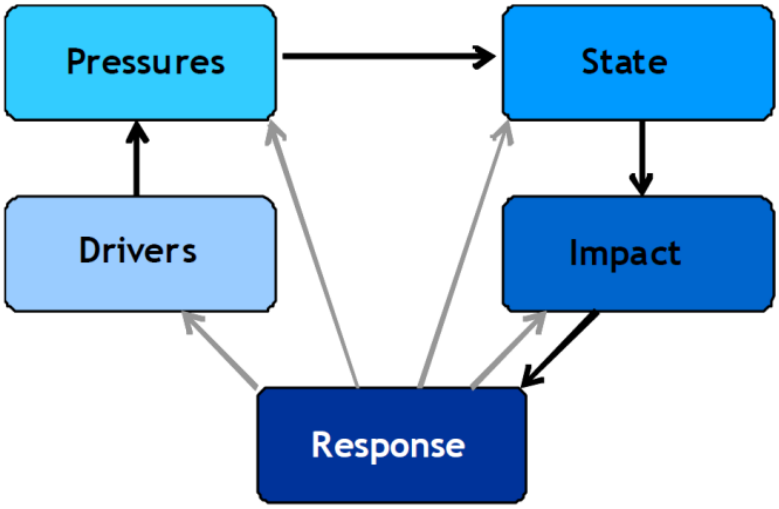
The PISCES project focused largely on stakeholder involvement and demonstrated how a stakeholder forum can assist in coordinating marine spatial planning and use of marine resources. Stakeholder involvement is a legal requirement of MSFD and consultation is proposed at the end of each of the five steps. It is recommended that stakeholders develop voluntary measures in order to meet targets and alleviate the need for future regulation. The PISCES Project, however, focuses solely on the achievement of GES and meeting environmental objectives. No real consideration is given to the integrated management of human activities within the marine environment, and the project recognises that future frameworks would require the use of marine spatial planning in order to aid the management of adjacent demands on marine space and resources. Furthermore, while the MSFD descriptors consider

the populations of commercial fish and shellfish, other ecosystem services are not covered within the directive.

The DPSIR Framework

The DPSIR approach is a sequence that has become increasingly used in marine environmental management. Elliott (2002) reviewed the framework with a focus on offshore wind power. The DPSIR framework follows a Drivers-Pressures-Status-Impacts-Response sequence. Knowledge is required of the 'Drivers' of change, such as the socio-economic and socio-cultural forces that drive human activities that increase or mitigate pressures on the marine environment. Each of these creates 'Pressures' upon the environment, and are the way that these drivers are actually expressed such as the effects of bottom trawling or coastal squeeze from sea-level rise. These pressures result in a change in the 'Status' of an ecosystem which needs to be assessed regarding the physical, chemical and biological conditions. This change in state results in 'Impacts' upon both human health and ecosystem health and integrity that must be defined. Impacts require the definition of monitoring procedures and indicators of change. These impacts elicit a 'Response' from society through various policy measures such as regulations, taxes or increased information (Elliott, 2002; Borja *et al*., 2006; ABPmer and eftec, 2012) (see Figure 9).

Figure A5: The DPSIR framework, illustrating linkages between components (ABPmer and eftec, 2012).



Elliott (2002) states that the human response to the changes resulting from our activities must meet the 'six tenets for environmental management'. These six tenets require human actions to be:

- Environmentally sustainable
- Technologically feasible
- Economically viable
- Socially desirable
- Legally permissible
- Administratively achievable.

The DPSIR approach and these six tenets are applicable for any stressor to the marine environment. Increasing knowledge of the complexity of marine systems and the effects that human activities have upon them has created a move away from the historical sectoral approach to marine management, and now attempts to consider the management of all features, both natural and anthropogenic. Elliott suggests a four stage approach to developing marine environmental management. These four steps first involve deciding priorities in order to set out aims, decide which aspects are important and to consider human influences. If possible, a matrix of effects/responses should be produced during this stage. The second step involves the use of tools with which to define, quantify and address the problems resulting from human activities. These may include the production of environmental quality classification schemes, biotope classification, indicators of change or the use of Ecological and Environmental Quality Standards and Objectives. In recent years more sophisticated software tools have become available to inform marine management (see below), although may require a broader background knowledge and various data inputs. The third step proposed by Elliott (2002) is the use of background knowledge to characterise the relevant system, catalogue biological features in relation to the physical and chemical environment, to define the natural variability of the system, signs and symptoms of change and to determine or quantify what level of change is acceptable. The final step of Elliott's (2002) four-stage approach is the use of case studies to define all the above aspects of management from actual scenarios. Management must no longer focus on small areas within the ecological footprint of a development or stressor but wider areas such as whole catchments, coastlines and sea areas.

Cooper (2012) provided a detailed critique of the DPSIR framework as part of the Knowledge-Based Sustainable Management for Europe's Seas (KnowSeas) project, in which limitations of the DPSIR framework were recognised. Cooper noted that a precisely defined set of information categories is required to facilitate comparability between studies and for the accumulation of knowledge on the consequences of specific human activities or the causes of specific ecosystem changes.

According to Cooper (2012), the DPSIR framework suffers from a number of definitional uncertainties. Driver and Pressure definitions focus on 'developments' and reflect changes in level rather than 'steady-state' on-going activities that nevertheless result in changes to ecosystems, e.g. increased demand for food crops (Driver) causes increases in the amount of nutrients released into a watercourse (Pressure). The DPSIR definitions are limited in that they do not encapsulate information on the relationships between the two activities when no change occurs i.e. on-going farming activities constantly contributing to eutrophication of a water body. The definition of State is ambiguous and refers to indicators of 'different' aspects of environmental systems. A definition of what is to be measured is required. The definition of Impact includes effects on ecosystems and the boundary between State and Impact is therefore unclear. Effects upon an ecosystem may be a manifestation of an Impact or an aspect of the State of the ecosystem. Information categories are defined independently rather than by reference to one another and linked definitions would emphasise the relationships between them and enhance the applicability of the framework.

The conceptual underpinning of the DPSIR framework is considered to be limited by Cooper (2012). Cooper states that the definitions of Driver, Pressure and State compress the representation of a number of potentially independent variables and may therefore disguise decoupling. Cooper includes an example of eutrophication, in which there are four variables involved in three relevant relationships within the Driver, Pressure and State categories: the demand for agricultural output and use of fertilisers; the use of fertilisers and the amount of eutrophicating agents available; and the amount of eutrophicating agents and the extent of any eutrophication. There are therefore four variables: demand; fertiliser use; the amount of eutrophicating agents; and eutrophication, and only three categories in which to place them. The first (demand) can be placed in the Driver category, the second (fertiliser use) in the Pressure category and the fourth (eutrophication) in the Impact category. This, however, compresses information regarding the scientific processes governing eutrophication and its remediation by leaving out the third variable, the amount of eutrophicating agents. Furthermore, the definition of Impact includes effects on both human and ecological receptors and therefore combines distinct concepts, disguising the link between the two. Such definition of Impacts complicates comparison with the human activities that cause them and hinders the Response or decision-making process. Separating human and ecosystem impacts would allow isolation of the effects on human systems from human impacts.

As a result of these limitations, Cooper proposes the modification of the DPSIR framework to DPSWR. DPSWR modifies the category definitions in order to focus more on human welfare. The Drivers category, for example, is defined as “an activity or process intended to enhance human welfare”, thus taking into account steady-state activities as well as developments. The proposed modification replaces the Impacts category with a Welfare category, defined as the changes in human welfare attributable to a change in State. Impacts are considered as the interaction between the State of the natural environment and effects on Welfare.

UK MSFD Implementation

To inform the implementation of MSFD in the UK, Defra and Marine Scotland have invested in the development of a number of spatial tools that have the potential to inform management decisions on possible requirements for management measures and to help to identify cost-effective management measures. These include:

- The development of ‘Business-as-Usual’ (BAU) projections of the state of the marine environment to 2020 and 2030 compared to a 2008 baseline (ABPmer and eftec, 2012) based around the DPSIR framework. The BAU model has been used as part of the MSFD Initial Assessment to identify the potential gap between expected environmental state (in relation to MSFD descriptors) and the requirements for GES. Defra is continuing to invest in the development of the BAU model to improve baseline data and scientific understanding of how current and future pressures may affect environmental state.
- The development of impact assessment tools based on Cost-Benefit Analysis (CBA) to inform the Initial Assessment (Cefas and eftec, 2012) and which could also be used to test the cost effectiveness of possible measures that may need to be implemented to seek to achieve GES.
- Development of the evidence base on marine ES, including the development of a spatial model that seeks to identify how ecosystem service provision of

sea bed habitats may change in response to changes in seabed fishing pressure (eftec and ABPmer, in progress).

While the development of these tools is still a work in progress, they are being taken forward through a collaboration by UK devolved administrations and relevant Government agencies and therefore has strong buy-in. It can be considered to represent the 'best UK model' for assessing broad scale impacts of MSFD policy measures. Owing to the nature of the model, it is also readily applicable to the assessment of other broad scale assessments of marine policies, including marine planning.

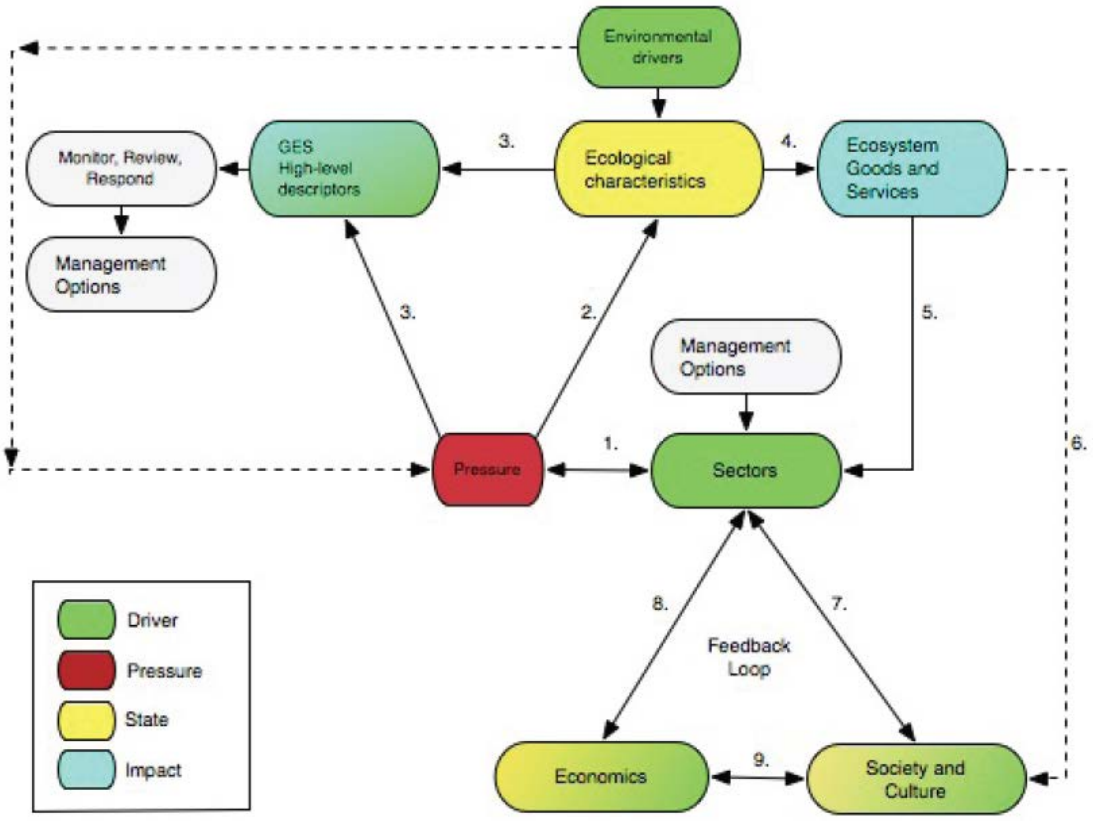
ODEMM Project

The ODEMM Project (Options for Delivering Ecosystem-Based Marine Management) is an EU project that aims to develop a set of fully-costed ecosystem management options to deliver the requirements of the MSFD, Habitats Directive, the European Commission Blue Book and the Guidelines for the Integrated Approach to Maritime Policy. The key objective of the policy is to produce scientifically-based operational procedures that allow for a step by step transition to fully integrated marine management. A number of Work Packages will be produced with numerous deliverables regarding the knowledge base, existing governance structures, operational objectives, management options (and evaluation of them), risk analysis and CBA, practical implementation plan, and dissemination.

The project produced a linkage framework that builds on the DPSIR approach to organise information to assess which management responses may reduce impacts on the state of the environment (Figure 10) (ODEMM, 2011). This framework builds on DPSIR by allowing the aspirations of the MSFD to be considered. The framework requires that the state of the ecosystem can be interpreted in terms of high level objectives for GES and impacts on the provision of Ecosystem Goods and Services (EGS), and the consideration of a wide range of interactions between ecological, economic and socio-cultural factors in terms of the likelihood of failing to achieve MSFD GES. A number of ODEMM Linkage Tables were produced that detail the specific interactions of the framework. Four of these tables were produced for linkages 1-4 of the interactions shown in Figure 10, listing interactions between sectors and human pressures (1), human pressures with ecological characteristics (2), ecological characteristics and pressures to GES descriptors (3) and ecological characteristics to EGS (4). ODEMM is yet to detail the interactions for links 5-8, which will be done in the next stage of the project (ODEMM, 2011). In Figure 10 different components of the framework are described as drivers (green), pressures (red), state (yellow) or impact (blue), or a combination of categories. Interactions between components are shown by arrows.

The ODEMM approach integrates the interactions between EGSs, socio-cultural, economic and sector components within a single framework that allows for feedback and complexity. The framework and tables can together identify those management options that will minimise human impacts on ecological characteristics while comparing these with the demand for EGSs and their benefits.

Figure A6: The ODEMM linkage framework for evaluating options for ecosystem-based management.



The first phase of the ODEMM approach was completed by August 2011 and brought together the context required in order to evaluate the barriers to MSFD implementation that exist around Europe. A number of methodologies were also developed to help interpret the situation. The first three work packages regarding the knowledge base, existing governance structures and operational objectives have been completed. The next wave of outputs from the ODEMM project will include development of tools for management scenario evaluation, risk assessment, CBA, the assembly of a toolkit to weigh up sustainable management options and providing recommendations for governance that would evolve to implement and regulate measures that support the ecosystem approach, in conjunction with stakeholder consultation on which governance structures best implement MSFD. This second wave of outputs is currently in development (ODEMM Newsletter).

BALANCE Project

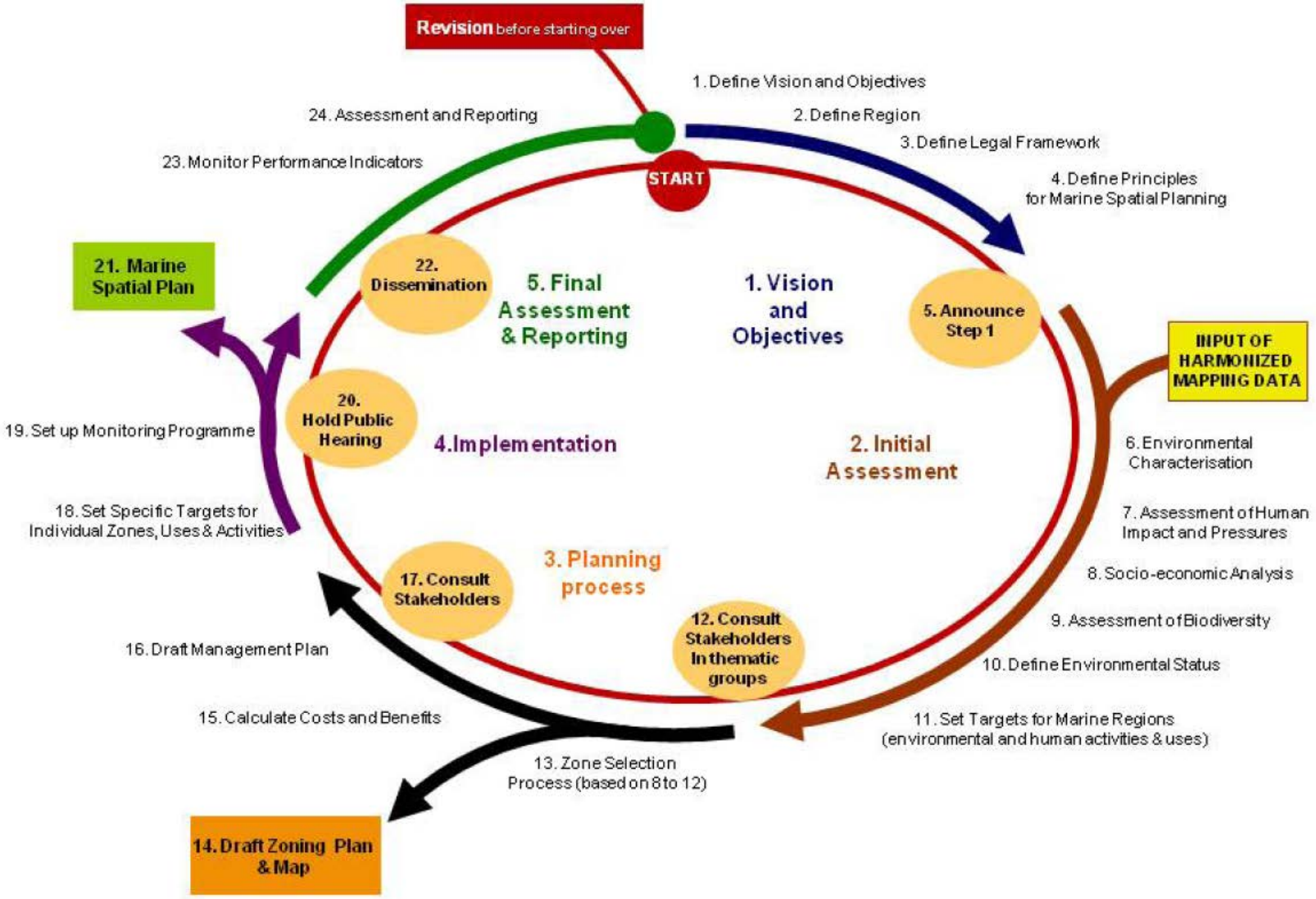
The BALANCE Project (Baltic Sea Management-Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning) aimed to take a holistic approach to marine spatial planning taking both human and environmental interests into account, operating within the multinational context of the Baltic Sea region. The approach was built around three key elements: a combination of ecological information and information on multiple human uses, pressures and impacts; a spatial planning template describing the steps towards marine spatial planning; and a simple, zoned approach allowing space for all human uses while minimising environmental impacts. The BALANCE approach was built around existing international obligations such as the regional sea convention, HELCOM

(Baltic Marine Environment Protection Commission) and EU directives, and relied heavily on GIS and spatial information. The project recognised that MSFD already requires Member States to characterise and map the marine environment and human uses and pressures, and that all that is needed is a framework to join these elements together into a consolidated plan. The BALANCE Project ran from 2005 to 2007 and produced a number of Work Packages focusing on data management, identification and mapping of Baltic Sea marine landscapes and habitats, demonstration of the “blue corridor” that shows the importance of passive transport pathways for pelagic life stages of marine fauna and flora, Natura 2000 networks, marine spatial planning and dissemination. The BALANCE template for MSP is a cyclic structure (Figure 11) that aims to promote adaptive management, following five steps: establishing a vision and objectives; initial assessment; planning process; implementation; and final assessment and reporting. The use of the precautionary principle is also promoted.

The BALANCE Project promotes a zoning approach as a tool to implement the ecosystem approach in MSP, and designates four simple zones within a study area. The nature of this zoning system demonstrates the requirement for spatial data and GIS software in its implementation. The General Use Zone is the least restrictive zone, covering all areas not covered by the other three zones. It provides equal opportunities to marine users and allows all human activities to take place other than those prohibited by law. The Targeted Management Zone applies to areas where authorisation (e.g. permits/licences) is granted for activities within the area or the area includes nature conservation targets that require regulation of activities. An example of a Targeted Management Zone is one in which fishing is managed in order to protect areas of importance such as spawning areas. The Exclusive Use Zone is the second most stringently managed zone and it is proposed to be as small as possible. This zone is reserved exclusively for a single use, such as wind energy parks or those areas set aside solely for nature conservation. The Restricted Access Zone is subject to the most rigorous regulations, with heavily restricted access to the zone. Again, it is proposed that the zone is as small as possible in order to prevent posing the public with more restriction than is necessary. The Restricted Access Zone aims to ensure proper protection of the area to prevent damage occurring. It may be applied to areas to ensure protection of historical artefacts or wildlife, such as use as a reference area for endangered and protected species.

The BALANCE Technical Summary Report (Ekebom *et al*., 2008) outlines the limitations of the project, stating that BALANCE is a demonstration project that seeks to provide guidance in applying zoning to MSP and stakeholder engagement and GIS methods. It is noted that the guidance is not comprehensive as new methods and tools are constantly developed.

Figure A7: The BALANCE marine spatial planning template, applying zoning.



Summary of different ecosystem approach initiatives

A range of initiatives have been proposed internationally which seek to deliver an ecosystem approach in the marine environment (Table 3). The various initiatives reflect the prevailing institutional and legal arrangements applying to the marine areas where they have taken place. Few of these initiatives have been applied and those that were applied have struggled to achieve practical or detailed implementation owing to a lack of political will, the lack of a supporting legal framework and/or a lack of data.

From a UK perspective, the most relevant initiative is considered to be the work that has been taken forward to support UK implementation of MSFD. This is because this initiative is directly applicable to the UK institutional and legal context, draws on directly relevant data and is seeking to answer some comparable questions those the ecosystem approach raises for MMO's marine planners. However, it is recognised that the main focus of the tools being developed is to support planning of the achievement of MSFD indicators and targets, although CBA tools used to inform the IA also help to take account of socio-economic factors to some extent. The tools are still very much work in progress and there are severe challenges associated with data limitations and lack of scientific understanding of linkages between human pressures, environmental state and the provision of ecosystem services.

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Annex 2: Tools to support implementation of the Ecosystem Approach

Introduction

This annex considers existing tools that might support delivery of the ecosystem approach. A number of tools have been developed in recent years that can be used to support the implementation of the ecosystem approach.

Tools to support implementation of the ecosystem approach

Tools may range from simple qualitative assessments using expert judgement to assessment methodologies and complex, data intensive computer software, as well as spatial tools such as the implementation of Marine Protected Areas (MPAs) and the zoning tool promoted in the 'Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning' (BALANCE) Project. Many of the computer software tools integrate social and economic data in order to facilitate decision making and can range from simple mapping programmes to complex simulation and impact assessment models. Stelzenmuller *et al.* (2013) suggest a range of GIS-based tools to support marine planning for example, to identify interactions between activities to reduce potential conflicts or assist in zone delineation, methods to facilitate a risk assessment of the cumulative effect of human pressures and tools offering decision support. These tools range from simple counts of activity within a defined area (as a proxy for potential human activity pressure), through to more complex assessments of the spatial distribution of human activity pressure linked to information on the sensitivity of ecological receptors.

OSPAR ecological quality objectives

Ecological Quality Objectives (EcoQOs) are tools that have been developed in order to assist OSPAR and the North Sea Conference process to apply the ecosystem approach to the management of human activities. EcoQOs define clear environmental indicators that promote a healthy North Sea ecosystem as part of the ecosystem approach. OSPAR developed EcoQOs in collaboration with International Council for the Exploration of the Seas (ICES), and after an invitation from North Sea Ministers in 2002 a first draft of EcoQOs has been applied by Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (OSPAR) signatory countries in the North Sea as part of a pilot project. In particular, the Netherlands and Norway are lead countries in the implementation of OSPAR EcoQOs[23].

The EcoQOs developed cover many elements of the marine ecosystem and most can be linked to human activities such as shipping, litter, fishing and pollution. EcoQOs function as indicators and objectives towards assessing ecosystem health. They provide detailed coverage of the ecosystem and the pressures acting upon it, and meeting all EcoQOs will therefore indicate the state of the ecosystem. Examples of OSPAR EcoQOs include healthy seal populations, reductions in the number of oiled guillemots, reduction in porpoise by-catch and keeping fish stocks at biologically safe levels. An update published in 2010 (OSPAR, 2010), concluded that

[23] http://www.ospar.org/content/content.asp?menu=00690302200000_000000_000000

the EcoQO system can be enforced by a more thorough implementation by North Sea countries and that the current set of EcoQOs does not currently cover all ecosystem components and processes. A comprehensive assessment of the overall status of the North Sea marine ecosystem is therefore not currently possible. Future work will aim to link EcoQOs with the eleven descriptors of Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD), as well as developing further EcoQOs.

The 2010 report evaluated the EcoQO system for the North Sea and discussed its strengths and weaknesses. Among the strengths was the fact that the development gained increasing political interest as a tool to implement the ecosystem approach. Furthermore, the North Sea is well studied with much information available and EcoQOs could be based on long-term data series, which may be difficult for other regions. Credibility to the EcoQO idea was provided by support from ICES who provided criteria for good EcoQOs and developed new ones. EcoQOs are also tested in practice during the development phase and, if necessary, adjusted, and are designed to explain the ecosystem approach to stakeholders and politicians. Weaknesses of the EcoQO system include a slow start due to the 'bottom-up' process initiated by few scientists. There is a need for the rapid development of monitoring programmes by EU Directives while biological monitoring remains in its infancy. A lack of coordination between the many organisations involved is also therefore cited as a limitation of the system. The implementation of the EcoQO system into the ecosystem approach may take decades before any observable improvements in the marine environment may occur. Due to a lack of any positive results it has only been through increased political commitment that EcoQOs became a promising concept. A lack of economic commitment from North Sea countries is also cited as a weakness of the system, as budgets for environmental assessment and monitoring are limited (OSPAR, 2010).

ODEMM Pressure Assessment (PA) Guide

The ODEMM Project PA User Guide (Robinson, 2011) provides a tool to identify the key pressures on marine ecosystem characteristics in order to prioritise management. Similar work was carried out by ABPmer on behalf of Defra as part of the MB0102 project, which sought to develop a pressures-sensitivity matrix to describe the sensitivities of MPA features to a variety of pressures (Tillin *et al*., 2010). The PA weights the interactions shown by the linkage tables according to the generic sensitivity of an ecological characteristic to any sector/pressure, the actual footprint of the overlap with the pressure and the ecological characteristic and the likely persistence of the pressure on the environment.

Expert judgement is used to complete the PA by categorising the following factors:

- Total extent of the pressure.
- Frequency of occurrence of the pressure.
- Degree of impact.
- Resilience of the ecological characteristic.
- Persistence of the pressure.

The ODEMM PA involves expert judgement in order to reach a number of steps. Such expert judgement requires information on spatial and temporal extent of

sectors and ecological characteristics and knowledge of the generic sensitivity of the different habitats to the pressures. Four steps are needed to be reached:

1. Actual footprint of sector/pressure
2. Generic sensitivity to a sector/pressure
3. Management potential
4. Confidence assessment.

It was noted that the PA was applied to the habitats of Europe's seas at a coarse ecological level, to very broad EUNIS level 2 habitats (e.g. all deep sea habitats were grouped together). The level of variation within such broad-scale habitats can therefore be high, in sensitivity and the extent of overlap with the human activity being considered. The ODEMM PA applied a majority approach by which the category that was suitable for most of the sub-habitats within a broad-scale habitat was chosen, although this approach has its limitations.

Transitional and Coastal (TraC) Waters Morphological Impact Assessment System

This tool (TraC-MImAs) was developed in order to support implementation of the WFD in transitional and coastal water bodies. The tool is based on a methodology developed for rivers and incorporates a number of customisations for TraC waters. The tool helps regulators identify those proposals that could threaten the aim of achieving good ecological status or cause deterioration. The TraC-MImAs tool uses a concept of 'system capacity'. As this capacity is consumed by human activities there follows an increased risk of morphological and ecological degradation. Morphological and ecological conditions are determined by the condition of attributes described within the WFD and 'modules' of the tool provide an assessment of the amount of system capacity that has been used up and can be used to determine the risk posed by new development proposals. These modules include: the eco-geomorphic attribute module, which defines the features that need to be protected; typology module, which allows assessment of how features vary between and within TraC features; sensitivity assessment that predicts the sensitivity of ecological and morphological features; impact assessment/pressure module that assesses the likelihood that a morphological alteration will cause an impact and the magnitude of the impact; and finally, a capacity-based scoring module. The scoring system calculates an 'impact rating' using the following equation (UKTAG, 2012):

Impact Rating = Relevance x Ecological Sensitivity x Morphological Sensitivity x Likelihood of Impact x Zone of Impact

As a tool that identifies the risk of not achieving good ecological status and reaching objectives laid out within the WFD, TraC-MImAs could be useful in implementing MSFD and attaining GES.

InVEST

InVEST is a scenario assessment tool developed by the Natural Capital Project that aims to map and value ecosystem services. The tool uses an 'ecosystem production function' that translates biophysical data into an estimation of the services they provide. It then adds a value to these services. The tool is designed for use with ArcGIS software and a marine-specific version enables the mapping and trade-off

analysis potential ecosystem services in order to assist academics and decision makers in the planning process. InVEST informs and assesses baseline conditions and tests the condition of the ecosystem under different scenarios in order to develop a spatial plan for management. It can be used to assess how ecosystems interact with each other and with marine users, although it is limited in how it models human interactions and indirect effects of activities. Benefits include the ability to compare multiple scenarios at one time, and that the software can be run at multiple geographic scales. Outputs can be in biophysical/ecological terms or economic terms and it uses a tiered approach to deal with data availability. Data requirements include spatial data on biophysical/ecological data, socio-economic uses of the area and valuation data. Changes in human behaviour are generally not modelled, however, and modelling of feedbacks between ecosystem services is limited (MMO and Marine Scotland, 2012).

The InVEST User Guide outlines a number of models that are of relevance to ecosystem services and ecosystem-based management. The Wave Energy Model (WEM) aims to map and value the provision of energy by ocean waves and to allow for the evaluation of trade-offs that might arise during the siting of Wave Energy Conversion (WEC) facilities. The WEM uses wave conditions and technology-specifics of WEC devices to assess potential wave power and harvested wave energy. The model evaluates net present values of building and operating a WEC facility throughout its life span, based on economic information such as the price of electricity, discount rates and installation/maintenance costs. Despite challenges in obtaining accurate information due to a lack of commercial-scale WEC facilities implemented to date, the WEM can help decision makers and stakeholders to better understand where best to install a WEC to maximise harvested energy and least effect on coastal/ocean ecosystems and other human activities (Natural Capital website).

The InVEST tool also supports an aquaculture model that analyses the volume and economic value of Atlantic salmon (*Salmo salar*) grown in aquaculture facilities, based on a number of factors. Inputs for the model include farm location, facility management practices, water temperature, economic data for valuation and the time period over which results are of interest. This model is most effective in evaluating the relationship between human activities (e.g. installation or removal of aquaculture facilities), climate change (e.g. sea surface temperatures) and the production and economic value of farmed Atlantic salmon. The model does have limitations, related to assumptions of harvest practices, prices and costs of production of farmed salmon over the study period. The model also fails to take account of disease outbreaks and variability between individual salmon. The developers have stated that future versions of the model will have the ability to be modified for other marine fish species, the quantification of waste production, a separate module for quantifying volume, economic value, filtration and waste production of shellfish and a sub-module to evaluate impacts of parasitic sea-lice.

The InVEST model may also be of use for implementing the ecosystem approach to management as it allows users to assess the risk posed to coastal and marine habitats by human activities, as well as the potential consequences of exposure for the delivery of ecosystem services and biodiversity. The model allows users to identify regions or habitats where human impacts will be highest and create trade-

offs with ecosystem services provision by compromising habitat structure and function. Such outputs may therefore allow decision-makers to identify the most appropriate management strategies to mitigate the risk of degradation of ecosystem function and services.

A key limitation of the InVEST tool relates to the availability of suitable spatial data. The tool also requires proficiency in GIS by the user. The tool also presents limited modelling of the feedback between ecosystem services, and changes in human behaviour and activity are generally omitted from the model. However, InVEST can compare outcomes of multiple scenarios within one model and may be run at multiple geographic scales, using a tiered approach. Outputs of the model may be economic, biological or physical.

ARIES

The ARIES methodology is a web-accessible tool for use in ecosystem services assessment, planning and valuation, although it may also provide scenario development. ARIES uses valuation data from the University of Vermont Ecosystem Services Database and obtains spatial data from open sources. Data for the UK is limited, although users may upload GIS data for analysis. This tool provides mapped outputs and valuation models can be made as simple or as complex as necessary. ARIES uses probabilistic Bayesian Network models to map ecological and socio-economic factors that contribute to the provision and use of ecosystem services (Villa *et al*., 2009). Outputs therefore come with an uncertainty rating, although this allows models to be run with incomplete data sets with caveats regarding uncertainty. The tool explicitly demonstrates spatial links from ecosystems to people and the strength of the flow of ecosystem services. Improved maps of provision, use and benefit flows can help guide policy decisions. ARIES can identify those areas critical to the supply of services to particular beneficiaries and therefore enable conservation and restoration activities to be focused in relevant places to increase or maintain benefit flows.

Currently, the only ARIES models that model marine ecosystem services have been developed for Madagascar, where the development of incentives for conservation has generated much interest due to high levels of deforestation and poverty. Madagascar is highly reliant on fish protein and is susceptible to tropical storms forming in the southwest Indian Ocean. The ARIES model for the Madagascan ecosystem services requires global terrestrial and marine datasets that are supplemented with local data. Probabilistic models of ecosystem services provision, use and flows for carbon and sediment in Madagascar were developed, while data was assembled and models for subsistence fisheries and coastal storm regulation were constructed using information from a UNEP-WCMC (World Conservation Monitoring Centre) workshop on mapping and modelling marine ecosystem service flows. ARIES' website states that with their 2011 'beta release' they are now "positioned to develop linked marine-terrestrial ecosystem service flow models for Madagascar, which can then be extended and tested in other coastal and marine environments" (ARIES Website).

A major limitation in the use of the ARIES software in the UK is a lack of data for the UK, although it is possible for the user to input their own data. There is no "off the shelf" model and the modelling methods are not transparent. There is a need for

long-term funding and a maintenance plan for both the tool and the database. The user can, however, use ARIES without a complete dataset, with indications of uncertainty provided, and build as simple or complex a model as is required. ARIES may be applied in the screening or scoping process and has the ability to compare multiple scenarios and potential ripple effects, as well as depicting bundled ecosystem services on a spatial map. Only a low level of effort is required for basic models to be run within ARIES.

POLCOMS-ERSEM Modelling

The POLCOMS-ERSEM model is a hydrodynamic-ecosystem modelling system that incorporates the Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOM) with the European Regional Seas Ecosystem Model (ERSEM), coupling the POLCOM physical model with the ERSEM ecosystem model. The POLCOM model is an eddy-permitting baroclinic model, while ERSEM is a complex, carbon-based lower trophic-level marine ecosystem model. ERSEM includes all processes that significantly influence ecosystem dynamics and resolve the ecosystem into sufficient functional groups. ERSEM has one bacteria, four phytoplankton and three zooplankton functional groups and a diurnal cycle with variable carbon to chlorophyll ratios. The model also includes a complex suite of nutrients and resolves microbial loop and POM/DOM dynamics. This complex pelagic component is coupled with a benthic model that provides information on the benthic ecosystem and nutrient coupling between benthic and pelagic systems (Siddorn *et al*., 2007).

The coupling of the two models can predict changes in ecosystem productivity in relation to changes in the hydrodynamics over time. However, the model does not include human factors in future projections and fails to take into account aspects such as the impacts of demographic change, future adaptation responses (e.g. to climate change impacts) and vulnerability to impacts.

Ecopath with Ecosim

Ecopath with Ecosim (EwE) is a software programme that creates an ecosystem model for a given area based on food web interactions and (optional) fisheries pressure. The software has three elements: Ecopath, Ecosim and Ecospace. Ecopath creates a model that presents a snapshot in time of the ecosystem. The goal is to create a ‘balanced model’ of predator-prey interactions that estimates biomass and food consumption of the ‘elements’ of the ecosystem (species or species groups) and requires information on the ecosystem’s trophic levels, biomass data for each group and diet information. Fishing data may also be added (i.e. mortality of highly fished species will be higher than others). Ecosim looks at the Ecopath model and analyses it over a time period (e.g. 50 years), displaying results as biomass graphs. This is useful in forecasting future biomass of species of interest in relation to fishing pressure.

Ecospace then displays the Ecosim model spatially by building a habitat map and assigning different species groups to different habitats, although this is a new element to the software and has not been trialled extensively. Ecospace was designed to remedy the deficiency of the Ecopath with Ecosim model that assumed homogenous spatial behaviour. The software presents a method of forecasting

future fish biomass and therefore provides a useful tool in modelling the provision of this ecosystem service in relation to present and future fishing efforts.

As a user friendly and free tool, EwE has many benefits. It allows users to explore models temporally and spatially and to add in variables that affect the system such as temperature and fishing effort. However, a number of pitfalls are identified in the User Guide that users should be aware of when considering ecosystem parameters (Christensen and Walters, 2004). One such pitfall is errors in predator/prey estimations. For example, a prey species may represent only a small proportion of the diet of a particular predator, although this predation may represent a high proportion of mortality within the prey population. Consideration should also be given for indirect trophic effects, shared foraging areas and temporal variation in species-specific habitat factors.

Cumulative Effects Assessment

A 2004 English Nature report (Gilliland *et al*., 2004) outlined the results of a workshop that focused on understanding and addressing cumulative effects when implementing Marine Spatial Planning (MSP). MSP can improve the assessment of cumulative effects and improve the decision making process regarding cumulative effects in the marine environment. The workshop focused on the key components of cumulative effects assessment and assessed the links between cumulative effects assessment and marine spatial planning. The fundamentals of any cumulative effects assessment process are spatial data (representing temporal and spatial extent and intensity of human activities), spatial data on key environmental components, analysis of how the two affect each other and GIS technologies to store data, model interactions and present final outputs of the cumulative effects assessment process. The workshop recognised that cumulative effects assessment is simply a tool to assess and inform decisions about cumulative effects. Other processes such as Strategic Environmental Assessment, Environmental Impact Assessment are all relevant tools that may feed into cumulative effects assessment and be used to inform the production of a spatial plan that could provide context for future specific developments.

Ecosystem Service Review for Impact Assessment

The World Resources Institute (WRI) has collaborated with environmental and social impact assessment (ESIA) practitioners to develop the Ecosystem Service Review for Impact Assessment, in order to integrate ecosystem services into ESIAs, for which until now, there has been little guidance. The Ecosystem Service Review for Impact Assessment (ESR for IA) is a structured methodology that involves six steps for ESIA practitioners to follow in order to incorporate ecosystem services into their assessments during the scoping, baseline, impact analysis and mitigation stages of impact assessment (Landsberg *et al*., 2013).

The WRI states that the ESR for IA can be used for two purposes; it can identify measures to mitigate potential impacts to ecosystem services, and can identify measures to manage operational dependencies on ecosystems. The six steps of the ESR for IA practitioners to follow are:

1. Identify relevant ecosystem services (scoping stage)
2. Prioritise relevant ecosystem services

3. Define the scope and information needs of the ecosystem service assessment
4. Establish the baseline for priority ecosystem services
5. Assess project impacts and dependencies on priority ecosystem services
6. Mitigate impacts and manage dependencies of project on priority ecosystem services.

The ESR for IA is not designed to replace the ESIA process currently in use and rather complements the process with an interdisciplinary, integrated framework for focusing attention on the socio-economic aspects of the environmental impacts of a development. Unexpected costs and benefits of a development can therefore be more comprehensibly understood and can identify stakeholders that potentially would otherwise be missed (Landsberg *et al*., 2013).

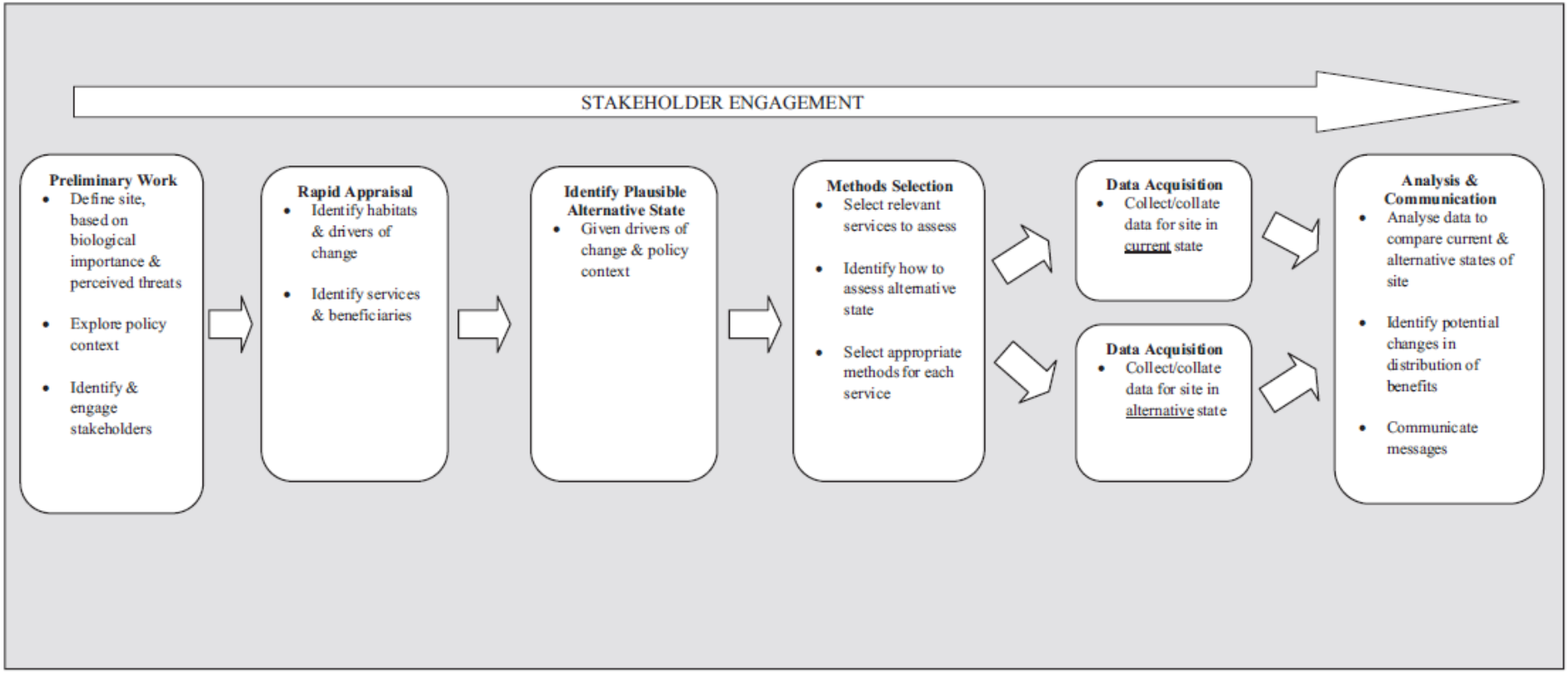
Toolkit for Ecosystem Service Site-based Assessment

The Toolkit for Ecosystem Service Site-based Assessment (TESSA) aims to combine the advantages of other approaches into a single toolkit suitable for site-scale assessments. The toolkit outlines a single framework that aims to estimate net benefits or consequences of a particular action (i.e. development) by applying a set of appropriate methods for two alternative states of a site. Peh *et al*. (2013) note that issues remain with other tools to measure ecosystem services, particularly regarding site-scale assessments, the technical and expensive demands of fieldwork and the use of data from other locations within models.

TESSA is designed to assist users in identifying which ecosystem services to assess, what data is required to measure them, which methods or sources may be used in different contexts and how the results can be communicated. Methods are designed as templates for users to adapt according to local conditions. The toolkit utilises the methodological framework outlined in Figure 12. The steps to identify habitats at the site and priority ecosystem services delivered by the site are repeated for both the current state and plausible alternative state of the site (Peh *et al.*, 2013).

The TESSA framework firstly involves preliminary definition of the site of interest based on biological importance and perceived threats, assessing local governance and policy and engaging with stakeholders. Secondly, an appraisal identifies the most important habitats, drivers of land-use change (or development) and the services provided by the site. Such information is then used, together with stakeholder engagement and local knowledge, to identify plausible alternative states or state of the site, such as post-development or after the restoration of a site. Once priority services and a plausible alternative state have been identified, TESSA can assist a user in identifying appropriate methods for assessing changes to each service and the best methods of communicating the findings.

Figure A8: Methodological framework as used in TESSA (Peh et al., 2013).



Limitations of TESSA include the lack of detail with all ecosystem services. Services such as cultural services are important to people, which should be considered and communicated. The developers of TESSA aim to add more services to the more detailed aspects of the toolkit in the future. Furthermore, the current version of TESSA allows monetary values to be derived for some services, although values for water-related services are difficult to derive. Plans to increase the socio-economic scope of the toolkit aim to generate more information on how service values relate to the well-being of their users, and there are plans to provide guidance on how to monitor changes over time. TESSA does not currently address sustainability or resilience, or deal with the variation in the delivery of services over time. Finally, disproportionate effects, whereby a small change to an ecosystem can have a large impact on the provision of services are also not taken into account within the framework, and a potentially significant omission of climate change projections within the framework exists.

MSFD Modelling Tools

Defra and Marine Scotland are progressing the development of a number of spatial modelling tools to support implementation of MSFD. These include:

- A UK-wide spatial model combining selected environmental features (habitats and species) and human activity pressures which, together with information on feature sensitivity to those pressures, can be used to prepare a vulnerability assessment to infer the state/quality of environmental features in relation to GES
- A comparable spatial model which is focused on supporting assessments of marginal change in the provision of marine ecosystem services in response to implementation of particular mitigation measures
- Impact assessment tools based on CBA which can be used to assess the costs and benefits of implementing particular mitigation measures to inform assessments of their cost effectiveness.

While these tools are still being developed, they are particularly relevant to English waters and draw on current best available information.

Marine Scotland Impact Assessment Tools

Marine Scotland has adopted spatial approaches to assessing socio-economic impacts within Scotland's seas as part of its SA process (Marine Scotland 2013a, b). The assessments adopt an 'interactions approach' and consider how potential interactions between human activities and between human activity and the natural environment may lead to social and economic consequences. The methods rely heavily on spatial analysis within GIS to identify the potential for interaction to occur and then draw on existing evidence and stakeholder consultation to identify and define the potential social and economic consequences of potential interactions. Potential economic impacts are quantified where possible using methods based on HM Treasury's Green Book (HM Treasury, 2011). Social impacts have been assessed using a social capitals approach, based on Harper and Price (2011). This has taken the form of a distributional analysis of economic impacts. The tools have been helpful in understanding the potential scale of impact associated with future

offshore energy development (Marine Scotland, 2013a) and the identification and designation of nature conservation MPAs (Marine Scotland, 2013b).

A detailed critical review of tools and methods to apply marine social and economic data to decision making in the marine planning process was produced by the MMO 1012 project (MMO and Marine Scotland, 2012). The project produced two main reports that separately reviewed the data and tools that may facilitate different stages of the planning and licensing processes. The review of relevant tools identified current gaps and made recommendations for future research. The review broadly covered tools relevant to mapping and visualisation, development of options, site selection, impact assessments and the monitoring and evaluation of objectives and targets. This report provides a good overview of currently available tools for use within the marine planning process.

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Annex 3: Discussion of environmental economic analysis with respect to the Ecosystem Approach

This section considers some technical environmental-economic analysis issues that are relevant to the implementation of the ecosystem approach within marine plans. It provides guidance on integrating the ecosystem approach into supporting economic analysis for marine plans, such as an IA (Impact Assessment). Such analysis is most relevant where marine plans will impact on the socioeconomic benefits society gains from the marine environment. These include market impacts of human activities, and non-market impacts, both of which can be captured in an Ecosystem Services (ES) approach.

To meet these environmental objectives, the concepts of ecosystem services (introduced in Section 5.7) and of maintaining and enhancing natural capital become relevant considerations for marine planning. Marine planning will influence the organisation, location and timing of marine human activities. The extent of these activities may be in line with existing policy objectives, but in making them more explicit, marine planning has the ability to influence the condition of marine ecosystems and the levels of goods and services society obtains from them. In addition, given the ongoing changes in the marine environment (in line with the ecosystem approach's recognition that change in inevitable, for example due to climate change), even if marine planning results in maintaining the status quo its consequences may still be that ecosystem services are changed. Ecosystem services should therefore be taken into account within marine planning, building on existing work.

Aims of this guidance

At the time of writing, for each marine plan that MMO produces, it is required to conduct an IA in line with current UK Better Regulation guidelines. IA is a systematic, iterative, forward-looking process with multiple stages and entry-points where the ecosystem approach thinking can be introduced. An IA can help to understand the economic, environmental and social consequences[24] of a policy. Currently IAs of marine plans are expected to focus on impacts of the identified preferred option and therefore are unlikely to offer the chance of a detailed integration and assessment of ES. However, as future requirements may shift and regarding that IA has broad marine management applicability, this guidance aims to show the potential of IAs to incorporate the ecosystem approach.

The ecosystem approach can strengthen and bring greater legitimacy to economic analyses by:

- Including the economic values of ecosystems (and/or their services) and other forms of natural capital in the formulation of policy options.
- Enabling the fullest possible and most systematic evaluation of those options, including drawing on information gathered through stakeholder consultations (including the specific distribution and social significance of human activities

[24] https://www.gov.uk/producing-impact-assessments-guidance-for-government-departments

in the marine environment, and the nature and distribution of non-market values amongst stakeholders), which may not otherwise be incorporated into the analysis.
- Complementing the implementation and monitoring of policy objectives once the marine plan has been adopted.

When integrating the needs of the ecosystem approach into an economic analysis, a full range of economic data should be utilised. In addition to market values of ecosystem services, several economic concepts are important for adequately capturing the economic value of ecosystems and other forms of natural capital in arriving at the best practicable plan. These concepts include option and quasi-option value, resilience value, and non-use value. Consideration should also be given to potentially hidden impacts on ecosystems from cumulative impacts that emerge across individual projects over time but which are not easily observed at the individual project (or plan) level. Planners, stakeholders, consultees and policymakers involved in the IA process should use these as 'conceptual tools' to help them account for the value of maintaining future ecosystem service flows from all forms of natural capital including ecosystems.

These concepts are particularly relevant for conducting IAs for marine plans because they help capture notions of uncertainty, ambiguity and risk. Compared to terrestrial environments, there is weaker scientific understanding about ecosystem features and functions; fluid nutrient flows and mobile species blur marine planning boundaries in ecosystem terms; and fewer precedents exist for the application of the ecosystem approach in marine impact assessments. This motivates the use of economic concepts that identify, structure, quantify and value the impacts on ecosystems of human activities in the marine context. The costs and benefits of these impacts can then be considered as fully as possible alongside the market value of costs and benefits of the human activities.

Economic concepts for integrating ecosystem value into marine plan IAs

Ecosystem services provide a suitable framework for analysis of the implications for human welfare of marine planning. This is because they use a framework that connects science on ecosystem processes and functions, to changes in human welfare. They provide a useful analytical and communications tool for marine planning (Bohnke-Henrichs *et al*., 2013)

MMO should support development of the knowledge base on marine ecosystem services (as introduced in Section 5.7). There are a choice of ES typologies available from which to develop this analysis, and Bohnke-Henrichs *et al.* (2013) suggest one that is particularly suitable for ecosystem based management and marine planning. However, it is suggested that MMO use the typology defined in the forthcoming UKNEA follow-on. This has developed a classification of UK marine ecosystem services and reviewed available literature, and is likely to shape subsequent UK research that will be a key evidence source for marine plans. The UKNEA follow-on has identified that in addition to there being only a limited number of studies valuing UK marine ES, the work that is available has not focussed on the most valuable or important services (prof Kerry Turner, pers. com., Jan 2014).

While ES provide a suitable analytical framework, their use can be supplemented by consideration of natural capital concepts. The Natural Capital Committee (NCC, 2013) defines natural capital as "...*those elements of nature which either directly provide benefits or underpin human wellbeing*". Natural capital is a useful concept to support thinking about maintaining the future capacity to produce goods and services that benefit people. This includes levels of ecosystem services, but natural capital also involves abiotic processes and resources that lie outside most ES frameworks (e.g. mineral resources).

Consideration of the future productivity of marine natural capital raises questions of its resilience against pressures. The ability of the marine ecosystem to withstand stresses and shocks is its resilience value. Some evidence suggests that more diverse marine systems can have greater resilience, but the resilience of systems not well understood.

Data availability is currently a restriction on the extent to which ES and Natural Capital frameworks can be used to analyse implications for human welfare in detail. Detailed systematic reviews of the available literature on marine and coastal ecosystem services (e.g. Turner *et al.*, 2014; Liquete *et al*., 2013), highlight significant gaps in ES coverage and also a bias towards coastal ecosystems. Where data availability is weak, ES analysis can be used flexibly to exploit best available data, for example to identify links from parts of marine ecosystems, and their condition and functions, to human welfare.

The framework outlined by Dunn (2012) describes stages for assessing environmental impacts, using ES thinking to help identify where impacts are a priority for detailed analysis and, where possible, valuation. ES frameworks, even when lacking accurate values for some services, can still be used to analyse benefits from the marine environment, and consider how these will change over time (e.g. Saunders *et al.,* 2010). Furthermore, experience in the Caribbean suggests that valuation of ES needs to be undertaken in the right context and then results communicated appropriately in order to influence decision making regarding coastal resource (Waite *et al.,* 2014).

While specific changes due to management (for example marine planning decisions) may not be quantified, some information can still support decision making. For example, by reflecting the value of ecosystem services put at risk by changes to the marine environment that marine planning can manage the impacts of. This involves a greater element of expert judgement, and should be subject to review by stakeholders and peers before it is used as evidence in relation to marine planning. Where data availability is stronger, ES analysis can identify, quantify and give monetary values to how changes in marine ecosystem can impact on human welfare. Giving monetary values to changes in ecosystem services may not fully capture all impacts on human welfare, and will be subject to uncertainty, which should be explicitly assessed and stated. However, doing so allows welfare changes to be compared to other economic data.

Valuing ecosystem services

Where the evidence base allows quantification of ES change, their monetary valuation can be undertaken through different methods. Where a choice of methods

is available, these should be chosen in line with the following valuation hierarchy, as shown in Box 2):

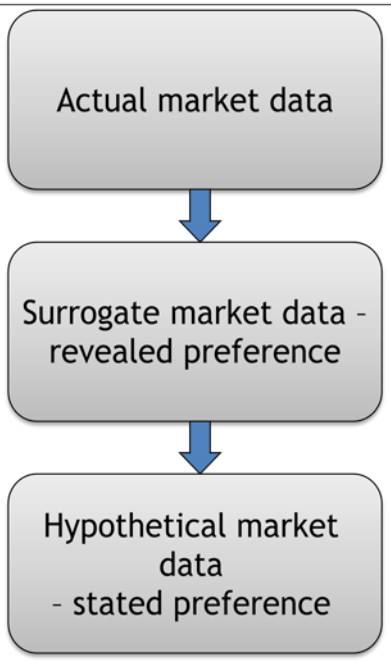
- Evidence from markets (where they exist) are preferred as the first source, ideally showing a demand curve (i.e. different levels of demand for different quantities of the good). Note that the value of these benefits can be different (potentially much larger) than the price paid for them due to consumer surplus.
- For impacts that do not have markets (non-market), there are two sources of value:
    - Surrogate market data, obtained by observing behaviours associated with market prices (known as revealed preferences) (e.g. purchase price of a house reflect its structure, size and also community cohesion in the area, air quality and landscape which are not directly measurable, or what individuals spend on travel for a recreational visit reflects their enjoyment of the activity, scenery, environmental quality etc.), and
    - Hypothetical-market data, in particular to value intangible or unquantifiable impacts, through use of stated preference methods (e.g. preferences for protection of marine biodiversity or of its potential medicinal properties (Jobstvogt *et al.*, 2013)).

Box 2: The valuation hierarchy

When markets exist:
- ⇨ Market prices; 'shadow pricing'; opportunity costs

When markets do not exist:
- ⇨ Market price proxies – e.g. cost of alternatives, mitigation costs
- ⇨ Economic valuation methods
    - ⇨ Revealed preference methods
    - ⇨ Stated preference methods

Intangibles, non-quantifiable…?
- ⇨ Cannot value everything – not possible, practical, nor warranted in some cases



Non-market values are discussed further towards the end of this Annex.

Option value

Option value is the amount that an agent would pay to preserve the possibility of a future use of resources, even though such use is not currently planned. A related

concept is quasi-option value which arises through avoiding or delaying irreversible decisions, where technological and knowledge improvements can alter the optimal management of a natural resource. Option and quasi-option values are relevant when society is uncertain as to whether a course of action will lead to the loss of some future opportunity to use resources. Society may wish to avoid or mitigate this loss, due to uncertainty regarding future demands or values for ecosystem resources and services and risk-averse preferences.

Examples of option values relevant to marine management include:

- Greater certainty over a positive outcome, like maintaining the ability of marine systems to support fish stocks in new locations they move to in response to climate change, is an example of option values related to uncertain future uses of resources in specific areas.
- In the marine planning process the future discovery of new compounds or materials (e.g. new medicines) derived from deep sea organisms is a possible outcome that society might like to preserve. The possibility of new compound innovation disappears or is severely diminished by some forms of intensely biologically disruptive marine economic activity. This activity creates immediate costs in the form of diminished ecosystem services and other value flows. It can also, additionally, preclude future possibilities that are unanticipated or uncertain. The value of the 'new compounds' option would be foregone in this example and therefore enter on the cost side of the cost-benefit ledger in the impact assessment process. This would make this disruptive economic activity look less economically beneficial, all else being equal.
- In the exploitation of deep sea environments, there was no value for deep-sea fish consumption before we realised there were fish to catch and started catching them. But the potential was always there. There are deep-sea fish resources that are not currently exploited, but it cannot be assumed these have no value; rather, there is a latent value that may be classified either as a future use value (i.e. society plans to use the resource in future) or as an option value (society does not plan to use it, but value keeping the option open)." (Armstrong *et al.,* 2012).

Option value is therefore the amount society is willing to pay to preserve an economically beneficial possibility. This includes preserving the possibility to mitigate an economic loss, or to achieve greater certainty that some future economic outcome or state that we do not expect to want will nevertheless be achievable should (future) society change its plans.

Resilience value and cumulative impacts

Ecosystem resilience is the ability of an ecosystem to withstand human-induced or natural disturbances and maintain its basic structures, functions, and the ability to self-regenerate (i.e. sustain itself). Eroding an ecosystem's ability to self-regenerate in turn impairs ecosystem function, integrity and/or longevity. Diminished resilience means that the same impacts on an ecosystem are more likely to diminish natural capital and reduce the ecosystem service flows available in the future. The value to society of preserving the resilience of the marine ecosystem, in addition to value of

preserving the flow-quantity of ecosystem goods and services, is the value placed on increased security of those services in the face of future changes or perturbations.

For example, society may wish to ensure that a fish spawning and nursery area in the North Sea is able to continue its productive functions despite anticipated environmental impacts or change arising from nearby marine industrial activities. The value of the services that flow from the area depend partly on fish spawning rates and the eventual quantities of edible fish produced. The value of resilience of the ecosystem is the value to society of the ecosystem's ability to repair and adapt itself when impacted by events that temporarily diminish those flows.

Resilience is not normally considered as part of economic appraisal of environmental changes. Recent work by Bateman *et al.* (2011) has sought to define Marginal Resilience Value (MRV). This is an innovative approach to the problem of assessing sustainability proposed by Mäler *et al*. (2009) and Mäler (2008). There is one study, relating to saline intrusion into the water table (by Walker *et al.,* 2010), that has quantified MRV (Prof. Ian Bateman, pers. com., Jan 2014). However, this analytical approach could be worth investigating further in relation to marine ecosystems. The concept of resilience value reflects the marine planning ecosystem approach principles described in Box 1, (e.g. involving all forms on knowledge (Principle 5), integrating socio-economic evidence (Principle 2), conserving ecosystem structure and function (Principle 7)), and offers a way of capturing these in the analysis accompanying marine plans.

It is suggested that, in order to capture relevant aspects of the ecosystems approach, further work is worthwhile to consider application of the MRV concept to the marine environment[25]. Resilience value is a stock in itself with a distinct asset value that can be degraded or enhanced over time. The stock of resilience at a given time generates a marginal shadow value. Where this relationship is more complex, this value can be weighted by the difficulty of reversing prior levels of depletion, giving a marginal resilience weighted shadow value. This value is expected to increase as the asset providing the resilience is degraded. The simplest relationship between resilience stock and a depleting driver is linear and perfectly reversible. This relationship may be non-linear, for example:

- Where a threshold exists: such that once stocks are depleted to some ecologically relevant level, then further increases in the depletion driver result in an accelerating rate of stock reductions.
- When the system has recovery hysteresis: that is the marginal resilience value is greater when the trajectory of the recovery path of an asset shows a slower recovery of production of goods and services compared to its depletion path.
- If society and/or policy makers are more risk averse: the more risk averse they are, the steeper the shadow value curve will be representing a stronger desire to avoid irreversible damage.
- When the goods and services produced have fewer substitutes: meaning the marginal shadow value rises more rapidly as asset is increasingly degraded.

[25] This section draws on Bateman *et al.* (2011).

Limitations of the MRV model relate to its high data requirements and high degree of scientific knowledge required (e.g. about substitutability and tipping points. Therefore further research into MRV is required to see if it can be practically useful in marine planning, particularly by providing quantified evidence. However, even if this is not possible, the concept of resilience of the marine ecosystem could be referred to in future marine IAs, along with a statement that this cannot currently be valued, and could be identified amongst the 'key non-monetised impacts' in the IA summary.

The concept of marginal resilience value is also of relevance to the SA of marine plans. It can be used to assess whether changes occurring up to the present day and the planned development path of economic activity, have or will progressively run down the natural asset base which underpins its viability. Analysis of future development is typically implemented through assessments of one or more future scenarios, the drivers of which include forecasts of environmental change, trends in domestic and world markets and potential (and possibly dynamically compensating) policy shifts. The UK NEA undertakes both forms of analysis, encompassing both a sustainability analysis of historic trends from the middle of the last century to the present day, as well as programme evaluations of different alternative futures from the present until 2060 as captured in a series of scenario analyses. Such analyses provide important early warning signals for non-sustainable growth patterns.

The most likely source of marine value to be amenable to analysis of marginal resilience value is the value of wild caught fish. As fishing activity has intensified and expanded they have resulted in depleting adult populations (spawning stock biomass) and changes in structure of marine communities. In order to reverse this situation fishing pressure would potentially need to be reduced by more than the original increase, because the elevated fish population degradation has changed the structure of marine systems and inhibits the recovery of stocks. The additional costs implicit in having to further reduce depletion drivers (such as fishing effort) in order to replenish ecological stocks (here the levels of harvestable fish) implies an elevated post-threshold shadow value of resilience. This imperfect and hysteretic reversibility case means that depletion of resources which have ecological thresholds imposes additional welfare losses above those associated with the perfect reversibility case.

The resilience approach to sustainability requires high degrees of knowledge and data availability particularly when stocks and thresholds are influenced by multiple interacting variables. Therefore, it requires primary modeling work by those with expertise in the ecology and economics of the stocks in question. However, further consideration should be given to other marine ecosystem services to assess the feasibility of quantifying their MRV. To do so will require some quantified evidence on the monetary value of these services, and how this value may change over time in response to marine pressures that marine planning will help to manage.

Individual economic activities incorporated into a marine plan have a mix of benefits and costs for ecosystems. The cost associated with an individual project's negative impact on an ecosystem is the project's 'marginal' environmental cost. The combined cost of two projects is often not equal to the sum of their marginal costs (estimated in isolation) particularly when ecosystems are damaged or vulnerable. This is because a small increase in pressures or degradation at the margin can cause large,

disproportionate, and unanticipated impacts on ecosystems. Cumulative costs can be different to the sum of marginal costs when economic activities are approved in isolation and without considering how the approval of one project could change the marginal impact of another (Hoehn and Randall, 1989).

The East Marine Plan has an explicit objective related to resilience: “Objective 6: To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas.” (in addition to Objective 7 relating to biodiversity). The rationale is recognition that a healthy functioning ecosystem is important in its own right - that it should be resilient and adaptable in the face of pressures upon it, and able to sustain the benefits that it provides to people. This reflects policies and commitments on the wider ecosystem, set out in the MPS, including MSFD and WFD, as well as other environmental, social and economic considerations. Elements include functioning of biological communities, nutrient and carbon cycling; water quality and pollutant aspects relating to healthy ecosystems, coastal processes, interactions among drivers and human benefits from ecosystem services. Knowledge is developing, and the topic is recognised as a priority evidence gap to support marine planning. Particular concerns include:

- cumulative impacts
- changes to water quality and resulting effects on wildlife and on people
- changes to hydrographical conditions
- introduction of non-indigenous species
- noise
- litter
- climate change influences on the above, considered under the separate objective 9.

Various policies and measures are ‘signposted’ as already in place to address these issues. Specific plan policies are:

- ECO1: Cumulative impacts affecting the ecosystem of the East Marine Plans and adjacent areas (marine, terrestrial) should be taken into account in decision-making and plan implementation.
- ECO 2: The risk of release of hazardous substances as a result of any increased collision risk should be taken account of in proposals that require an authorisation.

Stages and entry points for ecosystem value concepts in marine IAs

Individuals carrying out marine plan IAs in future should be aware of the multiple stages and entry points where the ecosystem approach can strengthen the process. An IA is a structured process whose purpose is to support the development of a policy, in this case a marine plan. The IA process identifies the problem in question and sets out policy objectives to be pursued through the process. It identifies the main options for achieving the objectives and evaluates their likely impact on economic, environmental and social outcomes. Best practice is to evaluate these options against a baseline business-as-usual scenario. The IA process systematically examines the advantages and disadvantages of each policy option, including trade-offs, synergies and interactions (EC, 2009).

The six conceptual steps in the IA process are as follows (HM Government, 2011):

1. Identify the problem: describes its nature and extent, identifies key interests and stakeholders, establishes the underlying drivers that cause the problem, and develops a baseline business-as-usual scenario for continuing in the status quo.
2. Define the objectives: sets objectives that correspond to the root problem and its cause, splits out policy objectives into those that are principle-based and over-arching on the one hand, and those that are narrower and focused on specific, practical outcomes on the other.
3. Develop main policy options: distinguishes between options for policy content and options for delivering policy content; develops measures and criteria for screening, comparing, and assessing effectiveness and efficiency of options; produces a substantial number of options for further analysis.
4. Analyse impact of options: identify direct and indirect economic, social and environmental impacts and the causal mechanisms through which they occur; identify affected parties; assess each option against the baseline in qualitative and quantitative terms; consider risks and uncertainties in policy options.
5. Compare the options: collects and organises the evidence base for each option, weighs up positive and negative impacts of options, applies quantitative scoring or costing measures in comparison where possible; identifies a preferred option where appropriate.
6. Policy monitoring and evaluation: identifies core indicators of progress towards most important objectives, sets targets and milestones for evaluation, anticipates possible corrective actions if targets are not being met.

The six conceptual steps are commonly carried out by individuals responsible for the IA process through four more practical procedural steps (IAIA, 2005; EC, 2009):

1. Process planning: sets out a timeline for the IA, establishes accountability for the IA outcome, identifies consultees, sets out procedures for reconciling competing views.
2. Public consultation and policy development (iterative): gathers collective expertise, facilitates learning and education, iteratively drafts and draws public reaction to policy options.
3. Proposal development: public dialogue closes, policy development and refinement process with best available evidence.
4. Policy approval and communication: achieves formal adoption of policy, communicates outcomes to consultees in particular, publishes IA process documentation.

Opportunities exist for integrating the ecosystem approach into both the six conceptual steps and the four procedural IA steps.

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Annex 4: Case study application of MSFD tools to East marine plan areas

This annex illustrates the application of two spatial analysis tools being developed to support UK implementation of Marine Strategy Framework Directive (MSFD) to the area covered by the East Marine Plans. The tools comprise:

- MSFD Business as Usual (BAU) project tools (ABPmer and eftec, 2012) which seek to project changes in the state of selected MSFD indicators over time in response to projected changes in human pressures; and
- A marine ecosystem services model that seeks to identify spatial changes in ecosystem service provision over time in response to abrasion pressure on seabed habitats from towed commercial fishing gears (eftec and ABPmer, 2013).

While the tools have been primarily developed to inform MSFD implementation, they will also have benefit to marine planning because they can be used to undertake plan-wide spatial assessments of the impacts of existing or potential future policies and human activities on the marine environment. However, they would only constitute some of the spatial work that would be required at a detailed level to apply an ecosystem approach within a plan area and need to be considered with a number of other analyses.

It has not been possible within the scope of this study to test suggested tools that can be used to evaluate social and economic impacts, although examples of the successful application of such tools are available elsewhere (Marine Scotland, 2013a; 2013b).

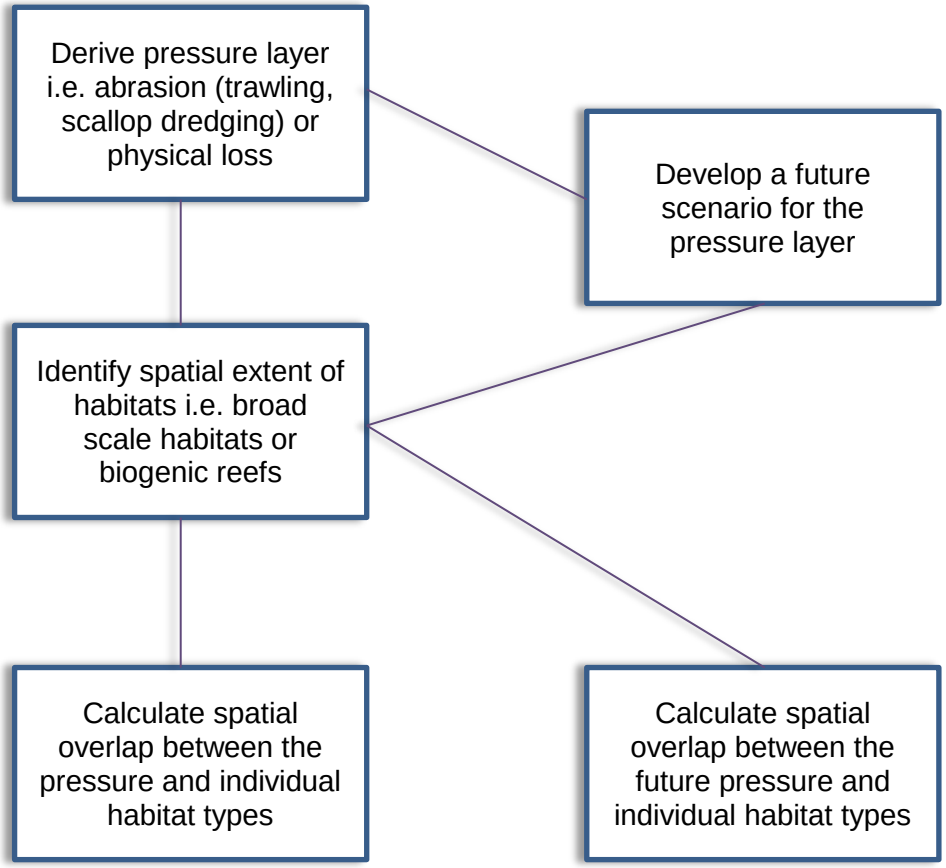
Methodology

The MSFD BAU model was used to estimate the following changes:

- Spatial extent of broad scale habitats subject to low, medium and high intensity trawling and scallop dredging in 2010 and 2030;
- Spatial extent of biogenic reefs (blue mussel beds, *Sabellaria spinulosa* beds, *Sabellaria spinulosa* reefs) subject to low, medium and high intensity trawling in 2010 and 2030;
- Spatial extent of broad scale habitats subject to physical loss from human activities (infrastructure and dredging) in 2010 and 2030; and
- Spatial extent of biogenic reefs subject to physical loss from human activities (infrastructure and dredging) in 2010 and 2030.

The approach used is summarised in Figure 13 below.

Figure A9: MSFD BAU model method (ABPmer and eftec, 2012).



The data layers were compiled from the MSFD BAU model and updated where an applicable updated version of the data layer existed. The MSFD BAU fishing intensity layers for both trawling and dredging were processed from Vessel Monitoring System (VMS) data for >15m vessels (Dunstone, 2008). All UK and non-UK vessels were included and fishing was estimated using a speed rule of 1-6 knots to represent fishing activity. Estimated fishing hours for individual gear codes were summarised to provide information on the fishing activity for gear groups. Data were summarised for every 0.05 degrees, equating to an average cell size of 3.3 by 5.6 km.

The layers for 2010 were not updated as this data represents the 2010 picture of fishing activity. The data layers representing 2030 fishing activity were updated using information available to describe fishing restrictions that might be applied within individual MCZs based on assumptions contained within the MCZ IA (Finding Sanctuary *et al.*, 2012). Where the MCZ IA assumed that fishing restrictions would be necessary to support achievement of management objectives, the MCZ extent was removed from the corresponding fishing intensity layer where a restriction to trawling or dredging activity will be applied as a management measure within the MCZ. It was assumed that the displaced fishing effort would be lost, although in reality, a proportion of the effort would be redistributed to existing and possibly new fishing grounds. It is also noted that the assumed restrictions in fishing activity by

2030, based on the MCZ IA, are likely to change. This may be a result of changing advice from SNCBs following recommendations or as a result of the risk assessment process undertaken to determine the management needs of sites during designation. These considerations highlight the challenges of being able to develop realistic assumptions of future scenarios to populate such models.

The limitations of historic VMS fishing activity data are well documented (Lee *et al.,* 2010), the main issue being that only >15m vessels are represented within the data set and therefore inshore activity, where most vessels <15m fish, is currently underestimated by the use of VMS data. From 2012, vessels >12m have been required to transmit a VMS signal and this may be further extended to vessels >8m. Other limitations relate to the assumptions made during the data processing stage including, vessel speed as an indicator of fishing activity and the resolution at which the data can be represented. Further concerns over the confidentiality and commercial sensitivity of VMS data also exist regarding the use of raw VMS points (Lee *et al*., 2010).

Human activity data layers were taken directly from the MSFD BAU model. An update was applied to the 2030 Offshore Wind Farm (OWF) layer, with all other 2010 and 2030 human activity layers remaining unchanged. Data describing the spatial location of turbines within OWF areas (http://www.4coffshore.com/) was used to update the MSFD BAU model layer for 2030 OWF. The method for data collation for each human activity layer, and any associated assumptions and limitations, are described within MSFD BAU report (ABPmer and eftec, 2012).

The data layers representing both broadscale habitats and biogenic reefs within the MSFD BAU model were derived from UKSeaMap and Altlantic MESH, respectively. Both data layers have subsequently been updated. The latest available versions, EUSeaMap (EUSmp_NC_habitats_201107.shp) and Atlantic MESH (C20121127_EUNISComposite_GBFRNLBE_v4a_WGS84.shp), were used to extract the relevant habitats and generate a new broad scale habitat and biogenic reef data layer for analysis.

Limitations are present for both the EUSeaMap and Atlantic MESH layers relating to the resolution, quality, distribution and method of generation for each data layer. EUSeaMap is a modelled predictive map and has a coarse resolution. Due to the resolution not all inshore areas are covered. EUSeaMap is based on a grid of around 300m, while some of the underlying data are at coarser grids. The maps are therefore unsuitable for fine-scale planning and are more intended to give a broad perspective of feature distribution at a regional or national scale. Further details are described in McBreen *et al.* (2011). The Atlantic MESH habitat map is a fine resolution map derived from survey data and has better inshore coverage and spatial resolution. The Atlantic MESH map is also more detailed in English waters compared to EUSeaMap. The extent of the map is limited by the availability of survey data throughout the geographic range of the study area, and therefore does not give even confidence in habitat extents across different survey areas (JNCC, 2008). Each of the datasets do not allow for any degree of temporal change and are representative of a snapshot in time, whereas in reality the extent of habitat features will change through time.

An ecosystem services model was used to estimate the potential reduction in secondary productivity of benthic habitats associated with current commercial fishing seabed abrasion pressure, linked to the potential reduction in fish production which contributes to the provisioning service 'food' (eftec and ABPmer, 2013).

The data layers from the ecosystem services model were extracted and then clipped to the East Coast Marine Plan areas. The secondary production data layer was generated from the EUSeaMap broadscale habitat layer described above. Secondary production data from Bolam *et al.* (2014) was then attributed to each Eunis level 3 habitat to give a value in KJ m^{-2} yr^{-1}. A number of assumptions were necessary to apply the attribution including using the mean secondary production value for each habitat sample sites and applying it to all of that habitat. For habitats which did not have any secondary production samples the values were inferred on the basis of what is considered to be the most similar habitat type (eftec and ABPmer, 2013).

A fishing seabed abrasion pressure data layer was generated from VMS >15m data, non-UK estimated fishing effort and the integrated fishing activity data layer for English and Welsh waters (Vanstaen, 2010). This data layer is more comprehensive than that used within the MSFD BAU model as it includes non-UK and estimations of the <15m fishing fleet, however many of the same limitations apply The resolution of the data layer is restricted to $1/200^{th}$ of an ICES rectangle and the processing steps for VMS data still include assumptions of fishing activity and vessel speed. Additional limitations are introduced through combining these fisheries datasets because they are all presented at different scales and levels of detail, meaning that in some grid cells it is not possible to separate out the mobile gear types. This will distort the levels of abrasion as not all the gear types included would result in the same level of abrasion. The pressure data layer was constructed on the basis of 2009 fishing data and similar to the habitat maps, represents only a snapshot in time. Furthermore, the model assumes that abrasion due to mobile fishing gear is the only pressure affecting benthic habitat types which is an oversimplification. In reality benthic habitats are subject to a range of pressures acting in synergy in the marine environment.

Results

Estimated spatial extent of broadscale habitats subject to low, medium and high intensity trawling in 2010 and 2030

The results are presented in Figures 14 and 15 and Table 18. They indicate a potential reduction of around 1400 kilometre^2 (km^2) (low) and 200km^2 medium intensity trawling on habitat A5.1 (Sublittoral coarse sediment) between 2010 and 2030, largely on account of removal of abrasion pressure from MCZs. This represents a reduction in low and medium pressure over approximately 10% of the area of the habitat occurring within East Marine Plan areas.

Estimated spatial extent of broadscale habitats subject to low, medium and high intensity scallop dredging in 2010 and 2030

The results are presented in Figures 16 and 17 and Table 19. They indicate that scallop dredging currently occurs on only a very small proportion of broad scale habitats within the East Marine Plan areas and that this is unlikely to change significantly in the period to 2030. The information could be used to inform the

acceptability of scallop dredging abrasion impacts on habitats in relation to targets established under MSFD. It could also be combined with information on impacts to broadscale habitats from other activities (including the impact of marine plan policies) to determine the overall acceptability of impacts in relation to any specific targets.

Estimated spatial extent of biogenic habitats subject to low, medium and high intensity trawling in 2010 and 2030

The results are presented in Figures 18 and 19 and Table 20. They indicate that low intensity fishing pressure currently occurs over a large proportion of each of the biogenic features assessed and that the spatial extent of impact is not predicted to change substantially in the period to 2030.

Estimated spatial extent of loss of broadscale habitats due to infrastructure/dredging in 2010 and 2030

The results are presented in Figures 20 and 21 and Table 21. They indicate that the relative proportions of broadscale habitats lost to infrastructure and dredging are very small relative to the overall extent of each broadscale habitats within the East Marine Plan areas. Some changes in the extent of habitat loss are projected for 2030 with increases in the loss of A5.1 (Sublittoral coarse sediment) and A5.2 (Sublittoral sand) as a result of marine aggregate extraction and offshore wind farm development.

Estimated spatial extent of loss of biogenic habitats due to infrastructure/dredging in 2010 and 2030

The results are presented in Figures 22 and 23 and Table 22. They indicate that the relative proportions of *Sabellaria spinulosa* reef lost to infrastructure or dredging are very small relative to the overall extent of this feature within the East Marine Plan areas. Some changes in the extent of habitat loss are projected for 2030 with estimated decreases in impact from marine aggregate dredging (as a result of improved knowledge of the distribution of the feature and better protection within licensing conditions). The assessment indicates a marginal increase in the extent of impact to *Sabellaria spinulosa* reef from offshore wind farm development, but this does not take into account the potential for micrositing turbines within arrays and thus is likely to be an overestimate of impact.

Estimated impact of abrasion from commercial fishing on secondary productivity of seabed habitats

The results are presented in Figures 24 and 25 and Table 23. The results suggest that for areas of A3.3 low energy infralittoral rock there could be a reduction of up to 27% in secondary productivity as a result of the overlapping abrasion pressure from mobile fishing gears. This is a greater reduction in secondary productivity than for most other benthic habitats, where the reduction in secondary production as a result of abrasion is typically less than 10%. It has not been possible to make an assessment of how this impact may change by 2030.

Discussion

The tools illustrate how, despite the inherent limitations and uncertainty, quantitative information can be obtained relating to how human pressures affect seabed habitats and ecosystem services and how such impacts might change as a result of existing

policies or human activities or as result of new marine plan policies. The limitations and uncertainty means that confidence in the maps is variable and, particularly for inshore areas, sometimes quite low. Further details on the modelling approach and these uncertainties are available in the project report.

Such information is essential for effective delivery of Principle 7 (conserving ecosystem structure and function and managing within functional limits). Given that many of the objectives for seabed habitats stem from the MSFD, the tools could also provide a useful mechanism for ensuring that marine plans conform with MSFD indicators and targets.

The information on the spatial extent of impacts to broadscale habitats or biogenic habitats could be used to inform the acceptability of trawling abrasion impacts on habitats in relation to marine plan objectives. It could also be combined with information on impacts to broadscale habitats from other activities (including the impact of marine plan policies) to determine the overall acceptability of cumulative impacts in relation to any specific targets.

The information on the impact of abrasion pressure on secondary productivity could be used to inform an assessment of the acceptability of cumulative impacts on the provisioning service ‘food’.

It is recognised that there is uncertainty associated with projections provided by the current BAU model and ecosystem services model (see ABPmer and eftec, 2012; eftec and ABPmer, 2013) owing to uncertainties in the underlying habitat maps and fishing pressure layers. The limitations and assumptions of the datasets used affect the confidence in the outputs of such models which must be recognised before using modelled results in plan policy development. This is particularly an issue in inshore areas, but less so for offshore areas where fishing pressure distribution is adequately captured by VMS data and the spatial resolution of pressure and feature data is reasonably consistent. Ongoing work by UKMMAS partners will lead to significant improvements in spatial data layers for marine habitats and species over the next five years, together with the development of standardised pressure layers which combine similar types of pressure across different human activities. This will extend the range of features for which spatial assessments can be made and improve the estimates of spatial change provided by such models. The tools provide significant advantages compared to expert judgement in providing a consistent means of quantifying the impact of human pressures on the environment. For offshore areas, the current tools are considered to provide meaningful outputs that could support decision-making now, but for inshore areas, further development of the tools would be necessary.

Figure A11: Estimated spatial extent of broadscale habitats subject to low, medium and high intensity trawling in 2010.

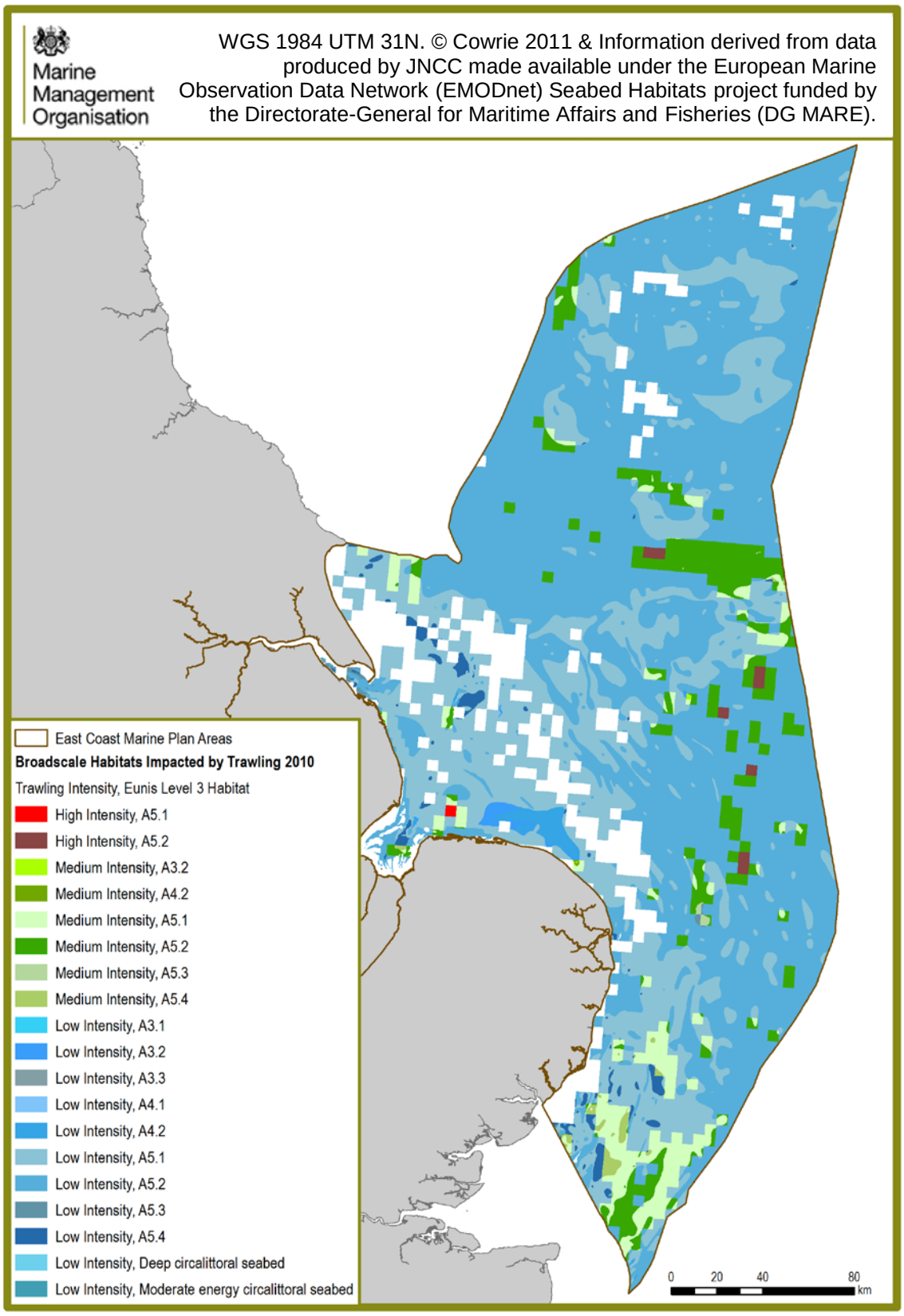


Figure A12: Estimated spatial extent of broadscale habitats subject to low, medium and high intensity trawling in 2030.

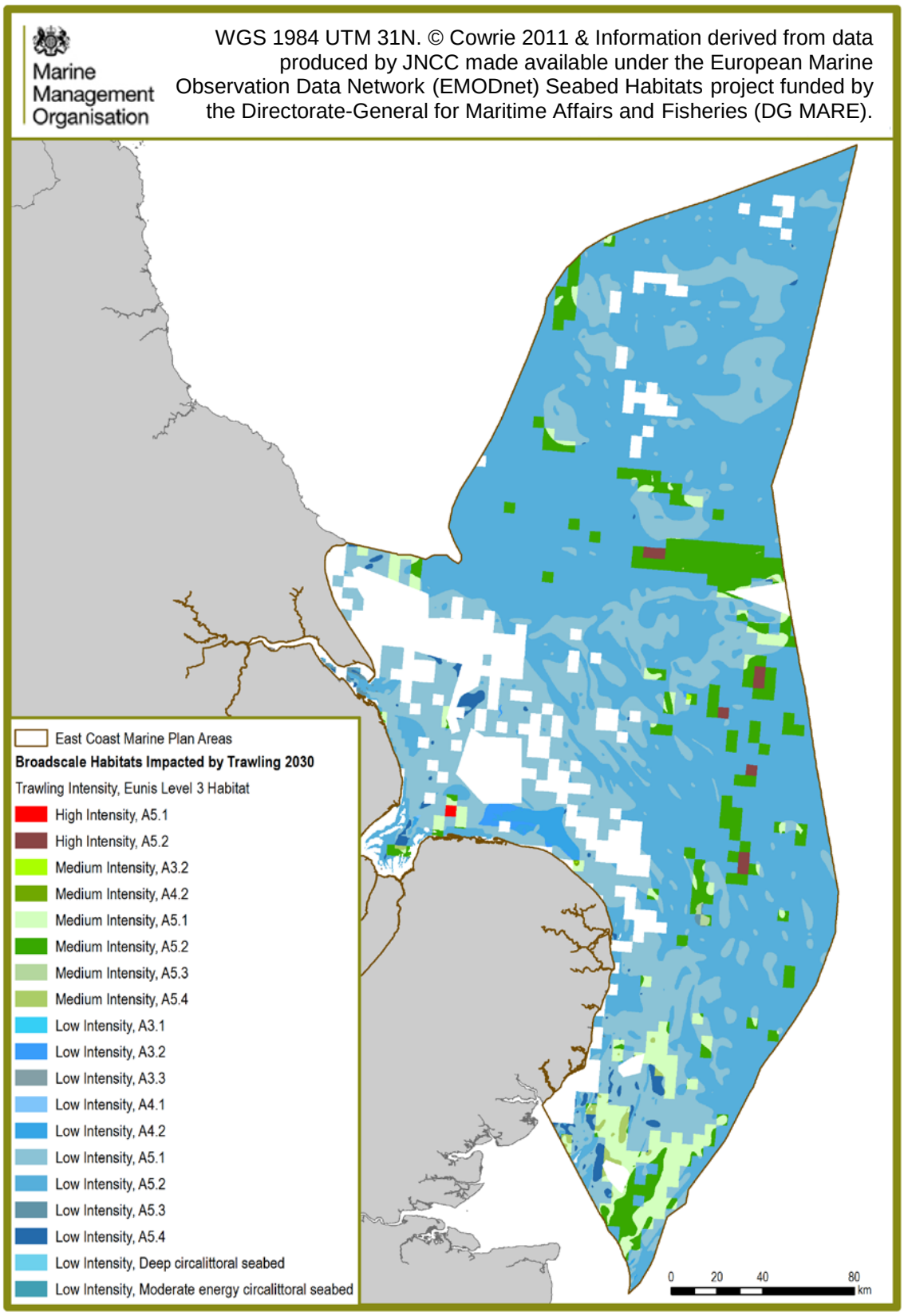


Figure A13: Estimated spatial extent of broadscale habitats subject to low, medium and high intensity scallop dredging in 2010.

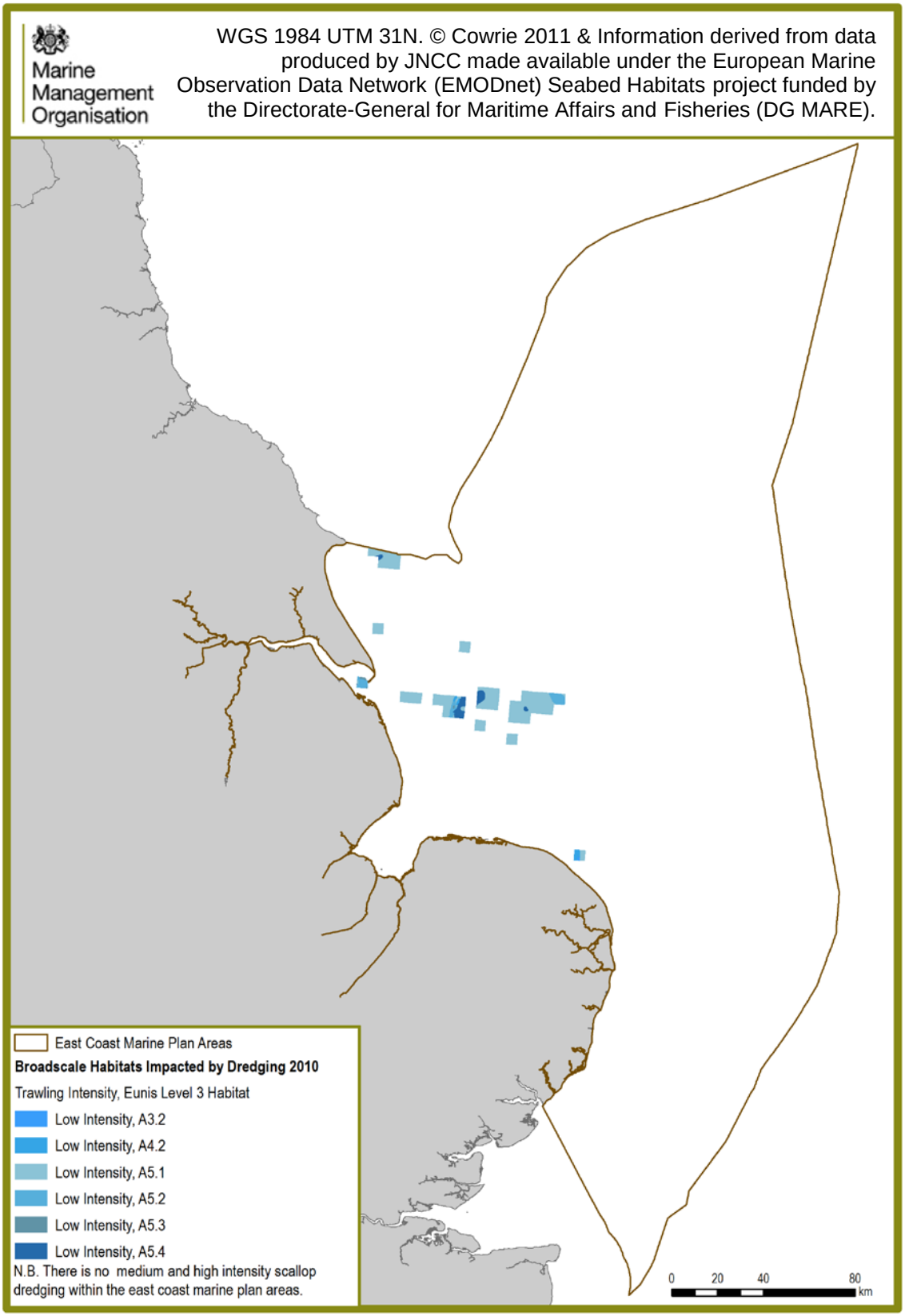


Figure A14: Estimated spatial extent of broadscale habitats subject to low, medium and high intensity scallop dredging in 2030.

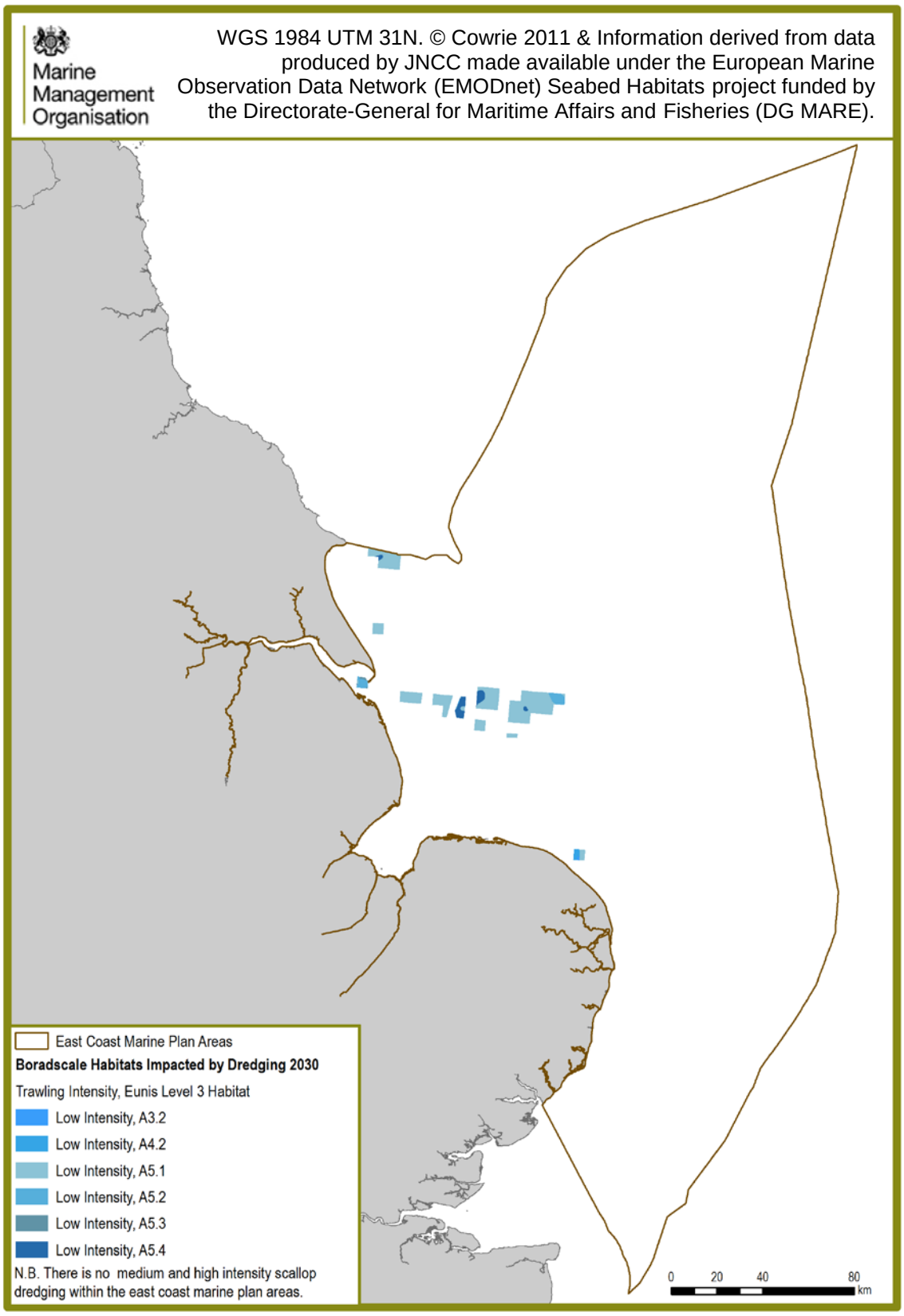


Figure A15: Estimated spatial extent of biogenic habitats subject to low, medium and high intensity trawling in 2010.

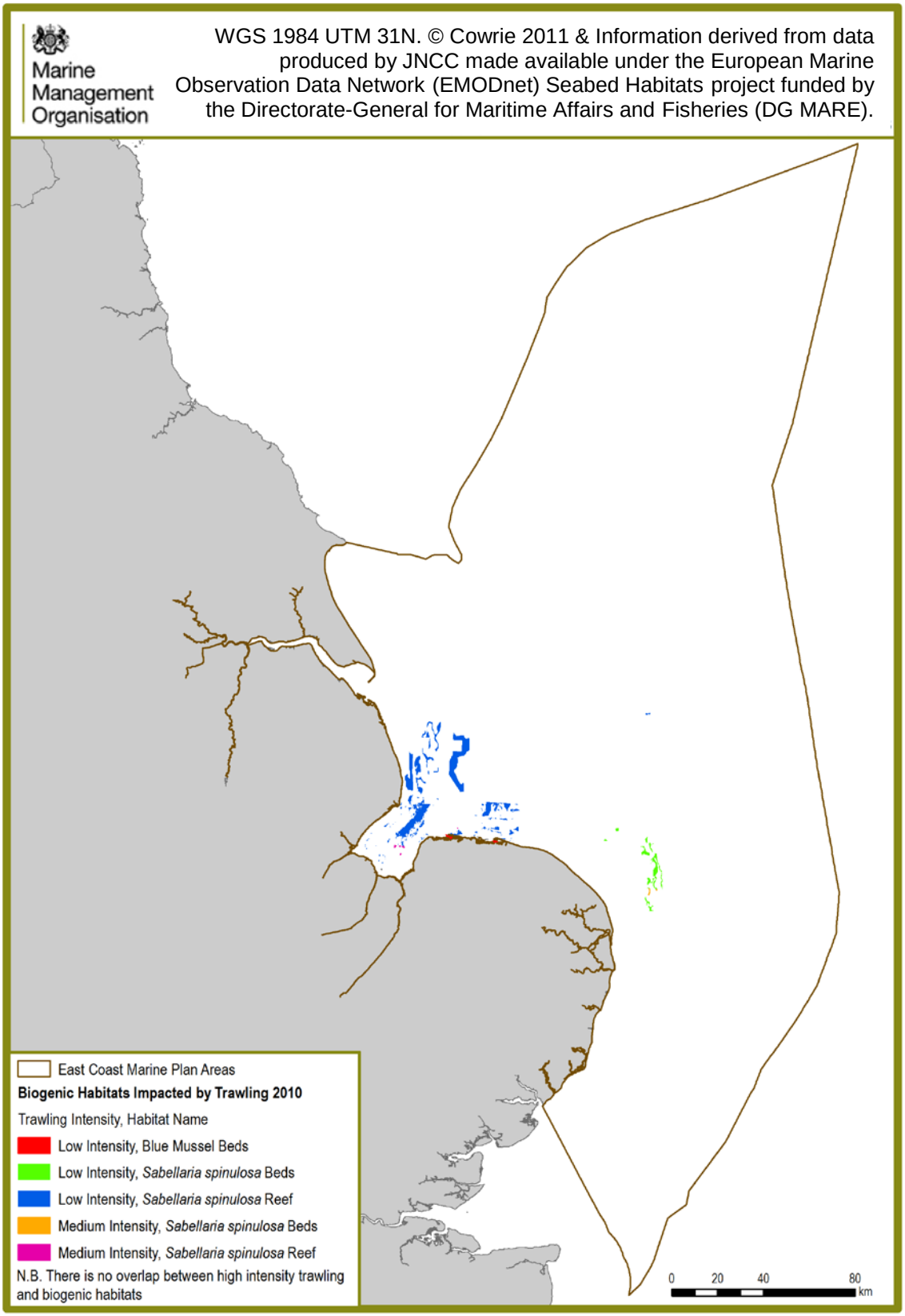


Figure A16: Estimated spatial extent of biogenic habitats subject to low, medium and high intensity trawling in 2030.

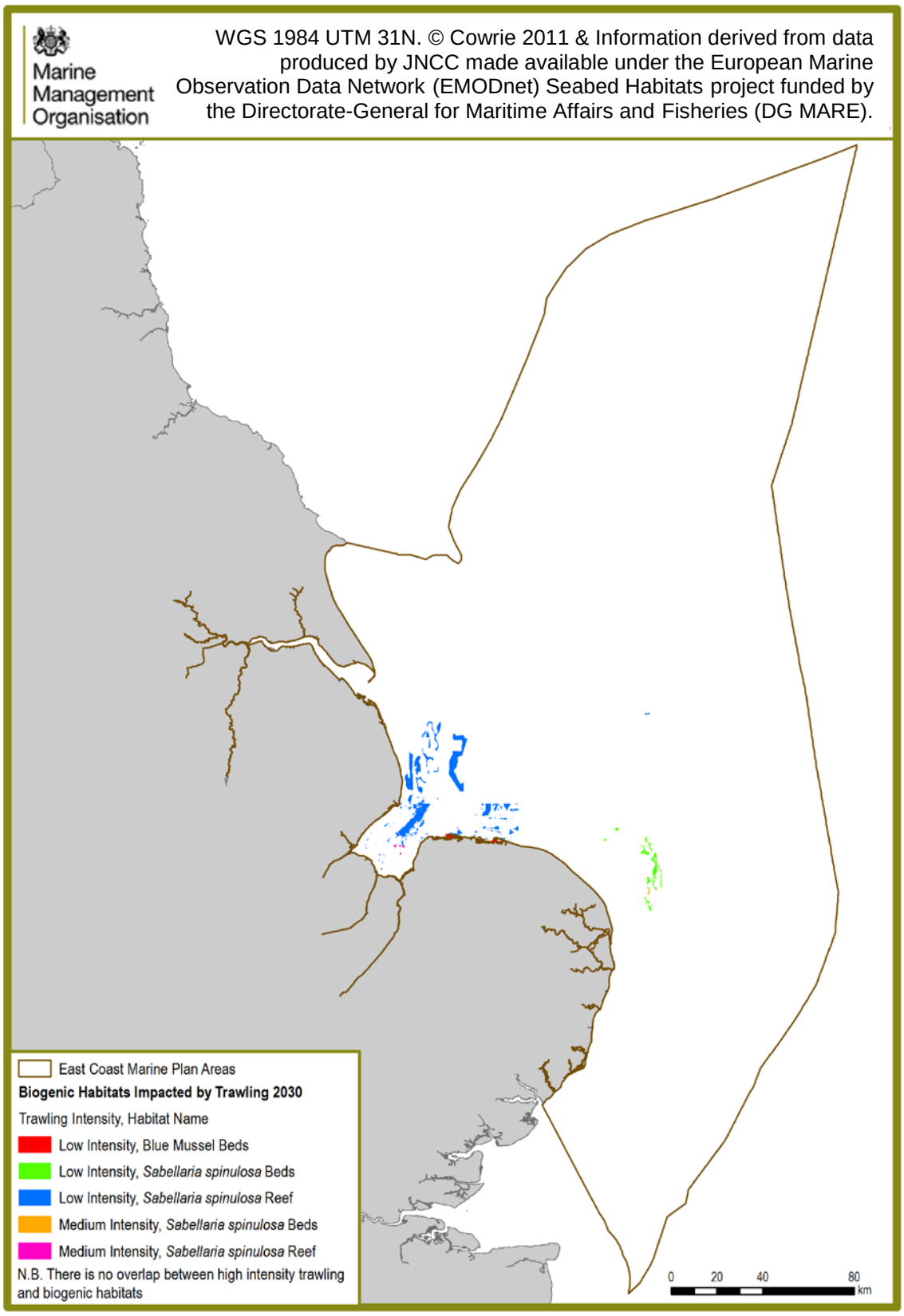


Figure A17: Estimated spatial extent of loss of broadscale habitats due to infrastructure/dredging in 2010.

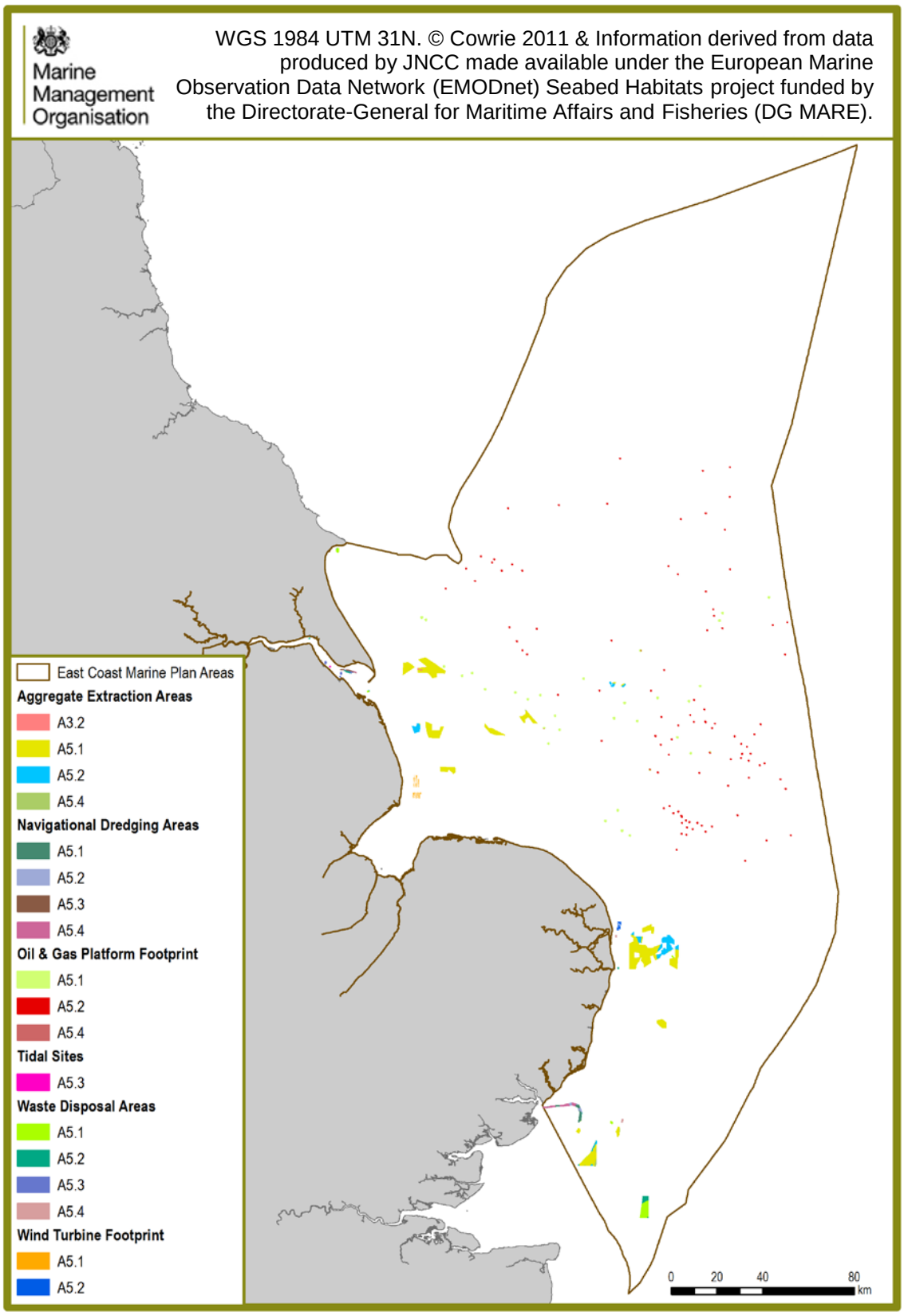


Figure A18: Estimated spatial extent of loss of broadscale habitats due to infrastructure/dredging in 2030.

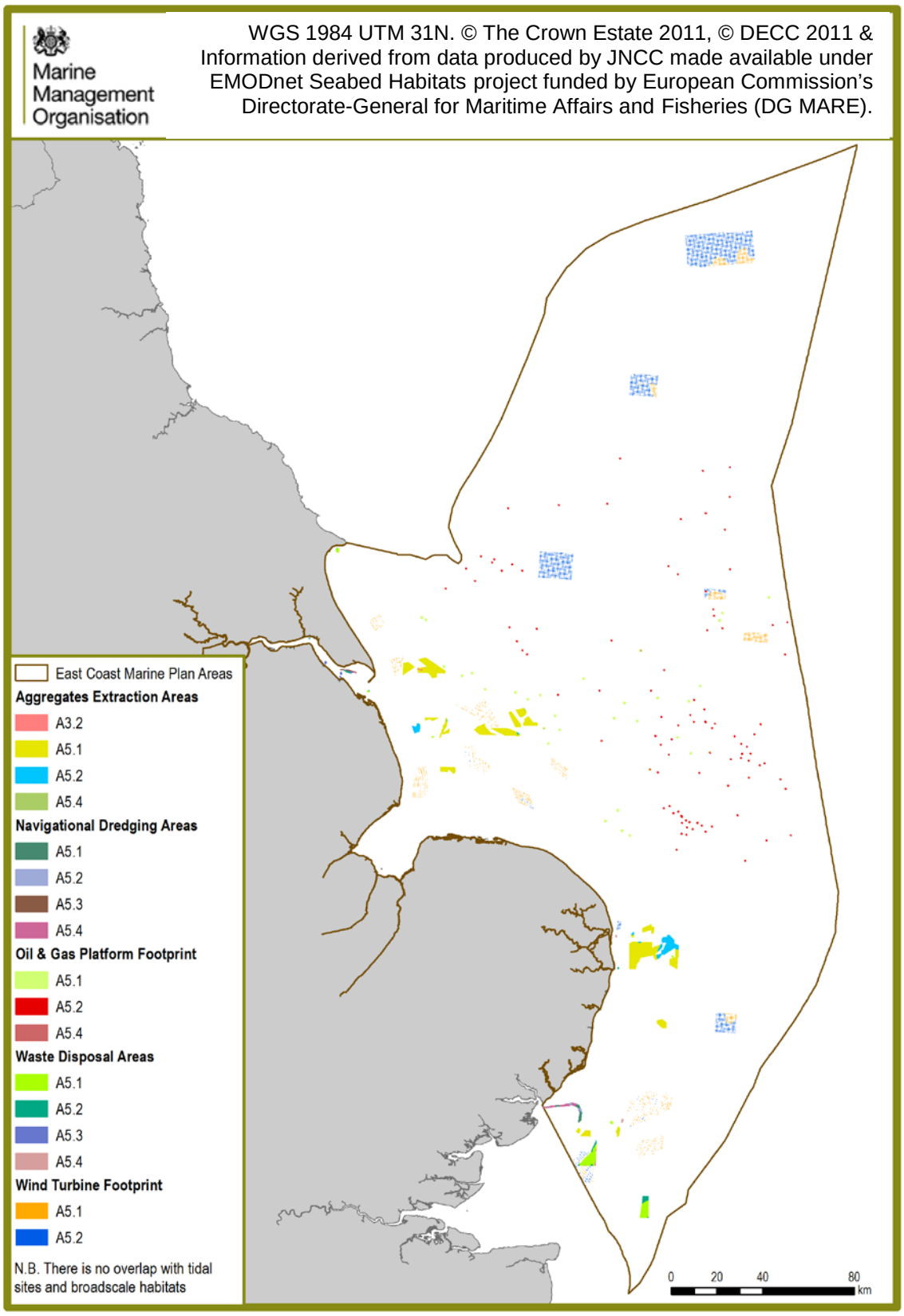


Figure A19: Estimated spatial extent of loss of biogenic habitats due to infrastructure/dredging in 2010.

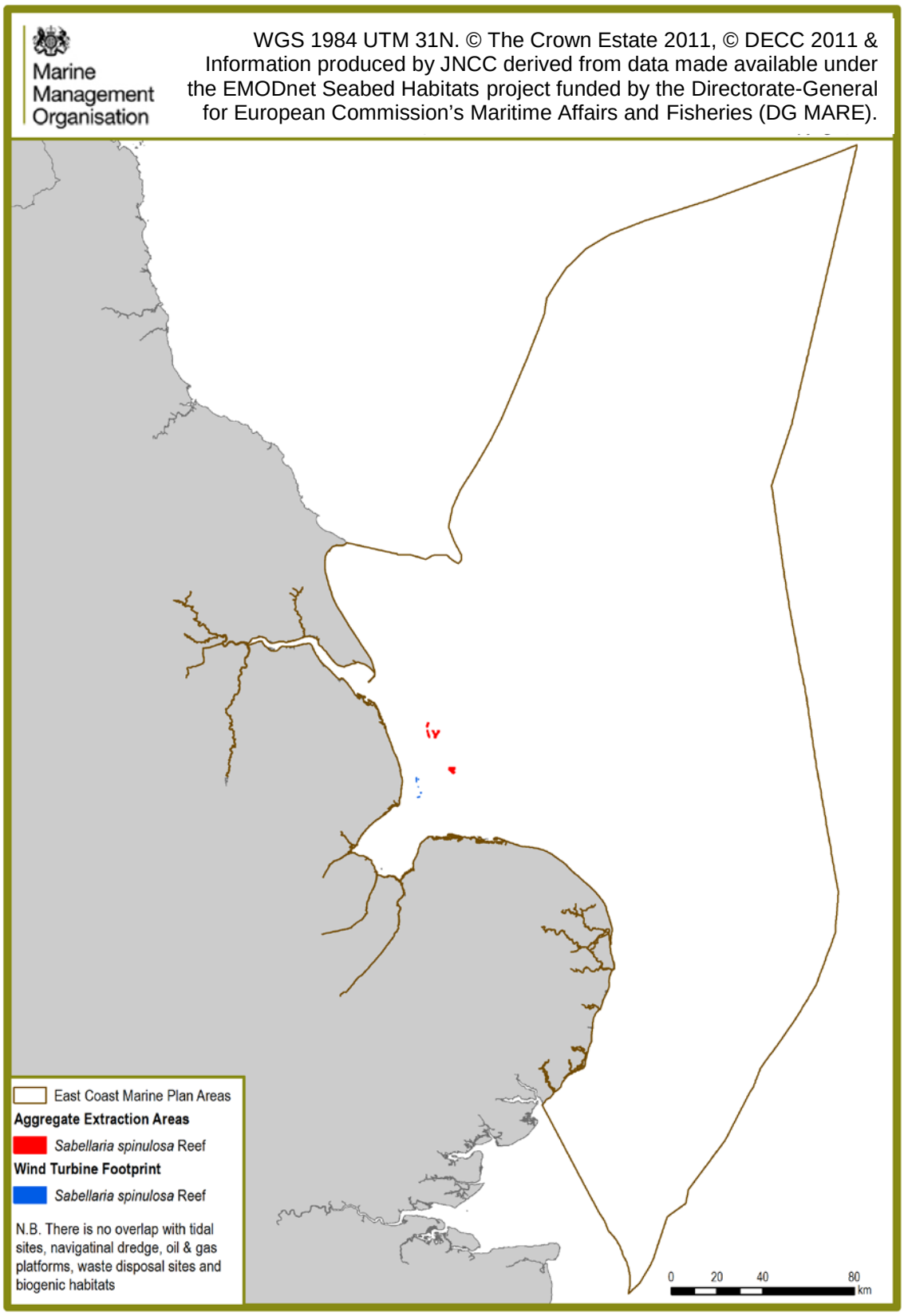


Figure A20: Estimated spatial extent of loss of biogenic habitats due to infrastructure/dredging in 2030.

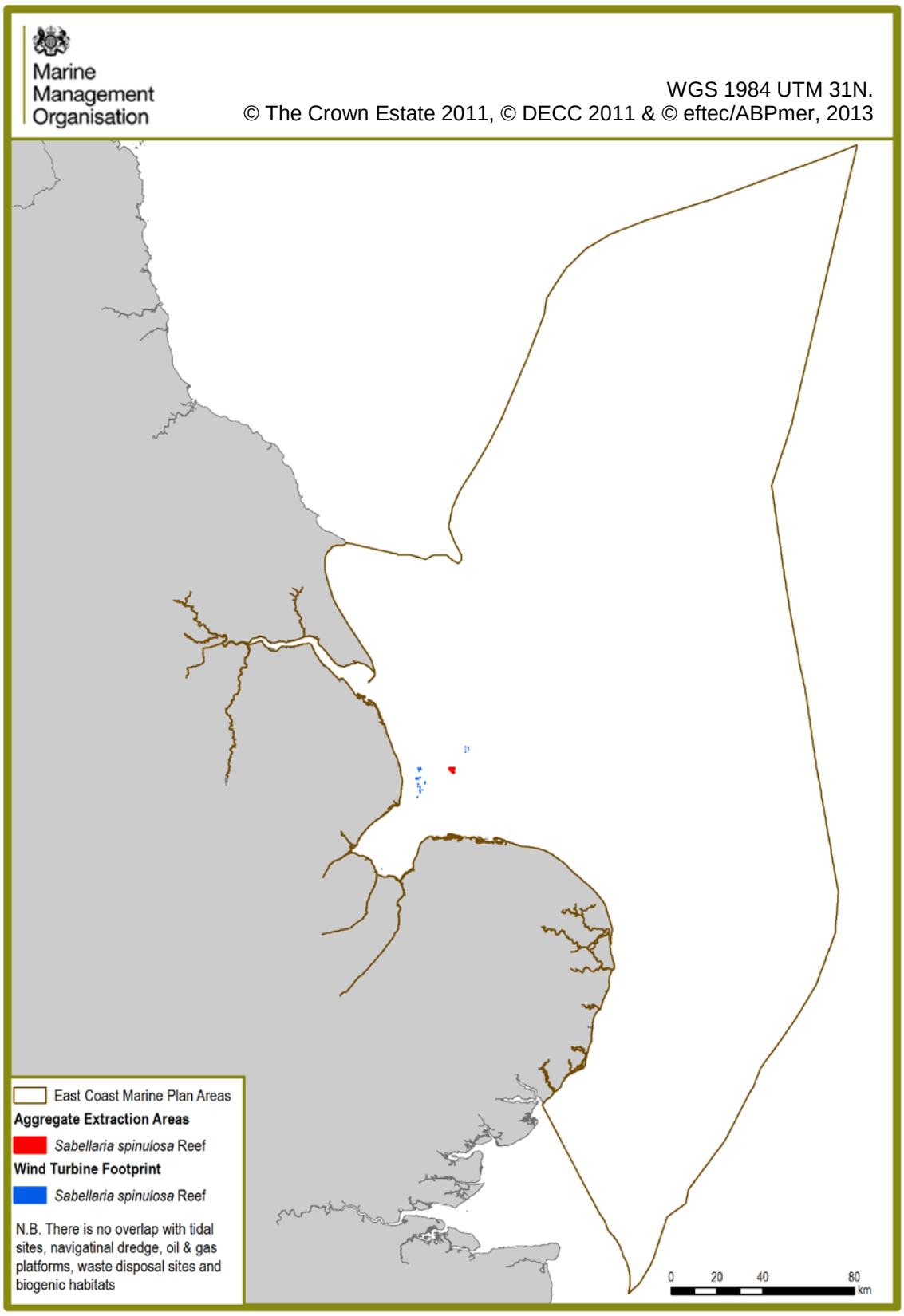


Figure A21: Estimated level of secondary productivity of seabed habitats impacted by abrasion from commercial fishing.

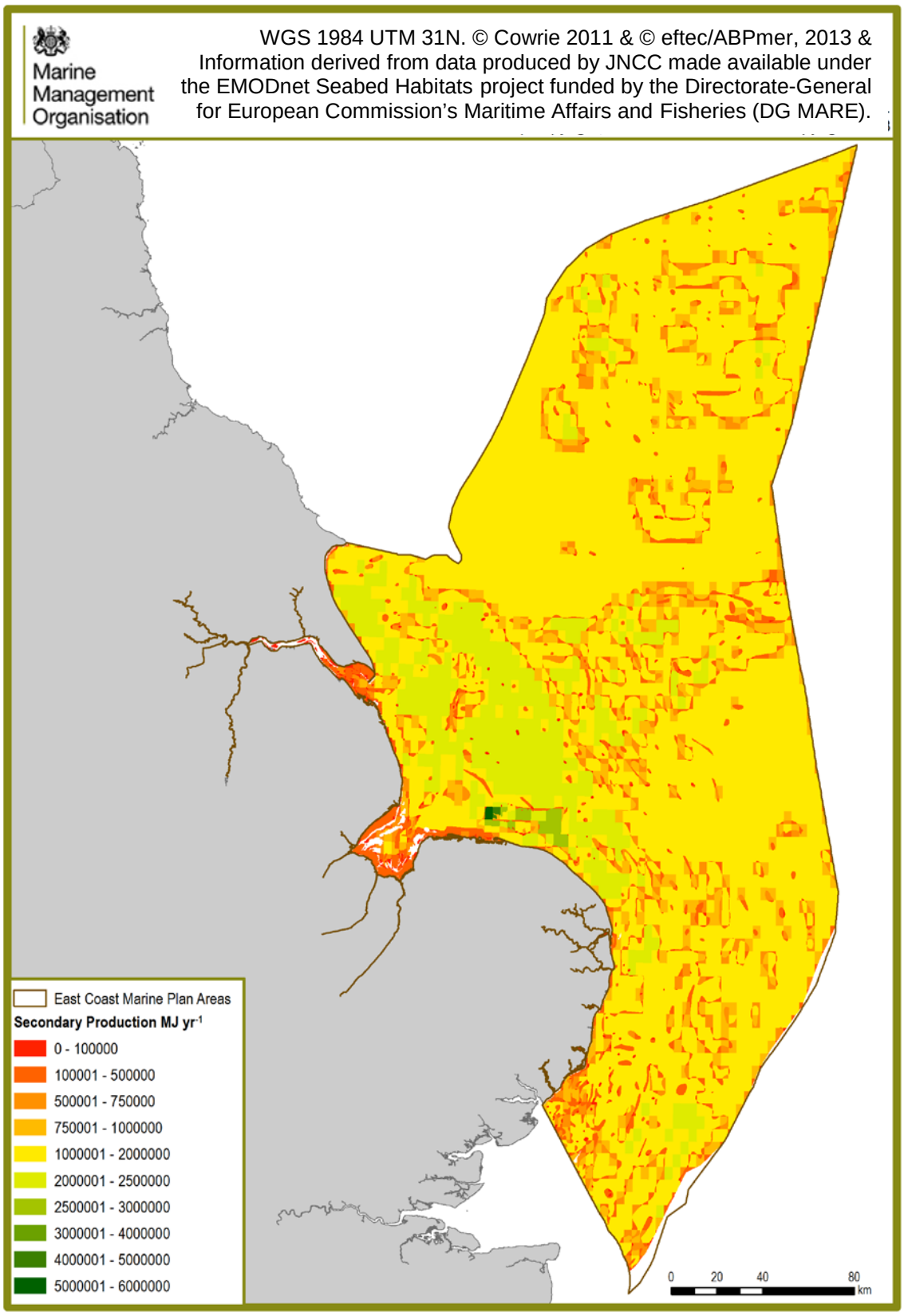


Figure A22: Estimated difference of secondary productivity of seabed habitats when there is no abrasion from commercial fishing.

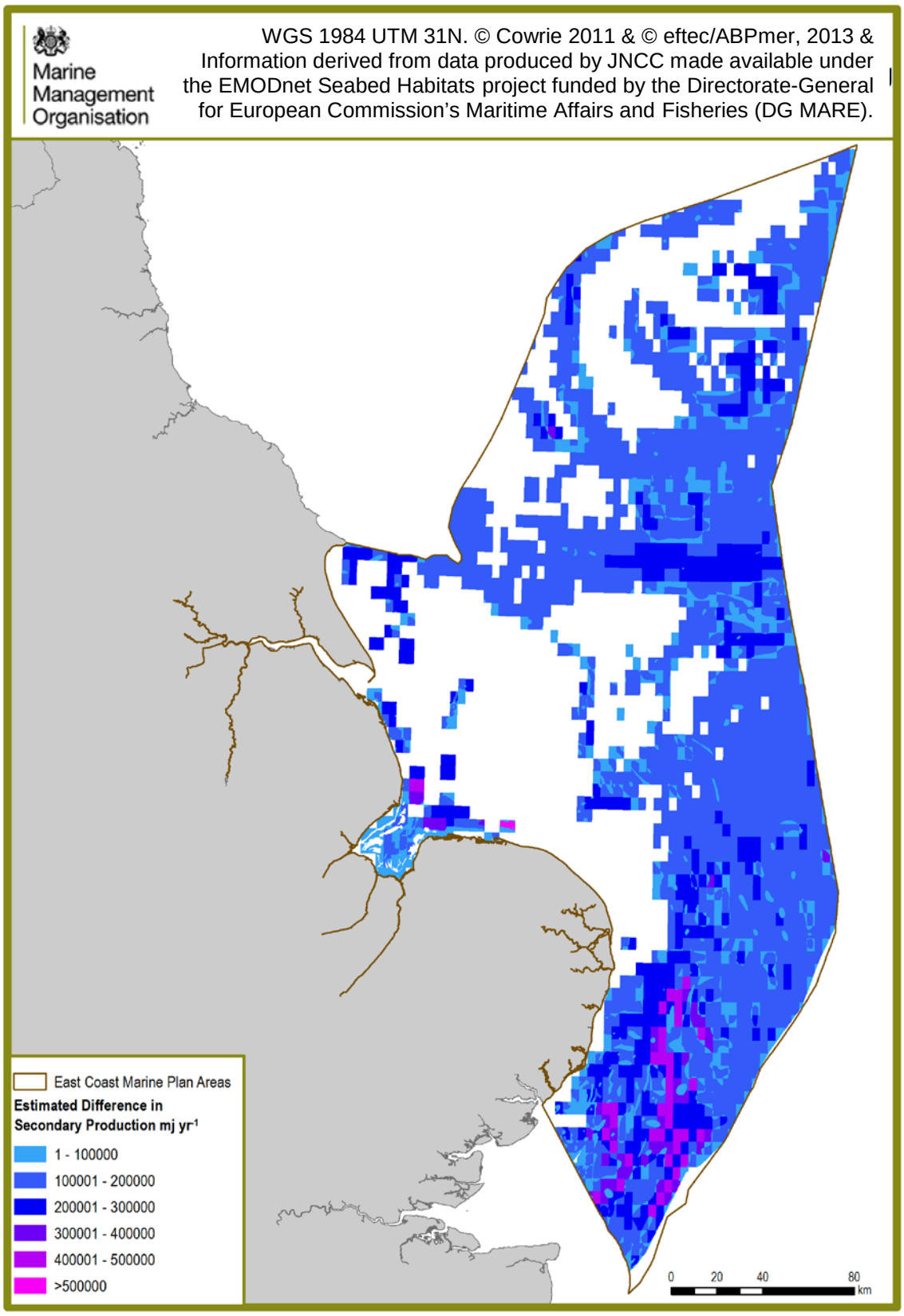


Table A3: Physical damage from trawling – Eunis level 3 habitats.

EUNIS Level3	Fish Intensity	2010		2030		Change	
		Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat
A3.1	Low Intensity	0.041	10.239	0.041	10.239	0.000	0.000
A3.2	Low Intensity	133.378	83.793	130.538	82.008	-2.840	1.784
A3.3	Low Intensity	0.228	100.000	0.228	100.000	0.000	0.000
A4.1	Low Intensity	2.332	100.000	2.332	100.000	0.000	0.000
A4.2	Low Intensity	356.484	98.426	345.914	95.507	-10.571	2.919
A5.1	Low Intensity	14886.885	72.995	13490.387	66.147	-1396.498	6.847
A5.2	Low Intensity	31040.890	86.496	30949.607	86.241	-91.283	0.254
A5.3	Low Intensity	58.821	53.058	58.400	52.678	-0.421	0.380
A5.4	Low Intensity	519.750	55.599	417.787	44.692	-101.963	10.907
Deep circalittoral seabed	Low Intensity	0.164	72.508	0.164	72.508	0.000	0.000
Moderate energy circalittoral seabed	Low Intensity	0.083	49.977	0.083	49.977	0.000	0.000
A3.2	Medium Intensity	6.165	3.873	6.165	3.873	0.000	0.000
A4.2	Medium Intensity	4.664	1.288	4.664	1.288	0.000	0.000
A5.1	Medium Intensity	2188.504	10.731	1996.374	9.789	-192.130	0.942
A5.2	Medium Intensity	3329.298	9.277	3299.329	9.194	-29.970	0.084
A5.3	Medium Intensity	29.270	26.402	28.957	26.120	-0.313	0.282
A5.4	Medium Intensity	188.853	20.202	153.623	16.433	-35.230	3.769
A5.1	High Intensity	22.990	0.113	22.990	0.113	0.000	0.000
A5.2	High Intensity	183.500	0.511	183.500	0.511	0.000	0.000

Table A4: Physical damage from dredging – Eunis level 3 habitats.

EUNIS Level3	Fish Intensity	2010		2030		Change	
		Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat
A3.2	Low Intensity	1.559	0.980	1.559	0.980	0.000	0.000
A4.2	Low Intensity	16.043	4.430	11.599	3.203	-1.227	1.227
A5.1	Low Intensity	569.575	2.793	521.553	2.557	-0.235	0.235
A5.2	Low Intensity	57.692	0.161	44.769	0.125	-0.036	0.036
A5.3	Low Intensity	4.111	3.708	3.212	2.897	-0.811	0.811
A5.4	Low Intensity	55.915	5.981	53.721	5.747	-0.235	0.235

Table A5: Physical damage from trawling – Biogenic habitats.

Biogenic Habitats	Fish Intensity	2010		2030		Change	
		Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat
Blue Mussel Beds	Low Intensity	1.631	97.957	1.631	97.957	0.000	0.000
Sabellaria spinulosa beds	Low Intensity	41.132	40.068	41.132	40.068	0.000	0.000
Sabellaria spinulosa reef	Low Intensity	307.827	86.064	291.548	81.512	-16.279	4.551
Sabellaria spinulosa beds	Medium Intensity	0.635	0.618	0.635	0.618	0.000	0.000
Sabellaria spinulosa reef	Medium Intensity	0.950	0.266	0.950	0.266	0.000	0.000

Table A6: Physical loss – Eunis level 3 habitats.

EUNIS Level3	Activity	2010		2030		Change	
		Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat
A5.3	Tide	0.008	0.007	0.008	0.007	0.000	0.000
A5.1	Oil and Gas	7.980	0.039	7.980	0.039	0.000	0.000
A5.2	Oil and Gas	26.517	0.074	26.517	0.074	0.000	0.000
A5.4	Oil and Gas	0.043	0.005	0.043	0.005	0.000	0.000
A5.1	Waste Disposal	79.198	0.388	79.198	0.388	0.000	0.000
A5.2	Waste Disposal	14.551	0.041	14.551	0.041	0.000	0.000
A5.3	Waste Disposal	2.442	2.202	2.442	2.202	0.000	0.000
A5.4	Waste Disposal	5.819	0.622	5.819	0.622	0.000	0.000
A5.1	Maintenance Dredge	5.422	0.027	5.422	0.027	0.000	0.000
A5.2	Maintenance Dredge	3.669	0.010	3.669	0.010	0.000	0.000
A5.3	Maintenance Dredge	0.862	0.778	0.862	0.778	0.000	0.000
A5.4	Maintenance Dredge	6.289	0.673	6.289	0.673	0.000	0.000
A3.2	Aggregate Extraction	1.949	1.224	1.949	1.224	0.000	1.224
A5.1	Aggregate Extraction	284.001	1.393	298.764	1.465	14.763	1.465
A5.2	Aggregate Extraction	46.852	0.131	45.637	0.127	-1.216	0.127
A5.4	Aggregate Extraction	3.797	0.406	0.937	0.100	-2.860	0.100
A4.2	Offshore Wind	0.000	0.000	0.023	0.006	0.023	0.006
A5.1	Offshore Wind	0.846	0.004	11.514	0.056	10.668	0.056
A5.2	Offshore Wind	0.235	0.001	22.721	0.063	22.486	0.063
A5.4	Offshore Wind	0.000	0.000	0.593	0.063	0.593	0.063

Table A7: Physical loss – Biogenic habitats.

Habitats	Activity	2010		2030		Change	
		Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat	Area km2	Percentage of East Coast Habitat
Sabellaria spinulosa reef	Aggregate Extraction	9.008	2.519	4.541	1.270	-4.467	1.224
Sabellaria spinulosa reef	Offshore Wind	0.121	0.034	0.221	0.062	0.100	0.006
Total		9.008	5.659	4.541	2.853	-4.367	-2.744

Table A8: Secondary production from Eunis level 3 habitats (MJ yr-1 Secondary Productivity in East Coast Marine Plan Areas).

EUNIS Level3	Baseline (MJ/y)	No Fishing Abrasion Pressure (MJ/y)	Change (MJ)	Percentage Change (%)
A1	157953	177051	19098	12
A2	13902209	14898290	996081	7
A3.1	123240	123240	0	0
A3.2	48561418	50092431	1531013	3
A3.3	29255	37101	7845	27
A4.1	87739	90802	3063	3
A4.2	55676241	56524748	848506	2
A5.1	2235355800	2373421740	138065940	6
A5.2	2543529196	2758458083	214928886	8
A5.3	7758990	8461500	702510	9
A5.4	86884340	94377750	7493410	9

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Annex 5: Application of Ecosystem Approach principles within marine planning

This annex provides further detail of each principle.

Principle 1: Clear, long-term ecosystem objectives, ideally linked to targets and indicators, against which progress can be monitored.

Importance of Principle

The establishment of clear objectives is a critical element within the marine planning process and a fundamental part of the management system in order to deliver the ecosystem approach. The use of targets and indicators allows the results of monitoring to give an indication of progress towards reaching such objectives, providing a basis for evaluation and adaptive management. A number of international commitments outline high-level and detailed environmental objectives which necessarily inform marine plan objectives (see Annex 3). Many of the requirements of marine plans in relation to objectives and monitoring of impacts is outlined in Defra's description of the marine planning process (Defra, 2011)[26].

Who Will Apply Principle in Marine Planning Process

The development of ecosystem objectives will require involvement from the public, policy-makers, marine managers, academics, regulators and other stakeholders in order to foster a shared understanding of the common goals of the ecosystem approach within marine plans. This process will be laid out in MMO's Statement of Public Participation (SPP). MMO should outline clear objectives within their plans, which will then require ongoing efforts to monitor compliance of the plan against targets and indicators. MMO will need to consult relevant Government Departments that set out objectives in a number of Government policy documents (Marine Policy Statement (MPS), Planning Policy Statement, National Policy Statement (NPS)) and stemming from national and international legal obligations (for example, the objectives, indicators and targets established by the Marine Strategy Framework Directive). MMO will also need to work with other public bodies that have specific responsibilities for planning the achievement of certain environmental objectives and targets, for example the Environment Agency (EA) relating to the Water Framework Directive. Monitoring is covered in detail in Principle 6.

How to Best Apply Principle and Confidence in Current Information

The development of specific marine plan objectives should take into account existing high level and detailed environmental objectives and information on the current state of the ecosystem and be clearly defined within the plan. Marine planning must seek to add value to existing national and international legislation that aims to implement environmental objectives. It must therefore be ensured that all relevant existing objectives are taken into account when developing marine plans and marine plan objectives are consistent with these requirements. Objectives must be defined in clear, unambiguous terms to promote a shared understanding and facilitate meaningful evaluation. In order to achieve transparency, marine plans aim to provide

[26] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183195/110318-marine-planning-descript.pdf

clarity on the linkages between marine plan environmental objectives and the plethora of more detailed environmental objectives. However, this is recognised as being very challenging, given the very large number of detailed environmental objectives that already exist.

A key process for evaluating to what extent a plan will achieve ecosystem and environmental objectives is the Sustainability Appraisal (SA), which includes a high level assessment of the impacts of plan policies on relevant objectives.

When to Implement Principle during Planning Process
This principle should be implemented early in the planning process with objectives clearly outlined in draft and final plans. Plans could include a commitment and timetable to monitor progress towards achievement of objectives. Medium and long-term objectives may be defined for marine plans. Monitoring of associated targets and indicators will be ongoing throughout the duration of the plan.

Links to Policies
Ecosystem objectives provide the framework within which marine plan policies are developed, where appropriate, to support achievement of the plan objectives. In many cases, however, there may be existing policies, in which case the marine plan simply needs to signpost these, for example objectives stemming from MPS, NPS, PPS, Marine Strategy Framework Directive (MSFD), WFD (Water Framework Directive), Wild Birds and Habitats Directives and nationally designated Marine Protected Areas (MPAs). Where marine plans can legitimately add value to support achievement of objectives, development of specific marine plan policies may be appropriate.

Data and Tool Requirements
Clear ecosystem objectives are best defined using long-term and reliable data, although this may not always be available. Information on the current and likely future distribution and state of environmental features and human pressures is required in order to develop realistic and attainable environmental objectives, against which progress can be measured. Plans should outline data sources that can be used to inform assessments of progress towards achieving objectives.

Principle 2: Integration of social and economic factors is necessary to support sustainable development

Importance of Principle
Integration provides the mechanism to balance environmental, economic and social interests in support of sustainable development.

Who Will Apply Principle in Marine Planning Process
MMO will integrate social and economic information into the marine planning process through the appraisal of draft plan options and policies. The results of these appraisals can be documented in the SA and in future the Impact Assessment (IA). This will require working together with stakeholders and other organisations with planning responsibilities for the marine environment such as Defra, EA, Department of Energy and Climate Change (DECC) and The Crown Estate. These organisations should be ensuring that their plans contribute to sustainable development in line with

legal requirements and Government policy, although marine planning can play a cross-cutting role.

MMO has prepared a Strategic Evidence Plan (SEP) (MMO, 2011a) and Social Research Strategy (MMO, 2011b) which, *inter alia*, will help to improve understanding of economic and social factors and to facilitate their integration within marine planning.

How to Best Apply Principle and Confidence in Current Information

Integration of social and economic factors is best applied through the use of appraisal of draft plan options and policies. The SA and IA should follow good practice (e.g. ODPM (2004) and HM Treasury (2011)). SA allows for the evaluation of the potential social and economic impacts alongside potential environmental impacts. The East Marine Plans SA adopted a largely qualitative approach to assessing impacts. This did not particularly affect confidence in the assessments because the plan policies were not expected to give rise to significant effects. However, assuming that future marine plans contain more directional policies which may give rise to significant impacts, a more quantitative analysis would be required to provide confidence in assessment outputs.

No formal IA was prepared for the East Marine Plans, as this was not required at the time, although an analysis of the potential impacts of plan policies was prepared (MMO, 2013a). For future marine plans, depending on requirements, it will be desirable to prepare more quantitative assessments, and to seek to monetise impacts using available valuation techniques and collate this data, for example using CBA, although confidence in assessment outputs may be limited due to uncertainties in the scientific evidence on expected changes and gaps in the evidence base. There also remains an overall lack of information on societal preference for environmental/economic changes.

When to Implement Principle during Planning Process

This principle should be implemented as part of the appraisal of plan options and draft plan policies. Revisions should be made to plans in light of feedback from stakeholder consultation on draft plans and policies.

Links to Policies

Social and economic factors must be integrated into the marine planning process in order to ensure the sustainability of policies and plans.

Data and Tool Requirements

Existing data and tools are currently inadequate. Key data gaps include:

- Adequate information on the distribution and intensity of some human activities (commercial fisheries, commercial navigation, recreation).
- Information on the distribution and intensity of pressures associated with human activities.
- Understanding of social impacts.
- Understanding of social and economic outcomes of interactions between human activities.
- Costs of management measures.

- Market and non-market data for activities.
- Information on employment linked to marine activities.

There is also a requirement to continue to improve tools and methods used to assess social and economic impacts, particularly as part of future IAs.

Principle 3: A robust dynamic baseline should be established against which progress towards achievement of objectives can be measured

Importance of Principle
The gathering of available evidence in order to establish a robust baseline against which progress can be measured is a fundamental component of any management system. Given that marine plans are only one of a number of management interventions in the marine environment, it is important that consistent baseline evidence is available against which to monitor the specific impact of marine plans alongside wider trends and changes in the marine environment.

Who Will Apply Principle in Marine Planning Process
MMO is responsible for determining its baseline evidence requirements and for establishing indicators against which impacts of marine plans might be measured. This should be done working closely with stakeholders. Evidence gathering is a key task within MMO's planning process guided by its SEP, for specific marine plan areas and in relation to wider marine planning issues.

How to Best Apply Principle and Confidence in Current Information
MMO should work with stakeholders to agree baseline evidence requirements and indicators. This should include using agreed assumptions to develop projections for the future baseline over the marine plan period. MMO published the evidence and issues report (MMO, 2012) during development of the marine plans that includes collation and analysis of existing information and invites stakeholders to identify and provide additional information that they consider to be relevant. The SPP supports public engagement by stakeholders and members of the public in the evidence gathering process (see MMO, 2013b). MMO should aim to communicate transparently with stakeholders the basis for its decisions on evidence priorities.

Confidence in existing baseline evidence is variable, depending on the type of evidence, and the nature and significance of data gaps (see Data and Tool Requirements below for details of principal gaps.

When to Implement Principle during Planning Process
Baseline evidence is important in providing the context for marine plans and in informing the identification of marine plan issues. There should therefore be a strong focus on evidence collection from the outset and during the early stages of plan development to identify evidence gaps and new priorities for evidence collection. MMO's analytical evidence reports are published in the early stages of each marine planning process. Evidence collection will be ongoing through the plan-making process and inform periodic reviews of marine plans.

Links to Policies
The collection of evidence is important to underpin the selection of preferred plan options and to inform draft and final plan policies. Monitoring progress towards objectives helps to measure the effectiveness of plan policies.

Data and Tool Requirements
A robust baseline should include the following data requirements:

Spatial baseline data:

- Current and future distribution and condition of ecological features.
- Current and future distribution of human activities and pressures.
- Current and future distribution of ES levels.

Non-spatial baseline data:

- Economic and social quantitative data.
- Understanding of marine natural capital (capacity of ecosystem to produce ecosystem services).

Current significant data gaps include:

- Spatial distribution and condition of benthic habitats and species.
- Spatial distribution of mobile features and their functional use of areas.
- Spatial distribution of ecosystem service provision and the benefits humans derive from the marine ecosystem.
- Spatial distribution and intensity of some human activities (commercial fishing (particularly <152m fleet), commercial navigation, recreation).
- Spatial distribution and intensity of human pressures.
- Standardised projections for future baseline over the marine plan period.

Spatial data needs to be managed within a GIS system in accordance with relevant data standards. It is desirable that consistent and agreed assumptions are used for developing future baseline information and for deriving pressures from human activity layers.

Principle 4: All forms of relevant information should be considered including scientific and local knowledge

Importance of Principle
It is important to consider all forms of information, including scientific and local knowledge. Information used in marine planning should be robust and any limitations of evidence should be transparent and taken into account in decision-making. Local knowledge may be helpful in identifying additional evidence needs.

Who Will Apply Principle in Marine Planning Process
MMO will apply this principle as part of the overall planning process. MMO's process currently provides opportunity for stakeholders and members of the public to contribute evidence and data to the marine planning process through the SPP. MMO applies a quality assurance process to all evidence gathered to ensure the quality and accuracy of data. The process of gathering evidence should solicit information

from stakeholders, although this poses challenges in engaging in-depth at early stages of planning.

How to Best Apply Principle and Confidence in Current Information
The collation of all forms of relevant information must be carried out during the evidence gathering stage of the planning process. The SPP encourages stakeholders and the public to contribute evidence and data to the planning process and MMO should aim to ensure that this is carried through to an appropriate level. Stakeholder events may currently engage national or regional stakeholders with little opportunity for contribution from local groups or individuals. MMO should encourage this level of participation, which may come under the role of local marine planning officers.

The current process may not, therefore, be accessing all sources of informal or local data, although effort should be proportionate to the potential benefit. It may also be beneficial to provide information to stakeholders concerning how information will be used, and the standards against which admissibility/confidence of information will be judged.

When to Implement Principle during Planning Process
It is beneficial to engage with stakeholders to gather information early in the planning process. At a local and informal level, however, this may be challenging. Engagement with stakeholders must be maintained throughout the plan-making process in order to inform plan reviews, SA and IA.

Links to Policies
Proper engagement with a range of stakeholders during the evidence gathering process will engender support and ownership for plan policies and ensure that plan policies are based on sound and relevant evidence.

Data and Tool Requirements
The key issue in applying this principle is to ensure stakeholder engagement at a local level to ensure accurate and relevant data is collected.

Principle 5: All relevant sectors of society and scientific disciplines should be involved

Importance of Principle
Stakeholder engagement is a fundamental component of the marine planning process and is vital in promoting ownership and support of plan policies.

Who Will Apply Principle in Marine Planning Process
MMO is responsible for stakeholder engagement throughout the marine planning process. MMO is legally obliged to involve stakeholders and the public in the process of developing and environmentally appraising marine plans. These obligations are imposed by EU Directives such as the Public Participation Directive, Strategic Environmental Assessment Directive and the Marine and Coastal Access Act.

How to Best Apply Principle and Confidence in Current Information

In line with such legal requirements, MMO issues a SPP at the outset of the planning process. This outlines the timetable for the plan and opportunities for engagement and facilitates early and broad engagement with stakeholders. The SPP identifies specific stakeholder groups that MMO aims to engage, along with mechanisms for engaging with the general public. This may be through Local Authorities and/or social media. The SPP also aims to consult with stakeholders who have interests adjacent to the plan area such as other member states and Crown dependencies. During stakeholder engagement MMO should make use of local MMO staff in order to engage at the local level.

The SPP might usefully reference the role of engagement in delivering the ecosystem approach. Guidelines for engaging stakeholders in the marine planning process have been outlined by Maguire *et al*. (2012).

There is potentially a conflict between MMO's obligation to run a compliant stakeholder engagement process, and the need to avoid overlaps with similar processes run by other organisations with respect to their areas of responsibility. The particular requirements of other processes, for example under the Public Participation Directive and Strategic Environment Assessment Directive, mean streamlining these processes may not be possible. The resulting multiple processes under different organisations with marine responsibilities inhibits the efficient delivery of this aspect of the ecosystem approach.

When to Implement Principle during Planning Process

This principle should be implemented from the outset of the planning process and maintained throughout. The SPP should identify the points throughout the planning process at which engagement with stakeholders and the general public should be sought.

Links to Policies

Involvement of all relevant stakeholders and the general public promotes support and consensus for marine plans, fostering a feeling of participation. It also ensures that all views and perspectives are taken into consideration during the development and appraisal of plans and plan policies.

Data and Tool Requirements

A key issue when applying this principle to the planning process is to ensure that engagement is carried out early during the planning process and at a broad scale, in order to collect all relevant data and information to inform the process from the outset.

Principle 6: Monitoring, review and adaptive management are important elements of the planning and management cycle

Importance of Principle

Monitoring and adaptive management are a fundamental component of any management system. Monitoring is vital for testing the effectiveness of plan policies and informing decisions on requirements for changes to plan policies (adaptive management).

Who Will Apply Principle in Marine Planning Process

MMO is responsible for coordinating monitoring, reporting and adaptive management of planning policies under Section 61 of the Marine and Coastal Access Act (MCAA), although information may be collected by a range of organisations. For example, Defra is the main organisation responsible for monitoring and gathering information in relation to MSFD, the EA for WFD, DECC gathers information on the renewables sector, JNCC and Natural England for MPAs and the Habitats Regulations, and The Crown Estate collects information with regards to aggregates, cables and other activities on the seabed. MMO must therefore work closely with relevant public bodies with specific monitoring responsibilities in relation to compliance with objectives, in order to avoid duplication of effort.

How to Best Apply Principle and Confidence in Current Information

Section 61 of the MCAA requires monitoring and periodical reporting of plan implementation. MMO has a duty to report on the effects of policies and their effectiveness in reaching plan objectives and regional objectives set out in the MPS every three years or less. It is then decided if plans should be amended or replaced. Furthermore, MMO is obliged to report to the UK Government every 6 years from adoption of the Act until 2030 on any marine plans it has prepared or adopted, including its intentions for amendments or further plans.

A clear plan for monitoring and adaptive management is required. This will be progressed through an Implementation and Monitoring Plan (IMP). The outlines what will be monitored, by whom and how it links to plan policies. The IMP is informed by recommendations from the SA and other tools such as cumulative effects assessment and Habitats Regulations Assessment (HRA). There is currently little international practical experience of implementing an IMP and the process will likely evolve and progress over time.

When to Implement Principle during Planning Process

The need for monitoring requirements should be recognised throughout the planning process and the development of indicators and objectives, although the main focus of monitoring will be once draft plan policies have been developed, as the IMP will need to relate to these specifically.

Links to Policies

Monitoring and adaptive management are fundamental in testing the effectiveness of plan policies and in assessing wider trends in the marine environment, therefore outlining requirements for adaptive management and any amendments required to plan policies.

Data and Tool Requirements

The IMP will need to identify specific data to assess plan policies within a wider monitoring framework. A recent MMO project is helping to define the information requirements to inform the monitoring of social impacts (MMO, 2014a). Further work is required to determine whether existing monitoring programmes are adequate to inform an assessment of the effectiveness of plan policies.

Principle 7: Conservation of ecosystem structure and function to provide ecosystem services should be a priority and ecosystems must be managed within limits of their functioning

Importance of Principle

This principle is fundamental to understanding the impacts of marine plans on the marine ecosystem and the maintenance of ecosystem services provision. Conservation of the marine ecosystem is recognised in the High Level Marine Objectives (HLMOs) laid out in the MPS, specifically in relation to 'living within environmental limits'.

Who Will Apply Principle in Marine Planning Process

MMO will be responsible for ensuring the conservation of ecosystem structure and function in relation to marine plan policies, although monitoring data and information to inform this may come from other agencies such as Defra and the EA. In line with the ecosystem approach, MMO will need to engage with stakeholders in developing appropriate policies.

How to Best Apply Principle and Confidence in Current Information

In order to best conserve ecosystem function and structure, it is preferable that quantitative assessments of change can be made in relation to relevant indicators and targets, such as those within MSFD and WFD. This will become increasingly important as marine plans develop and include more directional policies that have the potential to give rise to significant effects.

An understanding of how changes in ecosystem state translates to changes in ecosystem service provision and into economic analysis will also help to support conservation of ecosystem structure and function, particularly where such changes can be monetised. Tools being developed under the UKNEA follow-on project (in work package 1: Natural Capital Asset Check) provide a structure way to assess whether ecosystems are being managed within limits of their functioning (I. Dickie, pers. com., Dec 2013).

The marine planning process may simply need to signpost MSFD and WFD measures where such measures are considered robust. If MSFD planning is only undertaken at a high level, however, marine planning may add value by undertaking more detailed assessments.

Owing to the non-prescriptive nature of some marine plan policies in the East Marine Plans, there is reasonably high certainty that the plan policies will not give rise to significant ecosystem impacts. However, owing to the qualitative nature of the analysis, there is low confidence in the cumulative assessment of the effects of plan policies in combination with other existing marine policies. In addition, in the future, it is anticipated that marine plan policies might be more directional and thus there will be a greater potential for such policies to give rise to significant environmental effects.

When to Implement Principle during Planning Process

This principle should be applied during the appraisal of plan options and draft plan policies. The SA of the East Marine Plan considered effects of the plan on the

marine ecosystem within the 'marine ecology', 'geology, substrates and coastal processes' and 'water environment' topics of the SA, although this provided only a high level qualitative description of potential impacts.

This principle should also be considered during monitoring and adaptive management of marine plans, using monitoring data to measure progress against achieving ecosystem objectives and to inform planning policy to ensure marine ecosystem structure and function.

Links to Policies
The conservation of ecosystem structure and function is fundamental in underpinning ecosystem policies.

Data and Tool Requirements
To provide more quantitative assessments of impacts to ecosystem structure and function and to ecosystem services, additional data and tools are required. Key data requirements include:

Spatial data:

- Current and future distribution and condition of ecological features.
- Current and future distribution of human activities and pressures.
- Current and future distribution of ES levels.

Non-spatial data:

- Sensitivity data on ecological features.
- Understanding of marine natural capital (capacity produce ecosystem services) and thresholds in this productive relationship.
- Valuation data for marginal changes in ES provision.

Current significant data gaps include:

- Spatial distribution and condition of benthic habitats and species.
- Spatial distribution of mobile features and their functional use of areas.
- Spatial distribution of ecosystem service provision and the benefits humans derive from the marine ecosystem.
- Spatial distribution and intensity of human pressures.
- Standardised projections for future baseline over the marine plan period; and
- Valuation data for marginal changes in ES provision.

The tools that are being developed to support UK MSFD implementation will be helpful in seeking to make quantitative assessments for the SA and inform the IA. Because these tools are inherently spatial, they also contribute to an understanding of cumulative effects.

Principle 8: A co-ordinated and integrated approach should be adopted when considering effects of human activity, particularly taking account of cumulative effects

Importance of Principle

The integrated and co-ordinated approach to the management of human activities is a fundamental aspect of marine planning. This approach is supported by the MPS which requires a multi-sectoral approach to management in the marine environment.

Who Will Apply Principle in Marine Planning Process
MMO is responsible for co-ordination and integration during the marine planning process through comprehensive engagement with relevant sectors of marine industry and those interested in the development of marine plans. This includes ensuring that adequate linkages are made with the terrestrial environment. The WFD provides an important linkage between fresh waters, estuaries and coastal waters by taking account of pressures that may affect water bodies upstream and downstream.

How to Best Apply Principle and Confidence in Current Information
MMO's marine planning process currently facilitates integration and co-ordination between industry sectors and across the land-sea interface through the SPP and the SA. The SPP supports and encourages extensive engagement with the relevant interests that should be involved in the development of the plan, while the SA allows an assessment of the effects of draft plan policies and evaluating the combined effects of multiple activities within the plan area as well as influences external to the plan area.

Supporting economic analysis can also facilitate integration particularly through assessment of ecosystem services changes. Recent work to develop a strategic approach to cumulative effects assessment (MMO, 2014c) and scope an approach to assessment of co-existence (MMO, 2014b) may also begin to support integrated management.

Weaknesses in available data and tools currently limit the extent to which integrated assessments can be undertaken.

When to Implement Principle during Planning Process
Integrated management of human activities should be considered from the outset of the planning process when developing draft plans and policies and with regard to periodic reviews of plan progress.

Links to Policies
In line with the MPS, marine plan policies are required to support an integrated and co-ordinated approach. In the East Marine Plan, for example, certain policies specifically require consideration of cumulative effects during plan implementation, and for co-existence of activities to be maximised where possible (MMO, 2013c).

Data and Tool Requirements
Weaknesses in available data and tools currently limit the extent to which integrated assessments can be undertaken (see Principles 2 and 7).

Principle 9: Appropriate spatial and temporal scales should be applied

Importance of Principle

A clear definition of the spatial extent of the plan area and how it links to adjacent areas is required. A public consultation held by Defra on proposed marine plan areas recognised that the boundary between inshore and offshore areas is artificial and could hinder the delivery of the ecosystem approach. The identification of marine plan areas must take into account physical and administrative boundaries, as well as the distribution of human activities and biogeographic features.

With regard to temporal scales, marine plans must focus on the future, although uncertainty increases with increasing temporal scale. There is a need for periodic reviews of a plan in order to recognise change and adapt plan policy accordingly.

Who Will Apply Principle in Marine Planning Process
Regional plan areas have already been defined by MMO, largely on the basis of the factors outlined above. MMO has also established a 20 year time horizon for marine plans with periodic reviews.

How to Best Apply Principle and Confidence in Current Information
When developing regional plans, MMO must engage with stakeholders in order to assess any limitations in plan boundaries or temporal scales. Where plan boundaries cut across important issues it is possible to collect data from outside of plan boundary areas, in order to give proper consideration to issues within relevant adjacent plans.

The SPP prepared by MMO identifies and seeks to engage with transboundary stakeholders that may have an interest or be affected by the marine plan areas. When considering temporal scales of marine planning consideration must be given for key factors that may function over timescales that exceed that of the plan e.g. climate change, ecosystem functioning. There may be a mismatch between these timescales and those taken account in IA and SA.

When to Implement Principle during Planning Process
It is necessary to be clear of the spatial and temporal scale of a marine plan at the outset of the planning process.

Links to Policies
This principle will inform the spatial and temporal dimensions of plan policies and outline the points at which plan policies will be reviewed in light of monitoring results.

Data and Tool Requirements
The spatial and temporal scales of a plan will be based on data indicating physical and administrative boundaries, human activities and biogeographic factors. Data from beyond the plan area boundaries may be required in order to consider transboundary issues.

Principle 10: Planning and management should be decentralized to the lowest appropriate level

Importance of Principle
The decentralisation of planning and management is important in ensuring ownership of plan policies and promoting support and consensus. The development

of marine plans should have regard for existing policies and fora which may be in place at national, regional or local levels.

Who Will Apply Principle in Marine Planning Process
MMO should give consideration to the extent to which planning and management can be devolved during the planning process while working with regional and local stakeholders. There may be limitations to the extent of decentralisation, however, as plans must take into account high-level policy at the international and national level while attempting to translate it into local and regional planning frameworks.

How to Best Apply Principle and Confidence in Current Information
The devolvement of planning and management should be carried out during engagement with local stakeholders and the possibility of local plans to deal with specific issues should be considered.

MMO currently gives consideration to how sub-regional and local engagement can be facilitated within the SPP. The SPP for the South Inshore and Offshore Marine Plan Areas, for example, highlights the role of existing local fora in facilitating local stakeholder engagement. MMO should work towards optimizing local engagement and to involve stakeholders in discussions about trade-offs. Over time this should lead to co-decision making.

When to Implement Principle during Planning Process
It is necessary to engage locally from the outset of the planning process in order to assess to what extent planning and management can be devolved.

Links to Policies
The decentralisation of planning and management supports and promotes acceptance of plan policies by local stakeholders if they feel they are involved in the process of policy development.

Data and Tool Requirements
Existing fora and management at a local, sub-regional or regional level may be useful in decentralising planning and management where possible. In order to facilitate the devolvement of planning, data may be useful that indicates at what scale people and communities feel a connection to the marine environment. Work to progress techniques to enable the collection of this information has been carried out in the UKNEA follow-on project (2014).

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Annex 6: Agenda and attendees at stakeholder workshop on 19th November, 2013

This annex provides the agenda and list of participants at the workshop held to inform the development of the framework.

Workshop Agenda

Marine Planning Ecosystem Approach Framework Review Workshop
10.30am – 3.30pm, 19 November 2013
MMO Offices, Lancaster House, Hampshire Court, Newcastle upon Tyne, NE4 7YH.

Agenda:

10.00 Arrival, tea and coffee available

10.30 Welcome. Introduction to purpose of project (MMO)

10.45 Principles of ecosystem approach for marine planning (ABPmer)

11.15 Proposed framework for MMO to apply ecosystem approach in marine planning (eftec)

11.45 Group discussion and feedback on proposed framework

12.45 Lunch

13.30 Case study of applying proposed framework to East Inshore and Offshore Marine Plans (ABPmer)

14.00 Group discussion and feedback on case study

14.45 Data, indicators and socio-economic outputs from application of proposed framework to East Inshore and Offshore Marine Plans (eftec and ABPmer)

15.00 Discussion on outputs from applying ecosystem approach

15.15 Review of day and suggested ways forward

15.30 Close

Participants Represented:

ABPmer	eftec
The Crown Estate	Environment Agency
Joint Nature Conservation Committee (JNCC)	Oceans Governance
University of Hull	Marine Conservation Society
Natural Resources Wales	Agri-Food and Biosciences Institute
Department for Environment Food and Rural Affairs (Defra)	Seabed Users Development Group
World Wildlife Fund (WWF)	Natural England
Department of the Environment Northern Ireland (DOENI)	Marine Scotland
Marine Management Organisation (MMO)	VALMER: Valuing marine ecosystem services in the Western Channel (INTERREG project)
The Wildlife Trust	