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An analysis of methodologies for defining ecosystem services in the marine environment

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Summary

Ecosystem Services

Ecosystem services are described as the *benefits that people obtain from ecosystems.* Four categories of ecosystem services are generally classified to include provisioning, regulating, cultural and supporting services. In the coastal and marine context, provisioning services include services such as fisheries, fertiliser, and ornamentals; regulating services include climate regulation and natural hazard protection; cultural services include meaningful places and socially valued landscapes; and supporting services underpin the other services and include primary production and nutrient cycling. A number of frameworks have been proposed to elaborate ecosystem services, and recent practices in the marine context have emphasised the importance of separating services into intermediate and final categories. Final services are described as the contributions that ecosystems make to human well-being although they retain a connection to the underlying ecosystem function. Final services directly provide goods and benefits to human beneficiaries (individually and socially) and can be valued by a range of economic techniques. It provides a framework for structuring thinking about the relationship of humans with natural systems.

Development of a consistent definition of ecosystem services is imperative to moving from concept to practice, to enable communication between different stakeholders and to support policy deliberation. While it is important to have a consistent definition and understanding of the concept, ecosystem services application will be inherently purpose-dependent and contextual. There is a need for ongoing dialogue between scientists and policy over the evolving practice of service definition, understanding and implementation.

Much of the thinking behind ecosystem services has been developed in the terrestrial sphere. While this has built the general principles, it is important to clarify the limitations of terrestrial methods to the marine area. Coastal and marine ecosystem stocks possess high productivity and provide a diverse set of habitats and species with a consequent flow of services to society. Because the marine environment is less understood than land-based systems this poses a challenge to the operationalisation of ecosystem services. Where the spatial scale of a system can be defined in the marine environment habitat maps may be used in a similar way to terrestrial systems as input for the assessment of ecosystem services. The fluid and interconnected nature of the marine environment and presence of mobile species presents unique challenges for capturing and valuing the benefits of a space or site. Building this knowledge base for the marine environment is more costly than on land, and efforts should be made such as using data collected to inform the designation of marine protected areas and marine spatial planning to help identify final services, beneficiaries and goods and benefits.

There is emerging evidence on the link between biodiversity and ecosystem functioning - and conversely the loss of biodiversity impairing ecosystem function. A challenge remains in coastal and marine research to understand and quantify the influence of biodiversity on different classes of ecosystem services. Recent research highlights that the relationship of biodiversity to an ecosystem service depends strongly on the nature of the service and the beneficiary. Examples include the influence of biodiversity on fisheries yield (a provisioning service) and plant biodiversity on CO_2 sequestration (a regulating service). The evidence linking biodiversity with cultural services was poor and is an important area of future research. This reflects the poor conceptualisation of cultural services in general, in particular in coastal and marine environments. Recent research from the Valuing Nature Network identified a range of services generated by protected marine habitats. The findings demonstrated that the scientific understanding of the links between habitats, species and final services was variable and generally poor. While the concept is gaining influence,

ecosystem services are considered supplementary to the existing marine policy process and the availability of evidence is considered an obstacle to the implementation of marine biodiversity policy.

This report has highlights a number of future research needs with respect to marine ecosystem services. These include:

- Several projects are in initial stages of gathering data on coastal system function, the role of biodiversity in supporting coastal services, and valuation of services. Emerging data will be important for filling in gaps in the current debate and contribute to policy uptake. What ecosystem service inforamtion do decision-makers need?

- How can the valuation of coastal ecosystem services be implemented in a variety of policy and management contexts? What would be the ramifications for coastal communities?

- Other conceptualisations of value such as shared social value and non-monetary health and well-being values should be explored alongside monetary valuations. More research needs to be undertaken to understand how values change in different contexts.

- Building the evidence base to understand how marine biodiversity affects ecosystem functions and specific final services and beneficiaries will be important for informing biodiversity protection and management, e.g. in MPAs.

- The potential implications of future environmental, social and policy change upon marine ecosystem processes is uncertain. Linking the understanding of how marine ecosystems respond to environmental change at different scales and how this affects service delivery is a research challenge.

- Identification of the services provided by deep sea habitats and their value is a key research opportunity.

The report identifies a number of future policy recommendations for ecosystem services. They include:

- Integration of ecosystem valuation into decision-making remains poor - the growing supply of valuation evidence is not aligned with the needs of decision makers. Regular science – policy deliberation will improve this problem.

- When designing policy instruments the distribution of benefits must be considered, the relationship to poverty alleviation and a general discussion on equity and justice is needed.

- Decision makers and scientific providers should continue to work together to identify where the adoption of an ecosystem services framework and evidence has led to ‘better’ policy decisions.

- Policy processes such as marine protected area designation and management offer opportunities to evaluate the consequences of trade-offs between different services.

- Incorporation of ecosystem service concepts, indicators and valuations into marine policy and planning will improve understanding of the value of marine environments to society.

The Ecosystem Approach

The Ecosystem Approach considers ecological, economic and social considerations. It recognises that humans are an integral component of ecosystems and thus the focus is on the management of human activities rather than the ecosystem itself.

Many terminologies are used to describe the Ecosystem Approach such as ecosystem-based management and ecosystem services approach. This has propagated confusion amongst stakeholders and those charged with its implementation. A review of these terms, in an attempt to identify their key characteristics, has shown that although many different terminologies are used there is little distinction to be made between them; in general they are used interchangeably to mean the same thing. Such is the case that nearly any diverse initiative to do with understanding ecosystems, or working with ecosystem services, is being labelled as an Ecosystem Approach. The CBD Ecosystem Approach is a frequently cited definition. The approach includes the 12 Malawi Principles to guide users in its implementation. However, the review highlighted that the principles of decentralisation, societal choice and societal involvement seem the least likely to be associated with the term. Since the Malawi Principles represent some of the most ambitious thinking about what the goals and principles of environmental management should look like, diluting or ignoring parts of the concept means that management actions will not strive to achieve these goals.

The Ecosystem Approach is seen in the majority of contemporary legislative instruments and policies for managing the marine environment. Examples can be seen from the global to the local level, across a multitude of countries including those which lack resources and data, with poor governance structures, as seen in the example from Raj Ampat Islands, Indonesia. The use of the Ecosystem Approach in fisheries is particularly evident, though it has been argued a sector specific application is not a true Ecosystem Approach as it focuses on the impacts of one particular resource only. Increasingly the Ecosystem Approach is used in large scale applications such as in the Regional Seas.

Five case studies have been presented to illustrate the Ecosystem Approach in relation to marine policy and management. The case studies give further insight into the approaches to implementation and the different terminologies used. The Thanet case study highlights a stakeholder led process, designed from the offset to adhere to the 12 CBD principles. This process is an excellent example of how the issues of communication and terminology highlighted throughout this review can be overcome by using a shared (and easily understood) language to elicit the same information. The Marine Strategy Framework Directive adopts a framework approach for applying the Ecosystem Approach in marine management. The Directive is largely in accordance with the CBD Ecosystem Approach and provides a strong basis for further action by individual member states. The success of the MSFD will thus be dependent on political drive and the resources committed by Member States in ensuring such an approach is effectively applied at the regional level. Furthermore, its practical application will need to reflect the opportunities and constraints of Europe's marine governance, notably issues of allocation of competence, differing governance structures and the strong need for adaptive management. HELCOM and CCAMLR provide a similar basis for the implementation of an Ecosystem Approach and offer robust examples in areas of high political and economic pressure that arise with decision making between multiple national governments and decision making bodies.

A virtual expert panel was convened to discuss the Ecosystem Approach with experts working in the field and to identify barriers to the implementation of the Ecosystem Approach in UK policy. Twelve academic and policy experts from across the UK took part. The session identified the following barriers and areas for further work: communication and the need for clear and consistent messages including the terminology used; the need to sell the idea of implementing an Ecosystem Approach and what are the benefits in doing so; and the requirement for further capacity and resources to aide implementation. This could be progressed by the further translation of scientific understanding into case studies specific to the marine environment.

A number of future research needs have been highlighted with respect to the Ecosystem Approach. These include:

- How to embed the principles of the approach in policy and practice.
- How the approach offers a new dimension to current practice.
- Case studies of Ecosystem Approach implementation in the marine environment for use in policy and to take out to stakeholders.
- Ensure research and its outputs are clear, concise and practical.
- The social principles of decentralisation, societal choice and societal involvement which are part of the CBD's definition of the Ecosystem Approach need to be better associated with the term.
- Improved understanding of ecosystem service interactions i.e. what would be the result of a change and the effects of favouring one particular set of benefits is needed.

Policy recommendations include:

- The Ecosystem Approach should consider ecological, economic and social considerations within a single framework of which humans are an integral component.
- A clear message is needed of what we mean by the Ecosystem Approach. The misuse of terminology propagates confusion.
- A joint agency statement similar to HELCOM and the OSPAR Commission jointly adopted Statement on the Ecosystem Approach may be beneficial.
- Illustrate where the Ecosystem Approach is supporting current practice and using existing information e.g. how it can link to existing procedures.
- The presentation of the Ecosystem Approach is important – it should be promoted as an opportunity not a further hurdle or constraint-need to sell the approach, both internally and externally. This should make use of professional support to put this message across.
- Distil the 12 CBD principles into three themes which are easier to understand and communicate: Systems thinking and management; Involving stakeholders in decision making; Understanding the wider benefits provided by the environment.
- Communication should be tailored when interacting with stakeholders who have no understanding of the concept; the current terminology does not need to be used and is not helpful in many situations.
- Existing information including best practice on participation needs to be better used.
- The level of understanding by policy colleagues needs to improve as currently it is seen to limit progress and implementation.

- More attention should be paid to the resources that are required for effective marine planning.

- A nested scale approach to implementation is recommended but should reflect the individual circumstances, the stakeholders involved and the particular sectors

Economic Valuation of Marine Ecosystem Services

The importance of the economic valuation of marine ecosystem services has been recognised in science and there has been a more recent uptake of its use in the UK by government and other stakeholders to support decision making and help meet national and international obligations.

As recognised by the UK's National Ecosystem Assessment, it is important to distinguish between basic marine processes, intermediate and final services, goods and benefits when it comes to economic valuation of marine ecosystem services. It is not appropriate to value basic processes and intermediate services without identifying explicitly the associated final ecosystem services and goods and benefits which have human welfare implications. In addition, a number of general problems must be addressed for the effective valuation of marine ecosystem services, and these relate to the need to avoid *double counting* in valuation; *spatial explicitness* to clarify the level of understanding as ecosystem services are context dependent; *marginality* associated with the requirement that valuation should focus on incremental changes in ecosystem services rather than larger impacts; *non-linearities* which refers to the nature of the relationship between a given disturbance and its impact on ecosystem services; and *threshold effects* where a marginal disturbance can lead to an abrupt change into an alternative state.

A review of economic valuation methodologies reveals a range of economic techniques can be applied to value ecosystem services in the marine context. In general, economic valuation of marine ecosystem services relies upon both market and non-market techniques, recognising that whilst market prices may reflect the value of some marine ecosystem services, for others they either don't exist or are inadequate, and therefore non-market techniques must also be employed. Valuation data based on market prices (such as commercial fish species) are well accepted, whilst, non-market methods which require either revealed preferences (e.g. travel cost or hedonic pricing) or stated preferences (e.g. contingent valuation or choice experiment methods) are gaining a wider acceptance and are advocated by the UK Government for policy evaluations.

The skills required to undertake the economic valuation of ecosystem services will vary depending on the technique. Essentially, for monetary valuation the skills of an economist would be required for problem structuring, market, production and, often, statistical analysis. Often a multidisciplinary approach is called for because effective problem structuring is critical and a survey is frequently required based on questionnaires and interviews. These can be informed by focus groups and engagement with practitioners and stakeholders. Thus, along with economists, multidisciplinary teams might also include marine ecologists, systems practitioners, experts in stakeholder engagement, and others.

Turning to primary valuation evidence for the UK coastal and marine ecosystem services, the limited number of primary evidence studies is apparent as are the data gaps for a number of ecosystem services, goods and benefits. At present, these studies provide an incomplete coverage of ecosystem services and benefits, with their focus on key provisioning and regulating services including fisheries, carbon storage and coastal defences, in addition to tourism and recreation (a cultural service). Other services, such as those associated with many cultural services (e.g. spiritual and cultural wellbeing) still defy monetary valuation.

Where site specific data is not available, the UK Government advocates the use of value or benefit transfer as it offers the opportunity for time and resource savings associated with the use of primary data. Guidelines on the appropriate use of value transfer have been produced by Defra, and provide guidance on: whether value transfer is appropriate for a given appraisal; selecting the most appropriate approach and applying an appropriate level of effort; selecting the most suitable economic evidence from the literature; implementing the practical steps for value transfer; and presenting the results in an appropriate manner to inform decision-making. It is anticipated that as the body of primary valuation evidence grows, the capacity for, and quality of, value transfer will improve.

The use of modelling and scenario analysis to inform marine environmental management is becoming increasingly widespread and can be advocated as tools to identify changes in ecosystem service provision, including a range of human activities and other interactions. Modelling tends to emerge from the natural sciences and includes time series data analysis, biophysical models, spatially explicit food-web models, and whole-ecosystem models. The evidence base for scenarios may come from such modelling techniques which can project future changes in ecosystem service provision. To support decision-making, it may be advantageous to model the complexity of the whole system in which case Bayesian Belief Network offers a solution where such complexity cannot be feasibly modelled by other approaches.

A number of future research needs have been highlighted with respect to economic valuation of marine ecosystem services. These include:

- Developing techniques to value the range of ecosystem services recognising that, at present, some services in the marine environment belie valuation.

- Extending the number of studies of the UK marine ecosystem services to improve the primary evidence base on economic valuation.

- Refining the techniques associated with benefit and value transfer.

- Developing the role of economics in modelling and scenario analysis, which to date has been predominantly natural science based, to enable its use in valuing ecosystem services where data is poor.

Further, on the nature of the research that is undertaken, a greater promotion of integration between natural and social scientists is required given the multidisciplinary nature of ecosystem services research, including when it comes to non-market valuations.

Finally, with respect to economic valuation of marine ecosystem services, a number of policy recommendations have been made:

- Distinguishing between the basic marine processes, intermediate and final ecosystem services, goods and benefits provided for society in valuation should be advocated for marine ecosystem services.

- Robust guidelines on the most appropriate use of valuation techniques, aggregation and comparison of economic valuation evidence for the marine environment has a role when this evidence is to be used for decision support and policy purposes.

- The growing importance of economic valuation in the design and implementation of national and international marine policy calls for a greater UK primary evidence base, increasing the number of valuation studies and their coverage of the range of marine ecosystem services (especially of regulating and cultural services).

- Every effort should be made to quantify the goods and benefits provided by the marine environment (even if only partially) when valuation evidence is called for to support decision making and policy design.

- Where possible, primary economic valuation data should be stored centrally using online databases/catalogues etc., and apply a full and standardised approach for data entry to ensure that such evidence is easily accessible and understood when used to inform policy decisions.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

Coastal and marine ecosystems provide an enormous range of services that are integral for the functioning of society. Productive inshore systems such as salt marshes and mudflats are important for a range of regulatory services including sequestering carbon, nutrient cycling, and pollutant capture and provide an enormous range of social, cultural and economic benefits. From the offshore perspective, ecosystem services have received less attention in the literature and in policy as they are remote from human populations. Offshore marine environments provide a range of regulatory and provisioning services such as deep carbon storage, regulating the climate, providing food and cultural benefits such as educational and scientific opportunities. Capturing how these services are produced by marine systems, how they are valued by individuals and society, and how they change over time, is an important scientific and policy goal that is mandated by the Ecosystem Approach. There are an increasing number of studies which investigate ecosystem services and the linkages between services, ecosystem functioning, and biodiversity. As legislative demands such as the EU Marine Strategy Framework Directive place greater emphasis on delivering the Ecosystem Approach and valuing ecosystem services, there will be a strong demand for research that supports implementation.

The Ecosystem Approach is a term now frequently found in the research, management and policy literature relating to natural resource management. The approach aims to consider impacts on the wider ecosystem, rather than on a sector by sector basis and is increasingly been incorporated into policy and management documents aimed at promoting long-term sustainability of the marine environment. While definitions and interpretations of the approach are numerous, actual case studies demonstrating how the approach can be applied in the UK context are rare. This report presents a snap shot of the implementation of the Ecosystem Approach in the UK and abroad, and provides the results of an expert-led workshop on policy challenges.

There are considerable institutional and economic challenges in the valuation of ecosystem services, both in terms of methodology, data and ethics. However, understanding the complex interplay between the ecological and social components of the Ecosystem Approach at a range of scales is necessary to provide the foundations for integrated management. The challenge is to consider these dynamics within a coupled social-ecological system and develop practical applications that enable policy makers and the public to understand the contribution and importance of the marine environment to our collective wellbeing.

1.2 Aims and Objectives

The aim of this project is to provide JNCC with a review of methods developed for understanding ecosystem goods and services provided by the marine environment (Contract No. C12-0170-0612). To meet the requirements of the project specification, the review needs to consider the differences between proposed ecosystem service methodologies and provide an assessment of which methods are appropriate for different needs (e.g. management or policy development); how the Convention on Biological Diversity's Ecosystem Approach has been applied to marine policy and its implementation; and how economic valuation might be applied to the delivery of ecosystem goods and services from the marine environment. The aim of the project will be achieved with the completion of three main objectives:

Objective One – Ecosystem Services

- Provide an analysis of the similarities and differences between approaches being developed for defining and practically using ecosystem services (e.g. determining stocks, flows and valuation) including what are the limitations of the concept of ecosystem goods and services in the marine environment.

- Provide an analysis of how marine ecosystem goods and service methodologies differ to methodologies for terrestrial ecosystem goods and services.

- Provide a review of the existing research into the links between ecosystem services; ecosystem functioning; biophysical structure; ecosystem benefits to people in the marine environment.

- Provide a review of the research that has considered the relationship between biodiversity, ecosystem services and ecosystem functioning.

- What are the limits to using this concept in the marine environment?

Objective Two – Ecosystem Approach

- Review the different approaches developed to integrating the concept of the Ecosystem Approach in the marine environment, taking consideration of UK, EU and international policies and reports, and multinational environmental agreements. The CBD's Ecosystem Approach should be taken as the standard against which to assess other descriptions of the concept.

- Provide JNCC with a review of the integration of the Ecosystem Approach into policy affecting the marine environment in UK.

- Considering how the Ecosystem Approach is being applied both in the marine and terrestrial environments assess whether further action is required to mainstream the Ecosystem Approach in marine policy and what data, resources, actions would be required to do this.

Objective Three – Economic Valuation of Marine Ecosystem Services

- Assess how economic valuation of marine goods and services could be used within the context of UK marine policy.

- Provide a review of the types of data required and skills necessary for undertaking economic valuation exercises in the marine environment.

2 Understanding ecosystem services in the marine environment

2.1 Conceptualising ecosystem services

This section reviews the state of play of incorporating the ecosystem services concept into policy and the conceptual frameworks that underpin its delivery. It takes into account the system in Figure 2.1 from the fundamental underlying ecosystem components through to the identification and delivery of ecosystem services.

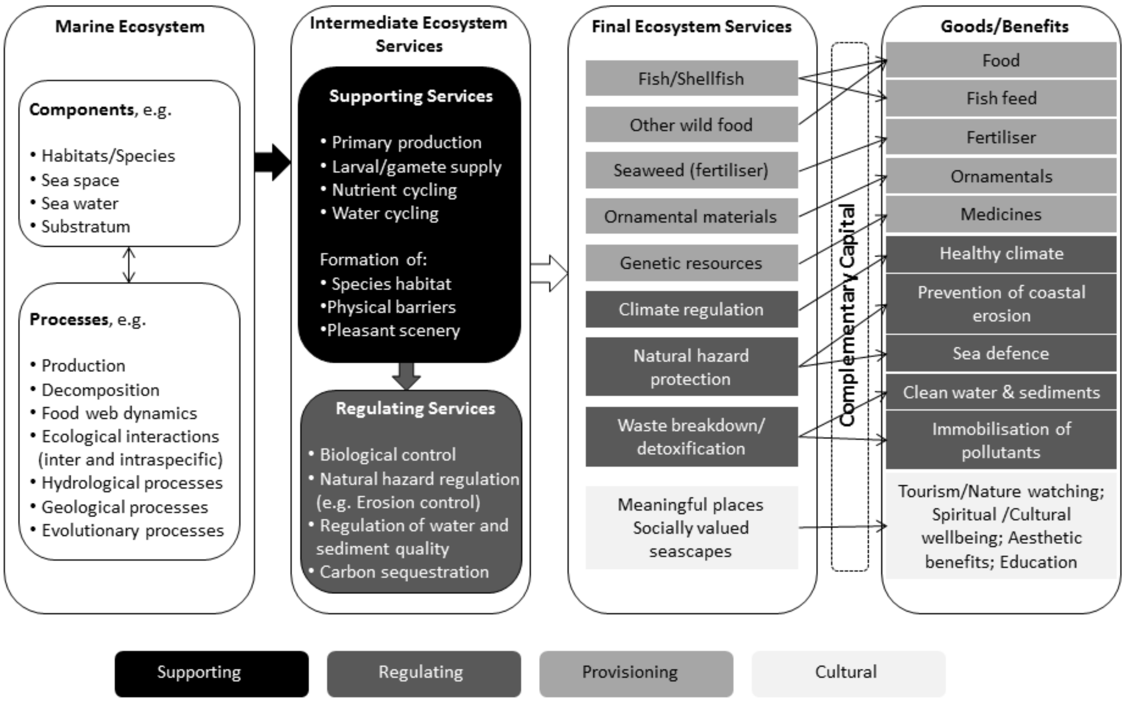


Figure 2.1. A conceptual model of coastal and marine ecosystem services developed by the members of the proposal (adapted from Turner *et al* 2013).

There are a range of frameworks that describe, connect and illustrate the ecosystem service concept. As outlined in Nahlik (2012) applications of models range from organising ecosystem services (Fisher *et al* 2009; Kremen and Ostfeld 2005; Rounsevell *et al* 2010), economically valuing ecosystem services (Hein *et al* 2006; Wainger and Mazzotta 2011), quantifying ecosystem services (Paetzold *et al* 2010), and mainstreaming ecosystem services into social behaviour, policy decisions or management strategies (Cowling *et al* 2008; Daily *et al* 2009; Maynard *et al* 2010; Turner and Daily 2008; Wainger and Mazzotta 2011).

According to Nahlik (2012), there are a minimum of six characteristics that should be incorporated into any ecosystem service framework for it to be effective at an operational level:

1. Definition and classification system of ecosystem service classes including how issues such as double-counting are addressed.

2. Trans-disciplinary – providing for the interaction and collaboration between a number of disciplines, including them in the development of the framework and ensuring that the terminology is appropriate for all.

3. Community engagement – framework development is done through open dialogue with local stakeholders and scientists.

4. Resilient – adaptable and responsive to changing conditions, experience and improved knowledge, to ensure that they are operational over the long-term.

5. Cohesive and coherent – conceptually sound and organised logically, realistically and its use demonstrated.

6. Policy-relevant – the framework should include policy objectives (and/or decision making) as a major component of the framework.

Several publications have explored ecosystem service concepts and set the stage for further scientific studies. Haines-Young and Potschin (2009) summarised the diversity of approaches to describe ecosystem goods and services in the terrestrial and coastal environment, linkages between ecological structures and biodiversity, and approaches to valuation. Austen *et al* (2008) identified research priorities for understanding services from marine systems and Fletcher *et al* (2011) identified service flows from marine protected areas. A UK approach through the National Ecosystem Assessment (NEA) clarified the broad typology and context of ecosystem services and outlined the role of services for society (NEA 2011). Importantly it identified that the role of ecosystems has been undervalued in conventional economic analysis and in decision making. As a result, the NEA has set the context and identified the challenges for future research. These UK initiatives are supported by wider deliberations at the international level with initiatives such as The Economics of Ecosystem and Biodiversity (TEEB) that explores ecosystem evaluation in the international policy context and sets out best practice methodologies. TEEB identifies that marine ecosystems are undervalued and that despite the poor datasets, there is considerable opportunity for issues such as blue carbon markets and payments for conservation of coastal systems for regulatory services (TEEB 2012).

The ecosystem services concept is centred around the utility of nature for human beings (Lamarque 2011). Debate continues regarding the application of ecosystem services both in terms of the underlying science and the ethics of valuation of nature. In the ecosystem service approach it is necessary to categorise ecosystem components and processes in order to understand their importance and relationship with other dynamic processes and to enable management approaches to be developed. This is coupled with the ambiguity of how to implement the approach into the policy and provide guidance for approaches such as impact assessment.

Coastal ecosystem stocks possess high biological productivity and through diverse habitats and species deliver a flow of services and benefits to society. A combination of basic processes and 'intermediate' services provide 'final' services of relevance to human welfare (Figure 2.1). Recognition of intermediate services is required in their supporting of final services. The term 'intermediate services' should not be interpreted as signifying lesser significance but rather as a necessary signal that provides a demarcation to avoid double counting when services are valued in economic analysis. This distinction has emerged with the difficulty to determine when a basic biophysical process (e.g. nutrient cycling) can overlap with regulating services (e.g. water purification) and values are subsequently aggregated. Double-counting is a feature of the complexity of ecosystem services and the difficulty in understanding their multiple interactions. This has been highlighted, for example, in a report commissioned by Natural England (Fletcher *et al* 2012).

Final ecosystem services are described as the ‘contributions that ecosystems make to human well-being’. These are final in that they are the outputs of ecosystems that impact human welfare, although they retain a connection to the underlying ecosystem functions, processes and structures that generate them. For economic valuation purposes Fisher *et al* (2009) clarifies the distinction between ecosystem services and benefits: “ecosystem services are the aspects of ecosystems utilised (actively or passively) to produce human well-being”. The processes become a service only if there are humans that directly or indirectly benefit.

2.2 Typology and definitions

Variability in the use of the term has been the subject of much debate which has hampered its implementation as a management tool. Definition of ecosystem services is usually equated to ecological attributes and processes that lead to benefits or the benefits themselves provided by the ecosystem to society. For example nutrient cycling and biodiversity may be identified when ecosystem services are equated to ecological attributes, while commercially-harvested fish as a form of food production may be identified as provisioning services (Nahlik 2012). The question arises to when a process provided by nature (e.g. biodiversity) becomes a benefit to human beings (e.g. food) and how this benefit can be captured through valuation.

Common definitions

Development of a consistent definition of ecosystem services is imperative to moving from concept to a practice, to enable communication between different stakeholders, and to provide direction for the scientific research effort that supports implementation.

Nahlik (2012) in asking the question ‘What do researchers think ecosystem services are?’ highlights the diversity in the meaning of the term. Figure 2.2 provides a useful illustration of the types of services categorized into processes and functions, structural components, goods, human uses, or securities that were cited across 25 publications.

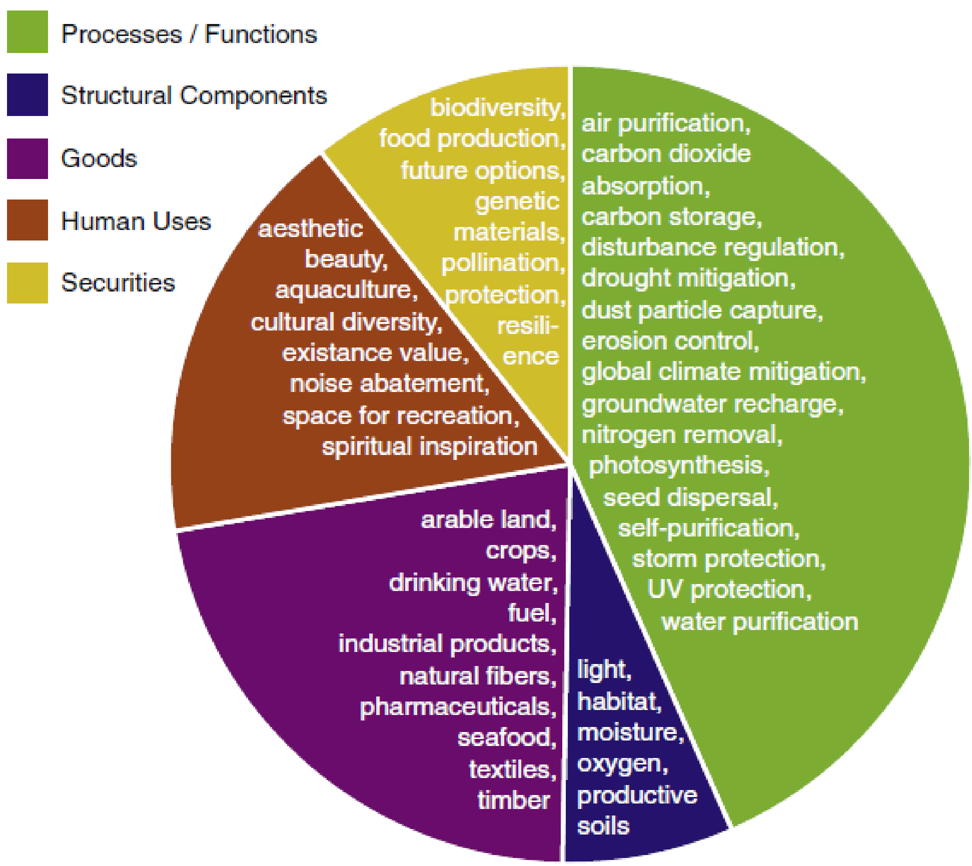


Figure 2.2. Examples of 'ecosystems services' categorised by processes and functions (reproduced from Nahlik 2012).

Lamarque (2011) describes the most common and contrasted definitions of the term ecosystem services along a scale that helps to define ‘functions’, ‘services’ and ‘benefits’ (Figure 2.3). Structure and process are the biophysical components (e.g. species abundance) that combine to create ecological functions that underpin the ability of the ecosystem to deliver services. Functions are translated into services when they are of potential benefit to society. With human inputs (i.e. capital) services become benefits that accrue different forms of value e.g. monetary. It is important to note that services are different to benefits - benefits have an explicit impact upon human welfare (Fischer and Turner 2008).

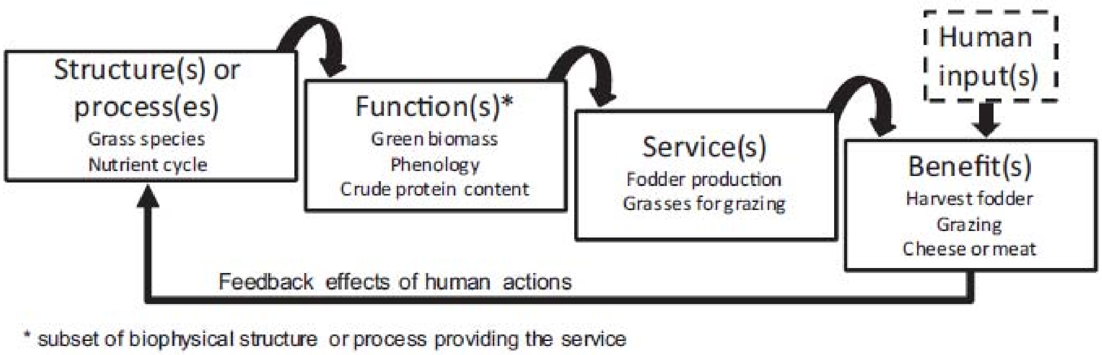


Figure 2.3. Conceptual cascade of ecosystem services from processes to benefits (sourced from Lamarque 2011).

Lamarque (2011) noted that a compromise must be found between a broad definition useful for communicating the concept and a refined definition for research and management. It is appropriate to acknowledge the limits of the approach and recognise the value as a communication tool, while concurrently pursuing science to improve understanding of ecosystem behaviour and responsiveness. As described in Bastian (2013), it provides a “framework for structuring thinking about the relationship of humans with natural systems” and providing a basis for documenting and understanding how environmental systems provide benefits to society.

Common definitions for ecosystem services

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth (MEA 2005).

Ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being (Fischer and Turner 2008).

Ecosystem services: the direct and indirect contributions of ecosystems to human well-being. The flows of value to human societies as a result of the state and quantity of natural capital (TEEB 2010).

2.3 Defining service classes

The principle definition which forms the basis of the ecosystem services concept is that ecosystem services are the ‘benefits people obtain from ecosystems’ (MEA 2005). The MEA approach identified drivers of change as ‘any natural or human induced factor that directly or indirectly causes a change in an ecosystem’ these are divided into categories of direct drivers which have a direct impact on ecosystems (e.g. removal of biomass) and indirect drivers whose impacts are more diffuse (e.g. climate change) (Nelson *et al*2006). The most recent review of the Common International Classification of Ecosystem Services (CICES) (Haines-Young *et al* 2013) confirms that ecosystem services should be framed around human needs.

Linking ecosystems and benefits

Ecosystem services are the link between ecosystems and things that humans benefit from, not the benefits themselves.

The MEA recognised four categories of ecosystem services, provisioning, regulating, cultural and supporting services. The TEEB study proposes a typology of 22 ecosystem services divided in four main categories: provisioning, regulating, habitat, and cultural services. This follows the MA classification, but instead of supporting services (which are seen as a subset of biophysical processes), TEEB uses the notion of habitat services which emphasises the importance of ecosystems as nurseries and gene-pool protectors which have (economic) value in their own right (de Groot 2011).This has been amended by CICES (Haines-Young 2013) into three major groups. Table 2.1 identifies the major groups, divisions and sub-groups of ecosystem service classes.

Definition of service classes (Haines-Young 2013)

a. Provisioning services: all nutritional, material and energetic outputs from living systems.

b. Regulating and maintenance: includes the ways in which living organisms can mediate or moderate the ambient environment that affects human welfare. It covers the degradation of wastes and toxic substances by exploiting living processes, the mediation of flows in solids, liquids and gases that affect benefit provision as well as the ways living organisms regulate the physico-chemical and biological environment.

c. Cultural Services: all the non-material, and normally non-consumptive, outputs of ecosystems that affect humanity.

Table 2.1. Categorisation of services from CICES (Haines-Young *et al* 2013).

Section	Division	Group
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass, Fibre
		Water
	Energy	Biomass based energy sources
		Mechanical energy
Regulation & maintenance	Mediation of waste & toxics	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous & liquid flows
	Mediation of chemical physical, biological conditions	Life cycle maintenance, habitat and gene pool protection
		Pest and disease control
		Soil formation and composition
		Water conditions
		Atmospheric composition & climate regulation
Cultural	Physical and intellection interaction with ecosystems and land /seascapes.	Physical and experiential interactions
		Intellectual and representational interactions
	Spiritual, symbolic & other interactions with ecosystems and land /seascapes	Spiritual and/or emblematic
		Other cultural interactions

The Final Ecosystem Goods and Services (FEGS) framework proposed by Boyd and Banzhaf (2007) is an recent approach supported by a number of scientific studies (Haines-Young and Potschin 2010; Nahlik 2012, Ringold *et al* 2013) and applied in the US EPA[1] Ecosystem Services Program to estuarine and wetland habitats. FEGS consolidates debates on the separation of intermediate and final services and benefits and codifies service outputs and beneficiaries. FEGS recognises that definitions and frameworks of ecosystem services are inconsistent, there is miscommunication and discord amongst proponents, and examples

[1] For example in a report by the US EPA 10 beneficiary categories and 39 beneficiary sub-categories were identified for estuaries and wetlands: http://www.epa.gov/nheerl/arm/streameco/

of policy implementation are few. At the heart of the FEGS approach is the clarification of the *direct* links between final ecosystem services and societal benefits. FEGS are defined as:

Final Ecosystem Services

'Components of nature, directly enjoyed, consumed, or used to yield human well-being'

This definition links measures of bio-physical features to human beneficiaries and counts only the direct interaction with the ecosystem service. The FEGS approach identifies a consistent set of beneficiaries that receive the ecosystem service. In the US EPA case, 33 beneficiaries were identified in the estuarine context and were cross referenced against a 22 estuarine ecosystem attributes to identify final services.[2] For example, an individual visiting a coastal wetland specifically to bird watch benefits from the birds that may be viewed; therefore, one FEGS provided by the wetland to the birdwatcher (the beneficiary) is the presence of birds that may be viewed. Even though habitat provisioned by the wetland, habitat condition, presence or absence of water, and many other ecosystem characteristics and processes influence the presence of birds, the beneficiary, in this case, is directly and ultimately interacting with the birds – not the habitat – to acquire a change in welfare. Under this scenario, the birds are the FEGS (Ringold *et al* 2011).

The strengths of the FEGS approach are that it:

- avoids much of the ambiguity associated with other definitions by restricting ecosystem services to the things in an ecosystem with which beneficiaries directly interact;
- eliminates double-counting of ecosystem services;
- encourages natural and social scientists to collaborate by connecting ecosystem services to both ecological features and beneficiaries; and
- can be understood by the public (i.e., non-scientists) without translation or interpretation because FEGS are determined by beneficiaries.

2.4 Comparison of terrestrial and marine methods

The frameworks described above have proceeded in a range of terrestrial and coastal environments. Marine management practice has generally been founded upon measures designed for terrestrial environments. It is relevant and appropriate to learn from land-based studies, as they are supported with evidence and can be closely monitored to assess effectiveness of approaches. However, it is important to clarify the limitations of the application of terrestrial methods to the marine area, to ensure that management regimes are adapted to the specific characteristics of inshore and offshore ecosystems.

Principally, the marine environment is less understood than land-based systems and the significant uncertainty will challenge approaches to operationalise ecosystem services. Processes which contribute to ecosystem services overlap to a great extent, and the number of possible interactions is so large that only a fraction of them is generally assessed and quantified (Legendre 2013). Variability in marine systems is such that significant amounts of data is needed to understand ecological behaviour over large spatial and temporal scales, and the costs of data collection will impede the collation of sufficient information. In some

[2] See above link for the full set of FEGS metrics and a downloadable workshop report.

cases detailed habitat maps are available, however the mobility of key species requires understanding of the connectivity between ecosystem features; this is much less clearly known or represented in modelling tools. Further, environmental impacts of activities in the marine environment are less well understood than those on land, particularly the novel uses (e.g. renewable energy development). It is therefore critical that the management tools are sufficiently cognisant of the uncertainty in modelling upon which subsequent decisions will be based.

Management frameworks are also different in the marine area, with a number of overlapping instruments with often differing policy objectives, resulting in a diffuse level of effectiveness in controlling change in the ecosystem (for example energy policy and conservation policy). Targeted regulatory approaches are more effective on land due to the modified nature of the environment and the contained provision of services. This is discussed to some extent by Cognetti *et al* (2010) who demonstrates that on land, particularly in developed countries, the influence of land use management means that the ecosystem can be conceived as a "matrix of human-altered landscape with fragments of original biodiversity". In the marine environment the opposite applies - human activities are fragmented and interact with a much larger and poorly defined matrix of biodiversity (Figure 2.4). Applying ecosystem services concepts at sea requires specific consideration of the characteristics underlying coastal and marine processes and in this context terrestrial management measures are limited in their applicability.

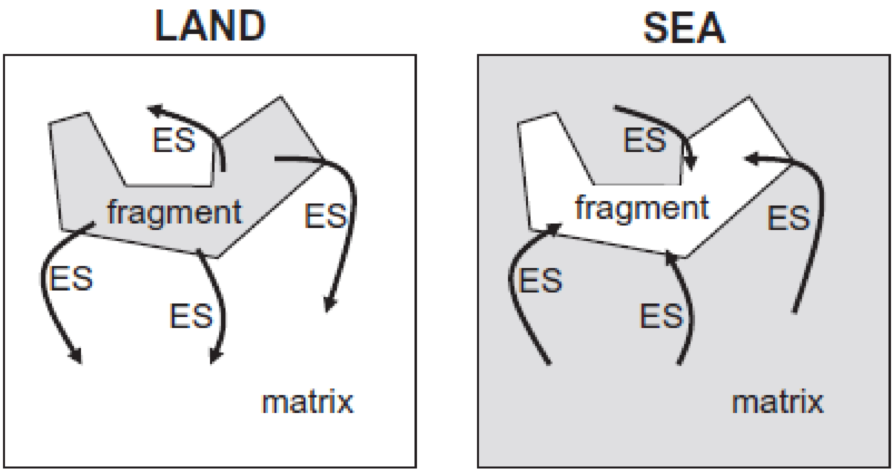


Figure 2.4. The two opposite models for ecosystem service (ES) provision in terrestrial and marine environments (reproduced from Cognetti *et al* 2010).

2.4.1 Models to conceptualise marine ecosystem services

When attempting to identify ecosystem services, methods need to exhibit characteristics that are appropriate for the specific parameters of the marine environment. Methods need to be able to operate under conditions of uncertainty. Cognetti *et al* (2010) proposes a simplified classification of ecosystem services for the marine environment that relies on the biological characteristics of the ecosystem to make the classification more amenable for ecological analysis. Within this ecological framework, three main classes of ecosystem services provision were identified: in natural, disturbed and human-controlled environments. These classes are presented in Table 2.2 with examples of service providers (SPs) and their link to ecosystem services.

Table 2.2. Example of classification of ecosystem services (from Cognetti *et al* 2010).

Classification	Example of Service Provider (SP) and link to Ecosystem Services
Natural (*relatively un-impacted*)	1. Bioturbation species (SP) → increases sediment oxygen concentrations → biomass of organisms → rate of organic matter composition → regeneration of nutrients for primary productivity. Juvenile fish in nursery areas (SP) → commercial fishery stocks 2. Benthic communities / cetaceans (SP) → recreational tourist development through SCUBA diving / wildlife watching
Disturbed Environment (*subject to critical levels of anthropogenic disturbance*)	1. Degrading micro-organisms (SP) → Biodegradations of oil in oil polluted areas → water purification 2. Bacteria, phytoplankton, etc (SP) → Biodegradation and antibiotic action in sewage polluted areas → Water purification & waste assimilation 3. Larval transport (SP) → Community recovery on harvested fishing grounds → Stock resilience / fisheries improvement
Human-controlled Environment (*relatively confined with controlled factors*)	1. Nitrophilous macroalgae in catchment basin collecting aquaculture discharge (SP) → Nutrient uptake → water purification. 2. Recovered biological community in fisheries no take zone (SP) → Stock resilience → Fisheries improvement

This provides a tool which can begin to conceptualise SPs in the marine environment, a step which is essential to support developing management frameworks based on the ecosystem services approach. This parallels the approach taken by the US EPA[3] under the FEGS approach where specific environmental classes are identified and linked to beneficiaries to specify the service. A multidisciplinary debate on these relatively new methods, with contributions from ecologists, economists, as well as policymakers and stakeholders, is needed, especially in the marine environment. This requires analytic–deliberative methods, such as deliberative mapping or interactive multi-criteria decision analysis (MCDA), which can be used to ensure that all sources of relevant information, including local knowledge and community values, are gathered and appropriately considered Gregory *et al* (2012). This should be considered along with mechanisms for developing strategies such as marine planning and protected site designation (e.g. the stakeholder interaction of the Marine Conservation Zone (MCZ) process or marine spatial planning (MSP).

Where the spatial scale of a system can be relatively well defined in the marine environment, then there is some validity to the suggestion that habitat maps in marine systems are analogous to land cover (Guerry, *et al* 2012). This suggests they may be used in a similar way to the models for terrestrial systems which use a land use / land cover data layer as input for the assessment of ecosystem services (e.g. Kareiva *et al* 2011). However,

[3] See: http://www.epa.gov/nheerl/arm/streameco/

recognising the multi-dimensional nature of benthic habitats and the lack of spatially-bound processes these are likely to be too simplistic. Models must also consider mobile species (e.g. cetaceans, seals and birds) as key ecosystem components which are often under-represented in models of marine management due to greater data needs and complexity.

Benthic habitat mapping is an obvious starting point for understanding relative importance and characteristics of particular areas, where data is available (such as Mapping European Seabed Habitats (MESH). Building this knowledge base for the marine environment is significantly more costly than on land, and strategic efforts should be made, such as building on the extensive data collection underway to inform the designation of MCZs and MSP. The coupling with MSP development is crucial as in addition to the habitat data being collected, information on the users of the environment e.g. fishing industry, energy infrastructure etc can inform the link between intermediate and final services, beneficiaries and goods and benefits.

2.5 The Links between Biodiversity and Ecosystem Services

2.5.1 Definitions and terminology

Ecosystem structure can be described in various ways that include: lists of taxa or other functional components; presence or absence, relative abundance of taxa or other functional types; numerical abundance, and / or biomass. This can be analogous to considering biodiversity, in the manner defined by the United Nations Convention on Biological Diversity (CBD), i.e. "*the variability among living organisms from all sources, including, inter alia [among other things], terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems*."

In some literature the benefits obtained from biodiversity is often used interchangeably with ecosystem services (e.g. Ruiz *et al* 2013) particularly where there are direct links between the presence of a species and benefits to humans e.g. non-extractive examples of marine services such as diving, kayaking, wildlife viewing cruises and seabird watching.

The holistic definition of biodiversity, therefore, is understandably interwoven with terminology associated with ecosystem service management and it is possibly unrealistic isolate a component with which it is directly synonymous. Clarity is needed on the use of the term 'biodiversity,' which has different definitions (Sheppard 2006), generally ranging from a lower to higher level of complexity; from simply 'species diversity' to the holistic definition presented by the CBD (above). A relevant 'biodiversity unit' is needed to express biodiversity in an ecosystem service model, whether this is assessment of the loss of species in general, or the effects of the identity and abundance of species with particular sets of traits (i.e. functional diversity) on ecosystem services (Lamarque 2011). Using functional diversity recognises that losses of biodiversity are likely to affect processes and services in different ways, depending on what component of biodiversity is lost (i.e. the functional type of the species lost may be more important for some species than others) (Raffaelli 2006).
It is important to understand how biodiversity contributes to ecosystem services so that the coherence of policy objectives can be assessed which includes identifying where trade-offs between aspects of biodiversity conservation may be emerging.

2.5.2 The Role of Biodiversity in Ecosystem Service Provision

Conservation policy, from the global to national level is aimed at protecting biodiversity as an inherent factor in the quality of the environment and all its functions. Recent scientific literature highlights unequivocal evidence that loss of biodiversity reduces the functioning of ecosystems and emerging evidence suggest direct links between biodiversity and specific ecosystem services (Cardinale, *et al* 2012).

There is clear evidence on the correlation between biodiversity and ecosystem functioning - and conversely the loss of biodiversity impairing ecosystem function. A challenge remains in coastal and marine research to understand and quantify the influence of biodiversity on provision of different classes of ecosystem services.

Effects on ecosystem functions and processes brought about by variations in biodiversity have been the mainstay of ecosystem service – biodiversity research. Research that focuses on the linkages to ecosystem goods and services is more recent and inherently complex (Rafaelli 2006) particularly in the marine environment. Recent data highlights that the relationship of biodiversity to an ecosystem service depends strongly on the nature of the service and the beneficiary. This report summarises a recent meta-analysis by Cardinale *et al* (2012) on biodiversity – ecosystem function – and ecosystem service linkages. This paper reviewed 1700 scientific papers to elaborate the links between biodiversity, ecosystem function and service delivery. In terms of services the paper focused on provisioning and regulatory services acknowledging that the evidence linking biodiversity with cultural services was poor. This reflects the poor conceptualisation of cultural services in general, in particular in coastal and marine environments. In addition poor marine data Table: 2.3 highlights the consensus statements from the paper.

Table 2.3. Outcomes from a recent meta-analysis of biodiversity and ecosystem services (adapted from Cardinale *et al* 2012).

Note: there is no relationship between the first and second column in the table.

Biodiversity and Ecosystem Functioning	Biodiversity and Ecosystem services	Examples of Biodiversity and Services
1. Unequivocal evidence exists that biodiversity loss reduces the efficiency by which ecological communities capture resources, produce biomass, decompose and recycle nutrients.	1. Sufficient evidence that biodiversity directly influences or is strongly correlated with specific provisioning and regulating services.	Provisioning service: fisheries. The stability of fisheries yield is strongly correlated to fisheries diversity. Regulating service: CO_2 sequestration is strongly correlated to plant biodiversity[4]
2. There is mounting evidence that biodiversity increases the stability of ecosystem functions through time.	2. The evidence for the effects of biodiversity on several services is mixed, and the contribution of biodiversity per se to the service is less well defined.	Regulatory service: CO_2 storage. Impacts of biodiversity on CO_2 storage across terrestrial and coastal systems are mixed.
1. The impact of biodiversity on any single ecosystem process is nonlinear and saturating, such that change accelerates as biodiversity loss increases.	3. For many services, there is insufficient data to evaluate the relationship between biodiversity and the service.	Provisioning service: A lack of data on the effect of fish diversity on fisheries yield. Regulatory service: A lack of data on the effect of biodiversity on flood regulation.
2. Diverse communities are more productive because they contain key species that have a large influence on productivity, and differences in functional traits among organisms increase total resource capture. 3. Loss of diversity across trophic levels has the potential to influence ecosystem functions even more strongly than diversity loss within trophic levels. 4. Functional traits of organisms have impacts on the magnitude of ecosystem functions. Extinction may cause a wide range of impacts on ecosystem function.	4. For a small number of ecosystem services, current evidence for the impact of biodiversity runs counter to expectations.	Regulatory service: Water purification. Conflicting results over the role of biodiversity in water purification.

[4] Our interpretation from Cardinale *et al (2012)* is that this relates to terrestrial systems as opposed to coastal or marine systems. Further investigation into coastal systems in projects such as CBESS (see below) are investigating coastal biodiversity influence on ecosystem services.

While the importance of specific functional groups is recognised, it is generally understood that increased species richness is generally linked to an increase in the functional repertoire present in the community, and greater capacity to ensure the continuation of ecosystem functions under different pressures. Ecological communities may hold as yet unknown functional potential that may prove instrumental to ensure the sustainability of ecosystem functions in the presence of disturbance or a changing environment (Duarte 2000).

Considering that ecological linkages are generally poorly understood in the marine environment, an assumption that all organisms have intrinsic economic value, regardless of more or less immediate and direct utilisation (Cognetti *et al* 1993), is not unreasonable. Sufficient regard should be given to the inherent uncertainty in conceptualising ecosystem functioning and service provision, and the unknown implications affecting biodiversity loss as it is not possible to predict the effects that the loss of a single species or a population and/or ecosystem service might have. Hence, a precautionary approach is required, and ecosystems should be maintained as far as possible, to ensure continued service provision, particularly where there is presently insufficient supporting scientific evidence for establishing the relative importance of components.

As an overall approach, it is useful to consider ecosystem services management in the marine environment as a means for understanding the contribution of any biodiversity component to the provision of services (Bastian 2013). From an operational point of view, a key challenge is to find criteria and indicators to assess the relationship between biodiversity and ecosystem services, in order to plan appropriate interventions, focussing on critical functional roles played by biodiversity in the marine environment. This report acknowledges that the data on coastal and marine systems is poor but improving through increased scientific investigation, particularly in the coastal zone (Section 2.6 below).

2.5.3 Integration with other biodiversity protection measures

There is a need to understand the coherence of policy objectives related to protection of biodiversity in the marine environment and how biodiversity strategy meshes with the ecosystem service approach. A recent EC communication stated that, "one of the reasons that the 2010 biodiversity target has not been achieved is the insufficient integration of biodiversity issues into broader policies, strategies, programmes and actions, and hence the failure to address the underlying drivers of biodiversity loss," (COM 2011). Both the CBD and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) call for scientific assessments and target setting to maintain biodiversity and ecosystem services (CBD 2004; UN General Assembly 2010). Policy-makers therefore need to establish how the ecosystem service concept relates to biodiversity conservation and adds value to conservation approaches; this remains insufficiently explored in Europe (Harrison *et al* 2010). Implicit in this, is the need to understand the role which biodiversity is considered to play in ecosystem services, and how other conservation mechanisms (such as the Natura 2000 network) contribute to biodiversity and ecosystem service provision.

Site designation measures and the associated improvement in habitat quality (Natura 2000 and Sites of Special Scientific Interest) have recently been assessed as providing benefits for biodiversity (and consequently ecosystem services) in the terrestrial environment (Maes *et al* 2012 and Christie and Rayment 2012). Research is needed to assess the contributions of conservation mechanisms to protecting biodiversity in the marine environment to fully integrate management approaches, however in the short-term, it would be pertinent to consider the measures such as the designation marine protected areas in parallel with the development of ecosystem services management approaches.

In a recent report by Potts *et al* (2013) for the Valuing Nature Network, UK and devolved approaches to the implementation of marine protected areas were examined in the context of ecosystem services. The authors identified that a range of specific services were generated by protected species and habitats (Figure 2.5 below) but the scientific basis of understanding the links between habitats / species and final services was variable and generally poor. The study examined a number of case studies from the UK context and concluded that while ES concepts are not absent, they could be considered supplementary to the existing policy debate. The availability of evidence on ecosystem services was considered an obstacle to the implementation of marine biodiversity policy, particularly in support of the designation of sites in terms of service flows and in generating public support for protection in terms of the flow of benefits from MPAs to human systems.

Extending this, the overarching holistic aims of marine spatial planning (MSP) to achieve 'sustainable development,' means that MSP needs to be developed in accordance with ecosystem management principles. As a framework for the collation of policy objectives and sector activities on a regional basis, MSP arguably presents the main vehicle for implementing ecosystem services management. The spatial planning framework (which includes conservation measures) may enable the examination of trade-offs in services and provide a quantitative approach for assessing the value of planning decisions and activities.

Feature Type†	EUNIS code ††	Feature	Primary production	Secondary production	Larval gamete supply	Food web dynamics	Nutrient cycling	Genetic resources	Formation of species habitat	Species diversity	Formation of physical barriers	Climate regulation	Natural hazard regulation	Regulation of water quality	Regulation of sediment quality	Biological control	Wild food (incl fisheries)	Fertiliser	Ornaments	Aquaria	Blue Biotechnology	Reduced Greenhouse gas emissions	Prevention of coastal erosion	Provision of clean water	Provision of clean sediments	Spiritual / Cultural significance	Tourism / Nature watching	Art	Research & Education
			Intermediate services: Supporting services									Intermediate services: Regulating services					Goods and Benefits: from Provisioning services					Goods and Benefits: from Regulating services				Goods and Benefits: from Cultural services			
Broad Scale Habitat																													
E,W	A1.1	High energy intertidal rock	3	3	2	2	3		2	3	1	2	1				3					2	1			1	1	1	1
E,W	A1.2	Moderate energy intertidal rock	3	3	2	2	3		2	3	1	2	1				3					2	1			1	1	1	1
E,W	A1.3	Low energy intertidal rock	3	3	2	2	3		2	3	1	2	1				3					2	1			1	1	1	1
E,W	A2.1	Intertidal coarse sediment	1	1	3	1	1		3	1	1		3				1						3			1	1	1	1
E,W	A2.2	Intertidal sand and muddy sand	3	1	3	3	3			1	1	2	3				1					2	3			1	1	1	1
E,EU	A2.4	Intertidal mixed sediments	3	1	3	3	3			1	1	2	3				1					2	3			1	1	1	1
E,W	A2.3	Intertidal mud	3	3	3	3	3		1	2		3	3		3		3					3	3	3		1	1	1	1
E	A2.5	Coastal saltmarshes and saline reedbeds	2	2	3	3	3		3	1	3	3	3	3			3	3				3	3	3	3	1	3	1	1
E,EU,W	A2.6	Intertidal sediments dominated by aquatic angiosperms	2	3		1	3		2	1	1	1	1	3			3	3				1	1	1	1	1	1	1	1
E,EU,W	A2.7	Intertidal biogenic reefs	1	2	1	1	2		3	2		2	2	1			2					1	2	2		1	1	1	1
E,W	A3.1	High energy infralittoral rock*	2	1	2	2			2	3	1		1				3						1			1	1	1	1
E,W	A3.2	Moderate energy infralittoral rock*	2	1	2	2			2	3	1		1				3						1			1	1	1	1
E,W	A3.3	Low energy infralittoral rock*	2	1	2	2			2	3	1		1				3						1			1	1	1	1
E,W	A4.1	High energy circalittoral rock**	2	2	2	1			2	2	1		1				1						1			1	1	1	1
E,W	A4.2	Moderate energy circalittoral rock**	2	2	2	1			2	2	1		1				1						1			1	1	1	1
E,W	A4.3	Low energy circalittoral rock**	2	2	2	1			2	2	1		1				1						1			1	1	1	1
E,W	A5.1	Subtidal coarse sediment	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
S	A5.1,A5.2	Offshore subtidal sands and gravels	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E,W	A5.2	Subtidal sand	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
E,W	A5.3	Subtidal mud	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
E,EU,W	A5.4	Subtidal mixed sediments	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
W	A5.4, A5.3	Subtidal mixed muddy sediments	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
E,EU,W	A5.5	Subtidal macrophyte-dominated sediment	3	3	2	3	2		2	3		2	1	2			3	3				2	1	2	2	1	1	1	1
E,EU,W	A5.6	Subtidal biogenic reefs	1	2	2	3	3		2	3		1	3	3			3			1		1	2	3	3	1	1	1	1
S	A7.A, A7.7	Fronts	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S	Various	Low or variable salinity habitats	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
EU	X02	Saline lagoons			3		3		3	3							1									1	1	1	1
Habitats																													
E	A1.32	Estuarine rocky habitats	1	1	1	1			2	2			1				1						1			1	1	1	1
E,W	A1.2142, A3.2112	Intertidal under boulder communities	1	1	1	1			2	2			1				2						1			1	1	1	1
E	A1.127, A1.223, A4.23	Peat and clay exposures		1	1	1			2	2																1	1	1	1
S	A1.325	Sea loch egg wrack beds	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	A1.441, B3.114, B3.11	Littoral chalk communities	1	1	1	1			3	3																1	1	1	1
EU	A1.44	Submerged or partially submerged sea caves				1			1	1																1	1	1	1
E,S,W	A2.2, A2.7, A5.6	Blue Mussel beds	1	1	1	1	1	1	1	2	1	1	1	3	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1
E,W	A2.71	Honeycomb worm *Sabellaria alveolata* reef		2	1	2	1		3	3	1	1	2	1		1	1					1	1	1		1	1	1	1
S	A3.126, A3.213	Tide-swept algal communities (Laminaria hyperborea, Halidrys siliquosa)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1
S	A3.126, A3.213, A1.15	Tide-swept algal communities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1
E,W	A4.12, A4.12	Fragile sponge&anthozoan communities on subtidal rocky habitats		1	1	3			3	3		1				1	3									1	3	1	1
W	A4.131, A4.2122	Subtidal rock with Ross 'coral' Pentapora foliacea		1	1	3			2	2		2				1	1									1	3	1	1
S	A4.133, A4.211	Northern sea fan and sponge communities		1					1	1																			
E	A4.22	Ross worm *Sabellaria spinulosa* reefs		2	1	2	1		3	3	1	1	1	1		1	1					1	1	1		1	1	1	1
E	A4.23	Subtidal chalk		1	1	1			2	2																1	1	1	1
E	A5.12, A5.13	Subtidal sands and gravels	1	1	1	2	1		2	2			1	1			2							1	1	1	1	1	1
S	A5.133	Shallow tide-swept coarse sands with burrowing bivalves (Morella sp.)		1		1	1		1	1					1		1								1	1		1	1
E,S	A5.361	Sea-pen and burrowing megafauna communities	1	1	1	2	2	1	3	3	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
S	A5.371	Inshore deep mud with burrowing heart urchins	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
W	A5.371	Mud habitats in deep water	3	2	3	3	3		3	3			3		1		2						3	3		1		1	1
E,W	A5.43, A2.41, A2.42	Sheltered muddy gravels		1	1	2	1		2	2		1		1	1		2					1		1	1	1	1	1	1
E,S	A5.434	Flame/ File shell beds	1	1	1	3	3		3	3		1	3			1	3					1	1			1	1	1	1
E,S,W	A5.435	Native Oyster *Ostrea edulis* beds		1	1	1	1		1	1		1	1	1		1	3					1	1	1		1	1	1	1
All	A5.51	Maerl beds	3	1	1	3	1		3	3	1					1	3	1	1							1	1	1	1
S	A5.5112	Maerl or coarse shell gravel with burrowing sea cucumbers	3	1	1	3	1		3	3	1					1	3	1	1							1	1	1	1
S	A5.52	Kelp and seaweed communities on sublittoral sediment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
All	A5.53, A5.545, A2.61	Seagrass beds	2	2	1	3	2	1	3	3	1	2	1	2	1	2	3	2	2	2	1	2	2	2	2	1	2	1	1
E,S,W	A5.62	Horse mussel (Modiolus modiolus) beds	1	3	1	3	1	1	3	3	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1
E	A5.63	Cold-water coral reefs		2	1	1	1		2	3	3	1					1					1				1	1	1	1
EU	A5.71	Submarine structures made by leaking gases				1	1		3	3		3					1				1					1		1	1
E,S	A6.61	Coral Gardens	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1
S	A6.75	Carbonate mound communities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E,W	Various	Tide-swept channels		3	1	1			1	2																1	1	1	1
W	Various	Sediment habitats with long lived bivalves		2		2	2		1	1	1	1		1		1	1							1		1	1	1	1
E	N/A	Areas of high planktonic primary productivity	3	3	1	3	3		1	1	1	2	1			1	2					2	1	1	1	1	1		1

Note: Deep sea habitats are excluded from this VNN assessment

Notes: Rocky reef kelp and algae are represented at EUNIS level 4 within each rocky habitat, e.g. A3.11 to A3.15

*Infralittoral rock includes habitats of bedrock, boulders and cobbles which occur in the shallow subtidal zone and typically support seaweed communities.

**Circalittoral rock is characterised by animal dominated communities, rather than seaweed dominated communities.

***Deep-sea bed excluded from this VNN assessment

†† Eunis codes were identified using the the JNCC EUNIS translation matrix http://jncc.defra.gov.uk/pdf/EUNIS_Correlation_2007-11_20101206v2.pdf some habitats do not have a direct relationship to the EUNIS code and it should only be used as a guide

Scale of ES supplied relative to other features

- # (black) Significant contribution
- # (dark grey) Moderate contribution
- # (light grey) Low contribution
- # (white) No or negligible ESP
- (empty) Not assessed

Confidence in evidence

- 3 UK-related, peer-reviewed literature
- 2 Grey or overseas literature
- 1 Expert opinion
- (empty) Not assessed

Feature type †

- S Scottish MPA search feature
- E English MCZ feature
- W Welsh HP MCZ feature
- EU EU Habitats Directive Annex 1 feature or sub-feature

Figure 2.5. Relative importance of designated habitats in providing intermediate ES and final goods and benefits (sourced from Potts *et al* 2013).

MSP could consider critical thresholds beyond which ecosystem services would be compromised beyond an acceptable level, and under which multiple activities can be collectively managed. Schneiders *et al* (2012) suggest the setting of thresholds for biodiversity, and then the use of ecosystem services as a tool to move from the present to the target objective. This should be on a biogeographically relevant basis (e.g. where hotspots of important conservation value can be identified) and would relate to the implementation of the Marine Strategy Framework Directive (MSFD) and achievement of Good Environmental Status (GES).

2.6 Reviewing Research on Marine Ecosystem Services

2.6.1 Overview of research projects

In recent times a number of projects exploring the concept and application of the ecosystem services approach have emerged in the UK. This reflects an increasing scientific interest in understanding the functioning of coastal and marine ecosystems and the role of biodiversity in delivering ecosystem services. Institutions such as the Natural Environment Research Council (NERC) have recently launched large scale research consortia (BESS – see below) to explore the links between biodiversity, ecosystem function and service delivery across a range of landscapes including coastal systems. The initiation of projects responds to the emerging policy and social interest in the valuation of coastal services and importantly, how they can be meaningfully incorporated into the decision making process where different values, methods, and data availability are realities for decision making.

It is clear from this assessment that valuation data (and in fact the focus of the science) is confined to inshore coastal systems and marine environments, with deep sea issues and service valuations only recently emerging on the agenda for research. Armstrong *et al* (2012) notes that while services from deep sea systems are highly valuable, even infinitely valuable, as they support biogeochemical processes and cycles that support life on earth, very little is known about total value of goods and services from these environments and how they respond to pressures. The third tier of projects are asking questions over how such information can be used in the decision making process. This is a highly topical area of research that is expanded within recent networks such as the Valuing Nature Network (VNN) and the National Ecosystem Assessment (NEA) and works in partnership with government agencies to explore the potential for ES research to support policy.

A collation of projects, websites and contact details is presented in Appendix 2. Several projects are in early or are approaching middle stages of development and over the next 3 -5 years the amount and quality of data based on monetary and non-monetary approaches will increase in the UK and EU. A number of projects including Knowseas and MARBEF have released initial data on valuations at the regional sea scale (Knowseas) and across specific coastal sites (MARBEF). Other projects including VECTORS, DEVOTES, UK NEA2, C-BESS and VALMER are preparing assessments and valuations for their respective case studies. An excellent resource for tracking the progress and collating data for coastal valuation studies is presented in the Marine Ecosystem Services Partnership.[5] This site identifies 76 studies to date in the UK (from a global database) that define monetary values for a range of regulatory, provisioning and cultural services using a variety of methods and linked to a global GIS database. Other sources of economic valuation evidence, including metadata catalogues, online databases, peer-reviewed primary valuation studies and unpublished (grey) literature are discussed in Section 4.

[5] See: http://marineecosystemservices.org/

Appendix Two highlights a range of studies that cross the range of ecosystem service research. Projects such as NERC BESS, CBESS, and MARBEF investigate the role of coastal biodiversity in providing services including the responses of biodiversity to pressures. DEVOTES and KNOWSEAS are preparing indicators and modelling tools to understand and manage pressures such as climate change on marine biodiversity and incorporating this knowledge into meeting Good Environmental Status under the EU Marine Strategy Framework Directive (MSFD). KNOWSEAS, VECTORS and VALMER have or are in the process of developing monetary valuations of marine and coastal services at different scales. KNOWSEAS and VECTORS work at the regional sea scale to develop support for MSFD implementation (e.g. The North Sea, Black Sea, Baltic, and Mediterranean) while VALMER intends to focus on a number of specific sites in the Western English Channel. Projects such as the VNN Coastal study, VNN BRIDGE, and the UK NEA work at the interface of ecosystem service valuation and decision making, identifying pathways and measures to incorporate valuation data into mainstream practice and build links between the research and policy communities.

2.6.2 Research outputs on ecosystem structure, function and services and research on service valuations

Appendix 3 summaries research on conceptual frameworks, ecosystem structure-function-biodiversity linkages and valuation. The projects highlight several ongoing investigations into the links between ecosystem structure and function and service provision and research into valuation methods and decision making support mechanisms. As identified above several programmes are in the initial stages of gathering data on coastal system function and the role of biodiversity in supporting coastal services (e.g. C-BESS); monetary and non-monetary valuation and policy processes (KNOWSEAS, VNN-Coastal, NEA-2, VECTORS, VALMER); and building closer links between decision making and the ecosystem services framework (VNN-Bridge, NEA2). While increasingly more data is being generated the ecosystem services approach is yet to become a mainstay of decision making or impact assessment and more work is required to improve data provision. The dialogue between science providers and policy makers over how the ecosystem services concept can be operationalised is an important one, particularly in the context of maintaining a diversity of value estimates (i.e. monetary, non-monetary, and shared social values). There is a niche for research that optimises the science into policy process around research from the ‘front end’ natural science initiatives to the more ‘back end’ approaches that deal with decision making and engagement.

In terms of research on ecosystem function, biodiversity and service provision, Appendix 3 highlights the NERC sponsored BESS and C-BESS as recent initiatives generating new data. BESS / C-BESS acknowledge the role that biodiversity plays in regulating ecological processes that underpin ecosystem services, but a quantitative understanding of biodiversity-ecosystem functioning-ecosystem service relationship is poor in the UK. BESS focuses upon landscapes including farming and urban systems and is the umbrella project for several consortia, C-BESS specifically focuses upon two regional estuarine sites (Morecambe Bay and Essex coastline) in addition to a UK-wide study. C-BESS will adopt a hierarchical approach to quantifying the linkages between biodiversity stocks (microbial, macroflora, invertebrate meio- and macrofauna, avifauna), multiple ecosystem functions, and flows of ecosystem services at different scales in coastal habitats. The services that C-BESS will explore and quantify are supporting services (nutrient cycling, healthy habitat); regulating services (coastal protection and climate regulation); provisioning services (goods obtained from the landscape); and cultural services (recreation). Variation in the service flow from biodiversity will also be explored in different seasonal contexts and in terms of site condition in intertidal flats and saltmarsh coastal habitats. Both monetary and non–monetary values will be derived from field studies, benefit transfer and direct engagement with stakeholders through site based workshops. C-BESS is proposing to work directly with stakeholders to elucidate non-monetary and shared values over recreational use of the estuaries which will inform the public and policy understanding of cultural services.

The EU FP7 KNOWSEAS project aims to develop a comprehensive knowledge base and guidance for the application of the Ecosystem Approach across EU regional seas. This included a large scale economic study at the regional sea scale and within national exclusive economic zones that estimate the future benefits that might be expected from the exploitation of European seas. Benefits accounted for sectors including energy, fisheries and mariculture, freight and transport; recreation; water quality and carbon storage in salt marshes and sea grass. This study used a benefit transfer approach that scaled up values observed in one case to a broader context and entails a number of assumptions and limitations on the applicability of the resulting dataset (Cooper 2011). The data used in the analysis was obtained from 2009 statistics in the case of direct market values. The values generated, while broad and subject to considerable caveats associated with the methodology, provide some evidence of the magnitude of services provided by Europe’s seas. The project developed specific analytical papers for each sector and service and developed forecasts to explore changes in service provision out to 2050. The analytical papers (currently internal Knowseas documents) are available from the project officer by request (see Appendix 2).

The analysis in Table 2.4 and 2.5 (Cooper *et al* 2011) highlights the significance of the Northeast Atlantic across several activities - energy production, fisheries and maritime transport, producing approximately €173 – 192 billion in services at 2009 prices. The dominance of the Mediterranean in the value of recreation measured by visitor expenditures and bathing water quality reflects the importance of tourism in this region. Somewhat surprisingly, the generated values for CO2 sequestration range from €297 million for saltmarsh across the EU to €1 billion for seagrass in the Mediterranean (Cooper *et al* 2011). It is important to note that these figures represent a snapshot in time and should be interpreted with the more detailed sector reports and taken into account with the caveats inherent in benefit transfer. Despite this, the valuations provide an interesting snapshot of the monetary value of different services at the European and regional sea scale and support policy implementation of the Marine Strategy Framework Directive.

Table 2.4. EU FP7 Knowseas data on European marine ecosystem services and valuation methods (sourced with permission from Cooper *et al* 2011).

Type of value	Sector/Activity	Evaluation method: Scope	Evaluation method: Valuation base	Value/€2010'm p.a.: Ecosystem services	Value/€2010'm p.a.: Marine space
Direct use	Energy	Principal hydrocarbon producers in NEA (>90% of EEA production)	Production quantities in 2009 at market values		114,362.4
	Fisheries – capture	EEA countries	Average catch 2007-2009 at market values	8,675.0	
	Fisheries – mariculture	EEA countries	Average production 2006-2009 at market values	5,515.2	
	Freight transport	Principal countries and main routes involving major ports (~55% of EEA traffic)	Maritime freight movement in 2009 evaluated at median cost per tonne nautical mile		13,745.5 - 62,359.6
	Recreation (visits)	EU27 countries with coastline	Estimation of aggregate expenditure by visitors based on meta-analysis	31,393.5	
	Recreation (water quality)				
	– health risk	EU27 countries	Representative WTP for avoidance/remediation grossed up by population	15,327.0	
	– eutrophication	EU27 countries	Representative WTP for avoidance/remediation grossed up by population	40,342.0	
Indirect use	Carbon storage – salt marshes	Total saltmarsh area in EU27	Marginal damage cost avoided	0.6 - 297.5	
	Carbon storage – seagrass	Mediterranean *Posidonia oceanica*	Marginal damage cost avoided	31.4 - 1,095.3	

Good scope coverage and reliable valuation base

Poor scope coverage **or** unreliable valuation base

Poor scope coverage **and** unreliable valuation base

Table 2.5. EU FP7 Knowseas summary of ecosystem service valuations by regional sea (sourced with permission from Cooper *et al* 2011).

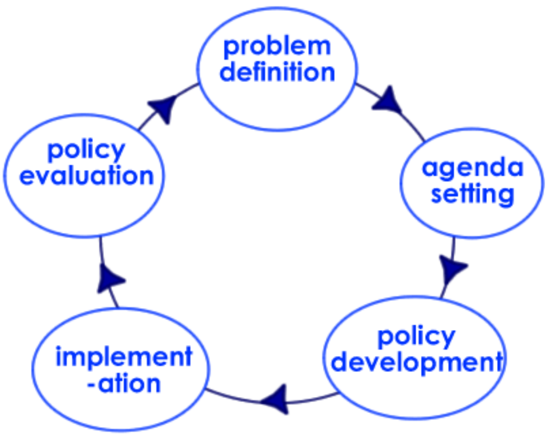
Type of value	**Sector/Activity**	**Value/€2010'm p.a.**				
		NEA	**Baltic**	**Mediterranean**	**Black**	**Total**
Direct use	Energy	114,362.4				114,362.4
	Fisheries – capture	6,062.0	347.2	2,262.4	3.4	8,675.0
	Fisheries – mariculture	4,305.1		1,210.1		5,515.2
	Freight transport					
	low median estimate	6,728.9	451.1	6,344.7	220.8	13,745.5
	high median estimate	30,527.3	2,046.5	28,784.2	1,001.6	62,359.6
	Recreation (visits)	12,566.1	3,605.5	15,204.5	17.4	31,393.5
	Recreation (water quality)					
	– health risk	5,855.0	212.0	7,723.0	1,537.0	15,327.0
	– eutrophication	23,226.0	12,134.0			40,342.0
Indirect use	Carbon storage – salt marshes					
	low end estimate	0.3	0.1	0.2	~0	0.6
	high end estimate	148.0	24.7	119.8	5.0	297.5
	Carbon storage – seagrass					
	low end estimate			31.4		31.4
	high end estimate			1,095.3		1,095.3
Indicative total (for comparison of seas only)	low end total	173,105.8	16,749.9	36,827.3	2,709.6	229,392.6
	proportion	**75.5%**	**7.3%**	**16.0%**	**1.2%**	**100.0%**
	high end total	197,051.9	18,369.9	60,450.3	3,495.4	279,367.5
	proportion	**70.5%**	**6.6%**	**21.6%**	**1.3%**	**100.0%**
	excluding energy, high end total	82,689.5	18,369.9	60,450.3	3,495.4	165,005.1
	proportion	**50.1%**	**11.1%**	**36.7%**	**2.1%**	**100.0%**

2.6.3 Policy recommendations from current research

The view from recently completed research projects (e.g. Knowseas)[6] is that the MSFD, and subsequently UK and devolved marine policy, requires integration of the value of marine ecosystem services into decision-making, so that policies are designed to achieve sustainable management of these ecosystems. To mainstream ecosystem services into decision-making requires understanding of provision of ecosystem services, understanding how ecosystem services benefit human well-being through different valuation metrics, and creation of incentives for sustainable ecosystem services through policy and governance reform.

It is clear that there are currently significant knowledge gaps relating to how the values of nature are used in decision-making. One reason that valuation is problematic, particularly in coastal and marine environments, is that it is difficult to organise information to represent interactions between different forms of capital (assets that generate value). As identified in the Knowseas project, natural capital (provided by ecosystems), financial capital (held by economic sectors) and social capital (individuals and communities) each has its own currency and responds to, and recovers from, changes over different timescales. These forms of capital, represented by our attempts at valuation across different metrics, do not often overlap in the decision making context. With the emergence of a range of inter-disciplinary ecosystem services projects and data, these interpretations and connections are increasingly recognised. As a result, the policy system will incrementally work with and incorporate these perspectives into the decision making process but as highlighted in Appendix 4, there is considerable ground to be covered in terms of biophysical and ecological understanding, coherent and appropriate data for the UK context, coupling research outputs with policy processes, and understanding what specific information is needed where in the policy cycle.

Communicating the interactions between society and the natural environment is challenging because key messages become lost in the web of links and different currencies used to measure values. While effort is placed on reducing complexity by focusing on the measurement of individual services, it is important to clarify that the sum of ecosystem services is often greater than the parts. In the VNN Coastal project, a finding from the valuation research is that the approach adopted has served to emphasise that basic ecosystem processes that underpin ecosystem services are fundamentally 'valuable' in their own right (for example the provision of life support systems) and that the total monetary economic value (related to the sum of the flow of ecosystem services) will always be less than the total system value.



Despite the issues with a lack of evidence, monetary, non-monetary and shared social values are increasing in scope and delivery with most evidence accruing to monetary estimates. All forms of valuation have a place at the 'decision table' yet this is an early area of research and must work closely with the policy system to ensure that monetary approaches do not dominate. In addition, as identified in the VNN Bridge project, a two way dialogue between researcher and decision makers should seek to understand the type of valuation information that is required across different policy contexts and

[6] See the recently established website: www.msfd.eu

across the policy cycle. The policy cycle is a sequence of actions that include problem definition, agenda setting, policy development, implementation and evaluation and this cycle may use different valuation metrics at different stages. How individuals, communities and stakeholders express values concerning ecosystem services and how those values are expressed in policy and at what stage will drive the acceptance and utility of the ecosystem services approach. In addition, ethical considerations including the distribution of ecosystem services across society are important in the valuation context but to date have received little attention in research or in policy practice.

Despite the growing amount of monetary valuation evidence this is not meeting or matching the needs of decision makers. Current research (VNN Bridge) suggests that this is in part due to a lack of dialogue between researchers and decision-makers on evidence needs and shortcomings in valuation to fully account for the complexities of social-ecological systems. This report endorses the view that research on ecosystem services needs to work in three interlinked spheres 1) connecting biodiversity, ecological function and service flows in the marine environment; 2) improving the coverage of valuation data in the UK and across all metrics including monetary, non-monetary, and shared deliberative approaches; and 3) understanding how different forms of valuation can be used in the policy cycle and at what stages it is effective and useful for decision makers.

3 Understanding the Ecosystem Approach in the marine environment

3.1 Background to the Ecosystem Approach

The Ecosystem Approach is a term now frequently found in research, management and policy literature relating to natural resource management. At the most general level, the approach aims to consider impacts on the wider ecosystem, rather than on a sector by sector basis (Grumbine 1997, Arkema *et al* 2006). Because of these ambitions, in the last three decades the Ecosystem Approach has increasingly been incorporated into policy and management documents aimed at promoting long-term sustainability of resource use and the environment (Grumbine 1994, Grumbine 1997).

Many alternative approaches exist in planning and decision-making which incorporate some of the principles and aspirations of the Ecosystem Approach. For example Strategic Environmental Assessment, Environmental Impact Assessment, Social Impact Assessment, and Sustainability Appraisal all look at the wider impacts of a project or policy. The Ecosystem Approach is intended to compliment these, with a holistic scope and a broad context to identify individual and cumulative effects and impacts on the wider system as part of a decision making process.

With increasing use of the term 'Ecosystem Approach', has come a rise in related terms, often with a variety of meanings attached to their use (Grumbine 1994, Grumbine 1997, Curtin and Prellezo 2010). For example, it has been used to refer to ecosystem assessments, systems approaches to management, ecosystem-based thinking and general holism.

The Convention on Biological Diversity (CBD) is perhaps the most well-known exponent of the Ecosystem Approach. Its concept as summarized in the 12 "Malawi Principles", advocates holistic, equitable and sustainable resource management (CBD SBSTTA 2000). This incorporates and builds on goals and insights derived from other fields and environmental sectors, such as the need to decentralise resource management and take into account broader forms of knowledge. Since the development of the CBD concept, the term has become increasingly popular, but its use is not always associated with the CBD's definition. This has led to the specifics of the Ecosystem Approach being altered in both terrestrial and marine contexts, or developed independently of the CBD process. The last point is particularly relevant in the case of some marine sectors, as 'ecosystem' type approaches have been around for decades within fisheries management and the principles are now recognised within fisheries legislation (Kempf 2010, Joji 2008).

3.2 Benefits of the Ecosystem Approach

The Ecosystem Approach in its broadest sense has several advantages over other approaches to natural resource management. First, it tends to consider ecological, economic and social considerations within a single framework (Grumbine 1997) helping to identify potential conflicts, interactions and trade-offs from the outset. Second, rather than setting humans aside from their environment, it recognises that humans, with their cultural diversity, are an integral component of ecosystems (CBD SBSTTA 2000). This is reflected in the CBD Ecosystem Approach recommendation to include a wide range of stakeholders at different scales of application. Third, it places emphasis on flexible and integrated methods taken from a broad base. This makes the approach adaptable to a wide variety of situations and policy and management decision-making.

3.3 Ecosystem Approach terminologies

The Ecosystem Approach is a frequently used expression. However, the meaning of it and its variants are not always clear, often leading to confusion.

An initial literature search has shown that the terms are used in many different ways: some uses were entirely unrelated to the environmental sector e.g. Barak (2000). Furthermore, similar terms, such as "an ecosystems approach" e.g. Thorns and Sheldon (2002) or "an ecosystem services approach" e.g. Turner and Daily (2008), appeared in the search returns and were used with related meanings - sometimes even mixed within the same source for example Rouquette *et al* (2009). Furthermore, various expressions such as "ecosystem management" (Grumbine 1994) and "Ecosystem Approach" e.g. (Greer 1996, Hill *et al* 1999, Jones and Taylor 1999) have at times, been used interchangeably and with variation in their emphasis (Yaffee 1996). The central theme is the need to attend to natural processes rather than individual species. This use of the term does not however, necessarily entail a focus on social influences, or how to involve society in resource management.

To define the CBD Ecosystem Approach (or any of its variants), is not a straight forward task. When can a policy or project be determined as having taken an Ecosystem Approach? When the approach has been taken into account when planning a management regime or forthcoming policy? When all CBD principles have been applied and met? Can retrospective applications of the approach to existing projects or policies be truly termed an Ecosystem Approach?

The literature shows that there are three main uses attached to the Ecosystem Approach concept: (1) as an alternative term for ecosystem-based management, characterised by a move away from a focus on habitats and species to consider the structure and function of the natural systems that support them. Frequently this seems not to include the socio and economic parts of the system rather an adherence to natural science principles; (2) as an integrated and equitable approach to resource management as adopted by the Convention on Biological Diversity; and (3) as a term characterised by an emphasis on ecosystem goods and services and economic valuation.

Based on the case studies undertaken for this work (presented below) and the literature search, we have endeavoured to give definitions of the different terminologies being used and identify their key features. These are set out below. The search included grey literature and peer-reviewed papers. The findings were categorised within an Excel spreadsheet, and observations noted as the task progressed. Any new terminology which emerged throughout the process was added to the spreadsheet and a further search conducted. This task focussed on elucidating how these terminologies are being used in practise. It did not attempt to characterise principles (akin to the CBD EA principles) of each approach. A difficulty arose in the fact that the terms are often used very loosely (e.g. three or more different terms used to refer to the same concept in one document).

3.3.1 Terminologies identified

The following terms were identified as being used to describe some form of Ecosystem Approach. Each one was used as the basis of a search.

<u>Generic</u>

- Ecosystem Approach
- Ecosystems approach
- Ecosystem Approach to management

- Ecosystem management
- Ecosystem-based approach
- Ecosystem-based management

Sector specific

- Marine ecosystem management
- Marine ecosystem based management / ecosystem based marine management
- Ocean ecosystem management
- Ocean ecosystem based management / ecosystem based ocean management
- Large marine Ecosystem Approach
- Ecosystem-based fisheries management
- Ecosystem Approach to fisheries (management)
- Ecosystem-based marine spatial management
- Ecosystem Approach to aquaculture
- Coastal ecosystem management

3.3.2 Analysis of results

i Ecosystem Approach

The search identified that the term "Ecosystem Approach" has been used in the academic literature for more than three decades. Figure 3.1 demonstrates the literature indexed by the Google Scholar search engine in mid-2012. The term appears to have become particularly popular since the mid-1990s.

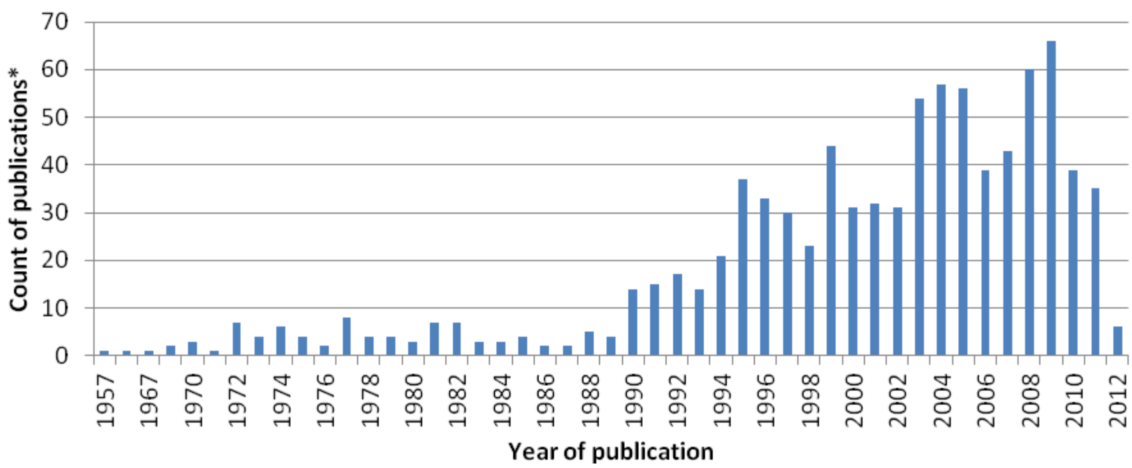


Figure 3.1. Google Scholar search engine returns for the "Ecosystem Approach" in article titles.

Note: Key limitations in interpreting this graph are that articles and sources published before the 1990s are less likely to be archived on the web. Google Scholar only makes available the first 1000 search returns.

In 2000, parties to the Convention on Biological Diversity adopted as its primary framework for action the "Ecosystem Approach" and defined it as "*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*"' (CBD SBSTTA 2000). The 12 'Malawi principles' which summarize the characteristics of the CBD approach (Table 3.1) recognise that decisions and actions to manage our environment should consider the ecological place of species and habitats in the wider landscape; and the impact of economies, human health and culture on the ability of the environment to promote a sustainable, wealthier and fairer society.

The CBD Ecosystem Approach may have several advantages over other, less integrated natural resource management methods, or other working definitions of the Ecosystem Approach. Foremost, it considers ecological, economic and social factors within a single framework helping to identify conflicts, interactions and tradeoffs from the outset. Secondly, it recognises that humans and our cultural diversity are an integral component of ecosystems, and provides a mechanism to allow greater stakeholder input rather than considering human activities aside from their environment. This is reflected in the approach's principles to include a wide range of stakeholders. Thirdly, it places emphasis on flexibility within its application and for users to tailor it to their own needs. This makes the approach adaptable to a wide variety of situations and policy and management decision-making.

Table 3.1. The 12 'Malawi' principles of the Ecosystem Approach (CBD SBSTTA 2007).

Principle	Description
1	The objectives of management of land, water and living resources are a matter of societal choice
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	Recognizing 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	Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term
9	Management must recognize 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

ii Ecosystems Approach

The findings show that there appears to be two main ways in which the term 'ecosystems approach' is being used. The first may be a general misnomer, where an article will refer to both the singular and the plural, or clearly is not being used in a different context to the singular. In general however, these articles are referring to a 'generic' Ecosystem Approach/environmental holism or the CBD approach. The other dominant use is in UK Government policy documents (largely Defra, but also the devolved administrations). Whilst the plural may be a misnomer which has been perpetuated, it may have been a deliberate attempt to offer new terminology to encompass an approach focussed on ecosystem services. There seems to be a great deal of emphasis on the ecosystem services concept (or on environmental benefits), and widespread reference to the Millennium Ecosystem Assessment and related initiatives (e.g. TEEB). This latter use of the term 'ecosystems approach' appears to be a UK phenomenon.

iii Ecosystem Approach to management

The majority of the ‘Ecosystem Approach to management’ (EAM) search results were in the context of the marine environment specifically fisheries; the National Oceanic and Atmospheric Administration (NOAA) seemed particularly prevalent in their use of this term. There appears to be little differentiation between an ‘Ecosystem Approach to management’ and ‘ecosystem-based management’. For example, NOAA use 'approach’ in the same way that 'based' is used in the other terminology - to make it more literally correct.

iv Ecosystem management

The term ‘ecosystem management’ (EM) is used too widely, and too generally, to specify or define based on a consensus of search results. The search returns made it very difficult to differentiate between EM and any other terminology, however, some offered the following (often contradictory) suggestions:

- When defining EM in the context of ecosystem-based management (EBM), the former relates to terrestrial environments and the latter marine environments.

- EM is used to refer to a holistic form of natural resource management with an ecosystem defined as an ecological unit. There is a clear trend towards the social and management principles of the CBD Ecosystem Approach within discussions of EM.

- It has been described as taking an 'Ecosystem Approach' to management, and so it is being conceptualised as the product of taking an Ecosystem Approach, as opposed to the two being separate approaches. Conversely, the search highlighted that research programmes exploring EM were ultimately concerned with ecosystem science.

- EM and ecosystem based management are essentially the same thing, however EBM is the more up-to-date and correct terminology in that it attempts to literally acknowledge that the management of actual ecosystems is not the goal, but the management of social systems.

- A number of scientific peer-reviewed papers discussed the difficulty of defining and characterising ecosystem management e.g. (Arkema *et al* 2006, Curtin and Prellezo 2010).

v Ecosystem-based approach

The results indicate that this term is not being used to refer to a particular sectoral approach, but as a general concept that could be used in the context of most of the other terminologies listed here (much like ‘Ecosystem Approach’ is often used). The majority of the search returns related to ecosystem-based *management* of fisheries (not an ‘ecosystem-based approach to fisheries’). Many of the articles and reports identified discussed taking an ‘ecosystem-based approach to management’ contrasted against a ‘traditional sectoral approach’. The meaning of taking an ecosystem-based approach was varied – some search returns referred to the CBD Ecosystem Approach, others to generic sustainable development principles, and others to ecological perspectives.

vi Ecosystem-based management

The findings have shown that since the 1980s and 1990s, ecosystem-based management (EBM) has been an increasingly dominant paradigm within the conservation literature. This refers mainly to the position that, since ecosystems are complex systems with multiple feedback loops and interactions, we cannot manage individual species in isolation (Slocombe 1993). Furthermore managers must deal with uncertainty and complexity via adaptive management (Johnson 1999).

The majority of search returns for ‘ecosystem-based management’ were related to a coastal or marine context, confirming the assertion made earlier. However, the assertion that EM and EBM are distinct in that EM is more concerned with 'ecological management' (as made in peer reviewed results) did not ring so true. Where EBM was defined, definitions rarely reflected a marine context and were thus indistinguishable from EM definitions. The definitions provided were generic in nature e.g.

“…… *EBM involves two changes in how management is practiced: (1) each human activity is managed in the context of ALL the ways it interacts with marine and coastal ecosystems, and, (2) multiple activities are being managed for a common outcome. To describe this, the terms ecosystem-based management and Ecosystem Approach (EA) are often used interchangeably, and they mean generally the same thing*” (UNEP 2011).

Overall, the key idea is the need to attend to natural processes rather than individual species. As such, the ecosystem-based management term does not necessarily entail a focus on social influences, or how to involve society in resource management. However, some peer reviewed interpretations do explicitly advocate interdisciplinarity, and building a shared vision between natural resource managers, scientists and the public e.g. (Szaro *et al* 1998).

vii Marine ecosystem management

‘Marine ecosystem management’ does not appear to be a concept developed in its own right – i.e. one with a particular definition and associated principles. The search indicated that it is either being used simply to refer to ecosystem management in a marine environment, or as an overarching term to encompass the different ways one might go about applying an Ecosystem Approach in the marine environment.

viii Marine ecosystem based management / ecosystem based marine management

This does not appear to be a developed concept. The search results were largely the same as those returned in the generic ecosystem-based management search. These indicated that it is typically being used to refer to ecosystem-based management in the marine environment, or as an overarching term to encompass different Ecosystem Approaches. There was one result which discussed ‘MEBM’(Michigan 2012) and defined the term in a marine context, however further discussion provided was on generic EBM (non-sectoral).

viiii Ocean ecosystem management

There were very few search results for the term ‘ocean ecosystem management’. Its use appears to be generic, in that it is a description of what is being discussed, but with no associated conceptual background (e.g. an ocean, as opposed to land ecosystem management approach). The exception to this was an initiative in California which consistently used the expression (COPC 2010). The concepts associated with the term appeared to be no different to those which use other terminology.

x Ocean ecosystem based management / ecosystem based ocean management

There were almost no search results for these terms, and is clearly not a conceptual strand in itself. Where it was used, it was a general description with no associated conceptual background.

xi Large marine Ecosystem Approach

The majority of search results for this term were academic discussions. The term delineates a particular approach using ecologically defined units. However, this is a strategy for EM (with developed tools and principles), and in more recent years it seems that is being more often discussed as a means of taking forward the fuzzy concept of E(B)M. Perhaps it could be viewed as the CBD Ecosystem Approach for the sea? There has been some discussion on the evolution of the concept, see for example Juda (1999) and Sutinen *et al* (2005). Although the LMEA incorporates 'modules' for socioeconomic assessments, these have received much less attention than those concerned with natural systems. It seems that the approach has, until recently, been a way of dividing geographical units of the oceans – a number of the academic papers discussing implementation discuss the unit of management as a LME, but make no reference to the tools provided when they argue for the need to implement EBM within that management area. With discussions on Ecosystem Approaches escalating, the search results demonstrate debate of the two intertwined concepts in concert with one another, and more effort to apply LME strategy to particular management problems such as fisheries (as opposed to simply taking an LME approach following recognition of anthropogenic degradation of the marine environment).

xii Ecosystem-based fisheries management

This is a term that has both significant discussions in academia and policy as well as local implementation. There were a large number of scholarly results, compared to less specific terms. Notably, many results were related to NOAA; the majority being from America in general. Much of this discussion covered EBM in a fisheries context, as opposed a more evolved self-defined concept. There is notably less discussion on principles (than what there was with non-sector specific terminologies), and a great deal of biological, ecological and biophysical discussion. What is being highlighted is that ecosystem-based fisheries management is more appropriate than taking a single species approach. According to Hilborn (2011) "*different people see EBFM very differently. One view holds that EBFM involves a reasonably simple inclusion of concerns regarding by-catch, forage species and habitat modification into traditional single-species management*". A second view of ecosystem-based fisheries management centres on trophic-connectivity, accounting for species interactions using ecosystem models rather than single-species models. The most comprehensive view encompasses the broad impacts of society, such as land use, national economic policy and human population growth when managing marine ecosystems" (Hilborn 2011). Most of the search results are examples of the second view. Notably these examples have in the main not been linked to more contemporary thinking, such as the CBD Ecosystem Approach. There was consensus in the scientific peer reviewed returns for agreement on what Ecosystem-based fisheries management should entail.

xiii Ecosystem Approach to fisheries (management)

The most frequent source of results an Ecosystem Approach to fisheries search was from the Food and Agriculture Organisation of the United Nations (FAO), with many of the other results making reference to their work. The term was adopted by the FAO in 2002 because of the parallel this offers with the precautionary approach, and that the term EAF is not narrowly limited to management. Instead it could be used to incorporate development, planning, and food safety, better matching the breadth of the FAO Code of Conduct (FAO 2003).

There appears to be more reference to the CBD Ecosystem Approach (when compared to EBFM). The results highlight desirable outcomes as being improved ecosystem and social 'well-being'. A report on EBFM by Link (2002)makes the point "*The argument has polarized at two extremes: either one can approach management from the perspective of the entire* *ecosystem, or from a single species approach that is cognizant of broader ecosystem considerations*". The majority of the search results for EBFM seem to reflect the latter, whilst EAF reflects the former.

xiv Ecosystem Approach to aquaculture

'Ecosystem Approach to aquaculture' results were largely comprised of FAO returns, many of which were discussing the same FAO document (FAO 2010). The approach appears to be in the early stages of development with workshops taking place to discuss suitable frameworks. Implementation appears to be minimal, as agreement on tools for implementation had not been reached. The FAO began its development of 'Ecosystem Approach to aquaculture' in 2006 and states that it:

"… strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems including their interactions, flows and processes and applying an integrated approach within ecologically and operationally meaningful boundaries" (FAO 2013).

xv Ecosystem-based marine spatial management (EB-MSM)

The results for this search were dominated by peer reviewed papers written by the same few authors (Douvere, Ehler and Katsanevakis), and published by UNESCO as part of their 'Marine Spatial Planning Initiative', which:

"…*is to help countries operationalize ecosystem-based management by finding space for biodiversity conservation and sustainable economic development in marine environments…*"

Where case studies have been presented they envision EB-MSM to be a way to integrate all marine sectors into an Ecosystem Approach. Outside of the dominant UNESCO discussion, other results included the Hellenic Centre for Marine Research; Helcom; CBD; an online portal on Ocean Renewable Energy; and the East Asian Seas Congress 2012. Although each of these discussed EB-MSM and in some cases defined it, the papers they referred to and used in their arguments were actually references to more general ecosystem based management discussions not EB-MSM e.g. Arkema (2006). Katsanevakis *et al* (2011) did offer an explicit EB-MSM definition: "*….an emerging paradigm of ocean management, which is being promoted by institutions worldwide as the best way to ensure the sustainability of marine ecosystems and their services to humans, and to deal with conflicts among various users of the seas*".

xvi Coastal ecosystem management

The results of this search indicated that the term is being used simply to refer to the concept of ecosystem management in a coastal environment. A coastal ecosystem management conceptual strand does not appear to exist in its own right. The majority of the results pertained to 'science for coastal ecosystem management' and the primary concerns were biophysical factors and coastal engineering. Notably it was frequently mentioned in the context of conservation initiatives in developing countries.

3.3.3 Terminology summary

Although there are many different phrases used to describe the Ecosystem Approach there is little distinction to be made between them; in general they are used interchangeably to mean the same thing. Ecosystem based management and ecosystem based fisheries management seem to have the longest academic paper trail whilst the CBD Ecosystem Approach, FAO Ecosystem Approach to Fisheries Management, FAO Ecosystem Approach to Aquaculture and NOAA Large Marine Ecosystem Approach appear the most solid 'entities'.

What is emerging is that when the terms ecosystem and management, with various combinations of 'based' and 'approach', fisheries and marine examples are coming forward first, with the terminologies being used interchangeably between contexts, and indeed in the same context, to refer to the same thing.

What we can infer from the findings is that the Malawi principles are compatible in part with EBM, since it does not appear to be specific to single sectors or species but instead support adaptive management of ecosystems, taking into account ecosystem processes and links over space and time (e.g. principles 3, 7 and 8). However, other Malawi principles also relate to involving and empowering stakeholders across levels (e.g. principles 1 2 10 11 12) reflecting some of the latest arguments about how different stakeholder groups should be involved and the value of different forms of knowledge. These latter principles are less likely to be found in an EBM approach and highlight a significant difference to EBM. The arguments for stakeholder involvement are long-standing, and thought to bring a variety of substantive, procedural and normative benefits to natural resource management outcomes (Blackstock and Richards 2007). So perhaps the individual elements of the CBD Ecosystem Approach are not unique in themselves, but its strength may lie in that no other single resource management approach addresses all 12 Malawi principles. To further this, Table 3.2 explores how the Malawi principles may be prioritized by some other selected approaches to natural resource management. This analysis is preliminary and only illustrative, since there are many other resource management concepts and further work would be required on this.

So, at present, nearly any diverse initiative to do with understanding ecosystems, or working with ecosystem services, is being labelled as an 'Ecosystem Approach'. This can be seen positively: a diversity of ideas can be valuable and reflect a healthy evolution in ideas and thinking. Furthermore, enthusiastic adoption of the term can be seen as encouraging for proponents of sustainable resource management. Conversely, the use of multiple terms may be confusing for stakeholders, reduce buy-in and result in the overall dilution of the concept.

Table 3.2. A preliminary analysis of the extent to which selected approaches within the environmental and natural resource management sector may reflect the 12 'Malawi' principles of the Ecosystem Approach as defined by the CBD (2007).
Definitions and details of each of these approaches are provided by the references.

12 'Malawi' Principles	**Community based natural resource management (CBNRM)**	**Ecosystem service approach (ESA)**	**Integrated catchment management (ICM)**	**Ecosystem based management (EBM)**	**Integrated coastal zone management (ICZM)**
Management objectives are a matter of societal choice.	♦		♦		♦
Management should be decentralized to the lowest appropriate level.	♦				
Ecosystem managers should consider the effects of their activities on adjacent and other ecosystems.		♦	♦	♦	♦
Recognizing potential gains from management there is a need to understand the ecosystem in an economic context….		♦			
A key feature of the Ecosystem Approach includes conservation of ecosystem structure and functioning.		♦	♦	♦	
Ecosystems must be managed within the limits to their functioning.		♦		♦	♦
The Ecosystem Approach should be undertaken at the appropriate scale.	♦	♦	♦		
Recognizing the varying temporal scales and lag effects which characterize ecosystem processes…. [set long term objectives]		♦	♦	♦	♦
Management must recognize that change is inevitable.			♦	♦	♦
The Ecosystem Approach should seek the appropriate balance between conservation and use of biodiversity.	♦				
The Ecosystem Approach should consider all forms of relevant information…..	♦				♦
The Ecosystem Approach should involve all relevant sectors of society and scientific disciplines	♦		♦		♦
Reference examples	Shackleton *et al* (2010).	Turner and Daily (2008).	Marshall *et al* (2010).	Clarke & Jupiter (2010).	Haines-Young & Potschin (2011).

3.4 Overview of the Ecosystem Approach in Marine Policy

A literature search has identified a snap shot of marine policies, agreements and management measures using some form of Ecosystem Approach terminology. Mostly, these have been limited to those that have the Ecosystem Approach as a central concept. Those with similar characteristics, but without explicitly making reference to Ecosystem Approach terminology are too numerous to search and review exhaustively and are not thought to offer value over and above those which make specific reference.

Due to the nature of this task, this section is limited to an overview of the results showing the breadth of incorporation of the Ecosystem Approach into marine and coastal literature and policy. All relevant identified examples have been compiled into an EndNote database and the examples are available in a matrix (Appendix 1).

The review of the academic literature, marine and coastal policies and management documents demonstrates that the concept of an Ecosystem Approach has been gradually incorporated into terrestrial and marine realms since the early 1980s, and that the ethos is now well established in marine management. Most contemporary marine documents including a series of international policies and legally binding instruments, make reference to the advantages of adopting an approach which takes into account wider ecosystem information to sustain long-term system health (Murawski 2007). The first global convention to adopt an Ecosystem Approach is thought to be the Convention on the Conservation of Antarctic Marine Living Resources. The Convention uses the phrase 'ecosystem-based management approach' to the management of marine living resources in the Southern Ocean. More recently, both the Marine Strategy Framework Directive and Marine and Coastal Access Act make reference to an Ecosystem Approach.

From the matrix it is clear that examples of implementing, or at least taking into consideration, some form of ecosystem management (which may or may not be termed Ecosystem Approach), can be seen at the global level, for both binding polices and management practices. Movement away from single species management to wider ecosystem management in the fisheries sector is particularly evident. The approach features prominently within the Common Fisheries Policy, the FAO Code of Conduct for Responsible Fisheries and the Oslo and Paris Conventions for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), where there is a strong commitment to its implementation (Laffoley 2004). Sectors which are further ahead in their development of ecosystem based management appear to be those with a shared or commonly held resource (such as fisheries), where the knock-on economic impacts of a reduced resource would be clearly apparent (PISCES 2010). There is however, contention in this approach. A number of authors for example Agardy (2011), differentiate between cross-sectoral ecosystem management and applying the ethos to policies within a specific sector e.g. fisheries. The authors state that while taking such an approach has made progress on maintaining or enhancing fish stocks, applying it to one sector in isolation lacks the integrated nature of a true Ecosystem Approach (Agardy 2011). Instead, ecosystem based fisheries management could be considered a vital part, sitting alongside other sector polices such as shipping and tourism, all within the umbrella of a wider Ecosystem Approach mechanism.

The review has highlighted with the introduction of the Ecosystem Approach, a drive to move away from small scale or sector specific management to larger ocean/sea based approaches. Examples of this can be seen in OSPAR, Regional Seas Programme, the Irish Sea Pilot Project, Convention on the Protection of the Marine Environment of the Baltic Sea Area, the concept of Large Marine Ecosystems, the Finding Sanctuary Project and the Firth of Clyde and Sound of Mull Pilot Projects. Each of these seeks to better manage marine resources in a large, usually clearly defined, geographical area.

The matrix identifies examples from across the world, with some countries seeming more advanced in their thinking than others. Notably the USA, Canada and Australia have embedded ecosystem management into key national marine legislation and policies (e.g. Endangered Species Act (USA), Coral Conservation Act (USA), Marine Sanctuaries Act (USA), Marine Mammal Protection Act (USA), US Ocean Commission Report-‘An Ocean Blueprint for the 21st century’, Oceans Act (Canada), and Australia’s Ocean Policy. The matrix highlights the Ecosystem Approach is being implemented at different scales from Large Marine Ecosystems to local scale projects. Interestingly, there is an example of the Ecosystem Approach in practice at the local level in Indonesia (Raja Ampat Islands). This example shows implementation of what is termed an ecosystem-based management approach. It demonstrates that in an area of poor governance, where resources and data are limited and managers have an incomplete knowledge base and understanding of the systems they are managing, an Ecosystem Approach can nevertheless progress.

Given the sheer number of potential examples to review which explicitly use some form of Ecosystem Approach terminology it is not possible to carry out a comprehensive search of these as well as those that do not use the terminology but do seem to adopt the ethos of an Ecosystem Approach. The Inner Forth Landscape study, Scotland is one such example of this. This project is in response to a number of drivers e.g. climate change, post-industrial landscape, development pressure, and a lack of public awareness of landscape change. The vision is for the landscape of the Inner Forth area where the natural, cultural and historical wealth of the area is revealed, valued, enhanced and made accessible to both residents and visitors.

3.5 Ecosystem Approach Case Studies

This section sets out case studies of the Ecosystem Approach (or variants of) in relation to marine policy and management (Table 3.3). The case studies aim to develop further insight from that gained in the previous section where an overview of the breadth of the incorporation of the Ecosystem Approach in marine policy was provided. A cross section of case studies is presented to highlight the different approaches to implementation and the terminologies used. For each case study the terminology used will be identified i.e. Ecosystem Approach, Ecosystem-based Management Approach; the method to implementation noting whether it is voluntary or mandatory; the scale at which it is being implemented as well as a review of progress to date.

Table 3.3. Case studies of the Ecosystem Approach and other ecosystem type management approaches.

Case Studies	Outline	Scale
Thanet Coast Natura 2000 Site Management	An example of where stakeholders voluntarily participated in a deliberately designed and facilitated consensus building process using the CBD Ecosystem Approach to develop a strategy for the conservation of the site.	Local
Marine Strategy Framework Directive (MSFD)	The Directive aims to achieve Good Environmental Status in Europe's seas by 2020 using an 'Ecosystem-based approach'.	EU
UK Overseas Territories	An overview is given of the degree to which the Ecosystem Approach is being implemented within the UK Overseas Territories	Mixed
Baltic Sea Region	A review of implementing the Ecosystem Approach in integrated marine and coastal management in the Baltic.	Regional Sea
Convention on the Conservation of Antarctic Marine living resources	The Convention was negotiated in the late 1970s as a result of unsustainable fisheries. The Convention uses an ecosystem-based approach.	Regional Sea

3.5.1 Thanet Coast Natura 2000 Site Management

Background: Reportedly the first process in England that deliberately addressed all 12 principles of the Ecosystem Approach for the management of a Special Area of Conservation (SAC). The work came about in recognition of the need to reconcile conflicting environmental and economic objectives arising from the Natura 2000 Management Plan. The plan set out to manage the protected species and habitats but did not consider locally important species or ecosystem processes and functions (Pound 2008). The process was designed to me*et al*l 12 principles of the Ecosystem Approach ensuring a holistic approach to managing the environment. The process ran for eight months during 2006.

Terminology used: Ecosystem Approach (as set out by the CBD).

Method to implementation: Voluntary. The project was initiated by the English Nature Project Officer for the European Marine Site and ran by external facilitators.

Scale at which it is being implemented: The SAC covers 28 miles of Kent Coast. The boundary and scale is driven by biophysical considerations, since it was designated due to its unique habitats.

Approach: Stakeholders (including resource managers, conservationists, users of the area and local people) were heavily involved in the process and were given a clear understanding of the Ecosystem Approach from the outset. As part of their involvement, stakeholder views were sought to inform future management. They were asked a number of key questions to ascertain their perceptions and preferences for the area (Table 3.4).

Table 3.4. Example of stakeholder involvement in the Ecosystem Approach (Pound 2005).

Questions	CBD EA Principle
It is 2020 and you are looking at the sea and shore delighted with what you see. What do you see?	1 & 7
What do you value now that you want people to be able to see or do in many years to come?	7
What coastal and marine plants do you value?	5
What does this coast and shore provide for us?	5
In the last 6 years what has changed for the better? What has changed for the worst?	9
Thinking about different parts of the coast and sea • What are the issues? • What is working well? • What else needs to happen?	
Ecosystem Questions • What kind of changes do you think are occurring and what evidence do you have? • Which of these changes do you think are part of natural cycles and processes? • What are the possible effects of locked in changes such as sea level rise and climate change? • Discuss possible ideas for long term objectives for the ecosystem and its function • What are the options for defining the ecosystem/s – which do you think works best? • What research is needed? • What action is needed to make this happen?	6,7,8,9

Following discussion of these questions, stakeholders were asked to consider the management and sustainability of activities which take place. Each activity had its own ‘Assessment Table’ which reviewed current management and identified where new actions were needed (Table 3.5).

Table 3.5. Example of stakeholder involvement in the Ecosystem Approach using individual activity assessment tables (Pound 2005).

Questions	**CBD EA Principle**
What is the long-term goal or vision for this activity?	1&8
What is the current situation?	
What are the current positive and negative effects of this activity on the following:	
• Social, economic and cultural interests?	1&4
• Habitats and species of local importance?	1
• Protected species and habitats?	1
• Ecosystem function?	5&6
• Other ecosystems?	3
What is the current management?	
Will it get us where we want to go?	
Can the ecosystem support this activity over the long-term? (Will you be able to do this activity at this level in 100 years if not why not?)	8
What if anything do we need to do differently?	
What is the long-term effect of what we want to do on: socio-economic and cultural interests, the environment and ecosystem function?	3, 4,5 & 6
How will we know if we are going in the right direction?	

This approach was designed to deliberately not use ecosystem service terminology due to the background of the stakeholders. Nonetheless, it did successfully elucidate information from participants on their values and preferences for the future use of the surrounding land- and seascape. Using this information the conflicts between provisioning services (i.e. fishing) and cultural services (i.e. recreation) were addressed.

The approach also used a strong interaction between both scientific and local knowledge prompting new discussion about the science needed to inform the Ecosystem Approach in a coastal context. This includes how to define the local ecosystem(s), ecosystem function, resilience and limits, the relationships with adjacent or linked ecosystems, and finding ways to distinguish natural from human induced change (Pound 2008).

3.5.2 Marine Strategy Framework Directive

Background: The Marine Strategy Framework Directive (MSFD), the environmental pillar of the Integrated Maritime Policy, aims to protect and conserve the marine environment. The Directive came into force in 2008.

Terminology used: Ecosystem-based approach

Method to implementation: Obligatory framework for community action. The Directive sets out the legal foundation for the management of Europe's seas using an ecosystem-based approach. Member States are required to transpose this into national legislation and into their own marine strategies, putting in place measures to achieve and maintain good environmental status of marine waters by 2020.

Scale at which it is being implemented: EU

Approach: The MSFD enacts the use of an ecosystem-based approach to help achieve its aims in the sustainable management of human activities which are detrimental to the quality of the marine environment. Although it is difficult to define what this means in practice, it does allude to an integrated approach to managing the various maritime sectors, as well as a reduction of the pressures on marine resources to ensure the continued delivery of ecosystem goods and services for current and future generations (Recital 2). The Directive has been dubbed the first concerted attempt by the EU to apply an ecosystem-based approach in regulation and management across the marine environment (rather than a sector based application) (Long 2011). The instrument is aimed at protecting and preserving the marine environment, preventing its deterioration or, where practicable, restoring marine ecosystems (Recital 43) (Directive 2008/56/EC).

Article 1 (3) of the Directive states that "*Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations*." Furthermore "*Programmes of measures and subsequent action by Member States should be based on an ecosystem-based approach to the management of human activities"* (Recital 44).

The text not only emphasizes the use of an ecosystem-based approach but also a balance between environmental, economic and social objectives. This inclusion provides the legal foundation to which Member States have to adhere by placing an ecosystem-based approach at the centre of their own marine management efforts. No further elaboration, however, on what constitutes an ecosystem-based approach or how it can be made operational is offered. This can be seen either as an opportunity for improved management or as a flaw in the legislation. Those holding the former view may see the MSFD and its requirement for an ecosystem-based approach as an opportunity to put in place an approach and complimentary suite of measures suited to local environmental conditions and the institutions and governance mechanisms which are in place. Conversely, holders of the latter view may see this omission as allowing Member States to modify the ecosystem-based approach thus weakening its potential to better balance the environmental, economic and social demands and objectives for the management of marine resources. Given this lack of definition, the concept maybe vulnerable to dilution, misuse, or not used at all.

The Directives' provision for the establishment of marine regions and sub regions is on the basis of geographical and environmental criteria. Furthermore in the requirement for Member States to each develop their own strategy for areas under their sovereignty and jurisdiction and achieve GES, the diversity of such areas is acknowledged. Recital 10 of the Directive states "*diversity should be taken into account at all stages of the preparation of marine strategies".* This sits well with the CBD Ecosystem Approach in two ways. Firstly, the boundaries of the marine regions are based on environmental criteria rather than administrative or political boundaries, offering a systems approach to achieving system wide improvements (GES). Many of the threats to the quality of the marine environment, both natural and anthropogenic, are transboundary in nature and in contrast to traditional management, often demand solutions at sea-basin level. The introduction of the concepts of the marine region/sub-regions is therefore a scientifically valid approach and will facilitate the application of the ecosystem-based approach. This model is consistent with the management approach advocated by the CBD Ecosystem Approach, which recommends that "*the approach should be bounded by spatial and temporal scales that are appropriate to the objectives*" (CBD EA Principle 7) (CBD SBSTTA 2000). Secondly, diversity of natural systems is recognised.

The MSFD, while ultimately putting the onus on Member States to implement an ecosystem-based approach, does provide a good basis for doing so. In line with the CBD Ecosystem Approach, the instrument acknowledges the dynamic nature of marine ecosystems which may evolve over time along with changing human activities and demands and in response to different impacts such as those attributed to climate change (Recital 34). Furthermore, the framework established by the Directive is designed to remain flexible to such changes. Principle 9 of the CBD Ecosystem Approach recognises this and states that management must recognise that change is inevitable. Furthermore, "*the Ecosystem Approach must utilize adaptive management in order to anticipate and cater for such changes and ….. consider mitigating actions to cope with long-term changes such as climate change*" (CBD SBSTTA 2000).

Some limitations do exist in the MSFD which may reduce its effectiveness (Long 2011). Notably, although the Directive has as a clear basis for the ecosystem-based approach to the management of human activities, Member States are required only to give '*due consideration'* to sustainable development (Article 13(3)). The measures which they take must be '*cost-effective and technically feasible'*; and adoption is not required where their cost '*would be disproportionate taking account of the risks to the marine environment*', provided that '*there is no further deterioration'* and the achievement of GES is not '*permanently compromised'* (Articles 13(3) and 14(4)). This aligns with CBD Ecosystem Approach in that the ecosystem should be managed in an economic context, with the caveat placed within the Directive that the costs should not be disproportionate. It identifies that current activities can continue as long as they are not detrimental to the marine environment or the achievement of GES. Where that activity is detrimental, the expectation is that the activity is stopped or negated by the adoption of measures, which may or may not be disproportionate. Unlike the CBD Ecosystem Approach however it makes no provision as to who is responsible for these costs. Principle 4 of the CBD Ecosystem Approach seeks to align incentives allowing those who control the resource to benefit and ensure that those who generate environmental costs pay (CBD SBSTTA 2000).

Additionally, a Member State is exempt from achieving GES for its marine waters where 'reasons of overriding public interest which outweigh the negative impact on the environment' exist, so long as this does not compromise the achievement of GES at the marine region level or in the waters of other Member States (Articles 14(1)(d) and (2)). Whilst this could be viewed negatively, it is in keeping with the CBD Ecosystem Approach to some extent in that it is making provisions for public interest or 'societal choice' (Principle 1).

The success of the MSFD and its ambitious targets of implementing an ecosystem-based approach will be largely dependent on political drive and the resources committed by the individual Member States in ensuring such an approach is effectively applied at the Regional level. This will need to take into account the successful coordination of any boundary disputes between opposite or adjacent states within each region or sub-region. Furthermore, its practical application will need to reflect the opportunities and constraints of Europe's marine governance. Notably issues such as the allocation of competence, the differing governance structures and the strong need for adaptive management will need to be considered by Member States in the development of their marine strategies if an ecosystem-based approach is to be successfully implemented (Farmer 2012).

3.5.3 UK Overseas Territories

Background: A comprehensive literature search was undertaken to identify examples of implementation of the Ecosystem Approach in the UK Overseas Territories. The search produced limited results.

Terminology used: Mixed

Method to implementation: Voluntary.

Scale at which it is being implemented: Mixed

Approach: A thorough literature search has identified few territory specific initiatives which make reference to an Ecosystem Approach in the management of their natural resources. Details of those identified are given below.

The **Government of South Georgia and South Sandwich Islands** policy aims to achieve sustainable fisheries in the South Georgia Maritime Zone using an Ecosystem Approach that seeks to conserve the whole of the marine environment and recognises both the Islands' significance for global conservation (including the importance of its seabird populations) and the value of its fisheries resource. These are explicitly recognised in the document South Georgia: Plan for Progress, Managing the Environment 2006-2010 (GSGSSI 2012). This provides the policy framework to conserve, manage and protect the Islands' rich natural environment, whilst at the same time allowing for human activities and for the generation of revenue. Specifically their fisheries policy aims to:

*"manage sustainable fisheries in the South Georgia Maritime Zone using an Ecosystem Approach and to conserve the marine environment" (*GSGSSI 2012)*.*

Furthermore, it states that the fisheries are managed within the wider framework of the Commission of the Convention on the Conservation of Antarctic Marine Living Resources which also advocates an Ecosystem Approach.

A new research focus being developed by the Virgin Islands Experimental Program to Stimulate Competitive Research (VI-EPSCoR) on **Integrated Caribbean Coastal Ecosystems (ICCE)** began in late 2008. VI-EPSCoR aims to promote the development of the Territory's science and technology resources through multi-disciplinary research and educational outreach programs. ICCE is an integrated island Ecosystem Approach which facilitates and supports interdisciplinary studies of terrestrial, coastal and oceanic environments, as well as the related social, health and economic impacts on island communities. The project is in response to the increasing demand for coastal resources and the cumulative threats and damage to reef ecosystems across the Caribbean. They recognise that healthy and resilient reef systems "*are paramount to continued provision of goods and services to coastal communities*" (VI-EPSCoR 2012). These services are identified as to include fisheries, conservation, tourism, coastal protection and the potential development of pharmaceuticals from marine organisms. The initiative is being led by an advisory board with members having expertise in various reef conservation areas. It makes no mention of wider stakeholder or community input.

A number of regional initiatives also exist which encompass some UK Overseas Territories within the geographical scope of the project. One such example is the development of the **Pacific Islands Regional Coastal Fisheries Management Policy and Strategic Actions** (Apia Policy). The policy was developed and endorsed by Heads of Fisheries in the Pacific Region during 2008. The policy emphasises the need to "*manage coastal fisheries on an ecosystem basis…including the coastal systems that support fisheries and must involve a wider range of government agencies and stakeholders*" (Community 2008). This regional initiative aims to address the long term sustainability of coastal fisheries resources and maintain healthy marine ecosystems. Wider activities are recognised to impact on fisheries, hence the need to manage stocks on an ecosystem basis. This policy uses both the terms ecosystem-based fisheries management and community-based fisheries management in acknowledgment of the fact that fisheries management needs to manage human activities, not fish stocks. Guidelines have been produced on how the two approaches can be merged to ensure a high degree of stakeholder and community participation. Much of the ethos of the CBD principles are covered in the Apia Policy including the need for adaptive management, the use of geographical boundaries rather than administrative ones, stakeholder engagement, recognition of the benefits provided to humans from the environment and understanding the limits of the ecosystem.

3.5.4 HELCOM Baltic Sea Action Plan

Background: HELCOM is the governing body of the EU Convention on the Protection of the Marine Environment of the Baltic Sea Area, also known as Helsinki Convention. Signed in 1974 and entering into force in 1980, the Convention aims to reduce all of the sources of pollution around an entire sea area. A further Convention signed in 1992 expanded this to include all land based sources of pollution. In 2007 HELCOM adopted an overarching action plan, the Baltic Sea Action Plan, to restore the good ecological status of the Baltic Sea by 2021.

Terminology used: Ecosystem Approach

Method to implementation: Voluntary agreement, no sanctioning mechanisms.

Scale at which it is being implemented: Regional Sea

Approach: HELCOM works to reduce pollution through regional cooperation between the Baltic States including setting of the policy agenda and environmental recommendations as well as coordinating the regional response to environmental threats. This regional approach is in accordance with the CBD Ecosystem Approach where ecosystems should be managed on appropriate scales, being ecologically focussed rather than constrained by administrative boundaries. The Baltic Sea Action Plan (BSAP) aims to implement the Ecosystem Approach and contribute to the implementation of the CBD in the region. HELCOM note that the Baltic Sea Action Plan is one of the first systems to implement the Ecosystem Approach to the management of human activities. It sets a target of achieving good ecological status in the Baltic Sea. The plan sets out actions to reduce eutrophication, prevent pollution, improve maritime safety, and halt both habitat destruction and the decline in biodiversity.

In 2003, HELCOM and the OSPAR Commission jointly adopted a Statement on the Ecosystem Approach to the Management of Human Activities. The statement recognises the provision of benefits, including the intrinsic value gained from the oceans and seas and the contribution this makes to our well-being. This is in keeping with the overall aim of the CBD Ecosystem Approach which promotes the sustainable use of resources in an equitable manner. Furthermore the Statement (and its title) explicitly alludes to an approach which manages human activities and impacts, not the ecosystems themselves.

Section 4 of the Statement sets out the components of the approach to include:

a. *managing human activities in order to respect the capacity of ecosystems to fulfil human needs sustainably;*
b. *recognising the values of ecosystems, both in their continuing unimpaired functioning and specifically in meeting those human needs;*
c. *preserving or increasing their capacity to produce the desired benefits in the future* (HELCOM 2003).

It goes on to provide a definition of 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 marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity*" (HELCOM 2003). Specific mentions are also given to the Ecosystem Approach in the Action Plan, reiterating and providing substance to the jointly adopted Statement.

The Statement and the subsequent Action Plan sets out the importance of stakeholder engagement in achieving the aims of the HELCOM and OSPAR Commissions, not only in informing stakeholders but to ensure their representation and buy-in. Interestingly, this will be achieved "*in ways more readably understood by the representatives of stakeholders*" (HELCOM 2003) perhaps noting the difficulties in getting buy-in to an approach and its terminology many struggle to understand.

The Action Plan itself is based on a clear set of 'ecological objectives' similar to that of the MSFD. The Plan is aligned with the goals of the MSFD and has expanded the expertise of HELCOM beyond its traditional focus on eutrophication towards a more holistic approach including an increased component of fisheries and biodiversity (Commission 2010). The Plan also has strong links with other regional and global processes such as EU Baltic Sea Strategy and the Common Fisheries Policy.

The Baltic Sea Action Plan appears to be in accordance with the CBD Ecosystem Approach in a number of ways. Firstly, its strive for comprehensive stakeholder participation, using many different forms of knowledge from science to local communities and secondly in its recognition of the need for adaptive management. A HELCOM Ministerial meeting is scheduled for 2013 where the implementation of the BSAP will be evaluated, including the effectiveness of the Plan and the progress made towards achieving GES. Based on this assessment, the BSAP will be adjusted and targets updated where this is felt necessary (Korpinen 2012). Finally, taking a systemic approach to defining a vision, objectives, environmental targets and indicators is identifiable as characteristic of the Ecosystem Approach (Backer *et al* 2010).

While HELCOM has managed to attain environmental targets, it is not an executive body with the power to carry out or enforce actions. In order to expedite the environmental goals of HELCOM, the Baltic Sea Action Group (BSAG) was founded in 2008 with the aim of delivering actions to improve environmental quality in the Baltic and achieve the regionally agreed goals of HELCOM and its Action Plan. The BSAG distributes, facilitates and coordinates financing for actions to improve the environmental status of the Baltic Sea but does lack sanctioning mechanisms. In relation to this, some authors feel the implementation of the Ecosystem Approach has not been successful in all areas. Gaia (2010) state that "regarding the goal of the Baltic Sea area becoming a model of good fishery management based on Ecosystem Approach its completion seems to be in the distant future". Other factors limiting the success to date is the cultural diversity of the Baltic area, where a number of countries place a lesser emphasis on environmental issues (Osterblom 2010); lack of progress in changing behaviour; and the complex sectoral frameworks and political structures. Backer *et al* (2010) note the criticism received by the BSAP because of its inclusion of targets and actions to be carried out by HELCOM under the auspices of separate frameworks. It does however appear to carry momentum to achieve these actions.

3.5.5 Convention on the Conservation of Antarctic Marine Living Resources

Background: The historic unsustainable 'boom and bust' approach of Antarctic fisheries led to growing concern within the Antarctic Treaty nations over the management of fishing activity. Central to this concern was the development of the krill fishery. The Convention on the Conservation of Antarctic Marine Living Resources (hereafter 'the Convention') was negotiated in the late 1970s as a result of this concern. The Convention was concluded in 1980 and entered into force in 1982. The Commission of the Convention (CCAMLR) was the first regional fishery management organisation to recognise and attempt to implement the Ecosystem Approach (Constable 2000, Hewitt 2000).

Terminology used: Ecosystem-based management approach

Method to implementation: Binding for contracting States.

Scale at which it is being implemented: The Convention area covers approximately 10 percent of the Earth's surface, and is defined in the Convention as the area south of the Antarctic Convergence.

Approach: The text of the convention alludes to the commitment to an Ecosystem Approach. Article I (2) and Article I (3) highlight the application to marine species within the Antarctic ecosystem (CCAMLR 1980):

Antarctic marine living resources means the populations of finfish, molluscs, crustaceans, and all other species of living organisms, including birds, found south of the Antarctic convergence.

The Antarctic marine ecosystem means the complex of relationships of Antarctic marine living resources with each other and with their physical environment.

Article I lays the foundation for the Convention as a management regime for the regulation and rational use of fisheries resources combined with an Ecosystem Approach (CCAMLR 2001a, Kock 2000). This ecosystem management mandate distinguishes the Convention from other multilateral, single species based fisheries agreements (Constable 2000, Kock 2000, CCAMLR 2001b). CCAMLR represented the first 'pro-active' fisheries regime established with a mandate to regulate across the ecosystem range, and specifically include the effects upon target, dependent and associated species.

Article 1 of the Convention established the foundation of an Ecosystem Approach with Article 2 setting the specific operational objectives for management. Article 2 states (CCAMLR 1980):

1. The objective of this Convention is the conservation of Antarctic marine living resources;
2. For the purposes of this Convention, the term 'conservation' includes rational use;
3. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:
(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;
(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in subparagraph (a) above; and
(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem, which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

The Convention objectives are markedly different from the traditional objectives for fishery conventions. The negotiations were in a climate of biological research and concern over ecosystem impacts, and resulted in a strong set of ecosystem-based objectives. Article II (3a) prescribes the maintenance of the target species by ensuring the stable recruitment of stocks. This is achieved by preventing the population falling below a level that allows the maximum annual increment of recruits (CCAMLR 1980, Kaye 2000). Maintenance of the target species is expanded in 3(b) to include the maintenance of the ecological system:

taking into account the relationships between the target species and the broader ecosystem. When harvesting the target species, management measures must take into account species that are ecologically related, including non-commercial species such as seabirds. Reference is also made to the restoration of depleted populations to stable levels (Kaye 2000).

Furthermore Article II (3c) calls for a precautionary approach with the prevention of changes, or minimisation of the risk of changes in the marine system in the context of broader environmental change, harvesting activities, introduced species, and uncertainty of data. The development of precautionary measures enables CCAMLR to minimise the risk of long-term effects on the ecosystem and take uncertainty into account when making decisions. CCAMLR, through Article II, focuses on ecosystem-based management and the precautionary approach, both cornerstones of sustainable development within fisheries. Parkes (2000) describes how a substantial proportion of the work performed by CCAMLR pre-dates the application of the precautionary approach in modern fisheries management. Despite no mention of the term in the Convention text, activities under CCAMLR are in accordance with the intent of the principle.

While CCAMLR was formed on an Ecosystem Approach and developed an innovative boundary, recent work has recognised that in addition to cetaceans, other marine resources such as lanternfish, Patagonian toothfish, squid, and seabirds cross the northern boundary of the Convention Area in significant numbers (Willock 2002). The trade of commercial species occurs outside CCAMLR influence, yet this pressure often determines the status of species within the convention area, which may jeopardise their aim of an ecosystem-based management approach. Many important issues related to the management of Southern Ocean resources and broader economic influences can only be tackled in collaboration with external regimes such as the CITES (Willock 2002). Over time, CCAMLR has developed a set of innovative tools to manage the living marine resources of the Southern Ocean within an ecosystem context. The challenges to this task have been formidable, especially within the context of political and economic pressures that arise with decision making between 24 national governments and an initial scientific foray into conceptual ecosystem management. The scope of the management domain, the entire Southern Ocean, and its jurisdictional challenges, has presented a unique aspect on the management of multiple marine resources in a regional context. Despite these challenges, CCAMLR has developed a comprehensive regime for monitoring, research and decision making for fisheries within an ecosystem basis, as prescribed by Article II, at a time when fishing conventions had little experience.

3.6 Implementation of the Ecosystem Approach in UK Marine Policy

This section focuses on how the Ecosystem Approach can be better implemented, rather than the approach to integration covered in previous sections. The approach and findings of experts working in the field will help identify barriers to the implementation of the Ecosystem Approach in UK policy directly from those tasked with its application. Two resources are being used to form the mainstay of this section including an Ecosystem Approach workshop report and expert input.

3.6.1 Workshop report- Model Ecosystem Framework project: issues for the implementation of the Ecosystem Approach

The Model Ecosystem Framework project (led by the Macaulay Land Use Research Institute) aimed to develop, test and refine the concept of an ecosystem framework, based on an Ecosystem Approach, into a workable methodology for Scottish conditions depicted in a field guide. Two workshops were held with stakeholders and potential users of the field guide. The aim of the workshops were to encourage participants (one with national and strategic level stakeholders and the other operational level local authority, or local agency, staff) to think about how they might use the Ecosystem Approach; to evaluate the draft field guide; and to synthesise different views from potential users of the Ecosystem Approach to feed into the drafting of the project output. Whilst the focus of these workshops was not marine, it is felt valuable insights were gained which relate to the task posed here by JNCC. At both workshops, people were positive about the need to embrace the Ecosystem Approach and its potential for improving how we protect, maintain or enhance natural environments. A number of implementation barriers however, were raised by participants. These are outlined briefly below.

The first point concerns making it explicit why stakeholders would want to adopt this approach. Some felt it would require it to become statutory; or at least be considered normal 'best practice' otherwise any approach that goes beyond standard practice would be open to legal challenge by developers. Others felt that if the Ecosystem Approach became statutory, it may undermine the whole ethos of the approach and lead to minimalism or a tick box approach. Avoidance of tokenism is best achieved by demonstrating that the Ecosystem Approach can make a difference. All participants were agreed on the need to 'sell' the approach and point out the 'opportunity costs' of not adopting. For example, its adoption could save time and resources by preventing conflicts with stakeholders. Using real life examples will make a case for the approach as a solution to existing problems. It is important to demonstrate that the same basic approach is flexible enough to be used in different circumstances. The Ecosystem Approach formalises integrated planning; however, there are still challenges of undoing 'silos' within and between departments.

The second, related, point was a suggestion to focus on getting the principles of the approach embedded in the way policy makers and practitioners think and then the interest will follow. If a voluntary approach is used, those reviewing policy implementation need to be influenced and encouraged to adopt the Ecosystem Approach as "good practice".

Following on from points one and two, it is important to illustrate where the Ecosystem Approach is supporting current practice and using existing information e.g. how it can link to existing procedures for example Environmental Impact Assessment and Strategic Environmental Assessment. But it is also important to show how the approach offers a new dimension to current practice.

The third point is related to capacity to implement the approach. Concerns were raised about the availability of resources, and the capacity of actors involved. Rolling out the approach will require capacity building. Implementing the Ecosystem Approach is not something that can be done by one individual; as it is about sharing and using many sources of knowledge and expertise. However, participants felt that involving people does not always make things easier; or lead to 'best outcomes'. The Ecosystem Approach will need better tools, better data and better capacity to interpret and use analysis. All stages will be constrained by best available information. It will also need a new institutional framework to facilitate access to data and to expert knowledge. The presentation of the Ecosystem Approach is important – it should be promoted as an opportunity not a further hurdle or constraint.

The fifth point relates to where the approach should be implemented. Many felt the strengths emerged at the regional level or for individual but large scale developments; as it helps look 'up' to national policy and 'down' to individual sites and projects. If the approach could gauge the cumulative impact of small scale developments, this would also be very useful. This is where the Ecosystem Approach differs from existing approaches such as Environmental Impact Assessment.

3.6.2 Expert input via virtual panel

A virtual expert panel was convened to feed into this review. This consisted of 12 academic and policy experts from across the UK who are currently engaged in the application of the Ecosystem Approach within their own organisations as well as participants with involvement in wider projects. Examples of these include the NERC Valuing Nature Network, UK National Ecosystem Assessment and European funded work such as Knowseas-a project looking at the application of the Ecosystem Approach to the sustainable development of Europe's regional seas.

A virtual platform (Webex) was used to facilitate the panel discussion. It is hoped the approaches used and the lessons from those working in the field will help identify barriers to implementation of the Ecosystem Approach in UK policy directly from those tasked with its implementation. This section is set out around the questions posed to the panel.
Specific organisations represented in the panel include:

- Natural England
- Dialogue Matters
- Scottish Association for Marine Science
- Argyll and Bute Council
- University of Exeter
- University of Hull
- Marine Management Organisation
- Scottish Natural Heritage (input to be provided out with the virtual panel)

3.6.3 What is the Ecosystem Approach

i How do you/your organisations define and practice the Ecosystem Approach?

The wording used to define the Ecosystem Approach varied within the group, though largely there was consensus over its concept. Participants see the Ecosystem Approach as an integrated resource management framework taking into account the broader environment. Managing human activities as the focus of an Ecosystem Approach was mentioned explicitly by some respondents as was the CBD definition, decentralized management and the value of having comparable units (ecosystem services). Though it was recognised that at times is at the expense of the broader approach.
One participant outlined the approach within their organisation which was to distil the 12 CDB principles into three themes which are easier to understand and communicate. These are:

- Systems thinking and management
- Involving stakeholders in decision making
- Understanding the wider benefits provided by the environment

Other participants expressed an interest in this and thought it was "*a useful way forward*".

Many were in agreement that the phrase 'Ecosystem Approach' gives the wrong idea about the concept and its perceived complexity. This makes it difficult to communicate and get buy-in. Participants reported external stakeholders have, in many cases, suggested a change of name to help with this.

ii Barriers to implementation of the Ecosystem Approach in UK marine policy

a Does it matter if we call it something different?

The group had divided opinion on terminology and whether it matters if we use different phrases to describe the same concept. One strand of thought was that it did not matter what we call it and if we are using different terminology but it is important that we are interpreting it in the same way (regardless of terminology used). Conversely, others felt terminology is important not only depending on who you are communicating with (agencies vs. members of the public) but notably because the initial terminology can steer the discussions from the outset, and therefore influences decisions made and the eventual outcomes. How we communicate the Ecosystem Approach and its aims was also noted by the group as a current barrier to its use; "*the term is not fully understood and thus has lost its credibility and subsequently buy-in*".

Other key points include:

- Need a clear message of what we mean by the Ecosystem Approach;
- the Ecosystem Approach is complex for stakeholders to understand; practical applications as pilot/demonstration projects can help overcome this;
- understanding within policy realms needs to be improved. Practical examples of implementation could help with this; and
- communication should be tailored when interacting with stakeholders with no understanding of the concept; the current terminology such as 'Ecosystem Approach' and ecosystem services' does not need to be used and is not helpful in many situations.

b What are the current technical and policy limitations to the implementation of the Ecosystem Approach?

Regarding technical limitations, the complexity of the approach in itself can be a barrier; participants noted this as a related point to communication. If we cannot successfully communicate the Ecosystem Approach concept and its benefits, this will ultimately impede its implementation. The lack of staff resources and data limitations are also seen as barriers. Notably supporting data are felt to be lacking i.e. what do existing data imply for current and future management.

Policy limitations were identified in three main areas. Firstly, the level of understanding by policy colleagues was seen to limit progress and implementation. Secondly, while policy instruments such as the MSFD help to steer the process and implement new ideas, making progress and resource availability a priority, they do impose new deadlines and targets. A further policy limitation was felt to be an institutional problem whereby new obligations such as MSFD require increased collaborative working. Through such engagement, those involved understand the bigger picture but are driven by individuals' own organisational objectives and budgets. This was found in the experiences of one participant, to constrain joint working.

iii Mainstreaming the Ecosystem Approach

a What specific support, information or expertise to you require to advance the Ecosystem Approach (including ecosystem services)?

Responses to this question were focussed around four main areas; resources; communication; improved understanding of system interactions; and case studies. These are set out below.

1) More attention should be paid to the resources that are required for effective marine planning.

2) Resources and action are required to improve communication at all levels to allow us to communicate the importance of taking an Ecosystem Approach. This should make use of professional support to put this message across. Better communication was also linked to points made about better using existing information including best practice on participation and cursory work by Defra on Ecosystem Approach application and scales. We should not be reinventing the wheel, rather using existing work and focus on how this can be married up to make best use of it.

3) A better understanding of interactions or trade-offs between ecosystem services i.e. what would be the result of a change and the effects of favouring one particular set of benefits.

4) Practical examples/case studies of Ecosystem Approach implementation in the marine environment would be useful both internally and to take out to stakeholders; "c*ase studies are very powerful to inspire and enthuse*".

b What processes and actions over the next decade are required to mainstream the Ecosystem Approach into UK marine policy?

When asked whether there is a most appropriate spatial scale at which the Ecosystem Approach should be applied, the universal answer was no. All participants held a nested scale approach was best, and whilst the difficulties of achieving this in practice were acknowledged, it should reflect the individual circumstances, the stakeholders involved and the particular sectors.

Following on from this, the group purported that although nested scales is the ideal, this is not supported by the governance structures. Structures in their current form do not support the implementation of the Ecosystem Approach due to responsibilities being split across land and sea, each with their individual remits. The outlook of those in governing organisations was also raised. One participant felt whilst good science and data are needed, they "*should not trump everything else including local knowledge. A top down science approach is appropriate in some cases but not when applying the Ecosystem Approach*".

The panel discussed large scale research projects e.g. VNN and UK NEA and how they influence the implementation of the Ecosystem Approach in the marine context. There was broad agreement that these initiatives are useful but the challenge is to ensure the information and outputs from these are clear, concise and usable/practical. One successful example of this was the provision of case studies translating scientific understanding in to practical examples in response to specific user community questions.

Some concerns were raised over the (mis)use of terminology and the confusion this propagates. UK NEA and VNN were given as examples here that are perceived to imply certain techniques and perspectives e.g. valuation, which steers future work but is only one aspect of a much broader Ecosystem Approach.

A number of suggestions were given for how the Ecosystem Approach can be aligned across land and sea. These include the use of Shoreline Management Plans; and a joined up approach to the management of activities across land and sea and the impact these may have on adjacent systems. One participant with experience in the Clyde marine spatial planning pilot felt the issue can be overstated. The work in the Clyde progressed even with 7 local authorities and 1 national park authority, strong dialogue was seen as crucial for success.

3.7 Discussion and conclusions

The Ecosystem Approach is now a commonly used term and is generally considered to mean an approach which considers the wider ecosystem rather than on a sector by sector basis. Increasingly this is taken as a focus on the management of human activities rather than the ecosystem itself. Such an approach is seen to be beneficial in that it considers ecological, economic and social considerations within a single framework. It recognises that humans, with their cultural diversity, are an integral component of ecosystems and places an emphasis on flexible and integrated methods making the approach adaptable to a wide variety of situations and policy and management decision-making.

It has become apparent that many terminologies are used to describe or allude to, the Ecosystem Approach (or aspects of it) such as ecosystem-based management, ecosystem based approach, ecosystem services approach or ecosystem based management for fisheries. This has shown to lead to confusion amongst both stakeholders and those charged with its implementation. Here we have reviewed the most commonly used terms in an attempt to define them and identify their key characteristics. The CBD Ecosystem Approach is a frequently cited definition. The approach has been developed to include the 12 Malawi principles to guide users in its implementation. The review identified that although there are many different phrases used to describe the Ecosystem Approach there is generally little distinction between them; however in some cases whilst the overall aim is the same the definitions do not always take all 12 Malawi principles into account. In general phrases are used interchangeably to mean the same thing (although this might not always be the situation – see below for more explanation). Such is the case that nearly any diverse initiative to do with understanding ecosystems, or working with ecosystem services, is being labelled as an 'Ecosystem Approach'. This has both positive and negative effects; firstly it may represent a healthy evolution in ideas and thinking and wide spread uptake.

Conversely, the use of multiple terms may be confusing for stakeholders, reduce buy-in and result in the overall dilution of the concept. A clear example of this is the steer towards ecosystem services. Although the Millennium Ecosystem Assessment (MA) did not conceive the idea of ecosystem services, it greatly popularised the concept and terminology. The CBD has explicitly noted the benefits of raising the awareness of ecosystem services terminology, and stated it to be helpful for supporting the Ecosystem Approach concept. Some have suggested that focusing on these concepts of environmental goods and services is a good way to ensure the integration of social, economic and environmental concerns e.g. (Beaumont *et al* 2007), as called for by the CBD. In general, since the MA, much of the content and terminology in the CBD's decisions and supporting documents has shifted to incorporate ecosystem services concepts. The MA catalysed a number of follow-on initiatives in the late 2000s, in particular The Economics of Ecosystems and Biodiversity, and national-level assessments such as the UK NEA. Similarly, in academic literature ecosystem service concepts have become increasingly frequent, and are now a dominant discourse with increasing focus on valuation of ecosystem goods and services. It is not the case that the CBD's conception of the term – with an emphasis on societal choice and engagement – has been so widely influential. This is perhaps unsurprising given that the words are inherently suggestive of a focus on ecological systems. In the literature, it now appears to be synonymous with existing approaches emerging since the 1980s and 1990s that focused solely on the need for adaptive approaches appropriate to a understanding of ecosystem functioning. Whilst adaptive management is indeed a part of the CBD approach, the social principles of decentralisation, societal choice and societal involvement which are also part of their definition of the Ecosystem Approach, seem the least likely to be associated with the term.

Since the Malawi Principles represent some of the most ambitious thinking about what the goals and principles of environmental management should look like, diluting or ignoring parts of the concept means that management actions will not strive to achieve these goals. As such, opportunities to attempt truly holistic and equitable management approaches are being overlooked. We suggest that the mixed meanings of the Ecosystem Approach are a cause for concern. Although elements of the CBD's concept are already applied through other principles and approaches to resource management, it is unclear whether focusing on any of these will quite achieve the interlinked aims of Ecosystem Approach as represented by the Malawi principles.

This review has shown that the Ecosystem Approach is commonly seen in the majority of contemporary legislative instruments and policies for managing the marine environment. Examples can be seen from the global to the local level, across a multitude of countries including those which lack resources and data, with poor governance structures, as seen in the example from Raj Ampat Islands, Indonesia. The use of the Ecosystem Approach in fisheries is particularly evident, though it has been argued a sector specific application misses the point and is not a true application of the Ecosystem Approach as it focuses on the impacts of one particular resource only. Increasingly the Ecosystem Approach is used in large scale applications such as in the Regional Seas.

Five case studies have been presented to illustrate the Ecosystem Approach (or variants of) in relation to marine policy and management. The case studies aimed to develop further insight and highlight the different approaches to implementation and the different terminologies used. The Thanet case study highlights a stakeholder led process, designed from the offset to adhere to the 12 CBD principles. This process is an excellent example of how the issues of communication and terminology highlighted throughout this review can be overcome by using a shared (and easily understood) language to elicit the same information. The Marine Strategy Framework Directive adopts a framework approach for applying the Ecosystem Approach in marine management. The Directive is largely in accordance with the CBD Ecosystem Approach and provides a strong basis for further action by individual member states. The success of the MSFD will thus be dependent on political drive and the resources committed by Member States in ensuring such an approach is effectively applied at the regional level. Furthermore, its practical application will need to reflect the opportunities and constraints of Europe's marine governance, notably issues of allocation of competence, differing governance structures and the strong need for adaptive management. HELCOM and CCAMLR provide a similar basis for the implementation of an Ecosystem Approach and offer robust examples in areas of high political and economic pressure that arise with decision making between multiple national governments and decision making bodies.

The final section looks at how the Ecosystem Approach can be better implemented. The approach and findings of experts working in the field were used to help identify barriers to the implementation of the Ecosystem Approach in UK policy. Both the workshop report (though not focussed on the marine environment) and the expert panel identify similar barriers and areas for further work. These were concentrated around: communication and the need for clear and consistent messages including the terminology used; the need to sell the idea of implementing an Ecosystem Approach and what are the benefits in doing so; and the requirement for further capacity and resources to aide implementation. This could be progressed by the further translation of scientific understanding into case studies specific to the marine environment.

4 Economic valuation of marine ecosystem services

4.1 Introduction

The aim of this section is to review current understanding of economic valuation of inshore and offshore marine ecosystem services. This section will begin by introducing some of the key economic concepts and issues associated with economic valuation. A review of economic valuation methodologies is undertaken within the marine context, and these are mapped onto the VNN ecosystem services framework for the marine environment (see Figure 2.1 above). This section then presents current sources of UK economic valuation evidence for the marine environment, including metadata catalogues, online databases, peer-reviewed primary valuation studies, unpublished studies, and other ongoing research which may generate economic valuation data in the future. The potential for value or benefit transfer is discussed in addition to the use of scenarios and their implications for data, economic modelling and decision making.

There has been an increasing attention given to ecosystem service valuation in science and this has recently been followed by an uptake and use by stakeholders. Examples that reflect this trend include, Defra (Beaumont *et al* 2006), the Crown Estate (Saunders *et al* 2010), the Wildlife Trusts (Fletcher *et al* 2012a) and Natural England (Fletcher *et al* 2012b). This has been in part motivated by the growing importance of economic valuation in marine policy where it is a requirement of many recent policy initiatives. An assessment of the value of marine ecosystem services is envisaged for example under the new EU 2020 Biodiversity Strategy which emphasises the need ‘to value ecosystem services and to integrate these values into accounting systems as a basis for more sustainable policies’. The EU Water Framework Directive (WFD) and EU Marine Strategy Framework Directive (MSFD) both explicitly call for the integration of economic valuation into environmental management processes. Under the WFD, Article 4 allows for possible economic justification, including economic valuation, for derogation (including designation of water body status); Article 5 requires ‘an analysis of river basin characteristics, a review of the environmental impact of human activities and an economic analysis of water use’; and Annex III provides guidance on ‘economic analysis’. Under the MSFD Article 8.1 states that ‘...Member States shall make an initial assessment of their marine waters, taking account of existing data where available and comprising…an economic and social analysis of the use of those waters and of the cost of degradation of the marine environment’ and Article 13 states that ‘Member States … shall carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure’. However, such valuation can be a problem in terms of impacting on decision-making; the recent impact assessment undertaken by Defra (2012) for the designation of a network of marine protected areas (under Section 123 of the UK Marine and Coastal Access Act (MCAA) 2009) concluded ‘It has not been possible to monetise the benefits of designating the sites, as benefits cannot be readily quantified or valued (as the majority of the benefits are not traded)’ (Impact Assessment Section 4.1.1, December 2012).

4.2 Economic valuation of marine ecosystem services

The UK National Ecosystem Assessment (NEA) framework recognises the importance, when it comes to economic valuation of ecosystem services, of distinguishing between basic processes, intermediate services and final services, and goods and benefits associated with the marine environment (see Figure 2.1 above). It is not appropriate to value basic processes and intermediate services without identifying explicitly the associated final services, goods and benefits which have human welfare implications; such a translation to goods and benefits is necessary for economic valuation if our focus is on human wellbeing.

Economic valuation of the majority of ecosystem services (e.g. habitat and carbon storage) can only be undertaken if the quality of the service change is known and this requires a process of scientific analytical measurement (physical, chemical and biological). Defra (2007) suggest a five-stage process for undertaking an economic valuation of ecosystem services; Figure 4.1 highlights these steps and the data requirements for each stage of the process. Where primary data on marine ecosystem services cannot be obtained, a qualitative assessment for each ecosystem service might be undertaken based on the existing evidence drawn from the literature and databases, and on expert judgement, including that elicited through focus groups and at stakeholder meetings.

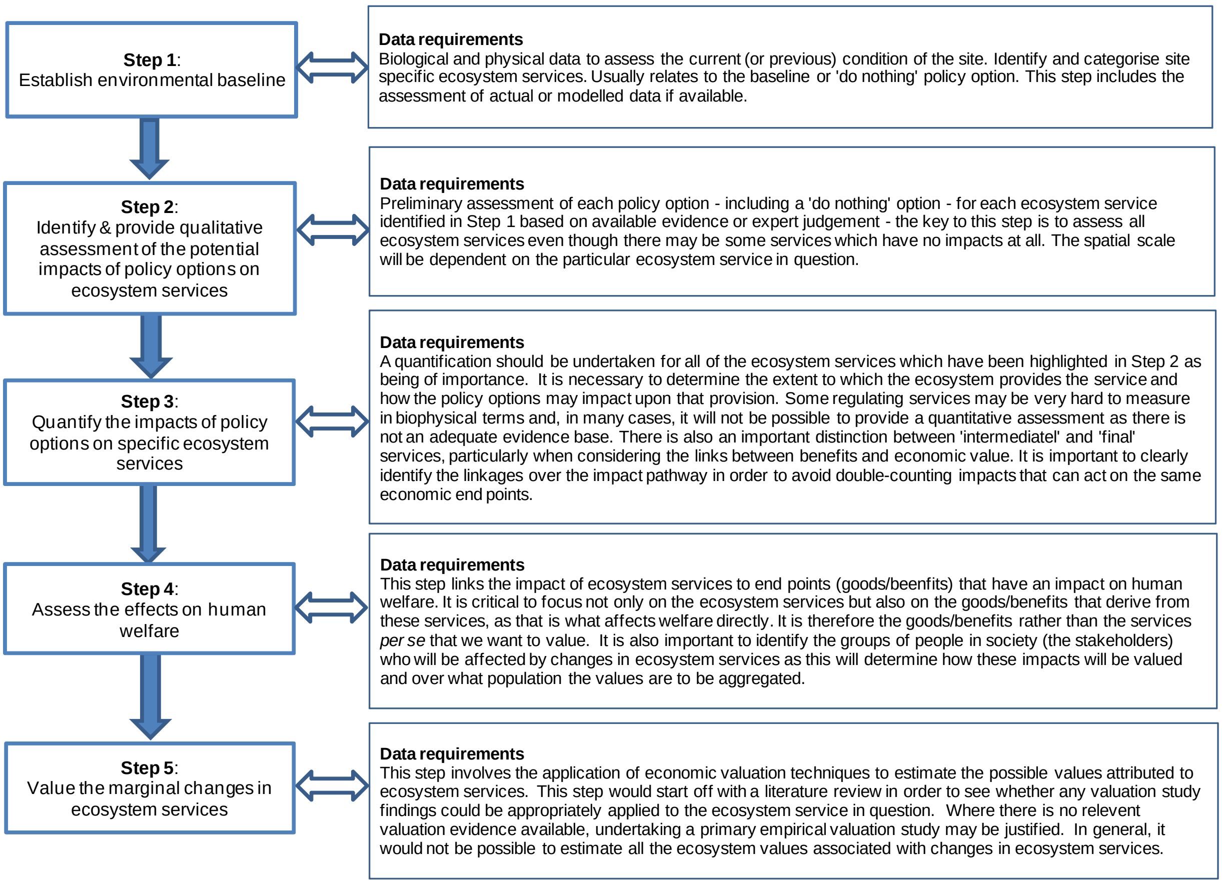


Figure 4.1. Evaluation of policy options using a ecosystem services approach (Cooper *et al* 2011b adapted from Defra 2007).

A key purpose in distinguishing ecosystem processes and intermediate services from final ecosystem services is to avoid *double counting* in the valuation of ecosystem services (Fisher & Turner 2008). For example, consider an assessment of the ecosystem services and goods and benefits associated with nursery habitat ('formation of species habitat' intermediate supporting service) and food provision (good/benefit). If the value of nursery grounds for commercially valuable marine species is measured in terms of the value of the landed catch and, separately, the value of the stock of specific species (a final provisioning service) is also valued by the landed catch then the value of species harvested are being double counted in any overall assessment of ecosystem services. Similarly, the value of a coastal wetland for nutrient cycling (intermediate supporting service) cannot be aggregated with consequent water quality benefits in terms of higher quality recreation and amenity (final cultural services). In essence, the potential for double-counting arises because of the 'complexity of ecosystem services and the difficulty in understanding their multiple interactions' (Turner *et al* unpublished).

Further general problems of a technical nature must be overcome for the effective valuation of marine ecosystem services and these relate to *spatial explicitness*, *marginality*, *non-linearities* and *threshold effects*. Taking each in turn, *spatial explicitness* is important to clarify the level of understanding as ecosystem services are context dependent in terms of their provision and their associated benefits and costs (de Jonge *et al* 2012). De Jonge *et al* citing the work of Luisetti *et al* (2011), illustrate using the case of coastal wetlands and their supply of climate regulation through carbon sequestration - the net effect of carbon storage and the simultaneous emission of methane is influenced by the prevailing salinity condition which, in turn, is governed by the spatial location of the wetland.

The values used to measure ecosystem services are *marginal values*. That is, economic valuation requires an assessment which focuses on relatively small or incremental changes in ecosystem services rather than larger impacts. Turner *et al* (unpublished) argue that scientific uncertainties which 'shroud' ecosystem functioning, including whether *thresholds* are being approached (see discussion below), can make it difficult to discern whether a given change is marginal in its impact. While it is appropriate to consider, as far as is feasible, economic value in terms of marginal changes, Turner *et al* referring to a review of the existing empirical literature, suggests that in fact very few studies do so. One example they cite is Mäler *et al* (2008) who explicitly undertook marginal analysis in estimating the accounting price for the habitat service provided by a conceptual mangrove ecosystem to a shrimp population. Their simplified model studied the provision of mangrove habitat service to fisheries, as a nutrient provider, to demonstrate how an accounting price for that service may be calculated; with empirical data, this model could be used to calculate the accounting price of the service.

A *threshold* effect refers to the point at which an ecosystem may change abruptly into an alternative steady state. For example, an increase in water temperature within the marine environment due to a thermal discharge may influence the survival of particular fish or invertebrate species if their thermal tolerance is exceeded. Wither *et al* (2012) review the available knowledge on the tolerance and behaviour of fish and other marine biota to heated effluents and recommend a set of guidelines for developing thermal standards in relation to the construction of a new generation of UK coastal power stations. For valuation, marginal changes in ecosystem services should not tip the system over a functional threshold or safe minimum standard. However, there is great uncertainty surrounding ecosystem functioning so that it is far from clear when a threshold may be reached.

More generally, the existence of *non-linearities* in ecosystem services contributes to the complexity of valuation. Here, non-linearities refer to the nature of the relationship between a given disturbance and its impact on ecosystem services. For example, the increased benefit received from an additional unit of saltmarsh, acting as a natural form of sea defence (good/benefit), cannot be assumed to be constant for all saltmarsh habitats given the non-linearities associated with wave attenuation in relation to the height, density and species of saltmarsh present in any given location.

The well-known notion of total economic value (TEV) provides an 'all embracing measure of the economic value of an ecosystem service supply' (de Jonge *et al* 2012). However, following Turner *et al* (2003), TEV will be less than the total systems value, as a minimum configuration of ecosystem structure and process is required before final ecosystem services can be provided, so the system posses extra value known as 'glue' or 'primary' value. Moreover, a precautionary approach is recommended given the uncertainty associated with what constitutes a sustainable healthy functioning state. Note also that TEV decomposes into use and non-use values, and does not include other types of values such as intrinsic values (usually defined as values residing in the asset and unrelated to human preferences) and cultural or symbolic values which groups of people have assigned to, say, seascape. This can be an area of difficulty: for example, some people's willingness-to-pay for the conservation of an asset may be influenced by their own judgements about intrinsic value (as expressed through human altruism or 'rights of existence') along with any use they make of it (de Jonge *et al* 2012).

4.3 Economic valuation techniques

The modest but growing body of literature suggest a range of techniques have been employed to assess the value that specific stakeholders and, more generally, society places on marine ecosystem services. In part, this reflects the finding common to other environmental resources: market prices may reflect the value of some marine ecosystem services, and for some others they either don't exist or are inadequate. Given such circumstances, a range of methods is available to assess the values that are placed on these benefits, including those based on revealed preferences (e.g. travel cost method, hedonic pricing) and those based on stated preferences (e.g. contingent valuation). Table 4.1 identifies the valuation methods and includes a relevant marine application for each technique. Many of the methods are categorised as non-market valuation approaches as they do not rely on market prices; such methods are gaining wider acceptance and are advocated by the UK Government for policy evaluations (HM Treasury 2003).

Table 4.1. Economic valuation techniques and their potential use in the marine environment (modified from Atkins *et al* 2011a).

Economic Valuation Method	Description	Marine example
Choice Experiment Method (CEM)	Discrete choice model which assumes the respondent has perfect discrimination capability. Uses experiments to reveal factors that influence choice.	Can be used to investigate preference trade-offs involving security of water supply and biodiversity.
Contingent Valuation Method (CVM)	Construction of a hypothetical market by direct surveying of a sample of individuals and aggregation to encompass the relevant population. Problems of potential bias.	The public might be asked to value a hypothetical environmental improvement, such as increased biodiversity.
Cost-of-Illness (COI)	The benefits of pollution reduction are measured by estimating the possible savings in direct out-of-pocket expenses resulting from illness and opportunity costs.	Loss of earnings due to illness caused by poor water quality.
Damage Avoidance Costs (DAC)	The costs that would be incurred if the ecosystem good or service were not present.	A salt marsh provides a natural form of flood prevention.
Defensive Expenditure Costs (DEC)	Costs incurred in mitigating the effects of reduced environmental quality. Represents a minimum value for the environmental function.	The cost of cooling water ponds to mitigate cooling water discharge effects.
Hedonic Pricing (HP)	Derive an implicit price for an environmental good from analysis of goods for which markets exist and which incorporate particular environmental characteristics.	House prices are determined by the characteristics of the houses, including environmental features such as their proximity to marine leisure facilities.
Market Analysis (MA)	Where market prices of outputs (and inputs) are available. Marginal productivity net of human effort/cost. Could approximate with market price of close substitute. May require shadow pricing where prices do not reflect social valuations.	Deriving the social and economic value of shellfish, such as oysters, from market prices, or of carbon from traded values.

Economic Valuation Method	Description	Marine example
Net Factor Income (NFI)	Estimates changes in producer surplus by subtracting the costs of other inputs in production from total revenue and ascribes the remaining surplus as the value of the environmental input.	The economic benefits of improved water quality can be measured by the increased revenues from greater aquaculture productivity when water quality is improved.
Production Function Analysis (PFA)	An ecosystem good or service treated as one input into the production of other goods: based on ecological linkages and market analysis.	The use of wetlands as fish nursery areas for species which eventually become commercial catches.
Productivity Gains and Losses (PGL)	Change in net return from marketed goods: a form of (dose-response) market analysis.	Improvements in water quality leading to reduced purification requirements following shellfish harvesting which would be reflected in higher net returns.
Replacement / Substitution Costs (R/SC)	Potential expenditures incurred in replacing the function that is lost; for instance by the use of substitute facilities or 'shadow projects'.	The costs associated with the creation of intertidal habitat to compensate for habitat lost following industrial development.
Restoration Costs (RC)	Costs of returning the degraded ecosystem to its original state. A total value approach; important ecological, temporal and cultural dimensions.	The costs of rehabilitating an affected/degraded wetland.
Shadow Price of Carbon (SPC)	A price that reflects the social cost of carbon consistent with the damage experienced under an emissions scenario such that e.g. a specific policy goal can be achieved (the precautionary principle might support a further adjustment to the price).	The value of carbon capture associated with a salt marsh created under a development's offset arrangement.
Social Cost of Carbon (SCC)	Damage costs of an incremental unit of carbon (or equivalent amount of other greenhouse gas emissions) imposed over the whole of its time in the atmosphere.	The loss of carbon sequestration by marine organisms/habitats e.g. kelp forests will lead to greater carbon emissions generating damage costs.
Travel Cost Method (TCM)	Cost incurred in reaching a recreation site as a proxy for the value of recreation. Expenses differ between sites (or for the same site over time) with different environmental attributes.	The costs borne by visitors to bird watching sites may be interpreted as the minimum value they attached to that site.

Given that the focus of this report is on the application of the VNN framework (see Figure 2.1 above), and recognising the importance of the link between the final ecosystem services and the goods and benefits they provide for society when it comes to economic valuation, Table 4.2 highlights such links and suggests appropriate economic valuation methods for each good and benefit. As highlighted in Figure 2.1, the importance of the requirement for complementary capital, in the form of human and man-made capital, is recognised here in order for society to obtain the goods and benefits. For example, in order to catch fish for human consumption, a fisher has to invest in resources such as labour, fishing gear, fuel, etc. in order to obtain the benefit from landing species of commercial interest. In addition, it should be noted that against each good and benefit are identified a number of valuation methods. Each of these approaches is potentially applicable but, importantly, priorities are not implied by their ordering. Priority in the choice of valuation technique depends to a certain extent on the specifics of the individual case under investigation. For example, where there is a market price for a marketed good (e.g. commercial fishery) it might not be appropriate to recommend using CVM or CEM to value the fish stock if this is required, whereas it would be appropriate to recommend CVM or CEM to value the impact of fishing on some other ecosystem services.

Table 4.2. Economic valuation methods for final marine ecosystem services and goods/benefits (adapted from Atkins *et al* 2011a and Turner *et al* unpublished).

Final Ecosystem Service		**Goods/Benefits**	**Economic Valuation Methods for Goods/Benefits***
Provisioning services	Fish/shellfish	Food	CEM, CVM, MA, NFI, PFA
		Fish feed	CEM, CVM, MA, NFI, PFA
	Other wild food	Other food e.g. algae, *Salicornia*	CEM, CVM, MA, NFI, PFA
	Seaweed	Fertiliser	CEM, CVM, MA, NFI, PFA
	Ornamental materials	Ornaments (e.g. shells, fish for aquaria)	CEM, CVM, MA, PFA
	Genetic resources	Medicines (e.g. blue biotechnology)	CEM, CVM, MA, NFI, PFA
Regulating services	Climate regulation (e.g. from carbon sequestration and storage)	Healthy climate	CEM, CVM, DAC, DEC, MA, PFA, PGL, RC, SCC, SPC
	Natural hazard protection (e.g. from damping of wave action and stabilisation of coastal features)	Prevention of coastal erosion	CEM, CVM, DAC, DEC, MA, PFA, RC, PGL
		Sea defence from flooding	CEM, CVM, DAC, DEC, MA, PFA, RC, PGL
	Waste breakdown / detoxification	Clean water and sediments	CEM, COI, CVM, DAC, NFI, RC
		Immobilisation of pollutants	CEM, COI, CVM, DAC, NFI, RC
Cultural services	Meaningful Places Socially valued seascapes	Tourism / Nature Watching (e.g. opportunities for recreation)	CEM, CVM, HP, TCM
		Spiritual and cultural wellbeing (e.g. sites of religious/cultural significance; folklore)	CEM, CVM
		Aesthetic benefits	CEM, CVM
		Education (e.g. resource for teaching, public information, scientific study)	CEM, CVM

* Acronyms refer to: Choice Experiment Method (CEM), Contingent Valuation Method (CVM), Cost-of-Illness (COI), Damage Avoidance Costs (DAC), Defensive Expenditure Costs (DEC), Hedonic Pricing (HP), Market (Price) Analysis (MA), Net Factor Income (NFI), Production Function Analysis (PFA), Productivity Gains and Losses (PGL), Replacement Cost (RC), Shadow Price of Carbon (SPC), Social Cost of Carbon (SCC), Travel Cost Method (TCM).

The skills required to undertake the economic valuation of ecosystem services will vary depending on the technique. Essentially, for monetary valuation the skills of an economist would be required for problem structuring, market, production and, often, statistical analysis. Often a multidisciplinary approach is called for because effective problem structuring is critical and a survey is frequently required based on questionnaires and interviews. These can be informed by focus groups and engagement with practitioners and stakeholders. Thus, along with economists, multidisciplinary teams might also include marine ecologists, systems practitioners, experts in stakeholder engagement, and others.

4.4 Sources of economic valuation evidence

Turning to the literature, the published journal articles presenting the findings of primary valuation studies can be identified using literature searches (e.g. Web of Knowledge, Science Direct, JSTOR and Wiley) and online catalogues. Examples of online catalogues include:

- Environmental Valuation Reference Inventory (EVRI) which includes over 2,000 international studies providing values, methodologies, techniques and theories on environmental valuation of various natural assets. One stated purpose is to facilitate the worldwide development and promotion of environmental valuation using the benefits transfer approach (see: https://www.evri.ca/Global/Splash.aspx).

- Marine Economic Data Portal, at Socio-Economic Marine Research Unit, National University of Ireland, Galway provides 'useful' marine economic data and 'related links' on the economics and the natural and social resources of the coast and oceans surrounding Ireland. The portal includes 'Ocean Economy - Market value data', 'Coastal Economy - Population and Coastal Economic Statistics', 'Marine Ecosystem Service Value Estimates' and 'Water Quality Estimates' (see: http://www.nuigalway.ie/semru/marine_economic_data.html).

- The Economics of Ecosystems and Biodiversity (TEEB) have launched a Knowledge Portal to track their project 'TEEB for Oceans and Coasts' (TEEB-OC). The site includes the Marine Ecosystem Services Partnership map holding a library of over 500 valuation studies (see: http://www.marineecosystemservices.org/).

As a further example of sources of primary valuation evidence, data sets are catalogued in the metadata catalogue of marine social and economic data developed and populated by a recent Marine Management Organisation (MMO) and Marine Scotland (MS) funded project (MMO & MS 2012) (See: http://www.marinemanagement.org.uk/ evidence/1012b.htm). Metadata is essentially data which describes the data, for example where and how the data was collected, the units and location of data etc. Thus, the catalogue provides information on data sets (metadata), but does not include the data itself.

Table 4.3 provides an inventory of *primary economic valuation evidence* for ecosystem services for the UK as published in refereed journal articles. While the inventory is not complete, particularly for research published before 2000, it is indicative of the range of primary evidence available both in terms of methods used and in coverage of ecosystem services. This summary reports from each identified study the specific ecosystem service or benefit under valuation, the date to which valuations refer, the site under investigation, and the valuation methodology adopted. Studies are ordered by publication date, from the most recent. The table demonstrates an incomplete coverage of ecosystem services and benefits by the valuation studies. It is evident that there is a focus on some key goods and benefits associated with provisioning services, with fish being particularly prominent, and the ecosystem services of regulating services and particularly climate reduction, natural hazard reduction, and waste breakdown through improved water quality; and those cultural services associated with recreation and tourism. Other ecosystem services, for example those associated with many cultural services, still defy monetary valuation.

Table 4.3. Primary valuation studies for the UK published in refereed journals between 1995 and 2013.

Citation	Ecosystem service / benefit	Valuation method	Evidence date	Case study location
Sen *et al* in press. Economic Assessment of the Recreational Value of UK Ecosystems. *Environment and Resource Economics.*	Recreation	Meta-analysis	2009/10	UK marine and coastal area (and other UK environments)
Crilly & Esteban 2013. Small versus large-scale, multi-fleet fisheries: The case for economic, social and environmental access criteria in European fisheries. *Marine Policy,* 37, pp. 20-27.	Cod fishery	MA	2006-08	UK North Sea
Ruiz-Frau *et al* 2013. Spatially explicit economic assessment of cultural ecosystem services: Non-extractive recreational uses of the coastal environment related to marine biodiversity. *Marine Policy,* 38, pp. 90-98.	Tourism and Nature watching	Expenditure	2007	Wales
Chae *et al* 2012. Recreational benefits from a marine protected area: A travel cost analysis of Lundy. *Tourism management,* 33, pp. 971-977.	Biodiversity/ landscape	TCM	2005	Lundy Island, UK
Ressurreição *et al* 2012, Different cultures, different values: the role of cultural variation in public's WTP for marine species conservation, *Biological Conservation* 145, pp. 148–159	Marine biodiversity	CVM	2007	Isles of Scilly, UK.
Christie & Gibbons 2011. The effect of individual 'ability to choose' (scale heterogeneity) on the valuation of environmental goods. *Ecological Economics*, 70, pp. 2250-2257.	Coastal defences	CEM	No survey date stated.	Borth, North Wales.
Luisetti *et al* 2011. Coastal and marine ecosystem services valuation for policy and management: managed realignment case studies in England. *Ocean & Coastal Management*, 54, pp. 212-224.	Fish nursery area (Bass)	MA	2007	Newly created salt marshes (managed realignment sites) on Blackwater, UK.
	Carbon storage	DAC; various carbon prices	2005/2007	Newly created salt marshes (managed realignment sites) on the Humber and Blackwater, UK.
	Amenity and recreation	Meta analysis; benefit transfer; CEM	2005/2007	Newly created salt marshes (managed realignment sites) on the Humber and Blackwater, UK.
Mangi *et al* 2010. Valuing the regulatory services provided by marine ecosystems. *Environmetrics* 22, pp. 686-698.	Carbon storage	SCC	No date given.	Isles of Scilly, UK.
	Bioremediation of waste	RC	No date given.	Isles of Scilly, UK.
	Sea defences	CVM	2008	Exe Estuary, North Norfolk, Essex & Humber Estuary
McVittie & Moran 2010. Valuing the non-use benefits of marine conservation zones: An application to the UK Marine Bill. *Ecological Economics,* 70, pp. 413–424.	Biodiversity/ landscape/non-use	CEM	2008	United Kingdom
Rees *et al* 2010. The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning. *Marine Policy*, 34, pp. 868–875.	Marine leisure and recreation	MA	2008	Lyme Bay closed area, SW England

Citation	Ecosystem service / benefit	Valuation method	Evidence date	Case study location
Bateman *et al* 2009. Reducing gain-loss asymmetry: A virtual reality choice experiment valuing land use change. *Journal of Environmental Economics and Management,* 58, pp. 106-118.	Freshwater nature reserve and mudflats	CEM	No survey date stated.	Beaches in coastal area at Holme, North Norfolk, UK
Birol & Cox 2007. Using choice experiments to design wetland management programmes: The case of Severn Estuary wetland, UK. *Journal of Environmental Planning and Management*, 50, pp.363-380.	Wetland area attribute	CEM	2004	Severn Estuary, UK, marine and coastal wetland.
	Species conservation	CEM	2004	Severn Estuary, UK, marine and coastal wetland.
	Species protection	CEM	2004	Severn Estuary, UK, marine and coastal wetland.
Lawrence 2005. Assessing the value of recreational sea angling in South West England. *Fisheries Management and Ecology* 12, pp. 369–375.	Recreational sea angling	CEM	2004	South West England
Bosetti & Pearce 2003. A study of environmental conflict: the economic value of Grey Seals in southwest England. *Biodiversity and Conservation 1*2, pp. 2361–2392.	Grey seal conservation	CEM	No date given	SW England
Hanley *et al* 2003. Valuing the benefits of coastal water quality improvements using contingent and real behaviour. *Environmental and Resource Economics* 24, pp. 273-285.	Improvement in coastal water quality	CEM	1999	Beaches in South West Scotland.
Parsons *et al* 2003. The value of conserving whales: the impacts of cetacean-related tourism on the economy of rural West Scotland. *Aquatic Conservation of Marine and Freshwater Ecosystems* 13, pp. 397–415.	Nature watching	Expenditure	2004	West Scotland
Mardle *et al* 2002. Objectives of fisheries management: case studies from the UK, France, Spain and Denmark. *Marine Policy 2*6, pp. 415–428.	Commercial fisheries	MA	1995	UK English Channel
Georgiou *et al* 2000. Coastal bathing water health risks: Developing means of assessing the adequacy of proposals to amend the 1976 EC Directive. *Risk Decision and Policy,* 5, pp. 49–68.	Water quality improvements for recreation amenity	CVM	1997	Beaches in the Anglian Water region, UK.
Whitmarsh *et al* 1999. Recreational benefits of coastal protection: a case study. *Marine Policy 2*3, pp.453-463.	Recreational benefits of coastal protection	CVM	1995	Lee-on-the-Solent, Hampshire, UK
Georgiou *et al* 1998. Determinants of individuals' willingness to pay for perceived reductions in environmental health risks: a case study of bathing water quality. *Environment and Planning A,* 30, pp. 577–594.	Water quality improvements for recreation amenity	CVM	1995	Beaches in the Anglian Water region, UK.
Edward-Jones *et al* 1995. A comparison of contingent valuation methodology and ecological assessment as techniques for incorporating ecological goods into land-use decisions. Journal of Environmental Planning and Management, 38, pp. 215–230.	Coastal intertidal habitat	CVM	1992	North Berwick and Yellowcraigs, Scotland
King 1995. Estimating the value of marine resources: a marine recreation case. *Ocean and Coastal Management* 27, pp. 129-141.	Amenity and recreation	CVM	1993	Beach at Eastbourne, UK.

* Acronyms refer to: Choice Experiment Method (CEM), Contingent Valuation Method (CVM), Damage Avoidance Costs (DAC), Market (Price) Analysis (MA), Replacement Cost (RC), Social Cost of Carbon (SCC), Travel Cost Method (TCM).

A distinction needs to be made between studies published in journals which present primary valuation evidence specific to a given ecosystem service typically at a local or regional site, and those that seek to aggregate such primary valuation evidence at a higher spatial level and/or higher level of ecosystem service aggregation. Only the former of these study types are included in Table 4.3. To take an example of the second type, an assessment of the total economic value of marine biodiversity in the UK was undertaken by Beaumont *et al* (2008). This provided annual monetary valuations for eight out of 13 'goods and services' that they categorised, drawing on published market evidence and valuations available from the published (and grey) literature for the purpose of valuation. The incomplete coverage of goods and services reflected gaps in available evidence. The methodology adopted meant that the marginal unit values were not estimated. Also, a number of issues surrounding measurement precluded any attempt at aggregating those goods and service categories for which valuation evidence was presented; some of the general issues that might be faced are discussed in the next paragraph and in the section on 'Value or benefit transfer'. Other studies conducted at a high spatial level include Morrissey *et al* (2011) and Morrissey and O'Donaghue (2012) which valued the commercial marine sector of Ireland at national and regional levels, respectively. These two studies are, again, partial in coverage as they have focussed on Gross Value Added (GVA) and, therefore, rely only on market values associated with commercial benefits.

Aggregation of evidence and, also, comparison of evidence needs careful consideration (Beaumont *et al* in prep.). Primary valuation evidence is collected using different methodologies, which are applied in different ways, resulting in a variety of different evidence. There needs to be focus on the analysis framework under which the evidence is collected to ensure that its coverage is complete. There needs to be consideration of the units of valuation (value per individual, per household, per hectare, present value, per given time period, etc) to ensure no aggregation error. Finally, when aggregating findings from studies it is important to consider whether constituent values are separable and/or do not overlap; otherwise there is, once again, a potential problem of double counting. Thus, a strong understanding of the evidence is essential if aggregation is to be successfully achieved. Note that some of these ideas will be returned to in Section 4.5 Value or benefit transfer.

Within a wider spatial context, an overview of European (and non-European) case studies on marine and coastal ecosystem services valuation was presented by Turner *et al* (2010); the review includes both published and grey literature between the years 1992 and 2009. At a global level, UNEP-WCMC (2011) outlines the ways in which economic valuation can be used to provide values and appraisals for ecosystem service changes in marine and coastal environments; global case studies are provided which illustrate the range of applications of economic valuation techniques and how these can be of practical use across a range of scales, in policy development, decision making and communication. This latter review also includes both published and grey literature between the years 2004 and 2010.

A number of studies have recently been undertaken in the marine environment, which have included economic valuation components, for example the UK National Ecosystem Assessment, Defra's Marine Conservation Zone Project, work undertaken on behalf of the Marine Aggregate Levy Sustainability Fund, and others. Although, these studies are not (as yet) reported within the peer-reviewed literature, and therefore do not feature in Table 4.3 above, such evidence is considered of importance for our baseline understanding of the economic value provided by parts of the UK marine ecosystem.

The UK National Ecosystem Assessment (UK NEA) undertook an analysis of available data on marginal changes in economic value of coastal margin and marine habitats, including a hind cast and a forecast where possible (Beaumont *et al* 2010). Following a prioritisation exercise, where each ecosystem service was scored on its significance and data availability, the study focussed on four ecosystem services (climate regulation, recreation and tourism, disturbance prevention, and food provision); a summary of the data produced by this study, including the economic valuation technique applied, is reproduced below (Table 4.4); care must be taken when assessing this evidence as not all of the values are reported in 2010 prices. An assessment of cultural services was not considered by Beaumont *et al* (2010) but was included within the wider NEA study (see Chapter 22: Bateman *et al* 2011).

The NEA study also provides findings from a number of earlier studies which presented snapshot values, as opposed to marginal changes, of the services provided by UK coastal and marine habitats (Beaumont *et al* 2006; Pugh 2008; Saunders *et al* 2010); values for the abiotic commercial activities, not included within the NEA analysis are shaded in grey. An assessment of the *total economic value* of marine biodiversity in the UK was undertaken by Beaumont *et al* (2006) on behalf of Defra; this work was subsequently published (Beaumont *et al* 2008); their findings were discussed earlier in this section. Pugh (2008) undertook an assessment of the 2005-2006 economic value of all marine sectors on behalf of The Crown Estate. This study produced sectoral contributions to Gross Domestic Product (GDP) with the majority of findings representing that of abiotic commercial sectors rather than ecosystem services *per se* and, as such, not all the benefits of the oceans have been included in the analysis. A further development of this work for The Crown Estate was undertaken by Saunders *et al* (2010) who conducted a valuation exercise of the marine estate and UK seas using an ecosystem services framework. This framework embraces the principles of the Government's existing Total Economic Value (TEV) framework and the existing research on the classification of marine ecosystem goods and services. The authors suggest that by combining their ecosystem services framework with a geographical information system (GIS) it can be applied to a range of spatial and temporal scales. This study identified significant limitations in information availability, particularly in relation to the evaluation of non-use benefits and the quantification of impacts of human activities, however, for some ecosystem services (such as fisheries where market analysis can be employed) there is sufficient valuation data available at a national level to populate the framework; such evidence can thus be used to inform decision making.

Table 4.4. Summary of data provided in the UK NEA economic assessment of coastal margin and marine habitats 2010 prices unless specified otherwise (Beaumont *et al* 2010).

Service	Method	Units	Time Series	Values
C sequestration – coastal margin	Avoided damage cost	tCO_2/yr	1900 - 2060	Sand dune: Decrease of 80,168 tCO_2/yr
			1945 - 2060	Saltmarsh: Decrease of 34, 774 tCO_2/yr
		£/ha/yr	2010	Sand dune: £32.25 - £241.49/ha/yr
			2010	Saltmarsh: £60.63 – 622.30/ha/yr
		£/UK/yr	2010 - 2060	Sand dune: 2010: £7.98 million/UK/yr 2060: £39.13 million/UK/yr **Increase of £31.15 million/UK/yr**
			2010 - 2060	Saltmarsh: 2010: £11.93 million/UK/yr 2060: £63.22 million/UK/yr **Increase of £51.29 million/UK/yr**
		Stock value £/UK	2010	Sand dune, Saltmarsh and Machair: £1282 million
C sequestration - marine	Avoided damage cost	tCO_2/yr	1961 - 2050	Variable, no clear trend
		£/UK/yr	2004 - 2050	2004: £6.74 billion/UK/yr 2050: £32.35 billion/UK/yr **Increase of £25.61 billion/UK/yr**
Disturbance prevention	Cost savings	£/ha £/ha/yr	2010	Saltmarsh: Capital costs: £0.47 – 0.94 million/ha Maintenance costs: £9400/ha/yr
		£/UK £/UK/yr	1945 - 2060	Saltmarsh: 1945: £481million/UK/yr 2060: £418 million/UK/yr **Decrease of £63million/UK/yr**
Recreation and tourism		£/UK/yr	2002	£17 billion
Fisheries (2008 prices)	Market prices	UK tonne/yr	1948 - 2000	1948: 1.2 million tonnes/yr 2000: 0.5 million tonnes/yr
		UK £/yr		1938: £1465 million/UK/yr 2008: £596 million/UK/yr **Decrease of £869 million/UK/yr**
		UK £/tonne	1956 - 2008	Demersal 1956: £1026/tonne Demersal 2008: £1119/tonne Pelagic 1956: £404/tonne Pelagic 2008: £561/tonne Shellfish 1966: £1488/tonne Shellfish 2008: £1796/tonne

Table 4.5. Review of UK per annum values of goods and services provided by marine and coastal margin habitats, including values of abiotic commercial activities (shaded grey) (Beaumont *et al* 2010).

Marine and coastal margin services	Beaumont *et al.* 2006 (£million, 2004)	Pugh 2008 (GVA, £million)	Saunders *et al.* 2010 (£ million, 2008)
Extractable biotic resources – Food Provision	£513 (fish)	£808 (fish, including processing, 2004/05)	£520 (GVA, fisheries and aquaculture, excluding processing)
Extractable biotic resources – Raw Materials	£81.5 (fish meal, fish oil and seaweed)	X	£89.41 (Turnover, fertiliser/feed)
Waste breakdown and detoxification	Insufficient data	£364 (2005)	Insufficient data
Climate regulation	£400 – 8470	X	Insufficient data
Disturbance prevention	£300	X	Insufficient data
Aesthetic, inspirational	Insufficient data	X	Insufficient data
Education, research and development opportunities	£317	£478 (2006)	£67 (research funding 2006/7) £95 (education, turnover)
Cultural and spiritual well being	Insufficient data	X	£1000 (stated preference)
Leisure and recreation	£11770	£3326 (2005-6)	£2500 (tourism, GVA) £1960 (leisure boating, turnover) £200 (surfing, turnover, 2007) £800 (Recreational angling , expenditure) £1.8 (Whale watching, expenditure)
Option and non-use values	£500 - £1100 million	X	X
Nutrient cycling	£800,000 – 2,320,000	X	X
Biologically mediated habitat	Insufficient data	X	X
Resilience and resistance	Insufficient data	X	X
Oil and gas	X	£19,845 (2005)	£36,814 (GVA, non-sustainable)
Aggregates	X	£114 (2006)	£31 (GVA)
Cooling water	X	X	£100 (replacement)
Salt	X	X	£4
Ship and boat building	X	£1223 (2004)	X
Marine equipment and materials	X	£3268 (2005)	X
Marine renewable energy	X	£10 (2005-6)	£62 (value of avoided emissions)
Construction	X	£228(2005-6)	X
Shipping operations	X	£3399 (2005)	£7100 (GVA, maritime transport)
Ports	X	£5045 (2005)	X
Navigation and safety	X	£150 (2005-6)	X
Cables	X	£2705 (2005)	Insufficient data
Business services	X	£2086 (2004)	X
Licence and rental	X	£90 (2005-6)	X
Defence	X	£2814 (2005-6)	£300 (GVA)

X – not included in report.

A recent example of economic valuation within a UK marine policy context can be seen within the English Marine Conservation Zone (MCZ) designation process as required under Section 123 of the Marine and Coastal Access Act 2009. An economic impact assessment (IA) has been undertaken to assess the potential impacts of a proposed suite of MCZs on the UK economy (Defra 2012) and was recently critiqued on behalf of the Wildlife Trusts (Atkins *et al* unpublished). One of the principle requirements of an IA is that estimates of costs and benefits should, wherever possible, be expressed in monetary terms and the data sources, methods and calculations used to produce estimates be transparent (Moran *et al* 2008). The IA covers a limited range of ecosystem services in its qualitative assessment of the benefits of each policy option, and no attempt has been made to quantify or value the benefits of designation, stating ‘It has not been possible to monetise the benefits of designating the sites, as benefits cannot be readily quantified or valued (as the majority of the benefits are not traded)’ (Impact Assessment Section 4.1.1, December 2012). As highlighted above (see Table 4.3), there is now a growing body of literature for economic valuation of specific marine sites and this resource could have been drawn upon within the economic IA. The contrast between the approaches adopted to provide estimates of the costs with those adopted to measure the ecosystem service benefits is strong. While the IA has provided a range of costs associated with the designation of MCZs there is no attempt to value the benefits of the individual MCZs and the wider network. While there may be good reason to delay designations in order to undertake more robust evaluation through further evidence collection, the delay may lead to further loss of ecosystem service provision including in relation to securing network-scale benefits.

A recent report, commissioned by the Wildlife Trusts, makes an initial attempt to value the potential benefits obtained from designation of a number of recommended MCZs (Fletcher *et al* 2012a) and it is suggested that a similar approach should be adopted within the MCZ IA process in order to value the potential benefits. It is considered here that the Government’s commitment to further research on the benefits side (in relation to ecosystem services provided by benthic habitats, and recreation and tourism associated with MPAs), though welcome, may be too late to provide significant additional evidence in the short-term future of the MCZ process. McVittae and Moran (2010) applied a stated preference choice experiment to undertake a top down valuation of the benefits of MCZs which describes the proposed policy change and elicits public preferences directly; the total aggregate value for a policy that halts UK marine biodiversity loss through the introduction of a UK MCZ network was estimated to be £1,714 million per annum.

A number of studies, within the grey literature, have been associated with economic valuation of the marine aggregate dredging sector. Austen *et al* (2009) undertook a scoping study to identify and value the impact of aggregate extraction on ecosystem service provision in the Eastern English Channel marine natural area. A partial evaluation was undertaken of ecosystem service provision, particularly in terms of food provision (£10.5m), the regulation of gases and climate (between £1.4m and £6.6m), and leisure and recreation (*c.* £1,096m through activities such as sea angling, seaside day trips and tourist visits). Only values for the impact of the marine aggregate dredging on gas and climate regulation (-£14,139 to + £8,792, depending on data used and site) and cognitive benefits (+£2.2m) could be attempted due to limited understanding of the impacts of the activity on the provision of ecosystem services. Cooper *et al* (2011b) made an assessment of whether the benefits of seabed restoration would justify the costs following the cessation of marine aggregate dredging at a case study site off the Thames Estuary, UK. The methodology employed was based upon the Defra (2007) framework for undertaking an economic valuation of ecosystem services, and incorporated the DPSIR framework, within an Ecosystem Approach (after Atkins *et al* 2011b). Although this methodology proved useful in identifying relevant issues, full economic valuation of the goods and benefits (such as recommended by Turner *et al* 2003) was not yet possible due to the lack of valuation data, and difficulties in establishing the appropriate boundaries for assessment, a constant difficulty in open marine systems.

Table 2.1 provides a summary of primary valuation research *in progress* in the UK and across Europe; a number of these studies have economic valuation components and will therefore produce additional valuation evidence in the future (see Table A2.2). At the UK-level, the National Ecosystem Assessment follow-on phase is currently investigating valuing ecosystem services in coastal and marine environments, how they link to changes in terrestrial and freshwater ecosystems through appropriate indicators of change; and how future changes to the marine environment may impact ecosystem service delivery (WP3b Marine Economics). The findings of this study will be reported later this year (2013) and should be highly relevant to this report (http://uknea.unep-wcmc.org). The findings of the Valuing Nature Network (VNN) on coastal management, which aims to define, quantify and value coastal ecosystem services and benefits will also be released later this year (http://www.valuing-nature.net/project/coastal-management). In addition, Defra has recently commissioned a consortium to undertake research on valuing ecosystem services in the context of the UK marine environment (Contract: ERG1202). This research project aims to develop economic evidence on the value of changes to provisioning, regulating and cultural services resulting from achieving good environmental status (GES) under the Marine Strategy Framework Directive (MSFD), with a particular focus on the targets for benthic habitats under MSFD Descriptors 1 (biological diversity) and 6 (sea floor integrity). The project consortium is being lead by eftec (Ian Dickie is the Project Manager); the findings are due to be reported in May 2014.

At the EU-level, a number of studies under the Seventh Framework Programme (FP7) are ongoing and will generate economic valuations for marine ecosystem services. Of particular interest here are the findings from the KNOWSEAS project which will generate EU level cost and benefit data for a number of marine sectors (fisheries, energy, transport, etc.) and ecosystem services (including tourism and carbon sequestration), the VECTORS project which will generate primary economic valuation data using choice experiments and deliberative valuation for a number of ecosystem services provided by the Dogger Bank (and other sites across Europe), and the DEVOTES project which will incorporate economic valuation assessments of the implementation of the MSFD in the Southern North Sea (and seven other pilot areas across Europe).

4.5 Value or benefit transfer

Recent projects have endorsed a role for value transfer (also referred to as benefit transfer) when there is not the time or resource to collect primary data for supporting decision-making associated with an ES at a particular site. Value transfer is a method of using primary valuation research results from one site to make secondary predictions about values at a different site. Defra published its official guidance on value transfer in 2010 (http://www.defra.gov.uk/environment/natural/ ecosystems-services/valuing-ecosystem-services/). The aims of the guidelines are to establish 'best practice' for value transfer to assist analysts in:

- deciding if value transfer is appropriate for a given appraisal;
- selecting the most appropriate approach to value transfer and applying an appropriate level of effort;
- selecting the most suitable economic value evidence from the literature;
- implementing the steps of value transfer; and
- presenting the results of value transfer to inform decision-making.

The guidance recognises that benefit transfer is a quicker and lower cost approach to generating economic valuation evidence when compared to commissioning, for example, a site-specific primary valuation study; this advantage makes value transfer a practical tool for analysis given the time and resources constraints decision-makers regularly face (eftec 2010). The guidance presents an eight stage process for value transfer, from establishing the decision-context (Step 1) through to reporting results for decision-making (Stage 8). A summary of the process and skill requirements for value transfer is presented in Figure 4.2.

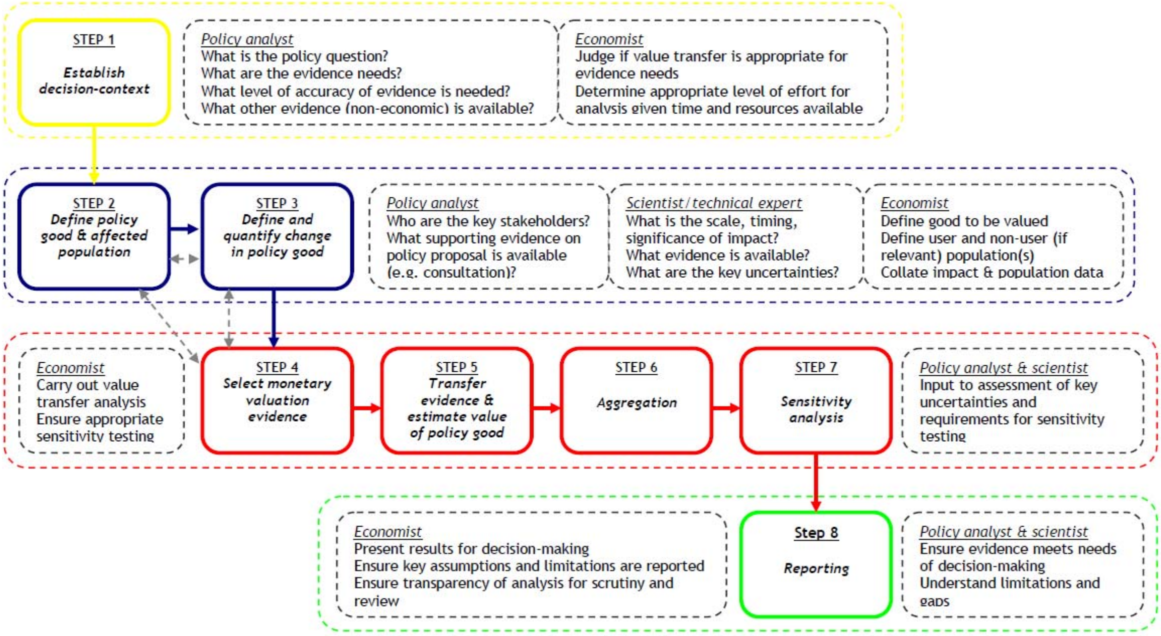


Figure 4.2. Practical steps for value transfer (eftec 2010).

The transference of values tends to be between sites which are similar in both environmental and social structure. Examples of the application of value (benefit) transfer in the coastal and marine environment include Luisetti *et al* (2011) who applied benefit transfer for amenity and recreation values between two UK estuaries (see Table 4.3) and the EU KNOWSEAS project (Cooper *et al* 2011a) which used benefit transfer for scaling up from observed data in one case to the wider EU context (see Table A2.2). In addition, eftec (2010) provide a marine benefit transfer case study which investigates the benefits of designation of the Haig Fras offshore cSAC. (http://archive.defra.gov.uk/environment/policy/natural-environ/using/valuation/case-studies/index.htm).

While the method is relatively simple, care must be taken when transferring values between sites as there is significant potential for error in the transference of values, particularly between different environmental settings. Therefore, a good understanding of the primary dataset, including the assumptions and conditions under which it was derived is essential.

It is anticipated that as the body of primary valuation evidence grows the capacity for, and quality of, value transfer will improve. This is because it offers the opportunity for time and resource savings associated with the use of existing primary data, and also because it supports a wider scale perspective of values.

There are a number of journal articles of relevance to the marine environment which report the findings of studies based on a *meta-analysis*. As an example of meta-analysis, Brander *et al* (2012) valued climate change induced losses of European wetlands. A meta-analysis is used to produce a value function, which is then employed to value site specific ecosystem services. Transferrable values are adjusted to reflect important spatial variables and to account for changes in the stock of ecosystems. The analysis draws evidence from a large number of studies and covers a wide range of wetland types including both coastal and freshwater studies. Sen *et al* (in press) report a large scale assessment of outdoor recreation in the UK, with the results described in detail in the UK NEA (Sen *et al* 2011). Based on a large survey about recreational behaviour among English households, numbers of visitors are estimated and the number combined with a meta-analysis on the value per recreational trip across different type of habitats (marine and coastal areas are included as habitats). The limited number of studies in the UK marine environment in this habitat type precludes the general application of the meta-analysis approach in the UK context at present.

4.6 Scenarios, data and economic valuation

The use of scenario analysis to inform marine environmental management is becoming increasingly widespread. Scenario analysis can be used to identify changes in ecosystem service provision, including a range of human activities and their interactions. A well-cited application is associated with the Intergovernmental Panel on Climate Change (IPCC 2001); more recent applications include the EU-funded ELME (European Lifestyles and the Marine Ecosystems) project (Langmead *et al* 2007) and the UK National Ecosystem Assessment (UK NEA; Bateman *et al* 2011).

Scenarios can be seen to be descriptions "of alternative visions of the future, created from mental maps or models" (Rotmans *et al* 2000; also adopted in EEA 2001) and are essentially pictures or representations of potential future conditions rather than forecasts (IPCC 2001, p.149) which can be used to highlight differences in particular features of interest that result from the characteristics of the scenarios employed (Cooper *et al* 2008). Turner *et al* (2010) present a typology of eight scenarios characteristics defined in terms of basic principles:

1. Forecasting scenarios which attempt to encompass future alternative development paths from the standpoint of the current situation; they can also include expected or desired policy switches.
2. Backcasting scenarios which take as their initial start point some desired future state of affairs or policy objective and then explore alternative strategies to maximise goal attainment.
3. Descriptive scenarios which set out a sequenced set of possible events in a neutral way.
4. Normative scenarios whereby sequences explicitly incorporate different interests, values and ethics.
5. Quantitative scenarios which are usually computable model-based exercises.
6. Qualitative scenarios which rely solely on narratives.
7. Trend scenarios which are based on the extrapolation of current trends.
8. Peripheral scenarios which attempt to include surprises such as unlikely and/or extreme events and their consequences.

It is argued that scenarios typically combine a number of such characteristics depending on their application. From the point of view of the evidence base required for scenario analysis, Cooper *et al* (2008) argue "their validity does not depend on an ability to predict precisely what would be observed at any particular point in the future even if the assumed conditions pertained". This is a notable strength given the complexity associated with marine environmental management (Atkins *et al* 2011b).

The evidence base for scenarios may come from modelling techniques. The development of robust tools which can project future changes in ecosystem services provision is an important step. Modelling techniques have been developed and applied in the marine environment for over six decades (Fulton 2010) and can be used to detect changes in the provision of ecosystem services; if such changes are marginal, then it might be possible to undertake an economic valuation using the appropriate methods as highlighted above (Table

4.2). However, to date, these models have principally emerged from the natural science with few contributions from economics.

A recent review of marine environmental modelling approaches relevant to ecosystem services has been undertaken for the EU-funded VECTORS project (Peck *et al* unpublished report); five main categories of modelling approach were identified which have been applied to investigate the factors responsible for changes in the distribution and productivity of living marine resources:

1. Statistical techniques to analyse time series data (e.g. Möllmann *et al* 2008).
2. Bio-climate envelope and other spatially-explicit statistical models (e.g. Cheung *et al* 2009).
3. Physiological-based, biophysical models of single and/or all life stages (e.g. Cucco *et al* 2012).
4. Spatially-explicit food web models (e.g. Rochette *et al* in press).
5. End-to-end or whole-ecosystem models (e.g. Fulton *et al* 2011).

Peck *et al* recognise that in order to further develop the predictive ability of models into the future requires the integration of biological and physical mechanisms into the model to provide a cause-effect understanding of the impacts of multiple pressures on the marine environment.

With an increasing understanding of the structure and functioning of the marine environment, and more recent technological developments in computing power, there has been an increase over the last decade in the development of end-to-end or whole-ecosystem models (Fulton 2010). Such models are complex, requiring considerable resource to develop, however they attempt to represent the entire ecological system (including human components) and the associated abiotic environment (extending through to climate impacts), integrating physical and biological processes at different scales, and allowing for a two-way coupling between ecosystem components (Travers *et al* 2007). Such end-to-end models are potentially wide ranging in their scope as they attempt to link the biophysical, economic and social components of the system. They are of particular use when attempting to road test management strategies before implementing them in reality (Fulton *et al* 2011). From an economic valuation perspective, end-to-end models provide opportunities to assess how multiple pressures may interact to cause changes in ecosystem service provision, allowing the analyst to identify the costs and trade-offs of different marine spatial policy decisions.

There are a growing number of end-to-end models being developed across the world and these include OSMOSE (e.g. Shin & Curry 2004), Ecopath with Ecosim (e.g. Christensen & Walters 2004) and Atlantis (e.g. Fulton *et al* 2011). Within Europe, Atlantis models are currently being developed for the Eastern Channel and the North Sea under the EU-funded VECTORS project. The models are being developed with their primary focus on the trade-offs between nature conservation, renewable energy developments and commercial fisheries. It is hoped that once developed, such models will be able to use scenarios to estimate how economic sectors (the drivers behind various pressures) will likely impact on the marine system and the costs and trade-offs to various management options.

At the UK-scale the UK NEA follow-on phase is currently examining the potential for using modelling to support scenario work (WP3b Marine Economics), particularly in the context of linking the outputs of an established terrestrial land-use model (Bateman *et al* 2011) to the estuarine, coastal and marine environments. The strengths and weaknesses of different modelling approaches (including hydro-biogeochemical modelling, food-web modelling, spreadsheet approaches, and others) are being considered for the UK marine environment, in order to address the full complexity of the marine system including the linkages with adjacent systems.

To support decision-making it may be advantageous to model the complexity of the whole system. Defining system boundaries and hence hierarchy and scale, representing connectivity between adjacent systems (terrestrial, estuarine and coastal) and multi-level interaction, are all of primary consideration to modelling the marine environment. Where such system complexity cannot be feasibly modelled by other approaches (such as those discussed above), a Bayesian Belief Network (BBN) may offer a solution. BBNs provide a decision support framework based on conceptualising a model domain (or system) of interest as a network of connected nodes (variables) and linkages (dependency relationship). BBNs use probabilistic relations rather than deterministic expressions to provide a quantitative description of the linkages. They can be used to identify knowledge deficiencies, leverage points and points for systemic intervention. Causal loop diagrams provide a framework for exploring interrelationships and patterns of change, and are a useful first stage in the creation of the BBN.

BBNs are based on underlying datasets and/or knowledge. BBNs provide a rational technique for integrating both subjective opinion (e.g. expert knowledge) on probabilistic relations and quantitative empirical data (e.g. monitoring data, modelling results, etc). Subjective expert opinions are made explicit in the formal structure of the network. New information can be incorporated as it becomes available – the conditional probabilities of the affected variables are re-determined, with probability calculus and Bayes' Theorem employed to propagate the evidence throughout the network.

For example, Haines-Young (2011) examines the use of BBNs as a means of implementing analytical-deliberative approaches in relation to mapping ecosystem services and modelling scenario outcomes, and as a tool for representing individual and group values. Earlier examples can be found in (i) the EU FP6 ELME project where BBNs were used to conduct scenario analyses, for example simulating the causality of eutrophication from its European drivers, through its pressures on and subsequent states of Europe's regional seas (Baltic, Black, Mediterranean Seas and the Northeast Atlantic Ocean) (Langmead *et al* 2007); and (ii) in the UK NEA where BBN was used to make land cover projections under different scenarios (the approach was not applied to the marine space by the NEA) (Haines-Young *et al* 2011).

5 Future research needs and policy recommendations

This report has covered substantial ground in elaborating the extent of research and implementation of the Ecosystem Approach including the concept of ecosystem services in the marine environment. With substantial policy reforms being enacted in UK (and European) marine management, it is an appropriate time to take stock of how these important integrative concepts can be operationalised to ensure coastal and marine systems are valued and well managed, now and into the future. This final section highlights the future research needs and policy recommendations.

5.1 Future research needs

5.1.1 Ecosystem services

- Several projects are in initial stages of gathering data on coastal system function, the role of biodiversity in supporting coastal services, and valuation of services. Emerging data will be important for filling in gaps in the current debate and contribute to policy uptake. A key issues is what evidence decision-makers need about ecosystem services?

- How can the valuation of coastal ecosystem services be implemented in a variety of policy and management contexts? What would be the ramifications for coastal communities?

- Other conceptualisations of value such as shared social value and non-monetary health and well-being values should be explored alongside monetary valuations. More research needs to be undertaken to understand how values change in different contexts.

- Building the evidence base to understand how marine biodiversity affects ecosystem functions and specific final services and beneficiaries will be important for informing biodiversity protection and management, e.g. in MPAs.

- The potential implications of future environmental, social and policy change upon marine ecosystem processes is uncertain. Linking the understanding of how marine ecosystems respond to environmental change at different scales and how this affects service delivery is an important research challenge.

- Identification of the services provided by deep sea habitats and their value is a key research opportunity.

5.1.2 The Ecosystem Approach

- How to embed the principles of the approach in policy and practice.

- How does the approach offers a new dimension to current practice.

- Case studies of Ecosystem Approach implementation in the marine environment for use in policy and to take out to stakeholders.

- Ensure research and its outputs are clear, concise and practical.
- The social principles of decentralisation, societal choice and societal involvement which are part of the CBD's definition of the Ecosystem Approach need to be better associated with the term.
- Improved understanding of ecosystem service interactions or trade-offs i.e. what would be the result of a change and the effects of favouring one particular set of benefits is needed.

5.1.3 Economic valuation of marine ecosystem services

- Developing techniques to value the range of ecosystem services recognising that, at present, some services in the marine environment belie valuation.
- Extending the number of studies of the UK marine ecosystem services to improve the primary evidence base on economic valuation.
- Refining the techniques associated with benefit and value transfer.
- Developing the role of economics in modelling and scenario analysis, which to date has been predominantly natural science based, to enable its use in valuing ecosystem services where data is poor.
- Further, on the nature of the research that is undertaken, a greater promotion of integration between natural and social scientists is required given the multidisciplinary nature of ecosystem services research, including when it comes to non-market valuations.

5.2 Policy recommendations

5.2.1 Ecosystem services

- Integration of ecosystem valuation into decision-making remains poor - the growing supply of valuation evidence is not aligned with the needs of decision makers. Regular science – policy deliberation will improve this problem.
- When designing policy instruments the distribution of benefits must be considered, the relationship to poverty alleviation and a general discussion on equity and justice is needed.
- Decision makers and scientific providers should continue to work together to identify where the adoption of an ecosystem services framework and evidence has led to 'better' policy decisions?
- Policy processes such as marine protected area designation and management offer opportunities to evaluate the consequences of trade-offs between different services. Incorporation of ecosystem service concepts, indicators and valuations into marine policy and planning will improve understanding of the value of marine environments to society.

5.2.2 The Ecosystem Approach

- Application of the Ecosystem Approach should always incorporate ecological, economic and social considerations (rather than focus on a sole issue such as fisheries) within a single framework of which humans are an integral component.

- A clear message is needed of what we mean by the Ecosystem Approach. The misuse of terminology propagates confusion.

- A joint agency statement similar to HELCOM and the OSPAR Commission jointly adopted Statement on the Ecosystem Approach may be beneficial.

- Illustrate where the Ecosystem Approach is supporting current practice and using existing information e.g. how it can link to existing procedures.

- The presentation of the Ecosystem Approach is important – it should be promoted as an opportunity not a further hurdle or constraint-need to sell the approach, both internally and externally. This should make use of professional support to put this message across.

- Distil the 12 CBD principles into three themes which are easier to understand and communicate: Systems thinking and management; Involving stakeholders in decision making; Understanding the wider benefits provided by the environment

- Communication should be tailored when interacting with stakeholders who have no understanding of the concept; the current terminology does not need to be used and is not helpful in many situations.

- Existing information including best practice on participation needs to be better used.

- The level of understanding by policy colleagues needs to improve as currently it is seen to limit progress and implementation.

- More attention should be paid to the resources that are required for effective marine planning.

- A nested scale approach to implementation is recommended but should reflect the individual circumstances, the stakeholders involved and the particular sectors.

5.2.3 Economic valuation of marine ecosystem services

Finally, with respect to economic valuation of marine ecosystem services, a number of policy recommendations have been made:

- Distinguishing between the basic marine processes, intermediate and final ecosystem services, goods and benefits provided for society in valuation should be advocated for marine ecosystem services.

- Robust guidelines on the most appropriate use of valuation techniques, aggregation and comparison of economic valuation evidence for the marine environment has a role when this evidence is to be used for decision support and policy purposes.

- The growing importance of economic valuation in the design and implementation of national and international marine policy calls for a greater UK primary evidence base, increasing the number of valuation studies and their coverage of the range of marine ecosystem services (especially of regulating and cultural services).

- Every effort should be made to quantify the goods and benefits provided by the marine environment (even if only partially) when valuation evidence is called for to support decision making and policy design.

- Where possible, primary economic valuation data should be stored centrally using online databases/catalogues etc., and apply a full and standardised approach for data entry to ensure that such evidence is easily accessible and understood when used to inform policy decisions.

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7 Appendices

7.1 Appendix 1

Table A1.2. Overview of the Ecosystem Approach in marine policy.

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
Marine Strategy Framework Directive	Directive which aims to achieve Good Environmental Status in Europe's seas by 2020	EU	Covers the main human pressures on the marine ecosystems	Ecosystem-based approach	Self-proclaimed	**Article 1 (3)** of the Directive states that "Marine strategies shall apply an ecosystem-based approach to the management of human activities." **Directive text**: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF
Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)	The legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic	Regional Sea	Prevent and eliminate pollution and to protect the maritime area against the adverse effects of human activities	Ecosystem Approach	Self-proclaimed	**Article 3 (1)** subject to Article 4 of this Annex, to aim for the application of an integrated ecosystem approach. **Directive text:** http://www.ospar.org/html_documents/ospar/html/ospar_convention_e_updated_text_2007.pdf
Common Fisheries Policy	To conserve fish stocks. Managing fisheries across borders and designed to make EU fishing grounds a common resource	EU	Unsustainable exploitation of fisheries resources	Ecosystem-based approach	Self-proclaimed	The Common Fisheries Policy is committed to applying the pre-cautionary principle and an ecosystem-based approach. http://ec.europa.eu/fisheries/documentation/publications/pcp2008_en.pdf (page 34)
Marine and Coastal Access Act 2009	The Act seeks to improve management and increase protection of the marine environment and improve recreational access to England's coasts	UK	The Act will help us to achieve clean, healthy, safe, productive and biologically diverse oceans and seas.	None specifically. Creates opportunities for ecosystem management.	Defra alludes to the Act being underpinned by facets of the EA	Authorities must act in accordance with the UK Marine Policy Statement which advocates an 'ecosystem-based approach'

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
Marine (Scotland) Act 2010	A framework which will help balance competing demands on Scotland's seas	Scotland	No single approach to managing Scotland's seas	Not specifically mentioned	NA	**(Art 11(2)(a)(1) and (b)(1))** The Act requires a 'duty to keep relevant matters under review including the physical, environmental, social, cultural and economic characteristics of the Scottish marine area and the living resources which the area supports'.
Finding Sanctuary Project	Partnership project which brought together a number of stakeholders to design a network of MPAs in South West England.	Seas surrounding the peninsula of south-west England, from MHWS to the continental shelf (sea area of 93,000 km2)	The goal of the MPA network was to safeguard our region's undersea habitats and marine life, and to help ensure the long-term sustainability of marine resources in the region	Ecosystems Approach	CBD case-study: demonstrate the value and practicalities of applying the EA to sustainable water management. Self-proclaimed also	One of four regional initiatives around the English coast under the Marine Conservation Zone Project established by Defra, Natural England and JNCC **Project website**: http:/www.finding-sanctuary.org/
Irish Sea Pilot Project	Test the potential for an Ecosystem Approach to managing the marine environment	Regional Sea	Conserve marine biodiversity and protected areas. To address the UK's commitments to the conservation and sustainable development of the marine environment based on an Ecosystem Approach	Ecosystem Approach	Self-proclaimed	The purpose was to help develop a strategy for marine nature conservation that could be applied to all UK waters and, with international collaboration, the adjacent waters of the north-east Atlantic. **Project website**: http://www.theirishseapilot.com/

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
Oceans Act (Canada) 1997	Conserve, protect and develop the oceans in a sustainable manner. Founded on 3 principles: sustainable development, integrated management, and the precautionary approach.	National	Achieving integrated oceans management.	Ecosystem Approach Ecosystem-based management	Self-proclaimed.	The EA is not explicitly mentioned in the Oceans Act but in the associated Oceans Strategy which came as a result **Strategy text**: http://www.dfo-mpo.gc.ca/oceans/management-gestion/governmentsrole-roledesgouvernements/index-eng.htm
United Nations Convention on the Law of the Sea (UNCLOS)	Defines the rights and responsibilities of nations in their use of the oceans, establishing guidelines for businesses, the environment, and the management of natural resource	International	Nations had varying claims of territorial waters for activities such as resource extraction, protecting fish stocks and reducing pollution	Article 119 of UNCLOS, although not using the term, represents the concept of the Ecosystem Approach	Self-proclaimed	**Convention text:** http://www.un.org/depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm
US Ocean Commission Report-'An Ocean Blueprint for the 21st century'	This order establishes a national policy to ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources.	National	Ensure the ocean, and coasts are healthy and resilient, safe and productive to promote the well-being, prosperity, and security of present and future generations	Ecosystem-based management Ecosystem-based approach within coastal and marine spatial planning	Self-proclaimed	In 2010 Executive Order 13547 was signed establishing a National Policy for the Ocean, Coasts, and Great Lakes. The Order directed agencies to implement the Recommendations of the White House Interagency Ocean Policy Task Force, a body established to make recommendations about U.S. ocean policy. Ecosystem-based management listed as number 1 priority out of 9. http://www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
Endangered Species Act (USA)	Conservation of endangered species, and the conservation of the ecosystems on which they depend.	National	Protection of nations living resources so that they don't become extinct.	Ecosystem Approach	Self-proclaimed	Not mentioned explicitly in the Act, but 1994 Interagency Cooperative Policy for the Ecosystem Approach http://www.nmfs.noaa.gov/pr/pdfs/fr/fr59-34274.pdf
Coral Reef Conservation Act (USA) 2000	Established to preserve coral reefs, promoting wise management and gaining baseline information reef condition	National	To reduce threats to coral reef ecosystems (direct anthropogenic, and indirect e.g. climate change and invasive sp).	Ecosystem-based approach and coral reef ecosystem management	Self-proclaimed	**Act text:** http://coris.noaa.gov/activities/actionstrategy/08_cons_act.pdf **Latest requested amendment:** www.govtrack.us/congress/bills/113/hr71/text Amendments: S 209 instructs that EBM should be followed; S 107 a request to strengthen coral reef and management
National Marine Sanctuaries Act (USA) 1972	The Act seeks to protect marine habitats and special ocean areas.	National	To protect marine resources, such as coral reefs, sunken historical vessels or unique habitats.	Ecosystem Approach Ecosystem-based approach	Self-proclaimed (NOAA)	The subsequent NMS strategic plan states they are taking an Ecosystem Approach to marine management **NMSA:** http://sanctuaries.noaa.gov/library/national/nmsa.pdf **NMS strategic plan**: http://sanctuaries.noaa.gov/management/pdfs/nms_strategic_plan_2005.pdf
Marine Mammal Protection Act (USA) 1972	All marine mammals are protected under the MMPA. Prohibits the "take" of marine mammals in U.S. waters and on the high seas, importation of marine mammals	National	Enacted in response to significant declines in marine mammals and the impacts of human activities.	Ecosystem Approach	Marine Mammal Commission	**MMPA :** http://www.nmfs.noaa.gov/pr/pdfs/laws/mmpa.pdf **MMPA Fact Sheet:** http://www.nmfs.noaa.gov/pr/pdfs/mmpa_factsheet.pdf **Ecosystem Approach terminology:** http://www.mmc.gov/legislation/mmpa.shtml

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
	and their products					
Magnuson–Stevens Fishery Conservation and Management Act	The primary law governing marine fisheries management in United States federal waters	National	Conservation and management of fishery resources within the U.S. EEZ, and authority over continental shelf resources and anadromous species	Ecosystem Approach and Ecosystem principles	Marine Mammal Commission	**(S 406)** need to examine the degree to which 'ecosystem principles' are being applied, and the need for a panel to help expand the use of such principles. **MSA Act:** http://mmc.gov/legislation/pdf/msf_cm_act.pdf
Large Marine Ecosystems	Large areas of ocean space of c.200,000 km² or greater. Delineated by NOAA on basis of (i) bathymetry, (ii) hydrography, (iii) productivity, and (iv) trophic relationships.	International coastal waters	In response to pollution and nutrient overenrichment, habitat degradation, overfishing, biodiversity loss, and climate change effects.	Ecosystem-based management and Ecosystem Approach	UNEP	**UNEP:** "The LME approach is a way forward for advancing ecosystem-based management of coastal and marine resources within a framework of sustainable development" **LME website:** http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=47&Itemid=28
Convention on Biological Diversity	Three main objectives: -conservation of biodiversity -sustainable use of biodiversity -fair and equitable sharing of the benefits from resources	International (193 Contracting Parties)	Threat to species and ecosystems caused by human activities	Ecosystem Approach	Self-proclaimed	The Ecosystem Approach is the primary framework for action under the Convention. CBD entered into force in 1993.

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
FAO Code of conduct for Responsible Fisheries	Voluntary Code which provides principles and standards applicable to the conservation, management and development of all fisheries	Global	Unsustainable exploitation of fisheries resources	Ecosystem Approach to Fisheries	Self-proclaimed	**Code text:** http://www.fao.org/docrep/005/v9878e/v9878e00.HTM
HELCOM Baltic Sea Action Plan	Programme to restore the good ecological status of the Baltic marine environment by 2021	Regional Sea: Baltic Sea area	Combat the deterioration of the marine environment resulting from human activities	Ecosystem Approach	Self-proclaimed	**Baltic Sea Action Plan**: http://www.helcom.fi/BSAP
Convention on the Conservation of Antarctic Marine Living Resources	Convention with the objective of conserving Antarctic marine life	International	In response to increasing commercial interest in Antarctic krill resources, a keystone component of the Antarctic ecosystem	Ecosystem-based management approach	Self-proclaimed	**Convention text:** http://www.ccamlr.org/en/organisation/camlr-convention-text
Nature Conservancy 'Reef Resilience' case study from Raja Ampat, Indonesia	The primary objective is to establish 2 MPAs to form the basis for a network of collaboratively-managed MPAs in Raja Ampat	Regional sea	Supporting the design and effective implementation of 12 MPAs spread throughout the seascape to protect a diversity of species, habitats and ecosystem services	Ecosystem-based management approach (to the development of MPA zoning plans)	Self-proclaimed (TNC)	http://www.reefresilience.org/Toolkit_Coral/C8_RajaAmpat.html http://www.reefresilience.org/pdf/Birds_Head_EBM_Fact_Sheets_09_051-1.pdf#page=1&zoom=auto,0,48 http://www.reefresilience.org/pdf/Halpern_etal_2010.pdf
Australia's Ocean Policy	Promotes the development of regional marine plans, now known as marine bioregional plans	National	Improved coordination to ensure reduced conflict, avoid degradation and facilitate sustainable use. A response to international	Ecosystem-based planning and management	Self-proclaimed	**S176 EPBC Act**: "sets in place the framework for integrated and ecosystem-based planning and management for all of Australia's marine jurisdictions."

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
			commitments (UNCLOS)			
Inner Forth landscape Study	The vision is of an Inner Forth landscape where the natural, cultural and historical wealth of the area is revealed, valued, enhanced and made accessible to both residents and visitors	Local. Inner Forth extending to c. 200 km^2	This project is in response to a number of drivers e.g. climate change, post-industrial landscape, development pressure, lack of public awareness of landscape change	The Inner Forth project is an example that has the ethos of the Ecosystem Approach but does not use the terminology	Ecosystem Knowledge Network	**Project website:** http://innerforthlandscape.wordpress.com/
Ecosystem-Based Management Initiative for Sustainable Coastal and Marine Systems.	Launched in 2004 to inform managers about ecosystem-based management and to ensure EBM strategies are used to maintain coastal marine systems	Multiple projects (regional)	To learn about EBM and develop it as an approach	Ecosystem-based management	Self-proclaimed	**Initiative website:** http://www.packard.org/what-we-fund/conservation-and-science/science/ecosystem-based-management-initiative/
Watershed management in the Susquehanna and Chemung Basins of New York	A watershed management plan developed using an ecosystem-based management approach to promote sustainable water resource management	Watershed	Maintaining high water quality	Ecosystem-based management	Self-proclaimed	**Action Plan:** http://www.stcplanning.org/index.asp?pageId=173

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
Fisheries management - Chesapeake Bay, USA	NOAA supports a move to Ecosystem Approaches to management for fisheries in the Chesapeake Bay to sustain fisheries and provide for a balanced Chesapeake Bay ecosystem.	Estuary	Fisheries decline	Ecosystem-based management	Self-proclaimed	http://chesapeakebay.noaa.gov/ecosystem-based-management/ecosystem-based-fisheries-management **Chesapeake Fisheries Ecosystem Plan Technical Advisory Panel report:** http://chesapeakebay.noaa.gov/images/stories/pdf/FEP_FINAL.pdf
West Coast Ecosystem-Based Management Network	Community-based initiatives to implement ecosystem-based management along the coasts of Washington, Oregon and California.	West coast USA	Putting ecosystem principles into action - to learn and share lessons/techniques	Ecosystem-based management	Self-proclaimed	http://www.westcoastebm.org/Homepage.html http://www.westcoastebm.org/WestCoastEBMNetwork_EBMGuide_June2010.pdf
New York Oceans and Great Lakes Ecosystem Conservation Act (2006)	Establishes a policy of conserving and restoring ocean and coastal resources	Regional	Lack of coordination between different uses and degradation/threats	Ecosystem-based management	Self-proclaimed	http://www.oglecc.ny.gov/ **Report** http://www.oglecc.ny.gov/media/Final_New_York_Ocean_and_Great_Lakes_Report_April_2009.pdf
Firth of Clyde Marine Spatial Plan	To develop and evaluate approaches to the sustainable management of Scotland's marine resources. Developed over 3 years under the auspices of the Scottish Sustainable Marine	Local	Social, cultural, environmental and economic resources are increasingly coming under pressure from the aspirations of a growing number of users	Ecosystem Approach	Self-proclaimed	**Clyde Spatial Plan:** http://clydeforum.com/SSMEI-MSP-2010.pdf

EA Example	Description	Unit (scale) of management	Management Problem	Terminology Used	Who calls it an Ecosystem Approach?	Details and further information
	Environment Initiative					

7.2 Appendix 2

Table A2.1. Overview of UK and European research on ecosystem services.
(* denotes references in reference list).

Project	Year	Geographical focus	Aims & Objectives	Status	Website	Contact
EU FP7 Knowledge-based Sustainable Management for Europe's Seas (KNOWSEAS)	2009-13	European Regional Seas: North Sea, NE Atlantic, Mediterranean, Baltic, Black Sea 32 partners from 15 countries	The objective of KNOWSEAS is a comprehensive scientific knowledge base and practical guidance for the application of the Ecosystem Approach to the sustainable development of Europe's regional seas. This will increase the evidence available for decision makers and facilitate the implementation of the Ecosystem Approach. KS developed a WP on economic analysis at the regional sea scale. Estimates of the aggregate, i.e. EU level, of annual benefits and costs associated with the exploitation of Member State Exclusive Economic Zones. This involved a scoping process to identify the principal benefits and costs built on the latest available annual data at the time (generally for 2009). KNOWSEAS estimates the future benefits that might be expected from the continued and future exploitation of Europe's seas. Benefits accounted for sectors including Energy, Fisheries & Mariculture, Freight / transport; recreation (visits); recreation (water quality). carbon storage (salt marshes and sea grass).	**Project completed**. Data: reports to EU commission and forthcoming publications.	http://www.msfd.eu/ http://www.knowseas.com/ For understanding ecosystem services: http://www.msfd.eu/what.html	knowseas-coordination@sams.ac.uk
Valuing Nature Network: Bridging the gap between supply of and demand for valuation evidence (BRIDGE)	2012	UK. Multi-sector and across different environmental contexts.	**Objective 1**: Assess the state of expert knowledge around VNN Challenge 4 (integrating knowledge into governance). **Objective 2:** Clarify central concepts around the supply of and demand for ecosystem service valuation evidence and develop a common vocabulary and theoretical approach to integrating this evidence into decision-making. **Objective 3**: Identify a future research agenda on how to best integrate ecosystem service valuation evidence into decision-making. **Objective 4**: Establish a transdisciplinary VNN hub of researchers and decision-makers that will investigate the interaction between demand for and supply of ecosystem service valuation evidence	**Project completed**. Publications in press*: Young *et al*2013) Cristie *et al* (2013) Kenter *et al*(2013) Jordan & Russel (2013) *See Reference list	http://www.valuing-nature.net/projects/bridge	Professor M. Christie mec@aber.ac.uk

Project	Year	Geographical focus	Aims & Objectives	Status	Website	Contact
Valuing Nature Network: Coastal Management project	2012	UK coastal and inshore. Valuation of North Sea estuaries.	This project aimed to define, quantify and value coastal ecosystem services and benefits; and to distinguish between the 'stock' position i.e. the available amount of coastal ecosystem services at a given point in time and the 'flow' position i.e. the incremental changes in the supply of services over time. 4 sub projects looking at valuation conceptual frameworks, valuation data, MPAs, and scenarios. MPA project explored questions relating to: • How are ecosystem service concepts built into policy relating to marine protected areas in different devolved jurisdictions? • What specific services do protected features generate? • How will Marine Protected Areas management affect the output of ecosystem services from sites • Do we have fit for purpose tools to measure flows of and changes in services?	**Project completed.** Final reports published April 2013.	http://www.valuing-nature.net/project/coastal-management	Project Director Professor Kerry Turner r.k.turner@uea.ac.uk
Marine Biodiversity and Ecosystem Functioning (MARBEF)	2004-2009	European coastal and marine waters: Flamborough Head, UK; Isles of Scilly, UK; Gulf of Gdansk, Poland; The Azores, Portugal.	The scientific objectives of the MarBEF programme are: • To understand how marine biodiversity varies across spatial and temporal scales, and between levels of biological organisation, in order to develop methods to detect significant change. • To generate theory, models and tests of the relationship between marine biodiversity and ecosystem function through the integration of theoretical and modelling exercises, comparative analyses and carefully-designed experimental tests. • To understand the economic, social and cultural value of marine biodiversity and hence develop the research base required to support the sustainable management of marine biodiversity . Contingent valuation surveys were undertaken at four locations across Europe.	**Project completed.** Scientific publications* Beaumont *et al* (2007) Ressurreição, *et al* (2011) Ressurreição (2012)	http://www.marbef.org/	Dr Melanie Austen mcva@pml.ac.uk

Project	Year	Geographical focus	Aims & Objectives	Status	Website	Contact
EU FP7: VECTORS of Change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts	2011-2015	European Regional Seas - North Sea, Baltic Sea, Western Mediterranean	VECTORS aims to improve our understanding of how environmental and man-made factors are impacting marine ecosystems now and how they will do so in the future. The project will examine how these changes will affect the range of goods and services provided by the oceans, the ensuing socio-economic impacts and some of the measures that could be developed to reduce or adapt to these changes. Choice experiment and deliberative valuation studies will be undertaken at a number of marine sites across Europe including the Dogger Bank, North Sea; Bay of Gdansk, Poland; and at a site in the Western Mediterranean (still to be decided).	**Project ongoing** Several publications from website, but no valuation studies on ES to date.	http://www.marine-vectors.eu/	Dr Melanie Austen mcva@pml.ac.uk Project officer: Jennifer Lockett jelo@pml.ac.uk
EU FP7 DEVOTES: Development Of innovative Tools for understanding marine biodiversity and assessing Good Environmental Status.	2012-2016	Eight pilot case study areas - 1) Gulf of Finland 2) Kattegat, 3) Southern North Sea, 4) Bay of Biscay, 5) Adriatic Sea , 6) Eastern Aegean Sea, 7) Sea of Marmara, and 8) Western open Black Sea.	DEVOTES main objectives are to: i) improve understanding of the impact of human activities and climate change on marine biodiversity**;** ii) identify the barriers and bottlenecks that prevent Good Environmental Status from being achieved; iii) test indicators and develop new ones to assess biodiversity in a harmonized way throughout regional seas; iv) develop, test and validate integrative modelling and monitoring tools to improve understanding of ecosystem and biodiversity changes v) propose and disseminate strategies and measures for ecosystems' adaptive management **WP2: Social-economic implications for achieving GES.** The objective is to determine the socio-economic implications of maintaining or changing monitoring and management practices aimed at achieving and maintaining GES. The aim is to support cost-effective monitoring systems and adaptive management strategies and measures. This will be achieved through: 1) Identification of cost-effective MSFD indicator monitoring and assessment systems relevant to each regional sea; 2) Identification and assessment of the economic consequences of management measures aimed at achieving and maintaining GES; 3) Exploration of the implications of these management measures for marine ecosystem services; 4) Identification of the barriers (socio-economic and legislative) that prevent GES from being achieved.	**Project ongoing** No data is available yet. Overview paper: Borja (2012)*	http://www.devotes-project.eu/	Project coordinator: Dr Angel Borja aborja@azti.es

Project	Year	Geographical focus	Aims & Objectives	Status	Website	Contact
UK National Ecosystem Assessment follow-up phase - WP3b Marine Economics	2012-2013	UK marine environment	To value ecosystem services in coastal and marine environments; investigate how they link to changes in terrestrial and freshwater ecosystems through appropriate indicators of change; and understand how future changes to the marine environment may impact ecosystem service delivery	The project is ongoing and has not made any policy recommendations. The project is due to be completed in August 2013.	http://uknea.unep-wcmc.org/NEWFollowonPhase/WhatdoesthefollowonphaseInclude/WorkPackage3b/tabid/146/Default.aspx	Project coordinators: Prof. Kerry Turner r.k.turner@uea.ac.uk Professor Mike Elliot mike.elliott@hull.ac.uk Prof. Laurence Mee Laurence.Mee@sams.ac.uk
NERC BESS: Biodiversity and Ecosystem Service Sustainability	2011-2017	UK environments: Lowland agricultural landscapes Freshwater, brackish and **near-coast marine wetland landscapes** ; Upland landscapes Urban landscapes	BESS is an overarching NERC funded program that coordinates 4 sub-projects. Its grand challenge is to ""To understand the role of biodiversity in key ecosystem processes" Overall goals are: * Define how biodiversity within landscapes underpins the delivery of different ecosystem services at a range of scales and across gradients. * Establish whether there are critical levels of biodiversity required to deliver different kinds of services under different driver-pressure scenarios, as well as which enhance the resilience of ecosystems to those different drivers * Develop novel tools and indicators appropriate for tracking and measuring biodiversity and ecosystem services under those different scenarios.	The project is **still ongoing** and is due to be completed in 2017 No outputs reported.	http://www.nerc-bess.net/index.php/documents (Science Plan) http://www.nerc-bess.net/	Director: Dave Raffaelli david.raffaelli@york.ac.uk
C:BESS: A hierarchical approach to the examination of the relationship between biodiversity and ecosystem service flows across coastal margins	2011-2017	Two regional landscapes (Morecambe Bay and Essex coastline) with a UK-wide study	CBESS will adopt an integrated hierarchical approach to quantify the linkages between biodiversity stocks (microbial, macroflora, invertebrate meio- and macrofauna, avifauna), multiple ecosystem functions, and flows of key ecosystem services (Provisioning: Regulating: Supporting: and Cultural) up to landscape scales in complex, but ecologically and socio-economically critical transitional wetland habitats. Exploration of cultural non monetary values.	The project is **still ongoing** and is due to be completed in 2017. No outputs reported.	http://synergy.st-andrews.ac.uk/cbess/	Project Officer: Meriem Kayoueche-Reeve mkr3@st-andrews.ac.uk

Project	Year	Geographical focus	Aims & Objectives	Status	Website	Contact
VALMER (INTEREG funded)	2012-2015	Western English Channel including North Devon, Plymouth Sound, Brittany, Iroise Sea, Morbihan	The project seeks to develop and apply methodologies that can be used to quantify and communicate the real value (economic, social and environmental) of marine and coastal ecosystem services. We will use monetary and non-monetary techniques to place a value on ecosystem services, using methods that have transferability elsewhere in the Channel/Manche region and beyond.	The project is **still ongoing** and is due to be completed in 2015. No outputs reported.	http://valmer.eu/wordpress/	Ness Smith ness.smith@plymouth.ac.uk

Table A2.2. Summary of conceptual approaches, research on ecosystem structure and valuation.

Project	ES Conceptual framework	Structure / function focus	Valuation focus
FP7 KnowSeas	The definitional approach adopted in KnowSeas is one based on the MEA (2005) and the Crown Estate benefits framework (Saunders *et al* 2010).	No - the focus of Knowseas is on the connections between State - Impact - Welfare -Response in the DPSIWR chain.	Estimates at the aggregate, i.e. EU, level of benefits and costs associated the exploitation of Member State Exclusive Economic Zones. Cases selected across Direct and indirect use that capture a selected list of benefits. Valued using data for direct market values (fisheries, recreation, energy, transport), willingness to pay (recreation and water quality) and indirect values, cost avoidance (carbon storage). Uses existing secondary data and uses benefit transfer for scaling up and cross case comparisons. Analysis represents a "snapshot" over a strictly limited period of time and it remains to be seen how the distribution of values across sectors/activities and across seas may change over time. Data exists but in form of internal project deliverables. Permission required for data. knowseas-coordination@sams.ac.uk
VNN BRIDGE project	Uses VNN core framework placing valuation of individual and collective values at centre of analysis.	No. focus is upon identifying questions and topics for the end user.	No. focus is upon identifying questions and topics for the end user.
VNN Coastal Management project	Uses VNN core framework (use in text) placing valuation of individual and collective values at centre of analysis. Conceptual paper and MPA paper developed new conceptual framework and matrices.	A number of marine protected areas (MPAs) have been established or proposed. This research has identified the ecosystem services most likely to be conserved/provided under this spatial designation process. Matrices for the provision of ecosystem services provided by key designated features (habitats and species) have been constructed (Potts *et al* 2013).	Has quantified and evaluated a set of ecosystem services (carbon storage, fish nursery provision and recreation and amenity) for several North Sea estuaries. The estimates of 'blue carbon' derived from saltmarshes and seagrass beds are highly relevant in climate policy. The approach adopted has served to emphasise that the basic ecosystem processes and structure that underpins the stock and flow of ecosystem services is fundamentally 'valuable' in its own right. The project proposes an interpretation of the ecosystem services stock and flow concepts in order to distinguish between the monetary accounting value of the ecosystem services stock (analogous to the economic measure Gross Domestic Product GDP); and the economic (marginal) value of incremental changes in flows of ES over time. * These monetary estimates can serve to emphasise the 'significance' of ecosystem services to the economy and human welfare; and may carry further traction with Finance Ministries and their thinking because they are explicitly couched in monetary terms. The approach adopted has served to emphasise that the basic ecosystem processes and structures that underpin the stock and flow of ecosystem services is fundamentally 'valuable' in its own right. Thus it is always the case that the total monetary economic value (related to the sum of the

Project	ES Conceptual framework	Structure / function focus	Valuation focus
			flow of ecosystem services) is less than total system value. This has implications for policy options appraisal and trade off in decision making. It requires that economic cost-benefit decision analysis must be constrained by regulations that reflect precautionary thinking if it is suspected that environmental 'limits' i.e. thresholds and irreversibilities may be approaching.
MarBEF	The over-arching classification applied here follows the Millennium Ecosystem Assessment and divides goods and services into provisioning, regulating, supporting and cultural A small deviation from this previous categorisations is the inclusion of the category ''Option use value'', with the accompanying service of future unknown and speculative benefits. The ES framework adopted is published in: Beaumont *et al* (2007).	No	Contingent valuation methods were applied to obtain willingness to pay values at 4 different case study sites. Willingness to Pay was elicited from visitors and residents at three of the sites (Isles of Scilly, Gulf of Gdansk, The Azores), and just for visitors at Flamborough Head. WTP was obtained to prohibit a 10% and 25% reduction of marine biodiversity in general, and also for 5 named taxa (fish, birds, mammals, seaweed, invertebrates). Overall, most participants were aware of biodiversity issues and were willing to pay to conserve biodiversity. However, the differences between countries suggested that people's conservation preferences were influenced by their associations with particular species in their own regions. For instance, in the Azores, scuba diving and fishing are important activities in both an economic and a cultural sense. This could lead local residents to place a higher value on fish.
VECTORS	The framework to be applied within the VECTORS project has been adapted from the TEEB study (and others) for the marine environment.	No data is available yet.	No data is available yet.
DEVOTES	Still to be decided, but it is envisaged that it will build on current EU and national projects such as TEEB, VECTORS, KNOWSEAS, and the UK NEA.	No data is available yet.	No data is available yet.
NEA WP3b	The framework to be applied within the NEA WP3b is that developed by the Valuing Nature Network (VNN) for the coastal and marine environment (Turner *et al* unpublished results). This framework categorises the marine environment into a set of components and processes,	No data is available yet.	No new valuation data will be elicited.

Project	ES Conceptual framework	Structure / function focus	Valuation focus
	intermediate services, final services and good/benefits and recognises the requirement for complementary capital to realise the goods/benefits from the final services.		
BESS	Builds on projects such as TEEB, VECTORS, KNOWSEAS, and the UK NEA.	From the BESS science plan: The fundamental role that biodiversity plays in regulating the ecological processes (e.g. primary production, nutrient recycling) that underpin ecosystem services is acknowledged, but a quantitative understanding of biodiversity-ecosystem functioning-ecosystem service relationships is poor. 1. Functional relationships between biodiversity and ecosystem services A major aim of BESS is to characterise the functional forms for the different services derived from multi-functional landscapes at different scales. 2. Resilience of biodiversity-ecosystem service relationships to changing conditions An aim of BESS will be to determine critical amounts of biodiversity necessary for the sustainable delivery of those goods and services desired by society in the face of such drivers of change. 3. Monitoring and evaluation of ecosystem services The responses of ecological stocks and flows to landscape management interventions need to be measured using appropriate tools and indicators. Whilst potential indicators exist for many aspects of biodiversity, such as the area	BESS is a NERC-funded programme, the natural sciences component is expected to dominate (80% or more of costs). Valuation of ecosystem services is not in the project remit but linkages are made with the VNN project and ESPA programme. Under theme 3 (monitoring and evaluation of ES) indicators will be developed that indicate the state and resilience of biodiversity-function-service systems with respect to specific critical thresholds and these indicators will have social and policy implications.

Project	ES Conceptual framework	Structure / function focus	Valuation focus
		and condition of BAP habitats few of these were developed with ecosystem service provision in mind.	
C-BESS	Uses an adapted NEA framework	1. Generate data on biodiversity and ecosystem service flows using a common framework 2. Quantify biodiversity and ecosystem service patterns across a hierarchy of spatial scales 3. Quantify context dependencies in biodiversity-ecosystem services across a hierarchy of spatial scales 4. Develop model frameworks to predict biodiversity-ecosystem service flows at landscape scales 5. Develop functional tools for predicting Ecosystem Service Provisioning (ESP) across a range of environmental contexts C-BESS looks at: Regulating services: coastal protection and climate regulation Provisioning services: goods obtained from the landscape Cultural services: Recreation Supporting services: nutrient cycling, healthy habitat	For cultural services CBESS will quantify the benefit provided by birds (a visible and well-known taxon) with cultural resonance. This includes both the perceived aesthetic and monetary benefits (Cultural services), in particular through bird-related recreation and tourism. CBESS will establish other important recreation activities by consultation with the user community through participatory approaches. The landscape scale provision of 'socio-ecosystem services' will be assessed through both Stated Preference Choice Experiments and non-monetary valuations. These can be mapped onto our biodiversity survey design, informing the scale dependence of single and combined socio-ecosystem services on biodiversity across UK wetlands.
VALMER		No. Focus on valuation	Phase 1: Assessing and valuing marine ecosystems Phase 2: Developing data support for VALMER Phase 3: Building scenarios for ecosystem service valuation Phase 4: Applying marine ecosystem service valuations to improve marine planning Phase 5: Communication and stakeholder engagement

Table A2.3. Policy and recommendations and challenges for ecosystem services research.

Project	Policy recommendations	Future Challenges
FP7 KnowSeas	Linking marine and coastal ecosystems to concepts of value, flow of goods and services and natural capital is important for a socio-economic contribution to the Ecosystem Approach through cost-benefit analysis to evaluate losses and benefits resulting from policy decisions. Advocates use of broad scale benefit and value transfer in policy. However, the complexity of the techniques and the amount of calculation needed to arrive at estimated values demonstrate the relative inaccessibility of economic values relevant to the assessment of benefits from the marine environment and costs arising from the degradation. Considerable caveat in the approach but useful for informing deliberation. When designing policy instruments the distribution of benefits must be considered, the relationship to poverty alleviation and a general discussion on equity and justice is needed.	There is a paucity of standardised data on individual preferences for the marine environment not represented by market while in other cases data are collected and reported at the level of Member States but without reference to their relevance to the marine environment, such as in the cases of the tourism and energy sectors. Paucity of data is particularly pertinent to the case of non-use values (e.g. existence, bequest). Studies have addressed such values in the case of certain marine mammals (see, for example, Beaumont *et al* 2008, and Langford *et al* 1998) but understanding of the economic trade-offs individuals would apply to broader aspects of marine ecosystems is strictly limited. Highlights that MSFD calls for social and economic assessments and challenges exist with appropriate social data sets.
VNN BRIDGE project	Top 10 questions for decision making integration: 1. How can people's values for provisioning, regulating and cultural ecosystem services be identified, measured, aggregated and used in decision-making? 2. How to express values: What preferences do people have for the way in which values are elicited (e.g. as individuals or in groups; using monetary or non-monetary measures), and why, and how can valuation techniques be adapted to account for these preferences? 3. Deliberation, participation and social learning: What opportunities do they bring to the development of valuation methods? Do these approaches influence people's values, do they provide people with different ways to express values, does their usefulness vary between different dimensions of value and ecosystem services, and how are the values perceived by decision-makers? 4. Evidence needs: What kind of evidence on the value of ecosystems and associated ecosystem services do decision-makers need and how needs vary across different decision-makers? 5. Decision-making processes: How do decision-makers incorporate ecosystem knowledge and value evidence in their decisions, and what factors account for this pattern of knowledge use? 6. Risk and uncertainty: How do people's perceptions of risk, uncertainty and vulnerability influence their held and expressed valuations and how might these perceptions be measured in a way that generates data useful for decision-making? 7. Shared social values: Can people simultaneously possess and express 'individual' values, 'social' values, and 'shared social' values, and if so, how do they relate to each other and how can they be defined, identified, measured, aggregated and used in decision-making?	Clear that there are currently significant knowledge gaps relating to how the values of nature are used in decision-making. Systematic integration of the value of nature into decision-making remains poor, as the growing supply of valuation evidence has seemingly not matched the demands of decision makers. Current research suggests that this is in part due to (1) lack of effective dialogue between researchers and decision-makers on evidence needs and (2) shortcomings in valuation to fully account for the complexities of social-ecological systems. The above questions and outputs would be of interest to both the academic and decision-making communities, and will lead to the creation of more targeted value evidence that better meets the demands of decision-makers. Although it was widely accepted that our understanding of the ways in which people value biodiversity, ecosystem services has progressed over the past few decades and that academics and decision-makers now largely accept

Project	Policy recommendations	Future Challenges
	8. Knowledge: How does people's existing knowledge and new knowledge acquired in a valuation exercise influence their held and expressed valuations and how might the impacts of this knowledge be measured in a way that generates data useful for decision-making? 9. Empirical evidence: How, why and in what circumstances has the adoption of value evidence, the ecosystems approach, the ecosystem services framework led to 'better' policy decisions? 10. How can evidence on the value of ecosystems and associated ecosystem services be presented in such a way that it is more useful?	these values, a number of knowledge gaps were identified. First, much of the evidence on values is based on economic criteria, and it was felt that there was scope to explore other conceptualisations of value such as shared social value and non-monetary health and well-being values. It was also suggest that more research needs to be undertaken to understand how values change in different contexts.
VNN Coastal Management project	Coastal zones are subject to relatively rapid and complex environmental changes and policy responses should therefore be guided by principles such as pluralism (i.e. get knowledge from a number of different disciplines, natural, social sciences and arts/humanities); pragmatism and conditional rationality (i.e. do what you can to 'improve' matters now and do not delay to search for optimal solutions which probably require more evidence collected over long periods of time). Deploy interdisciplinary research to inform real world adaptive and timely decision making, accepting that there is always uncertainty and that in many cases decisions create 'winners' and 'losers'. In simple terms this is a 'learning by doing' approach. In this context, the project has proposed the use and development of a decision support tool, the 'balance sheets' method/approach, which seeks to provide a more comprehensive set of information to the policy process.	What overall decision support systems are required to better inform adaptive coastal management in the future? In the light of the prevailing uncertainties in terms of science and its data, combined with social uncertainties in multiple possible futures, what are the best ways to proceed in taking decisions shrouded by lack of knowledge or even complete ignorance? How can the valuation of coastal ecosystem services be implemented in a variety of policy and management contexts? What would be the ramifications for coastal communities? Given the 'contested' nature of coastal socio-ecological resource systems, questions of trade-offs and social justice equity and compensation are likely to loom large in public debate. Appropriate decision support systems are therefore likely to be informed by a better understanding of social and policy networks; and via methods and techniques encompassing multiple decision criteria.
MarBEF	The findings of the economic valuation studies were included in the June 2012 edition of Science for Environment Policy (the DG Environment News Alert Service) and state that there is clear evidence of a social demand for conservation of marine biodiversity in Europe. In addition, although marine mammals were always highly valued, they were not valued as far above other species as the researchers expected. They suggest that the public are becoming more aware of the need to conserve biodiversity across a wide range of species. However, effective conservation policies should be consistent with social beliefs and values, which vary from country to country.	No challenges identified
VECTORS	The project has not yet made any policy recommendations.	No challenges identified
DEVOTES	The project has not yet made any policy recommendations.	The project is still ongoing and is due to be completed in August 2013.
NEA WP3b	The project is still ongoing and has therefore not made any policy recommendations yet. The project is due to be completed in August 2013.	
BESS	The project is still ongoing and has therefore not made any policy recommendations yet. The	The fundamental role that biodiversity plays in regulating

Project	Policy recommendations	Future Challenges
	science plan states: Develop frameworks, tools and indicators that can be used in a scientific and policy context to monitor ecosystem service provision and identify trends over time relative to any critical thresholds and in response to changes in external drivers. Evaluate likely consequences of trade-offs between different services from multi-functional landscapes.	the ecological processes (e.g. primary production, nutrient recycling) that underpin ecosystem services is acknowledged, but a quantitative understanding of biodiversity-ecosystem functioning-ecosystem service relationships is poor (NEA 2010). The ongoing conversion of natural ecosystems to human-dominated systems for the production of food, fibre and energy has generated undeniable social benefits, but at a significant cost to other environmental values, including the biodiversity that underpins those products. Indeed, it is the lack of understanding and quantification of the wider role that biodiversity plays in delivering social benefits that results in the failure to include its value in decision-making. There is concern that present landscape management approaches that reduce biodiversity may not only ultimately reduce these benefits but in some cases lead to non-reversible ecosystem states that are socially undesirable. In addition, the potential implications of future environmental, social and policy change for ecosystem processes and landscape management are uncertain. Understanding these issues is fundamental to meeting many of humanity's greatest current challenges – food security, renewable energy, environmental protection, climate change and poverty alleviation.
C-BESS	The project is still ongoing and has therefore not made any policy recommendations yet. The science plan states: CBESS provides new knowledge, new data, and tools to assist the sustainable management of coastal landscapes. Theme 5 of CBESS will also deliver new and innovative methodologies, equipment, techniques, and technologies to assess the role of biodiversity in the provision of ecosystem services. This framework is based on the HiMOM (Hierarchical monitoring of marine systems) EU programme, in providing a 'tool kit' and case studies for use by coastal managers. The research itself is based on an interdisciplinary framework that will provide a model for future programmes in the UK and abroad. CBESS will host interdisciplinary workshops to establish a two-way exchange of information and arrange output report meetings as themes 1-4 are completed to enhance the outputs of our research. CBESS has already established a body of representatives from industry, management and policy and will organise ad hoc meetings as appropriate with these organizations to develop specific issues. The workshops will provide a forum for the dissemination of research as well as an opportunity to exchange ideas about the implications for	C-BESS responds to the NERC call to help understand the landscape-scale links between the functions that coastal systems provide (ecosystem service flows) and the organisms that help provide these services (biodiversity stocks) and offers an important opportunity to move beyond most previous work in this field. There is a clear challenge to translate from laboratory studies into policy and coastal managers require a clearer evidence base to understand how ecosystem service flows operate at much larger spatial scales, e.g. entire salt marshes or regions of intertidal flat and salt marshes, and flows respond to different management regimes and future scenarios.

Project	Policy recommendations	Future Challenges
	management and policy development.	
VALMER	The project has not yet made any policy recommendations.	No challenges identified