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Report on possibilities of application of Ecosystem Services and Natural Capital approaches in OSPAR activities

Colofon

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Contents

Summary

The North-East Atlantic provides many ecosystem goods and services which contribute significantly to the economies of the countries that bound it. It is therefore essential that the biodiversity, resources and environmental quality of this ocean ecosystem are conserved, protected and sustainably managed. The increasing appreciation of the important role that marine ecosystems play in providing goods and services that contribute to human welfare and the growing recognition of the impact of human actions on ecosystems have led to the recent interest in integrating ecology and economics.

The concepts of natural capital and ecosystem services today are a common tool for the interaction between specialists from different fields - ecologists and economists. The use of an ecosystem approach in management contributes to a deeper understanding of the relationships and interactions between ecological, social and economic systems. Significant environmental changes that have been encountered by marine ecosystems due to vigorous economic activities recently, in particular in the North Sea, are a stimulus for improving interaction both between different countries and between specialists in different areas. A lack of economic valuation may lead to underestimations of the importance of such resources and to detriment of the marine ecosystems.

OSPAR (the convention for the protection of the marine environment of the North-East Atlantic) provides an opportunity for countries to establish cooperation in the protection of the marine environment, helps to ensure the regulation of human activities in the North Sea, and supports monitoring, data sharing and assessment of the state of the marine environment. In 2010, OSPAR committed itself to help EU countries to coordinate their assessments for the Marine Strategy Framework Directive, since according to this directive, Member States are expected to make efforts to ensure that assessment methodologies are consistent across the marine region or sub-region. This implies "the need to define and collate marine socio-economic data in a consistent manner across member states – particularly in the case of those member states that are bordering common seas".

In September 2018, during a workshop on ecosystem services and natural capital, representatives of various OSPAR countries indicated that they thought that ES and NC approaches could potentially be a convenient tool for assessments and monitoring, which will take into account environmental mechanisms and allow for a fresh look at the benefits. This report is a follow up of that workshop and is meant to support further discussions on this at OSPAR level.

The objective of this report is to determine how the ES and NC approaches can contribute to the activities of OSPAR, what are their pros and cons, and to understand how these approaches are already applied for the marine environment.

For this purpose, in the course of this study, a literature review was conducted, in which ideas about ES and NC were examined in detail. Various classifications, assessment methods and indicators of ES were considered. The study also analyzed the question of why ES and NC are relevant approaches for OSPAR and how these approaches have already been applied in policy and management. It was concluded that these approaches have many advantages and therefore exploration of the possibilities of using them is beneficial for OSPAR.

Around the world many cases are found where the assessment of ES and NC was used for decision-making, and there are many ways in which they can be assessed and how data can be analyzed. This report compares various approaches that have been used, and describes their strengths and weaknesses.

The main conclusion of this report is that the NC accounting approach is an excellent tool for monitoring and integrated analysis of the trends and developments in the pressures and the state of marine ecosystems, and is therefore the most relevant approach to support OSPAR decision making processes.

There are many approaches based on ES that can be used for various management problems. At the moment, the concept of ES is already sufficiently developed to implement it in the decision-making process. It has advantages over other methods of benefits accounting, such as cost-benefit analysis, as it allows the analysis to include the relationships between the various components of specific ecosystems with the socio-economic system and as a result get the most effective solution.

However, the development of marine ecosystem accounts is still in its infancy, although there are already some cases of their application, including the development such accounts in the Netherlands and the UK. It is therefore suggested that OSPAR should start to develop its own system of marine NC accounts and improve upon it in the future.

<table>
<tr><th>Approach</th><th>Type of question that can be answered using this method</th><th>Benefits of application</th></tr>
<tr><td>Natural Capital accounting</td><td>What are the dynamics of flows and stocks of ES?</td><td rowspan="2">The approaches expands the possibilities of monitoring the state of the ecosystem that provides the ES, and therefore supports the economy. Simple output data allows you to see the root cause of economic change and to adapt measures in the management. Such an assessment allows you to identify the types of human activity that most strongly affect the ecosystem, as well as to identify which activities are most dependent on ES. This information will allows better prioritize management.</td></tr>
<tr><td>ES list</td><td>What is the volume of ES of this ecosystem and what is their value?</td></tr>
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Comparison approach	Which ES are most vulnerable to pressure caused by human activity? Which sectors of the economy are most dependent on the flow of ES?	Such an assessment allows you to identify the types of human activity that most strongly affect the ecosystem, as well as to identify which activities are most dependent on ES. This information will allows better prioritize management.
Spatio-economic modeling of ES	What development scenario will be most beneficial in terms of benefits and costs, and ecosystem health?	The approach is adapted for the decision-making process and the selection of the most profitable scenario
Integrating Ecosystem Services into Development Planning	How can one or another management problem be solved? (the approach aims to collect all the necessary information to solve a specific problem)	An approach addresses the environmental and economic trade-offs associated with development measures, and helps to systematically incorporate ecosystem service-related opportunities and risks into conservation and development strategies and plans.

1 Introduction

1.1 Background

For centuries, marine environment and its natural resources have been used by humans for multiple benefits, such as fishing, recreation, and other activities. In addition to its ability to provide economic benefits, nature also has other qualities and functions that support life on earth (Brundtland, 1987). However, human activities can also be detrimental to the functioning of ecosystems. For example, pollution by marine activities, climate change, and oil and gas extraction can all have very significant impacts. The consequences can be catastrophic for both nature and the economy. The European Union has coined the concept of Blue Growth, which not only refers to the increase in marine sectors, but also to a long-term strategy promoting sustainable development (European Commission, 2012). One of the examples is the North-East Atlantic Ocean, which, over the past decades, has experienced a significant expansion of marine industries, such as the exploitation of energy resources (CBS, 2016).

The increasing appreciation of the important role that marine ecosystems play in providing goods and services that contribute to human welfare and the growing recognition of the impact of human actions on ecosystems have led to an increasing interest in the concept of natural capital accounting and ecosystem services. The analysis and assessment of the value of ecosystem goods and services are therefore expected to play an important and increasing role in conservation planning and sustainable integrated ecosystem-based management (Fister et al., 2009). It can allow to be sure that the chosen path of development does not pose a threat to nature and future generations, whose well-being largely depend on the state of ecosystems.

1.2 OSPAR

By providing a large variety of ecosystem goods and services, the marine ecosystems of the North-East Atlantic contributed significantly to the economies of the countries that bound it. It is therefore of utmost importance that the biodiversity, resources and environmental quality of this marine ecosystem are conserved, protected and sustainably managed. The sea does not respect national boundaries. Therefore, the problems of ecosystem degradation are relevant for all countries and can only be dealt with through joint actions, for which joint assessment of marine ecosystems is needed.

OSPAR (The Convention for the Protection of the Marine Environment of the North-East Atlantic) provides an opportunity for countries to establish cooperation in the protection of the marine environment, helps to ensure the regulation of human activities in the North Sea, supports monitoring, data sharing and assessment of the state of the sea (www.ospar.org). Therefore, the OSPAR Commission has an important task to ensure that the 16 Contracting Parties are able to work together in the North-East Atlantic and deliver on their collective commitments. One of the topics OSPAR is working on is the analysis of ecosystem services (ES) and natural capital (NC). During an OSPAR workshop in September 2018 on this topic, the OSPAR contracting parties came to the consensus that approaches to ecosystem services and natural capital could be a useful tool to support economic assessments for integrated sustainable management of marine ecosystems, which is one of the overarching objectives of OSPAR.

1.3 Ecosystem services and Natural capital

NC and ES approaches can probably contribute to this the overarching objective of OSPAR of integrated sustainable management of marine ecosystems goal (Millennium Ecosystem Assessment 2005; European Commission 2015). ES is a popular tool in ecological economic analyses for assessing benefits. In addition, many studies claim that ES is a convenient language for interaction between specialists from different fields – such as ecologists and economists, because these approaches aim at integrating the socio-economic system with the ecosystems, reflecting the key role of ecosystems and biodiversity for humans and human welfare (Guerry et al., 2015). Understanding of the relationships between human benefits, economic activities and state of nature is therefore of utmost importance for sustainable management. Largely used indicators, such as GDP (Gross Domestic Product), cover just a part of the economic story, since it hides and excludes services provided by natural capital, and focuses only on flows of income and output, and does not value stocks of capital, including natural capital, that underpin them.

The NC approach is relevant for strategic action planning, since natural capital determines the future consumption opportunities. Most existing assessments of natural capital are devoted to the terrestrial environment. Therefore, an important task of the underlying study is to determine how this approach could be implemented for the marine environment. Some countries are already actively engaged in this task. For example, the UK have developed a system of marine accounts (Eftec, 2015). An important value added of natural capital approach is that it provides information on headline indicators that measure how policies are performing over time, and check whether they are achieving goals and targets. However, as in the case of the ES approach, there are also some challenges in its application which are also described in this report.

1.4 Aims and research questions

The main objective of this report is to identify whether and how approaches to analyse natural capital and ecosystem services can support decision making and establishing OSPAR plans, strategies and joint management actions by performing integrated sustainability assements of marine ecosystems.

In this study, the following research questions will be answered:

- What are the pros and cons of ecosystem services and natural capital frameworks?
- Are there cases where these approaches are applied in the marine environment? What can be learned from them?
- What is the potential role and relevance of natural capital and ecosystem services for OSPAR plans and strategies?

In the second and third chapter of the report, the approaches of ES and NC will be described in more detail, based on available literature. General information on the various approaches be analyzed, resulting in an overview of possible advantages and disadvantages. After that, in chapter four, the information obtained will be compared with the OSPAR objectives and the benefits of application of these approaches in the OSPAR context will be investigated. Chapter 5 will then present case studies in which these approaches are applied to support marine policy making.

The applied methods and approaches will be analyzed and an overview of advantages and disadvantages of using the various NC and ES approaches to support the management of the marine environment will be presented. Finally, chapter six concludes with some conclusions and discussion. Thus, based on the most up-to-date information on ES and NC application in marine policy and management, this report presents and discusses how these approaches could contribute to the integrated assessment of the marine environment and OSPAR goals and decision making.

2 Ecosystem services

Ecosystem services (ES) are the direct and indirect contributions of ecosystems to human well-being (TEEB; D0). They support directly or indirectly our survival and quality of life. Ecosystem services are a useful concept to aid policy design and sustainable resource management, and are increasingly used in the policy and management of both land and water resources (Guerry et al., 2015). It is difficult to establish when ES came up, but we can say that there was 3 movements: political (SCEP 1970), scientists in ecology (Costanza, Braat) and scientists engaged in environmental protection (Mooney and Erlich, 1983). The integration of ecosystem management into policy is becoming more frequent, for example, in the framework of the EU Strategy on Biodiversity (European Commission, 2009), and the MESEU project which supports its implementation, under several EU FP7 research programs such as OpenNESS, OPERAs, or GreenSurge as well as EU H2020 projects such as ESMERALDA, but also worldwide, for example with the guidance for U.S. Federal agencies to integrate ES into decision making (Donovan et al., 2015). Nevertheless, whilst the concept of ecosystem services is widely used to assess the benefits derived from ecosystems, there is no single definition of the concept and the classification of services.

2.1 Classification of ecosystem services and their use.

Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza et al. 1997).The Millenium Ecosystem Asessment (MEA, 2005) (Fig.1) definition follows the works of Costanza and his colleagues, defined as “the benefits people obtain from ecosystems”. The MEA identifies services as benefits that people get from ecosystems and categorizes them (supporting, regulating, provisioning and cultural services).The MEA provided one of the first classifications and definitions, thus creating a connection between ecosystems, services, politics and society.

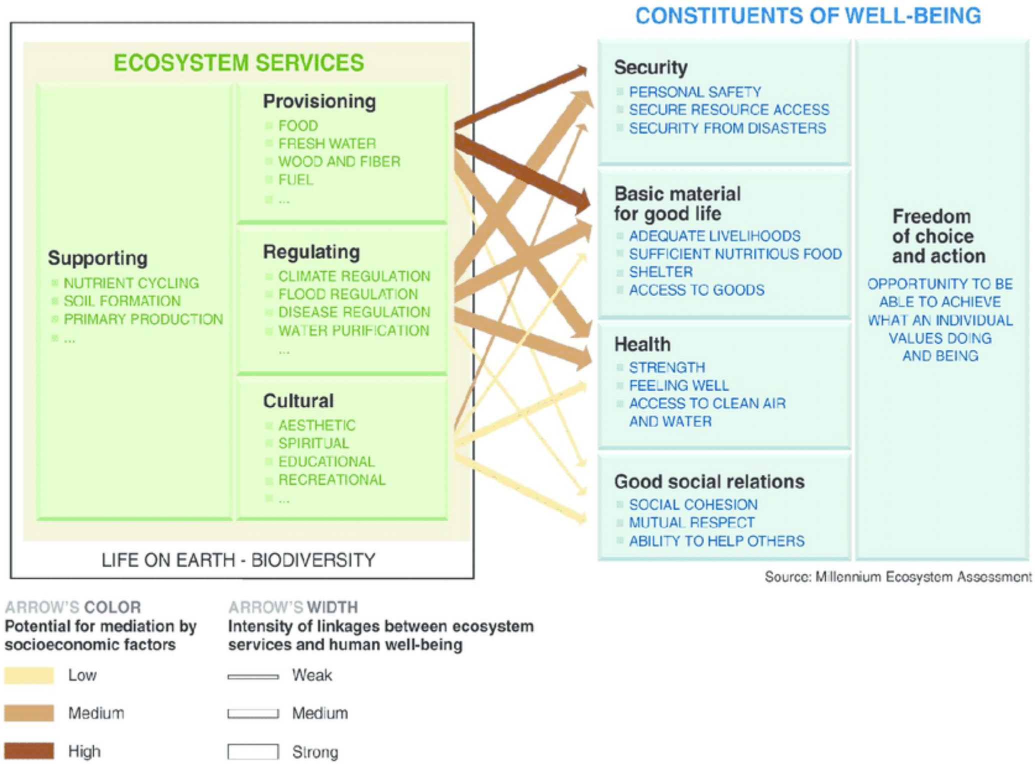

Figure 1. The Framework of the Millennium Ecosystem Assessmen (Bennett and Chaplin-Kramer, 2016)

Since the publication of the MEA a number of challenges have been identified: For example, there is a risk of double counting the benefits from the services. For example, Fisher et al. (2011) describe how this can be the case for water-related services, where nutrient cycling is a supporting service, water flow regulation is a regulating service and recreation is a cultural service.

Under the Common International Classification of Ecosystem Services (CICES), ecosystem services are defined as “the contributions that ecosystems make to human well-being” (EU Commission/JRC 2013). Ecosystem services are considered as the end result of the interaction of biotic and abiotic processes or as "products of ecosystems," i.e. something that is consumed and used directly by human. In contrast to the classification of the MEA, CICES does not consider "supporting services" as a separate category. Instead they are considered only as part of the basic processes and functions of the services since they are used and consumed only indirectly.

CICES identifies provisioning, regulating and cultural services, thus double counting is avoided. The CICES classification structure is hierarchical. Nine classes of services are embedded in the three main categories (Table 1). The aim is to provide a framework for linking data on ecosystem structure and dynamics and information on economic performance. CICES identifies the "final product" from an ecosystem service and, therefore, it only includes directly provisioning, regulating, and cultural services. Following the MEA, the term "service" has generally been taken to include both goods and services.

Section	Division	Group
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass, fibre
		Water
	Energy	Biomass-based energy sources
		Mechanical energy
Regulation &	Mediation of waste, toxics and other nuisances	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous / air flows
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
		Pest and disease control
		Soil formation and composition
		Water conditions
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions
		Intellectual and representative interactions
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic
		Other cultural outputs

Table 1. The CICES classification (Mutiu et al., 2017)

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focusing on drawing attention to the economic benefits of biodiversity and ecosystems, as well as the costs of biodiversity loss and ecosystem degradation (TEEB, 2013). The conceptual understanding of ecosystem services is the same as for CICES. An important distinction of the TEEB classification is the identification of a "habitat service" to emphasize the importance of habitats for the viability of the ecosystem. The classification was also adopted for the sea (Böhnke-Henrichs et al., 2011), and then improved for marine management and planning (Böhnke-Henrichs et al., 2013).

National TEEBs have been completed in a number of countries (e.g. Finland: Jäppinen & Heliölä, 2015). The TEEB for Oceans and Coasts aims to improve marine environmental and economic policies in order to increase the productivity and sustainability of marine systems.
A comprehensive methodological framework for valuing ecosystem services was developed and applied for the UK NEA (UK National Ecosystem Assessment)

(Fig. 2) (Bateman et al., 2013). The concept is based on MEA (2005) and TEEB (Ring et al., 2010). The UK NEA avoids the risk of double counting as supporting services are not a class in the UK NEA, as in TEEB, CICES and MAES. The UK NEA has a more clear emphasis on policy than the other concepts and by its focus on scenario development and assessments the UK NEA approach is especially suitable to evaluate the changes in ecosystem services delivery from both policy- and natural changes.

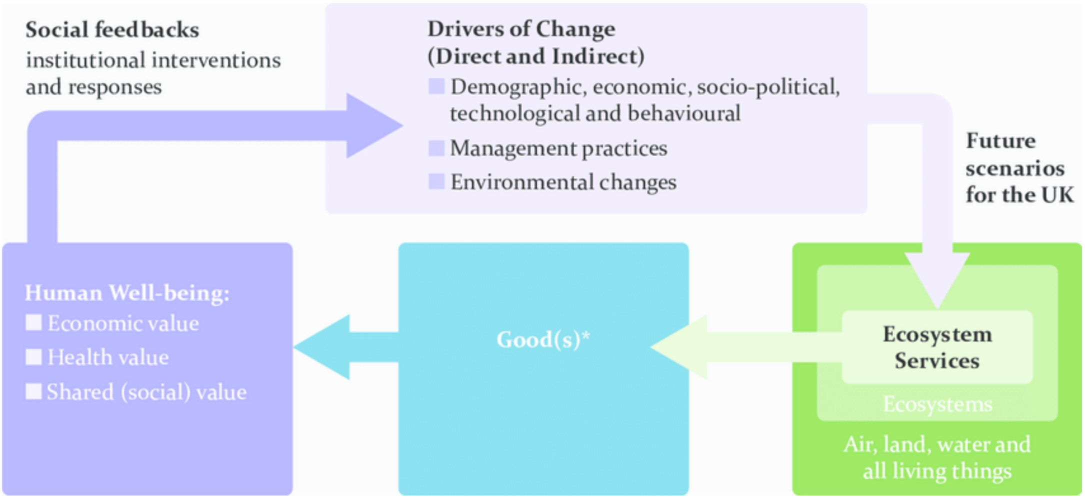

Figure 2. The UK National Ecosystem Assessment conceptual framework (UK NEA, 2011)

The Working Group on Mapping and Assessment on Ecosystems and their Services (MAES) coordinates approaches for the national ecosystem services assessments for Target2/Action 5 of Europeans Biodiversity Strategy that aims to maintain and restore ecosystems and their services. The MAES working group developed an analytical framework, linking ecosystems, biodiversity and ecosystem services with the socio-economic systems, promoting the CICES classification for ecosystem services (MAES, 2013). The framework integrates TEEB and the UK national ecosystem assessment approach, together with aspects of the DPSIR framework (driver, pressure, state, indicator and response framework. The recommendations from the MAES group (MAES, 2013; MAES, 2014) suggest that the ecosystem service can providing a tool for visualizing and evaluating trade-offs between different services and goods, and be used to guide the most appropriate choice of management strategy.

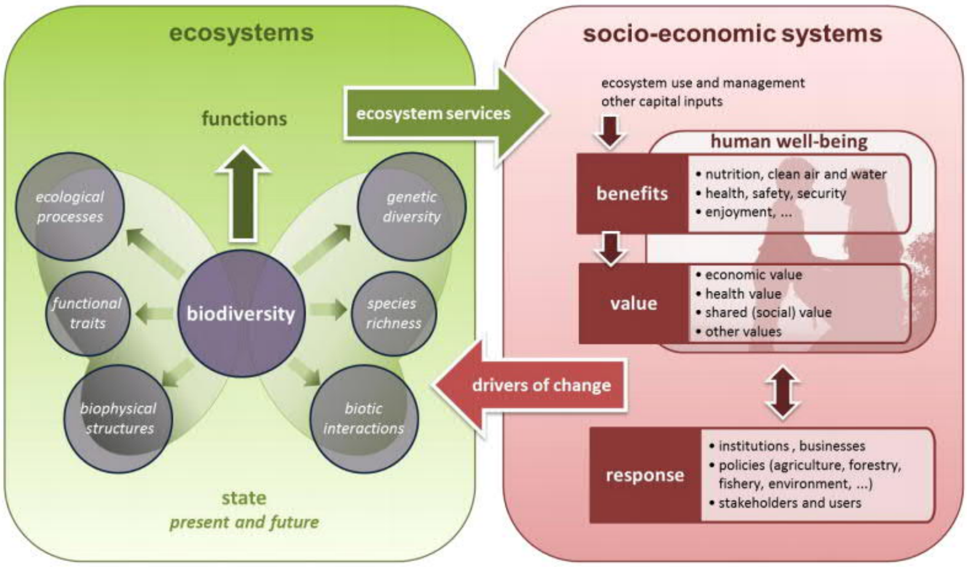

Figure 3. MAES framework (MAES, 2013)

The “state” of an ecosystem, e.g. its condition, is accounted for (Fig. 3) as it is an important determinant of potential ecosystem function and ecosystem service delivery. Ecosystems in general consist of both abiotic (physio-chemical) and biotic (species and populations) components. This approach has been applied to marine ecosystem services (MAES, 2013). In this application the basic marine ecosystem structures are characterized by a typology that reduced the 3-dimensional structure of the ocean to 2 dimensions: 1) seabed (benthic habitats) and 2) depth zones (pelagic habitats).

	Strengths	Weaknesses
MEA	Defined ecosystem services, high policy impact	Double-counting, not dealing with changes
TEEB	Avoids risk of double counting by focusing on final services. Habitat services are included as separate category. TEEB are currently developing a TEEB Ocean concept and assessment.	Not explicitly dealing with scenarios and changes
CICES	Avoids risk of double counting by distinguishing clearly between intermediate and final services Complementary tables for abiotic outputs can be developed	Not explicitly dealing with scenarios and changes Very detailed, and can be difficult to have an overview of the many classes and categories
MAES	MAES applies the concepts of TEEB and CICES, and focus on the mapping of the ecosystems. Develop and use consistent links between ecosystem structures and functions to the values of the ES.	
UK NEA	Concept is inspiring for scenario and policy assessments, trade-offs between ecosystem services	

Table 2. Evaluation of approaches for marine ES classification (Brower et al., 2013)

In addition to those outlined above, further classifications have been developed (eg, Fisher et al., 2009; de Groot et al., 2010a; Balmford et al., 2011; Mace et al., 2011; EEA, 2013) and some of them were adapted for the marine environment (eg, Atkins et al., 2011; Böhnke-Henrichs et al., 2013; Liquete et al., 2013; Turner et al., 2014). Neverthless, according to De Groot et al. (2010a) there can be no definitive classifications and there will always be unambiguous definitions due to the complex relationships between people and the environment. Despite this, the concept of ecosystem services continues to be actively implemented in management and policy.

The most appropriate classification of services is influenced by regional characteristics and the ability to accurately evaluate the services present. Therefore, in order to integrate the ecosystem approach into OSPAR activities, it is first necessary to determine which framework will be most relevant for the North Sea marine services. For OSPAR, the question of the relevance of using this approach should be considered, as should how it can be implemented. As previously mentioned, the classification system used should be decided at the planning stage of a specific study to reflect the context of the location.

2.2 Indicators of Ecosystem Services

Indicators are used as proxy measures of variables (e.g. biodiversity, ecosystem services) that summarize complex or hard to obtain information and which help scientists, managers and politicians understand and make decisions. For example, in the context of the provision of services, they can display the change in flow over time. However, there are many sets of indicators even for one classification, which makes the selection of indicators extremely difficult, especially for the marine environment (van Oudenhoven et al., 2012; UNEP-WCMC, 2011). At this moment there is no single approach to the selection of indicators for ecosystem services. Indicator selection is often inconsistent with a focus on arbitrary categorical indicators and monetary values (Seppelt et al., 2011).

In order to understand and manage the potential effects of ecosystems services, indicators are required that not only describe ecosystem services, but also the functions that provide a flow of services and the benefits they provide (Nicholson et al., 2009; de Groot et al., 2010b). However, due to the complexity of the system, no single indicator can fully capture these elements; requiring composite set of indicators (Hattam et all, 2014, 2015). Indicators of ecosystem function should be ecological and display processes within the system, while indicators of services reflect usage by humans. As in the case of service classifications, the choice of indicators should be individual for each specific case.

Indicators should meet the following criteria (Doran, 1981)

- Measurability: is there data available for the measurement and quantification of the indicator?
- Sensitivity: does the indicator detect change in the ecosystem service over time?
- Specificity: Can this indicator display changes in management?
- Scalability: Can the indicator be used when changing the spatial scale?
- Transferability: Can the indicator be used in another study?

2.3 Valuation Methods

All the available method to value ecosystem services have advantages and disadvantages, with different levels of time and resource costs, data requirements, accuracy, acceptability to stakeholders, and applicability to specific contexts. The most commonly methods used are the preference-based methods which rely on models of human behavior and rest on the assumption that values arise from the subjective preferences of individuals (MEA, 2005). Valuation techniques essentially seek to estimate “Willingness to Pay” – the maximum amount an individual is willing to sacrifice to procure a good or avoid something undesirable

There are three main families of economic valuation techniques: market based, revealed preference, and stated preference. Expenditure measures are also used, although these measure costs, not values (i.e., not Willingness to Pay). In addition to these economic methods, there are also a number of methods available for assessing and taking into account the ways in which ecosystems are valuable to humans. These include deliberative methods such as focus groups and citizens' juries, and various participatory methods in which stakeholders become more intimately involved in the valuation, planning, and management decisions. Although sometimes seen as conflicting, economic and deliberative or participatory methods can work well together. In fact, economic valuation methods increasingly make use of focus groups or other techniques as part of the valuation process.

Market-based techniques

Market-based techniques use evidence from markets in which environmental goods and services are traded, markets in which they enter into the production functions for traded goods and services, or markets for substitutes or alternative resources (Brower et al., 2013, Daly Hassen, 2016).

Market prices can be used for traded goods, for example fish. However, market price is not equal to value. For example, it is necessary to correct market value for 'distortions' such as subsidies or taxes. In addition, prices do not reveal the 'consumer surplus', i.e., the profit or value to the consumer over and above the price paid. Furthermore, prices include the resource cost (for example the cost of boats, fuel, nets and labor) that do not form part of value (this is often dealt with by reporting 'value added', i.e., price net of costs);

Production functions use statistical analysis to determine how changes in a ecosystem function affect production of another good or service which is a traded resource, or which can be valued using another technique. The primary difficulty with this method is the availability of scientific knowledge and/or data necessary to estimation the production function.

Avoided cost methods value an ecosystem service through the reduction in costs that would be incurred if those services were no longer available/ delivered).

Replacement cost methods estimate a value based on the cost to replace an ecosystem function or service. This can be applied to entire ecosystems (for example, the cost of providing new habitats to compensate for habitat losses) or more often to replace specific ecological functions with human engineered alternatives, e.g. the cost of wastewater treatment plants instead of wastewater processing by natural systems such as saltmarshes.

Expenditure measures

Assessments of the "economic value" of ecosystem services may focus on their contributions to local or national economies. This is particularly the case for tourism and recreation, and extractive industries such as fishing. Expenditure is not the same as economic value, as it includes resource costs, and ignores any additional benefit to resource users. Instead, expenditure measures can serve different purposes, in particular assessing impacts on local communities, or securing funding from organizations with a focus on economic development.

Revealed preference methods are based on deducing the value of ecosystem services by interpreting observed human behavior. Revealed preference methods estimate demand for an ecosystem good or service through econometric analysis of individuals' willingness to incur the costs associated with benefiting from the good or service.

- Travel cost methods use data on the costs of travelling for recreational activities (both market costs, e.g. fuel, and non-market costs, e.g. personal time), and participation rates.

- Hedonic pricing estimates the implicit price paid for environmental characteristics of the area a property is in, through the differences in the property prices for the same property in different areas with the different environmental endowments.

Stated preference methods are based on surveying representative samples of a population in order to estimate willingness to pay (or accept compensations) for hypothetical changes in ecosystem service provision. SP techniques are very widely applicable, used for example for biodiversity, and are the most commonly used techniques to capture non-use values.

- Contingent valuation (WTP) uses a direct question of willingness to pay for a specified change.

- Choice experiments estimate implicit values from choices between options with different specified characteristics.

Revealed and stated preference studies have different strengths and weaknesses and are often used together, either in order to value different services with the most appropriate methods or as a means of cross-checking estimates using different methods.

Appraisal methods

Values can be used in a wide range of practical decision-making contexts, for example to help decide on courses of action such as coastal development proposals, to determine where and how much of the marine environment to protect from exploitation, to formulate resource management policies, to determine compensation payments for damage to marine features, and so on. Appraisal methods that capture values include:

- Cost-benefit analysis (CBA) is a decision support method which compares, in monetary terms, as many benefits and costs of an option (project, policy or programme) as feasible, including impacts on environmental goods and services. Its application to any natural environment category is limited by the availability of the necessary data. CBA is designed to target two of the most crucial appraisal questions: “is a given objective worth achieving?” and if so, “what is the most efficient way of doing this?”

- Cost-effectiveness analysis (CEA) is a decision support method which relates the costs of alternative ways of producing the same or similar outcomes to a measure of those resulting outcomes. CEA is similar to CBA in that it reveals the cheapest or most cost-effective way of achieving a given objective, but not whether an objective is worth attaining; it implicitly attaches a value to the benefits of achieving the objective.

- Multi-criteria assessment (MCA) covers a variety of approaches which involve: (i) developing a set of criteria for comparing policy or management options; (ii) evaluating the performance of each of the options against each criterion; (iii) weighting each criterion according to its relative importance; and (iv) aggregating across options to produce an overall assessment. Deliberative or participatory approaches are commonly used for developing weights or valuations;

- Regulatory Impact Assessment (RIA) is a framework for complete assessment of a proposed policy or decision, covering appraisal, implementation and ex-ante evaluation. Valuation evidence can be important at each of these stages.

2.4 Challenges in ecosystem service valuation

Risk and uncertainty

Policy decisions are often made with significant economic or ecological uncertainty in which future outcomes, either good or bad, are unknown. Uncertainty encompasses risk (where the probability of outcomes is known or can be estimated) and ambiguity (where the sorts of outcomes are generally known but there is no reliable information on which to estimate probabilities), as well as radical uncertainty. Uncertainty in marine ecosystem services assessment and valuation stem from imperfect knowledge of ecological and economic relationships and randomness (for example, flood events, or random climate effects on fish stock-recruitment relationships).

The solutions: There are different ways of dealing with risk/uncertainty within the valuation approaches. In practical terms, economic valuation and cost-benefit analysis deal with risk reasonably well, and with ambiguity to some extent, through the use of expected values and various forms of sensitivity analysis. However, economic methods tend to be quite limited under situations of radical uncertainty, where it is not possible to enumerate all of the likely consequences of a decision, nor its probabilities (Weitzman, 2009). Discounting, sensitivity analysis, use of scenarios can be used as well.

Double-counting

'Double-counting' of values often stems from valuing intermediate and final services, or when techniques are used where it is not clear exactly what services are included in a value. This requires careful treatment. Double-counting is a particular risk when applying valuation techniques to intermediate services (notably supporting services and some regulating services), where the benefit to humans is indirect, accruing through the impact of these services in enhancing final services (notably provisioning and cultural services).

The solutions: If the final services are included in the assessment, then it is double-counting to include separate values for the intermediate services. But if the final services are not included – as is often the case, for example, where dealing with the role of the marine environment in supporting services on land – then the intermediate services should be valued separately.

Cumulative impacts

Ecosystem services may be strongly affected by the cumulative impacts of different drivers, and this must be taken into account in valuation and decision making. The same resources may be subject to multiple ongoing pressures, and also to possible shocks (such as storms or disease outbreaks), and analysis of values focusing on just one pressure could miss the dangers associated with the overall impacts. For example, when determining fisheries policy it may be necessary to consider not only the level of fishing effort or harvest, but also the impacts of marine pollution, destruction of fish nursery habitats, climate change and so on.

The solutions: Including cumulative impacts, accounting for spatial scale factors, and incorporating aspects of the demand for ecosystem services based on locations and preference of human populations, can be complex. Ideally, these factors should be taken into account via formal 'production function' models that link particular ecosystem and management characteristics to specific ecosystem service outputs. This can be data-demanding and difficult, and 'value transfer' offers an alternative, less resource intensive approach. Alternatively, scenario-based analysis can be used to explore the possible impacts of cumulative pressures and shocks.

Critical natural capital

Where resources become very scarce, marginal values may change so rapidly that valuation becomes difficult; if dealing with thresholds and essential resources and services, valuation may become inappropriate. There are limits to the realm within which valuation techniques make sense. When imminent ecological thresholds threaten vital natural resources, conservation is essential, and marginal valuation becomes inappropriate. A resource that is abundantly available, such as oxygen to breathe, will have low or zero marginal economic value (even though the total value is essentially infinite). An abundant fish resource may likewise command a lower price per fish than a depleted stock, because it will not be as scarce. Generally speaking, as a resource or service becomes very scarce, it is likely to become very valuable; and in some cases, there may be some minimum level of provision that is essential to avoid catastrophic consequences.

The solutions: If a threshold level of 'critical natural capital' exists beyond which catastrophic losses occur, valuation may become largely meaningless. The 'solution' here may be to use other methods – safe minimum standards, sustainability constraints – limiting the use of valuation methods to zones within which values change more gradually.

2.5 Conclusions.

Proper management of the marine environment requires an understanding of the functioning of ecosystems, as well as a rational assessment of the benefits that these ecosystems provide to humans. The concept of ecosystem services is relevant by connecting people to nature. ES is a convenient way to connect the ecological and economic system through the flow of services and goods, as well as to take into account drivers of change (for example, an oil spill). Although ES evaluation should not be the only decision making factor, the use of this approach may significantly contribute to more sustainable management of the marine environment.

However, there are still many questions that do not have a definite answer. This includes uncertainty stemming from the lack of a generally accepted classification of services and indicators; difficulties assessing services that arise from ecosystems (especially marine ones); difficulties during a monetary valuation of ecosystem services and a lack of scientific knowledge about how changes in policy and management of marine resources affect ecosystem functioning, service flows and biodiversity. However, new approaches are emerging that gradually eliminate existing gaps in knowledge.

Despite the difficulty of economic evaluation, even a qualitative assessment of services can increase the efficiency of the management. Since the sustainable management and achievement of Good Environmental Status is OSPAR goal, it is necessary to continue exploring the possibilities of using this approach.

3 Natural Capital

3.1 Definition of Natural Capital

Natural capital includes air, water, soil, and all living things (Natural Capital Forum 2016), which provides humans with goods and services. The concept of natural capital is broader than ES and includes not only the flow of services, but also a stock of recources. As an example, natural capital can also serve: waste assimilation; carbon dioxide absorption; minerals; arable land; habitat; visual beauty; biodiversity; fossil fuel. As a result natural capital has financial value and is an important component of the economy. (Natural Capital Protocol, 2016).

Thus, everything that is part of nature and brings benefits to a human, or is able to provide with it in the future, is part of natural capital, therefore, ecosystem services are part of it. However, the concept of natural capital is broader and includes not only the flow of services, but also resources, some of which may even be unavailable now. The value of these flows and stocks can be estimated in economic terms.

3.2 Why is it used?

The concept of natural capital is based on the understanding that nature is the source of human well-being, both material and spiritual, and is the key to its wealth, preservation of culture, identity and happiness (Costanza, 1997).

Decision making can be very difficult when economic, social and natural systems interact and when there are many stakeholders compromises are often needed. It is precisely for this reason that decision making without taking into account natural capital may be biased and ineffective as important factors affecting human well-being may be missed. Despite the challenges, natural capital can unite many complex factors that, in their basis, have one similar feature - the benefit to humans.

3.3 Pros and cons of Natural Capital

The concept of Natural Capital, like the ES framework, is anthropocentric in nature, as it focuses on those aspects of nature that benefit humans, and makes no attempt to reflect the so-called ‘intrinsic value’ of nature or benefits to other species. However, in certain contexts it can play an important political role, as it can help to shed light on the benefits that nature provides to human society, and consequently on the need for nature protection not only for moral reasons but also as a way to enhance human wellbeing and the economy. As such, it can influence policy-making towards an improved environmental protection, besides acting as an environmental education tool for awareness rising.

The Natural Capital concept has risks, challenges and skeptics: The principle means that only the benefits that people receive are considered, ignoring the benefits to nature. Linked to this, it is not possible to known all the anthropocentric values of biodiversity, which may lead to biases and errors in judgment. Furthermore, it can be seen as encouraging the commoditization of nature (McCauley, 2006; Kosoy and Corbera, 2009; Mace, 2015) and may lead to prioritizing the protection of areas and environmental resources that are more directly used by humans over those with greater biological diversity. For this reason, the Natural Capital concept needs to be seen in conjunction with wider biodiversity objectives: similarly, accounting needs to be used as a complementary tool to wider biodiversity and sustainability indicators (Fig. 4).

Furthermore, it is important to understand to what extent accounts do (or could) take into account different types of Natural Capital, changes in the quantity and state of the natural assets, and the flow of associated ecosystem services, so as to understand the meaning of the accounts and how to interpret the outputs. This is a moving target as guidance and methods develop, as new data become available, and as initiatives at national (and subnational), EU and global scale improve our practices, tools, understanding and results.

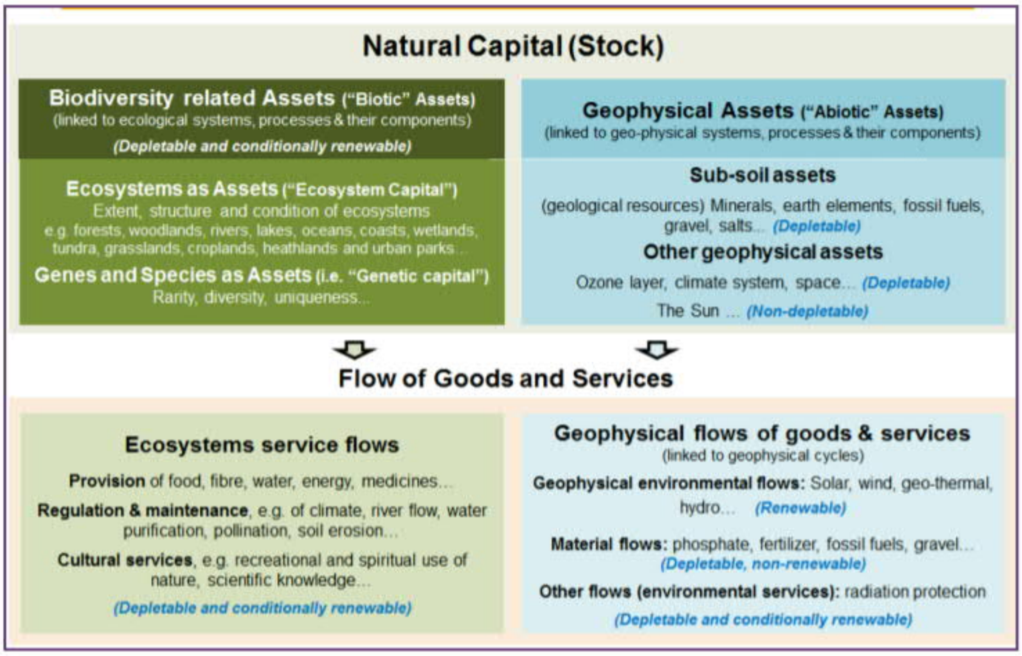

Figure 4. MAES analytic framework, European Commission (2013a)

3.4 Natural capital accounts

The Importance of Accounting for Natural Capital

Natural Capital Accounting is the process of accounting for stocks and flows of natural resources and services that exist in a region or ecosystem and can incorporate both physical and monetary values. Nature has great potential. In order to preserve it for future generations, it is necessary to improve accounting of stocks and service flows. This process can facilitate and increase the efficiency of the decision-making outcome for those who are involved in it: governments, corporations and consumers. However, approaches to valuation often do not take into account the non-market value of natural capital, for example, cultural ecosystem services, and as a result society may incur more losses than understood. It is therefore necessary to adjust the accounting of natural capital so that intangible benefits can be accounted for in economic terms. Failure to do so will result in inefficient allocation of resources.

The System of Environmental-Economic Accounting

In 1993 The United Nations Statistics Commission published a detailed methodological guide for the preparation of environmental-economic accounting - the System of Environmental-Economic Accounting (SEEA). Recently, the UN Committee of Experts on Environmental-Economic Accounting reviewed it and published a new version in three volumes.

The SEEA-Central Framework (SEEA-CF) - Volume 1- includes both biotic and abiotic stock and flows, and typologies of ecological-economic accounts that are not part of natural capital but which can have a positive or negative effect on it impact (SEEA, 2014). For example, environmental accounts which include accounts of expenditures on environmental protection, environmental goods and services, environmental taxes and environmental subsidies. The methodology provides accounting standards that can be further integrated into the System of National Accounts (SNA).

SEEA-Experimental Ecosystem Accounting (SEEA-EEA) - Volume 2 - includes ecosystem service accounts and ecosystem accounts. These type of accounts are currently experimental and there is currently no standards at the international level.

Accounts included in both volumes complement each other. For example, Volume-1 provides information for identifying the state of ecosystems, and Volume-2 provides information about the state of the ecosystems themselves, which provide the natural resources recorded in SEEA-CF.

The SEEA-Central Framework (SEEA-CF) - Volume 3, “Applications and Extensions of SEEA”, provides example applications of SEEA data, environmental indicators, analysis of taxes and subsidies in policy and research. It also includes an overview of the various methodologies that can be used together with the SEEA data.

In order to emphasize that SEEA embraces not only assets but also ecosystem flows, SEEA uses the wording “Ecosystem Accounts” instead of “Ecosystem Capital Accounts”, as for example the European Environment Program Agency. The asset accounts included in SEEA-CF measure capital stocks mainly in biophysical terms, but the information can be supplemented with monetary data, where appropriate and where the methodology allows. SEEA-CF flow accounts cover flows from the ecosystem to the economy, such as exploited resources, and flows from the economy to the environment, such as pollution.

Ideally, accounting should include a wide range of types of natural capital, as well as the entire spectrum of the flow of ecosystem services. However, in practice, only partial integration of NC and ES is possible so far, and only a part can be evaluated in monetary terms.

Marine Natural Capital Accounting

The sea provides humans with a wide range of different ecosystem services, for example, flood protection, the provision of fish and the accumulation of carbon. However, a multitude of pressures have reduced its capacity to do so: the environment is polluted, fish are caught excessively, climate change is occurring, and habitats are being destroyed. This has direct effects on people, the well-being of society and the sustainability of cities and communities. Natural Capital Accounting (NCA) can be used to analyze and monitor the reserves and flows of ecosystems. Historically, this approach has been applied mainly to terrestrial ecosystems, however, there is growing application in the marine environment and great interest in the introduction of NCA both at the national and international levels.

The North Sea and North-East Atlantic Ocean is an excellent area to test the application of a NCA approach in the marine environment, partly due to the variety of relevant data sources available for the region.

Advantages of marine natural capital accounting

NCA contributes to decision making that is beneficial for economies and nature. The approach can be useful in the following ways:

<u>Assessing the economic viability of coastal development plans</u>

Modern development projects often ignore or underestimate the value of coastal ecosystems. As a result, people involved in decision-making processes may not fully understand the consequences of adverse impacts and therefore not take all factors into consideration when making decisions. The NCA framework provides an opportunity to include economic benefits and losses of undervalued ecosystems in national accounts and help reverse this trend.

<u>Informing marine and coastal management plans</u>

Determining the most appropriate way to manage marine resources in order to provide maximum benefits for nature and society is a challenge. For example, it is possible to create a Marine Protected Area, or just to control fishing activities in order to preserve fish resources. In addition, these measures can be combined, or applied partially, for example, by limiting the catch only in a certain season.

In order to move forward, people involved in the decision-making processes should be able to weigh all possible options and assess the economic and environmental benefits of each of them. Improving the understanding of the economic value of marine and coastal ecosystems and their inclusion in national accounts is a helpful step for a smart distribution of investments and a choice of a strategy to deliver economical, social and ecological benefits.

3.5 Evaluation techniques

Total Economic Value

For economic valuation the different components of natural capital are important and their benefits as well as losses need to be assessed. To ensure a comprehensive assessment, the concept of choice is generally the "total economic value" (TEV) (Talberth, 2015).

In order to determine the economic value of natural capital, various categories of benefits are considered, which are summed to arrive at the TEV, these tend be use (utility value) and non-use values. Use values are further divided into consumptive (e.g. consumption of wood or fruit, i.e. the amount usable for other users is being diminished) and non-consumptive values (e.g. recreation, in which the consumption of one person has no influence on the consumption opportunities of another person). These direct value categories are usually the easiest to assess in monetary terms, since existing markets and market prices can be referred to. They also include indirect use values. The pollination by bees as a prerequisite for the production of food, for example, is part of this category. In order to account for uncertainties about future benefits, the "option value" is introduced. It refers to possible advantages and benefits derived from nature in the future, which are still unknown to date. The tropical rain forest is often cited as an example. It is assumed, that there are hitherto unknown animals and plants whose economic value will only be revealed in the future (e.g. medical use). If the species is lost however, this possible value cannot be realized. These potential losses as well as the lost potential for carbon storage must therefore be accounted for when rainforest is being destroyed, for example through soy cultivation or cattle farms.

In contrast "non-use values" or non-use dependent values capture benefits such as people knowing that certain animal or plant species exist, even if they never interact with it. In addition, cultural and spiritual benefits can be drawn from nature and are included in the TEV as use categories (Kaval 2010; Boardman et al. 2001). A challenge with non-use values is attributing economic value. These components can be captured at least partially by means of non-use values. Due to the immateriality of these value categories, the figures are difficult to compare, vague and subjective.

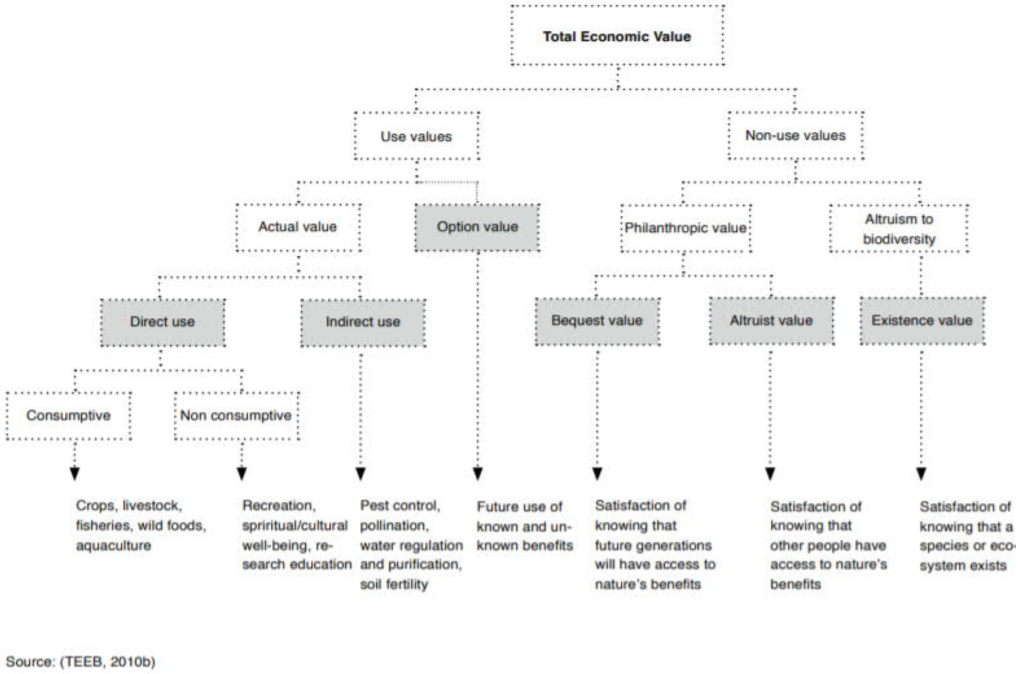

Figure 5. Total Ecosystem Value framework. (TEEB, 2010b; Turner et al., 1998)

Methods for economic valuation

Here, the same evaluation methods are used as in the chapter "Ecosystem services" in the section "2.3 Evaluation methods".

3.6 Restrictions in natural capital accounting

Ecosystem Accounts are still at an early stage of development, and only a few pilot experiments have been developed so far. This is partly due to a range of challenges that still need to be addressed.

One important challenge regards data availability. For many ecosystems and ecosystem services, significant data gaps hinder the development of reliable accounts. In some cases, data may be available at a different scale than the one required for accounting, and therefore models and approximations need to be used. Also, data on ecosystems and ecosystem services are often location specific and require indicators relevant to the scale at which the accounts are developed (e.g. through aggregation or extrapolation). In some cases, accounts are compiled using empirical and modelled data and the degree to which they can be directly compared and/or aggregate needs careful consideration. It is important to remember that not all ecosystem services can be covered in Ecosystem Accounts, due to a lack of data and methodological difficulties. For this reason, expectations need to be managed a balance found between quick and easy indicators and more detailed, time-intensive accounts. It is also key to be transparent as to what accounts cover (and don't) and how to interpret the results. For example, accounts do not cover issues related to irreversible depletion or erosion of natural resources, ecosystems or ecosystem services in relation to ecological limits and thresholds (and nonlinearity), in order to address these issues they would need to be combined with other analytical tools and data (Harris and Khan, 2013).

Another challenge is the development of a coherent and agreed-upon conceptual framework, methodology and definitions. SEEA-EEA presented an important step in this sense, however, for some of the most controversial topics, as for example monetary valuation, SEEA-EEA only offers an overview. Finally, gaps in the scientific evidence base regarding key biophysical and ecological processes that replenish Natural Capital and generate ecosystem services remain a key challenge for environmental accounting.

As well as, many challenges with respect to monetary aspects of Natural Capital national an international experiments are is crucial to gain experience and be able to highlight potential promising ways forward.

3.7 Conclusions

In the decision making process traditional indicators such as GDP are often used to determine value and importance. However, as outlined above, such indicators fail to capture all of the things that are important to a country and its citizens. This is where natural capital accounting comes in; considering the services provided by the natural world (its capital) and considering how its health is vital to the world we live in.

The Natural Capital approach is of direct relevance for strategic planning, yet, compared to the terrestrial realm it is relatively under used and as such understanding and trialing its use in the ocean is of vital importance. Some countries are already actively engaged in this task, for example, the UK is developing the marine accounts (see section 5.3 for a short illustration), however, challenges relating to data and valuation gaps, predicting changes in stocks and future flows and developing and refining accounting principles remain.

4 Why should OSPAR be interested in ES/NC?

4.1 OSPAR

4.1.1 Background

The diversity and intensity of human activities taking place in and around the North-East Atlantic places put tremendous pressure on the marine ecosystem: Land-based pollution, fishing, oil and gas extraction together with climate change all have very significant impacts. As the North-East Atlantic makes a significant contribution to the economies of the countries that bound it, it is essential that the biodiversity, resources and environmental quality of this ocean ecosystem are conserved, protected and sustainably managed.

OSPAR was established in 1972 on the basis of the Oslo Convention and the Paris Convention of 1974m and the convention was updated and expanded to form the OSPAR Convention in 1992. In 1998, a decision was made to protect biodiversity in the North Sea as was adopted and ratified by 15 countries and the European Union. The new Convention entered into force on March 25, 1998.

The Convention provides an opportunity for countries to establish cooperation in the protection of the marine environment; helps to ensure the regulation of human activities in the North Sea and supports the monitoring, data sharing and assessment of the state of the sea.

The convention seeks to protect human health and the marine ecosystem to maintain and, where practicable, restore marine areas affected, through sustainable management

There are two main principals of this:

- preventing and eliminating pollution of the marine environment.
- protecting the maritime area against the adverse effects of human activities

Sustainable management, is defined according to the preamble of the treaty as "[the] management of human activities such that the marine ecosystem, the legitimate uses of the sea can continue to wear and can continue to meet the needs of present and future generations."

4.1.2 OSPAR and "the ecosystem approach"

The ecosystem approach is "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (https://www.cbd.int/ecosystem/). This frameowrk is central to amny of OSPAR's objectives; helping member states undertake assemments for the Marine Strategy Framework Directive (MSFD) and in making progress towards the EU 2020 Biodiversity Strategy.

Understanding the link between marine health and human well-being can help to support the effective management of human activities and management of marine resources. Under the requirements of the MSFD, Member States are expected to make every effort to ensure that assessment methodologies are consistent across the marine region or sub-region. This implies "the need to define and collate marine socio-economic data in a consistent manner across member states – particularly in the case of those member states that are bordering common seas". Where possible the same data sources should be used to inform policy and to link change in environmental quality to industry activities.

As part of its Environmental Strategy for the North-East Atlantic, OSPAR develops and improves methodologies, including a social and economic analysis of the use of the OSPAR marine and coastal areas. However, the integration of ecosystem service valuation into marine and coastal policy formation is particularly challenging due to the fact that these ecosystems tend to be large and therefore often overlap multiple political jurisdictions and economic sectors, and may not even be governed by an integrated institutional framework. As such parties are trying to promote more coherent economic and social analysis at the OSPAR level and develop sets of indicators that would be convenient for everyone.

4.2 Example uses of ecosystem service

4.2.1 The ES approach to support decision-making.

The first example of such use is reflected in the paper by Crossman et al (2015). Research summarize a project (CSIRO 2012) commissioned by the Murray-Darling Basin Authority, an Australian Federal Government Agency, to support decision-making on water allocations associated with the development of policy guiding the re-allocation of water resources under a new government policy and legislative framework, the Murray-Darling Basin Plan.

Since the goal of the project was to maintain and improve the ecological health of the wetlands, the Basin Plan project focused primarily on the necessary volumes of water to achieve hydrological goals. The ES approach was able to provide an analytical framework for interdisciplinary integration between the biophysical and socio-economic sciences. Thus, the quantitative assessment was improved, and the process of justifying the benefits for the well-being of the population, stakeholders and the economy from sustainable management, and politics was simplified.

➔Use of ES approach:
- fostering interdisciplinary work
- as a process to justify a decision

4.2.2 ES as a tool for communication between the stakeholders.

The second example of the successful application of ES can be considered the case described in Maynard et al (2015). As in the previous case, this article described in detail the advantages of implementing this approach in management. Stakeholders (e.g. government, non-government, business, industry, community, traditional owners, researchers) across South East Queensland (Australia) have jointly developed the South East Queensland Ecosystem Services Framework, a tool for assessing the ecosystem services of this region. (Maynard et al. 2010, 2012).

The approach prompted stakeholders to develop a common conceptual understanding of the functioning of the ecosystems of South East Queensland. The classification and systematization of the natural-social system, which was developed by the parties, offers a simple structure and a common scientific language that serves to translate the understanding of how communities and individuals in the region benefit from the provision of ecosystem services.

Implementation of the ES-based approach makes it possible to change how decision makers communicate with their audience. The language of ‘benefits and services’ provides a basis for building social capacity and informed decision-making through positive communication, rather than the negatives of poor management. The ES approach creates the potential for community education and for joint, coordinated planning and management at the local, regional and state scales.

According to the paper, the South East Queensland experience also demonstrates that the ES approach helps to identify areas where ecosystem functions are degrading, which allows to be proactive in planning a recovery, thereby to compensate losses prematurely. The paper concludes that the developed framework, has brought numerous advantages. It is emphasized that joint mapping and RS assessment are an important tools for identifying common information and data sets, which is necessary for integrating ES-based approaches, as well as for local and state planning and management of natural resources.

➔Uses of the ES approach:
- as a positive communication tool
- as an integrated conceptual framework

4.2.3 ES for implementation of the European Water Framework Directive

The third example presented by Blackstock et al (2015) explores in detail the benefits that the ES approach can bring in the process of application of the European Water Framework Directive as well as in management and policy. According to authors, this approach is able to identify interested parties that are most vulnerable to various factors of the aquatic environment, since ES takes into account many ecological links. This can help to take into account more users of recreational and other aquatic ecosystem services in planning and use (Ravenscroft & Church 2011). These changes can reduce the negative impact on the aquatic environment, since responsibility for the impact and recovery will be more competently distributed (Keeler et al. 2012). In addition, ES, allows to balance goals with a concern for social, not just economic, wellbeing.

Accounting for the ES allows to monitor the positive and negative effects on the aquatic environment, to identify what affects the services, to see the root cause of changes in people's well-being. It could add a new dimension to economic characterization by including all the services arising, not just those that can be monetized or linked to a specific pressure. The implementation of ecosystem services supports the goals of the WFD, as it can scientifically explain the need to maintain a healthy aquatic environment (Volker & Kistemann 2011).

According to Blackstock et al (2015), the ES approach allow to create a more holistic picture for managing water objects, that allows one to correctly prioritize the decision-making process, as well as take into account more points of view and stakeholders, and prevent legal, social and environmental problems in the future.

➔Uses of the ES approach:
- as a tool to take into account the interests of a stakeholders
- helps correctly prioritize management

4.2.4 ES for resource management

Tammi et al (2017) review a regional case study on the mapping and assessment of ecosystem services in the Tampere region in Southwest Finland. The document examines in detail the results of the research project on the ES and Natural Capital and the application of these approaches to regional development planning. This project was carried out at the same time as the regional strategic planning process until 2040. That made it possible to establish a connection to regional and local decision making. In addition to accounting for ES and NC, the project aimed at facilitating assessment for a regional strategic plan, designed to assist in the assessment of impacts and in the allocation of resources. One of the most important objectives of the study was to assess the capacity and effectiveness of the ES in the management of resources and land use.

Despite the difficulties in application, the ES approach was able to contribute to the management objectives. The results of the study already affected the Tampere regional plan 2040 proposal, altering the plan towards a more comprehensive guidance solution for ecosystem service hot spots. The key issue here was a spatially explicit inventory and valuation framework that allowed comparing the stated land use plan with the results. It is still difficult to draw conclusions on the effectiveness of the implementation of the ES approach in the implementation of this plan, since the plan cover a long period. The results can be traced, since, for example, one of the goals of implementation of this approach was to exchange information on the planning hierarchy and raise awareness of land use issues. The approach allowed stakeholders to be guided by common information in regional development projects. This research aroused media interest and affected and aided already several large and small scale planning processes from impact assessments to bio and circular economy projects to participatory landscape planning, not only within the region but in different parts of the country.

Previously, the usefulness of an ES approach for policy and management has been questioned (Primmer and Furman, 2012). However, as in the examples described above show that the implementation of ES accounting leads to a gradual improvement of the process of data exchange and decision making in a variety of plans and projects.

➔Uses of the ES approach:
- as an information exchange tool

4.2.5 Summary of potential benefits of using ES/NC to support OSPAR level decision-making

Based on the examples described above, it follows that the approach based on ES has a number of advantages over other ways of assessing benefits and monitoring. The ES approach creates opportunities for taking into account all economic, environmental and social effects and integrating this data into management. The evaluation of an ES can raise awareness and inclusion of the interdependence of nature and people for a sustainable management of water resources (Grizetti et al., 2016). ES allow to consider more broadly, what is happening in ecosystems. Despite the fact that the implementation of ES and data collection for this purpose is difficult, it is likely that these actions can bring significant benefits in the future. These include:

- A main advantage of ES is that the approach allows to take into account a greater number of interconnections in planning and decision-making.

- ES also allow to track or even to predict changes in the ecosystem, which are unavoidable during any human activity in the marine environment. This is an approach that will allow to see not only momentary benefits, but also to get an idea of the further change in the flow of services over time, based on ecological links.

- The next obvious advantage is that it significantly increases the accuracy of taking into account the interests of all parties. All ecosystem services are somehow related. Biodiversity reduction will inevitably affect recreational services and so on. The implementation of the ES in the assessment in the development of projects at sea will help to take into account the benefits and losses for all who benefit from the ecosystem.

- If this approach allows to unify the stakeholders, then it will also contribute to the interaction of the parties among themselves. ES can become a common language for communication both for specialists from different fields, and between different structures, stakeholders at various levels.

- The monitoring of the ES contributes to more competent management at sea, since the degradation of an ecosystem, further losses of services and vulnerable stakeholders can become more evident earlier. This will make knowingly more profitable decisions, as well as plan a recovery.

Despite the fact that the implementation of the approach presents certain difficulties, as well as the fact that there are many views on the definition of ES, assessment methods and classifications of ES, it is likely that the application of this approach in the future may bring significant benefits for OSPAR. It will be necessary to ensure regular data collection. Such an accounting can be gradually improved and expanded, and these data will undoubtedly find their application over time.

5 Case Studies of application of ES and NC for marine environment

There are many approaches for assessing ES and NC and applying the results of this assessment. During the existence of the concept of ES, many case studies have been conducted, many approaches have been proposed. Each of these approaches has its advantages and disadvantages. Several of the many existing approaches are considered in this chapter referring to the cases of their application. After that, these approaches are compared and the conclusion on their advantages and disadvantages is made.

5.1 Natural capital accounting

5.1.1 Developing UK natural capital accounts: marine scoping study (Eftec, 2015)

METHOD

This study attempts to develop accounts for marine ecosystems. It takes into account the unique features of the marine environment, however it is based on the principles of conventional accounts for stocks and flows of ecosystems. The study contains the principles and methods of developing accounts, as well as a "mini-roadmap" for the development of accounts.
The marine account to be developed is an ‘ecosystem account’. Office for National Statistics is developing a set of environmental accounts, which will now include marine accounts.

RESULTS

Accounts are a set of four related accounts that provide an overview of the state of an ecosystem asset. This set includes both a physical account reporting the extent of recources and the condition of the ecosystem, an account reporting the provision of ES flows and monetary accounts in which ES and stocks are estimated in monetary values. The study consider several ecosystem services, but the focus is on fish, carbon, and recreation. Using the example of these three services, the study clearly demonstrates the principles for the development of ecosystem accounts.

		Type of ecosystem asset	
		Marine	
		Flow (Annual, 2014)	Profile of Flows (‘20’ yrs)
Provisioning	**Fisheries** Single species model (Cod)	North Sea cod UK quota ***10,977 tonnes***	North Sea cod UK quota ***1.02 million tonnes (20 yrs; 2014-2023)[1]***
	Fisheries Single species with multi-species interaction (Cod)	***10,977 tonnes***	***0.51 million tonnes (20 years, 2014-2023)[1]***
Regulating	Carbon Sequestration[2]	***Saltmarsh: 67,375 tC*** ***Offshore sediments (50-200m depth): 0.98 tC*** ***Offshore sediments (>200m depth): 0.004 tC*** ***North Sea carbon pump: 2,161,296 tC*** ***Maerl beds: 16,707 tC***	***44,907,590 tC (20 years, 2014-2033) i.e. constant flow assumption***
Cultural	Recreation	***99 million visits to coastal margins and the marine environment in Great Britain in 2013***	***1,980 million visits to coastal margins and the marine environment in Great Britain (20 years, 2013-2032) i.e. constant flow assumption***

Table 3. Example: Physical account of ecosystem service provision (flow) (Eftec, 2015)

Ecosystem Asset: Marine 2014		Ecosystem extent	Characteristics of ecosystem condition						
		Total Area	North Sea cod (volume) Single species model			North Sea carbon pump	Blue flag beaches	Coastal paths	Scuba diving sites
			TAC	UK quota*	Discard as a % of total catch	Area (covers entire area of North Sea)	Number of awarded sites	Length of coastline	Number of sites
	Habitats	***km²***	***tonnes***	tonnes	***tonnes***	km²	Number of awarded sites	Km of coastline	Number of sites
Closing Stock (2014)	Marine	773,676	33,391	10,977	23%	261,026	99	2,650	732
	Saltmarsh	337							
	Offshore sediments (50-200m depth)	230,599							
	Offshore sediments (>200m depth)	218,167							
	Maerl beds	84							
Data Sources		Sea Around Us Project	ICES simulations			Environment Agency, MESH Atlantic Habitat Map, Thomas et al. (2007)	British Marine Federation, MENE, Natural England		
Coverage (Nations)		**UK**	**North Sea**			UK	UK	UK	UK

Table 4. Example 2. Physical account of ecosystem asset condition and extent (stock) at the end of an accounting period (Eftec, 2015)

For each of the services, the research report details the assessment methods as well as the available data sources. The work done by the UK is experimental. They were one of the first to develop ES and NC accounts for the marine environment.

LESSONS LEARNT

According to the result of the study, the following conclusions were made:
Defining the stock and flows of the marine ecosystem asset through its extent and condition faces severe complications. Despite a range of information being available on factors or proxies of the various ecosystem characteristics, the relationship between these and the extent or value of ecosystem service benefits is rarely known in the marine context. It will therefore be necessary to use different methods. Next big problem is lack sufficient data to capture how marine ecosystem service levels are a function of physical, chemical and biological processes, and cannot be determined from the extent and condition of blocks of benthic habitat. This study is one of the first in the development of marine ecosystem accounts. It can serve as a guide in deciding whether to implement this approach in OSPAR activities.

5.1.2 Port Phillip Bay – Seagrass case study (Australia) (Eigenraam, 2016)

METHOD

This case study shows how an environmental-economic accounting framework can be applied – both conceptually and quantitatively – to seagrass ecosystems to demonstrate the link between biophysical information and socio-economic benefits. Accounts provide initial information on the location of seagrass beds and the ecosystem services and benefits they can provide.

Asset	Condition	Services	Benefits
7,347 hectares of seagrass across Port Phillip Bay Composition: • 209 hectares of Amphibolis stands • 138 hectares Halophila beds • 6,444 hectares Zostera and Ruppia beds • 556 hectares unsepcified Location: • 3,733 hectares in Exchange area • 3,280 hectares in Corio area • 209 hectares in Intertidal area • 123 hectares in Hobsons area • 1 hectare in Central area	A condition measure for seagrass heath is currently not available	Provisioning Uncultivated marine plants, algae and animals for food Nutrients and natural feed for cultivated biological resources (aquaculture) Regulating Climate regulation - carbon sequestration and storage (280,700 tonnes of carbon stored) Water cycle regulation - nutrient cycling, oxygenisation Water flows regulation, mass flow regulation Maintenance of habitat and nursery populations (minimum 343 tonnes of fish stock enhancement) Cultural Recreation Information and knowledge Spirtitual and symbolic Non-use - existence and ecosystem capital for future generations	Seafood Climate change mitigation ($2.9-16.0 million carbon stored; up to $0.06-$0.35 million sequestered per year) Clean water Coastal erosion prevention Fish stock enhancement (minimum $6.1 million per year) Recreational fishing, diving, snorkling

Table 5. Seagrass in an environmental-economic accounting framework. (Eigenraam, 2016)

Seagrass beds deliver a number of ecosystem services that are of significant benefit to people. Table provides on overview of key ecosystem services.

Ecosystem service	Description
Provisioning	
Uncultivated marine plants, algae and animals for food	Seagrass ecosystems provide fish and shellfish which can be taken up for food (commercially or recreationally), providing a benefit to people.
Nutrients and natural feed for cultivated biological resources	Nutrient resources for aquaculture products.
Regulating	
Climate regulation	Seagrass ecosystems sequester and store carbon dioxide. This reduces greenhouse gases in the atmosphere, mitigating the impact of climate change.

Table 6. Ecosystem service classification (Eigenraam, 2016)

RESULTS

This study has valued the flow of two ecosystem services provided by seagrass ecosystems – the maintenance of nursery populations and the provision of habitat. Both the maintenance of nursery populations and the provision of habitat services are intermediate ecosystem services. These services are ultimately of benefit to recreational and commercial fisheries along with passive recreation activities such as snorkeling and diving.

In addition to qualitative and quantitative assessment, the report describes in detail the established relationships between ecosystem functions and ES, which allows to obtain more complete understanding of the existing human interactions with the ecosystem and conduct more competent policies. In addition, all ES related to seagrass were economically evaluated.
Benefits

- Recreational Fishing
  Port Phillip Bay is a popular destination for recreational fishers. On an annual basis, recreational fishing catch may exceed that of the commercial sector. Recreational fishing is a benefit provided by seagrass ecosystem services, as seagrass provides habitat that supports fish species that are recreationally caught.
- Commercial Fishing and Aquaculture
- Wild seafood is commercially caught in Port Phillip Bay, providing benefits to producers and consumers. However, the Victorian government has committed to phasing out commercial netting in Port Phillip Bay as part of the Target One Million plan that aims to improve recreational fishing opportunities. While the exact relationship between seagrass and aquaculture farms is unknown, seagrass ecosystems provide important water filtration services and stabilize sediments through their root systems. This provides improved water quality required for aquaculture farms.
- Recreation

Port Phillip Bay provides opportunities for recreation experiences. The direct benefit to Victorians and visitors is the personal enjoyment gained while undertaking activity in and around the Bay, which then provides additional health and economic benefits. Whilst information on Bay recreation and tourism is available from a range of sources, it is difficult to define and quantify the relationship between seagrass assets and recreation.

- Climate Change Mitigation.
  Seagrass provides carbon sequestration and carbon storage.

The ES-based approach helps the Australian government to find a compromise between commercial and recreational fisheries. The amount of seagrass (intermediate ES) is limited, which means it is necessary to achieve a trade-off between different stakeholders. ES help to take a correct decision in this issue.

Port Phillip Bay builds on previous environmental-economic accounting undertaken by the Victorian Government to demonstrate the relationship between healthy bays and economic and societal wellbeing in Victoria. The study has used available data to produce a draft set of ecosystem extent accounts for the Bay. This approach allows for the integration of terrestrial accounting with marine and coastal accounting to provide a more complete picture of both the economic and environmental relationships. The application of an integrated accounting framework across all environmental dimensions would provide a set of information that can be used to make decisions involving tradeoffs between the use and management of ecosystems in a transparent and consistent manner.

LESSONS LEARNT

According to the report, robust, comprehensive and fit-for-purpose data is core to decision making. A lack of ecosystem health and spatially referenced data was a key issue in populating accounts for Port Phillip Bay. The development of marine ecosystem condition indicators is a key priority, which should continue to be addressed. Going forward, the accounts can provide a robust reference point against which to compare future information to report on changes to asset and support the assessment of program/policy investments.

5.1.3. Natural capital accounts for the North Sea

In the Netherlands work is also ongoing to test and implement SEEA EEA ecosystem accounting. The “Natural capital accounts for the Netherlands” project has been developed since 2016 by Statistics Netherlands and Wageningen University and is funded by the Dutch Ministries of Economic Affairs and Infrastructure and the Environment. In 2017, Statistics Netherlands carried out a short study or the Rijkswaterstaat on the natural capital accounting possibilities for the Dutch continental shelf. Research in this area is ongoing. A project is currently being implemented for compiling and testing experimental physical SEEA EEA accounts for the Dutch part of the North Sea (CBS, 2017).

5.2 ES list method

Valuing Ireland’s blue ecosystem services (Norton, 2018)

This report is focused on the ecosystem service benefits that society receives from Ireland’s marine environment, complementing previous work on the Irish ocean economy.

Authors highlighted as a key action the need for further research into generating “economic values of marine biodiversity and ecosystem services to ensure best practice planning and management of the ocean resource”. In particular, it aims to:
- Provide a profile of the marine ecosystem services derived from Ireland’s coastal, marine and estuarine natural resources.
- Provide estimates of the value to society of these marine ecosystem services.
- Provide data that assists in the delivery of management and planning decisions relating to human activities in the marine environment.
- Provide information on the relative importance and potential economic trade-offs of existing marine uses as reflected in their social and economic values. This information should feed into assessments that are required under the EU Marine Strategy Framework Directive and Maritime Spatial Planning Directive.
- Identify knowledge gaps that continue to exist in the valuation of marine ecosystem services.

METHOD

Using the CICES classification, the authors identified a list of Ireland ES. A quantitative assessment was carried out using a large number of different external data sources. For economic valuation, the TEV framework was used, where for each of the services a specific economic valuation method was also chosen individually.

Type and methods	Notes	Where used in report
Revealed preference methods	Methods based on values for ecosystem services that are 'revealed' by behaviour in associated markets.	
Market prices	Market prices are rarely equal to values. Prices do not generally reveal the 'consumer surplus' (the value to the consumer over and above the price paid). They can also be distorted by taxes and subsidies.	Capture fisheries, aquaculture, algae/ Seaweed harvesting
Production functions	Production functions are statistical models which relate how changes in some ecosystem function affect production of a marketed good or service.	
Avoided costs/ Replacement costs	Avoided or replacement costs are a measure of the value of a service based on the cost to replace the ecosystem function or service.	Waste services, climate regulation, coastal defence
Non-market revealed preference techniques	Methods based on values for ecosystem services that are revealed by behaviour in associated markets.	
Travel cost	The travel cost method is used to estimate the value of sites which people travel to (i.e. for recreation) based on the theory that the time taken and travel costs represents the value of access to the site.	Recreational services
Hedonic pricing	Hedonic pricing is a statistical modelling technique which estimates the implicit price paid for environmental characteristics of the area or for a pleasing sea view through the variation in the property prices in different areas.	Aesthetic services
Stated preference methods	Methods based on surveys in which respondents give valuation responses in hypothetical situations	
Contingent valuation	Contingent valuation is a method of valuing a single change to an environmental good or service where the change is described and the respondent is asked their WTP/WTA.	Non-use values
Choice experiments	Choice experiments estimate values from the choices respondents make between options with different specified attributes of an environmental good.	Non-use values
Value transfer(VT)	A secondary valuation methodology that uses existing value evidence to be applied to new cases without the need for primary valuation studies.	
Point, function and meta-analysis transfer methods	Point VT transfers a single value or mean of value which may or may not be adjusted. Function transfer a function which has be estimated using a primary valuation method. Meta-analysis pools similar primary studies together to generate statistically robust function for use in VT.	Waste services, climate regulation, aesthetic services, recreational services

Table 7. Main methodologies for estimating marine ecosystem service values (Norton, 2018)

RESULTS

The report indicates the significant contribution that provisioning, regulation and maintenance, and cultural marine ecosystem services make to our welfare, health and to economic activity. The authors also attempted an economic evaluation of the ES. Even though not all of the ecosystem services provided by the marine environment can be monetized, the research does indicate that the value of those that can is substantial. The information put together on the marine ecosystem service benefits from Irish waters complements the information generated on Irish ocean economy industries by providing policymakers with information about the value of market and non-market marine ecosystem services, and the potential costs if these services are lost.

This case study describes in detail all the ecosystem services of the Irish marine area, and in addition to this, they conducted a quantification and monetary evaluation of ES, the results of which partially are given below. This study is unique as it describes in detail and calculated all the marine ecosystem services that have been identified.

Ecosystem Service	CICES classification	Quantity of ES per year	Estimate of the value of ES per year
Provisioning ecosystem service			
Off shore capture fisheries	Wild animals	469 735tonnes	€472 542 000
Inshore capture fisheries	Wild animals	14 421 tonnes	€42 113 000
Aquaculture	Animals — aquaculture	39 725 tonnes	€148 769 000
Algae/ seaweed harvesting	Wild plants & algae/plants & algae from Aquaculture	29 500 tonnes	€3 914 000
Genetic materials	Genetic materials from biota	Not quantified	Not valued
Water for non-drinking purposes	Surface water for non-drinking purposes	1 189 493 326 m3 of seawater used for cooling	Not valued
Regulating and maintenance ecosystem services			
Waste services	Mediation of waste, toxics and other nuisances	9 350 642 kg organic waste 6 834 783 kg nitrogen 1 118 739 kg phosphorous	€316 767 000
Coastal defence	Mediation of flows	179 km of coastline protected by saltmarsh	€11 500 000
Lifecycle and habitat services	Lifecycle maintenance, habitat and gene pool protection	773 333 ha protected through special areas of conservation	Not valued
Pest and disease control	Pest and disease control	Not quantified	Not valued
Climate regulation	Atmospheric composition and climate regulation	42 647 000 tonnes CO_2 absorbed	€818 700 000
Cultural services			
Recreational services	Physical and experiential interactions	96 million marine recreational trips per year	€1 683 590 000
Scientific and educational services	Scientific & educational	Marine education and training fees	€11 500 000
Marine heritage, culture and entertainment	Heritage, cultural and entertainment	Not quantified	Not valued
Aesthetic services	Aesthetic	Flow value of coastal location of housing	€68 000 000
Spiritual and emblematic values	Spiritual and/or emblematic	Not quantified	Not valued
Non-use values	Existence & bequest values	Not quantified	Not valued

Table 8. Values of Irish Coastal and Marine Ecosystem Service Benefits1 (Norton, 2018)

LESSONS LEARNT

According to the report, without an understanding of the working of ecosystems, their functioning and the biodiversity associated with them, the assessment and valuation of ecosystem services may produce poor or in some cases misleading information and values for use in policy and decision-making. It is imperative therefore, that those using ecosystem services classification systems, frameworks and values understand the basis of those values and the uncertainty associated with such values. Knowledge gaps still exist for many ecosystem services, both in measuring the quantity of the ecosystem service in physical terms and a lack of information and understanding needed to apply an economic value to certain ecosystem services.

The following conclusions were made:
Factoring marine ecosystem service values into ocean economy account frameworks may help to ensure a sustainable "blue economy" for Ireland by making sure that growth in the ocean economy does not exceed the carrying capacity of the marine environment. The application of ecosystem services assessment at a smaller spatial scale may help to improve knowledge in the planning process whether it be a local area plan or a one off development. The planning process requires that the impact on humans in addition to the environment be examined. While valuation of ecosystem service values should not be the sole determinant of a decision, their inclusion in impact assessments should contribute to a more explicit and transparent decision making process.

5.3 The method of comparing the pressures on the ES and the dependence of the human activity on the ES

Developing the ecosystem service approach in the ESA framework (Ahtiainen et al., 2018)

The ecosystem services approach has been applied in Sweden within the SPICE project coordinated by Helcom. The aim of the study was to assess the current impact of pressures on ecosystem services caused by human activities in terms of lost service to economic activities and not only pressures on services. Moreover, it was examined to what extent different human activities depend on ecosystem services.

METHOD

The ecosystem services classification adopted used 22 ecosystem services, was based on the Millennium Ecosystem Assessment, and was in alignment with previous works performed at the national level. In this study, two methods were used: a direct method and an indirect method.

The direct method assessed the impact of human activity on the ES. For this, quantitative data were used, and in case of their absence, expert judgments were applied.

The indirect method, in its turn, makes use of existing knowledge on links between activities/pressures to ecosystem components. The assessment of impacts on ecosystem services is made by adding conversion factors for each ecosystem component, which estimate to what extent it contributes to each ecosystem service. The impact on ecosystem services is assessed based on the “sensitivity scores” (which estimate the likely sensitivity of each ecosystem component to each pressure), or alternatively based on the “impact sums” (which estimate the likely impact from each pressure on each ecosystem component).

RESULTS

The results showed the most influential activities that impact on the ecosystem services, and that pressures from land based activities have more significant consequences in the marine environment than initially expected. Then, the dependency of the human activities on the ecosystem services was assessed. The analysis considered both the dependency on the quality and the quantity of ecosystem services. The results showed that activities such as tourism are largely dependent on the quality of the ecosystem service and have a moderate impact on the ecosystem services, while the fisheries sector is both highly dependent on the quality of the ecosystem services and have a high impact on the ecosystem services itself (and ports are not dependent on quality, with a slight impact on quality). In the graph presented, the economic value of the various activities (measured by added value) was depicted by the relative size of the balls

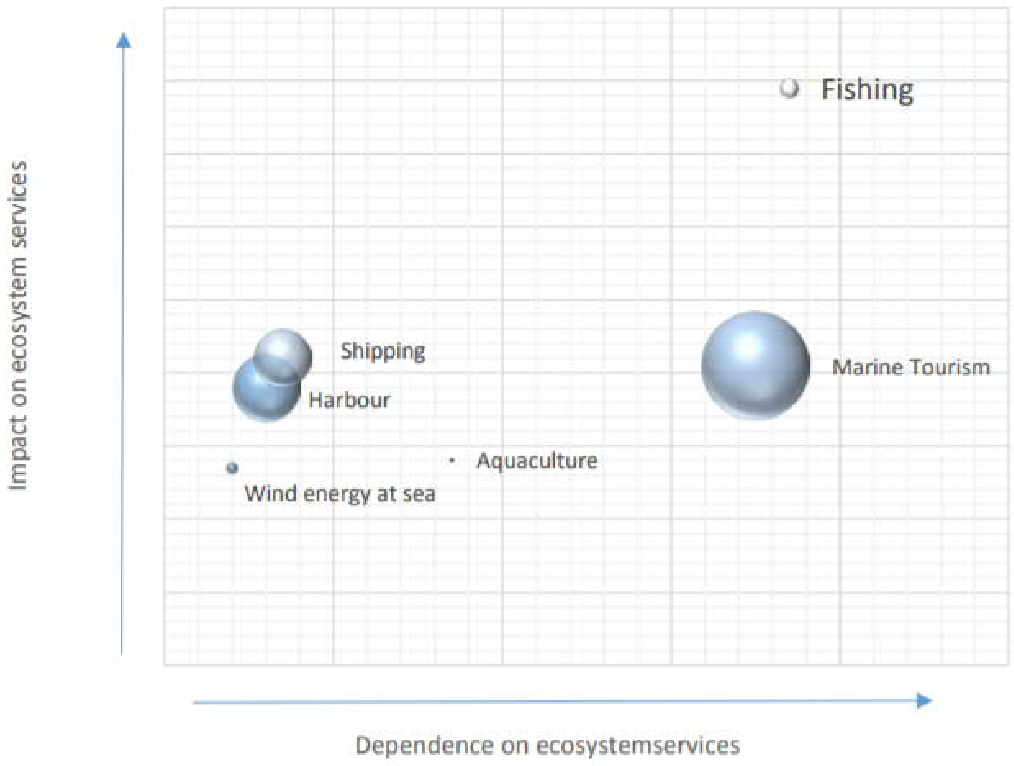

Figure 6. Tentative results for the dependency of human marine activities on ecosystem services (x-axis) and their impact on ecosystem services (y-axis). The size of the bubbles represents their value added. The total value of all the sectors represented in the diagram is 1.5 % of the Swedish Gross Domestic Product. (Ahtiainen et al., 2018)

The figure showed the sectors that are important to Sweden. The indirect method linked the pressures by activities with the ecosystem components in order to estimate the impacts on the ecosystem services. A remarkable result when comparing the results of the direct and indirect method was that for underwater noise, the impacts according to the indirect method are far more important than initially expected, because noise travels long distances and therefore have more impacts than initially expected.

5.4 Spatio-economic modeling of ecosystem service benefits and scenario development

Identification and Valuation of Adaptation Options in Coastal-Marine Ecosystems: Test case from Placencia, Belize (Rosenthal et al., 2013)

This study was carried out to assess and compare the relative costs and benefits of alternative adaptation options to defend the coastline around Placencia, Belize against level rise and coastal storms. The study compared various packages of ecosystem-based options (including conservation and restoration of coral reefs and mangroves, forest restoration and rehabilitation) and grey infrastructure (such as sea walls). The study sought to generate information to feed into and influence coastal zone planning processes led by the Belize Coastal Zone Management Authority and Institute (CZMAI), including the development of a nationally binding Integrated Coastal Zone Management Plan (ICZMP) with region-specific spatial planning and guidance.

METHODS

The study included ecosystem services assessment, scenario development and cost-benefit aspects. The ecosystem services assessment was based on InvEST (integrated valuation of ecosystem services and tradeoffs). This is a spatially-explicit, software-based tool for modelling ecosystem service values and trade-offs that uses maps as information sources and produces maps as outputs.
Four ecosystem services were modelled: lobster fisheries, coastal protection, tourism and recreation, carbon storage and sequestration. This yielded estimates of the locations and levels of ecosystem service provision. Three adaptation scenarios were compared.

The cost-benefit analysis then looked at the monetary impacts of the different adaptation measures in terms of their physical establishment and maintenance costs as well as the value of the ecosystem services they would generate.

For each of the three adaptation scenarios under consideration, future cost and benefit streams were calculated, and discounted in order to yield a single measure of net present value (NPV). Data was obtained from a number of sources. Ecosystem services data were collected as part of a three-year coastal zone planning process led by CZMAI. Information was also provided by a variety of government agencies in Belize, WWF offices, local non-governmental organizations and private entities, and peer-reviewed literature. Many of the cost and benefit figures that were used came from desk reviews and benefit transfer techniques, supplemented by extensive stakeholder dialogues and consultations with policy-makers.

RESULTS and LEASONS LEARNT

The main findings of the study was that adaptation measures based primarily on grey engineering would pose the highest risk to sea grass, coral reefs, and mangroves. The greatest benefits overall and highest levels of efficiency are achieved with a package of adaptation measures which combine grey and green approaches. Even though this option does not provide the highest returns for coastal protection, its costs are far lower, and it generates a substantially higher level of co-benefits for fisheries, tourism and climate mitigation.
It can be concluded about the effectiveness of this approach in identifying the most advantageous scenario in management.

5.5 "Integrating Ecosystem Services into Development Planning" (IES) approach

"Integration ES into Development Planning" valuation of economic contribution of protected area ES in Mexico (CSF, 2017)

The valuation studies were carried out in response to the general lack of attention paid to ecosystem services in most decision-making processes, especially in the sectors that depend and impact most on the natural environment. The studies aimed to communicate the value of ecosystem services to decision-makers in both environmental and non-environmental agencies, and to make the case as to why Protected Areas (PAs) are key to economic development. They also served to build technical capacity in ecosystem valuation within Mexico's National Commission of Protected Natural Areas (CONANP), and to generate recommendations about policy actions and instruments that might be used to strengthen PA conservation effectiveness. Three PAs were valued.

METHODS

The valuation studies adopted “Integrating Ecosystem Services into Development Planning” (IES) approach. The IES approach addresses the environmental and economic trade-offs associated with development measures, and helps to systematically incorporate ecosystem service-related opportunities and risks into conservation and development strategies and plans. In line with the IES approach, each of the studies therefore focused on a specific management issue and associated ecosystem services, according to the conservation priorities, threats and opportunities in the PA which was being valued. These were identified during intensive 2-day workshops held with PA managers and other local resource managers, users and experts. After identifying these focal areas and issues, stakeholder maps were produced to trace the dependencies and impacts of various different groups on ecosystem services. Valuation methods were chosen which were appropriate and applicable to the selected ecosystem services, could generate information that would be convincing and relevant to the target groups that the study aimed to influence, and were realistic and achievable in terms of their data and research requirements.

For example, in the Cozumel PA complex, the main conservation management and development planning issue was the threats posed to coral reefs, mangroves and other natural habitats and species by unsustainable tourism and coastal infrastructure development. The key concern was to generate information that could be used to better align policies and practices in these sectors with ecosystem services, and improve public budget allocations to PA conservation activities. Three sets of ecosystem services were selected for valuation: recreational and leisure activities (valued by means of choice experiments and benefit transfer techniques), protection against storms and flooding (valued using the spatially explicit, map-based InvEST model), and other benefits provided by mangroves and coral reefs (valued using a combination of different techniques).

RESULTS

The studies confirmed how valuable ecosystem services are, and underlined the importance of the three PAs to local, national and even global economies. In Cozumel, for example, the findings emphasized the significant value that mangrove and reef conservation generates for the tourism industry. It also showed how these natural habitats help coastal settlements and infrastructure to avoid substantial costs, losses and damages from the effects of storms and extreme weather events. Based on these results, it was recommended that a priority for decision-makers at all levels of government is to take actions to secure the ecosystem services provided by the PAs, which are the foundation of regional and national economies.

LESSONS LEART

Key lesson learned was the importance of phrasing information about ecosystem values in practical, policy-relevant and jargon free terms, and to express it through indicators that were of interest and concern to the target audience that the studies aimed to influence. The main concern was to demonstrate to sectoral decision makers that PAs made a tangible contribution to output, income and employment. The focus of the studies, and the IES framework that they were based on, was on showing how ecosystem services offer development opportunities and can act as an engine for economic growth. This kind of orientation to real-world issues and needs ensured that the valuation studies were of credible, relevant and useful, rather than being purely academic exercises to generate numbers.

Approach	Natural Capital accounting (Eftec, 2015), Eigenraam, 2016), (CBS, 2017).	ES list (Norton, 2018)	Comparison approach (Ahtiaine et al., 2018)	Spatio-economic modeling of ES (Rosenthal et al., 2013)	Integrating Ecosystem Services into Development Planning (CSF, 2017)
Type of question that can be answered using this method	What are the dynamics of flows and stocks of ES?	What is the volume of ES of this ecosystem and what is their value?	Which ES are most vulnerable to pressure caused by human activity? Which sectors of the economy are most dependent on the flow of ES?	What development scenario will be most beneficial in terms of benefits and costs, and ecosystem health?	How can one or another management problem be solved? (the approach aims to collect all the necessary information to solve a specific problem)
Method	Accounts can include both ES flows and resources, as well as contain information about economic value. The most simple and affordable methods are used for quantitative and monetary evaluation.	First of all, a complete list of services should be made. Then, each of the services should be quantified, and then a monetary evaluation should be done.	Two methods: The direct method firstly assessed the effects of human activities on ecosystem services using quantitative data, if available, or expert judgments when quantitative data were lacking. The indirect, in turn, makes use of existing knowledge on links between activities/pressures to ecosystem components.	A combination of ES modeling (mapping), cost-benefit analysis and of adaptation scenarios development.	First, key management issues should be identified. Secondly, It is needed to list ecosystem services that need to be assessed to solve these problems. Modeling (InVest) and the most convenient methods of economic evaluation are used.

Advantages	It is possible to assess just a few ES. The easiest way to account.	The approach provides the most global view of the flows and stocks of the ecosystem assessed. After conducting of such an assessment, it is possible to obtain data on all the benefits provided by this ecosystem and on the economic value of all services.	Results of an assessment are convenient for interpretation.	Modeling methods are used, which allows taking into account the spatial structure of and ecosystem and processing more data.	The application of the approach is aimed at solving a specific task, for example, making a decision on the preservation of a certain territory for supporting a certain set of ES.
Disadvantages	Difficulty in data searching. Insufficient knowledge of connections in marine ecosystems. Difficulty in choosing optimal indicators.	It is unable to provide monitoring. Due to the requirements for data and a wide range of methods applied, it is extremely difficult to repeat the assessment regularly.	A complicated and poorly tested assessment method.	Different types data processing is required using not the simplest valuation methods, such as InVest modeling and CBA for monetary valuation.	The need for coordination of cooperation between different stakeholders to identify problems of the territory and aspects of the assessment. Different types data processing is required using not the simplest valuation methods, such as InVest.

Benefits of application	The approaches expands the possibilities of monitoring the state of the ecosystem that provides the ES, and therefore supports the economy. Simple output data allows you to see the root cause of economic change and to adapt measures in the management.		Such an assessment allows you to identify the types of human activity that most strongly affect the ecosystem, as well as to identify which activities are most dependent on ES. This information will allows better prioritize management.	The approach is adapted for the decision-making process and the selection of the most profitable scenario.	An approach addresses the environmental and economic trade-offs associated with development measures, and helps to systematically incorporate ecosystem service-related opportunities and risks into conservation and development strategies and plans.
Data	Each service is selected a small set of indicators, and therefore the application of the approach requires a small amount of input data.	A large number of indicators that are used for an extended list of ES requires a large amount of input biophysical data. Since the approach also includes economic valuation, data for monetary valuation methods are also required.	Quantitative data on the ES, the results of expert judgments and data on links between activities/pressures to ecosystem components.	Data on the spatial distribution of the ES; data required for the CBA	Data on the spatial distribution of the ES; data required for the economic evaluation

Table 9. Comparative table of different approaches

5.6 Discussion

According to the results of the studies presented in this chapter, approaches based on ES are an effective management tool, and are often used in practice, including the marine environment. Since the ES concept is relatively new, approaches to the assessment of ES and to the implementation of this concept in policy and management are not fully defined yet. Some of these approaches were considered in this chapter, however, in view of the growing popularity of ES, new studies that suggests new approaches are emerging.

Approaches have their advantages and disadvantages. They can be divided into:

1. Approaches that are designed for monitoring (e.g., NCA)
2. Approaches that can provide enhanced vision of what occurs in the socio-environmental system (e.g., ES list and Comparison approach)
3. Approaches that are aimed at solving a specific problem in management (e.g., Spatio-economic modeling of ES and IES).

The first group is characterized by ease in use. The list of ES is determined by the data availability. Services that are easier to evaluate on an ongoing basis are evaluated. The simplest methods of evaluation are used. These approaches allow to provide a regular assessment, thus to monitor the state of the ecosystem.

The second group of approaches is more difficult in application. This kind of assessments is more similar to scientific research. The goals of these assessments are more global. A variety of methods of quantitative and monetary evaluation, and even expert judgments are often used. In addition, approaches are characterized by a large amount of input data. For which many data sources have to be used. Conducting such assessments is time consuming than the first group of assessments.

The third group is characterized by adaptation of the approach for a specific case. They typically include modeling, CBA, and scenario development. Approaches have repeatedly proven their effectiveness in management and they continue to improve. A large amount of data is required, both on the spatial distribution of the ES, and for conducting the CBA or other monetary valuation.

The choice for a particular approach should be determined by the policy question and availability of data.

6 Conclusion

In modern ecological economics, up to the present time, a stable opinion has formed that approaches of ecosystem services and natural capital can be effective in policy making related to the management of terrestrial and aquatic ecosystems. This is confirmed both by numerous scientific studies and by the fact that all over the world these approaches are increasingly being used to solve policy and management problems. The objective of this study was to identify the relevance of ES and NC approaches for OSPAR activities, to find out advantages and disadvantages, and to determine how these approaches can currently be integrated into maritime management, by considering existing case studies.

The most relevant information on the ES and NC was collected in this report. In addition, the approaches for classification, monetary and quantitative assessment were analyzed. The main conclusion of this study is that, although the assessment of ES and NC is a difficult task, requiring a lot of input data and the use of complex methods of assessment, these approaches have many benefits that make them a relevant and useful tool to support OSPAR decision making.

6.1 Relevance of ES and NC

The ES and the NC approaches are unique tools for obtaining information about the ecosystem, since they can take into account not only the costs of potential measures and their obvious benefits, but also take into account the ecosystem processes behind it. These methods allow to consider benefits from a new perspective, increasing the understanding how ecosystems and benefits depend on each other. This understanding can help to determine – and therefore support the discussion on – the relevant trade-offs in decision-making processes. NC and ES approaches can also help to develop a common language between specialists from different fields - ecologists and economists, and thereby stimulate and facilitate interaction between various disciplines, a key requirement in sustainable management of the marine environment.

Ecosystem service values can be used in every step of the planning process; from motivating financial support for planning efforts by defining the benefits from better planning, to providing information on the relative importance of existing uses as reflected in their estimated social and economic values, and improving the understanding of potential economic trade-offs. Application of NC and ES approaches may help to take into account all interests of all parties. Biodiversity reduction will inevitably affect recreational services and so on. The implementation of the ES in the assessment in the development of projects in the marine environment will help to take into account the benefits and losses for all human activities that depend on the marine ecosystem. In this way, the application of NC and ES approaches will also contribute to the interaction of the parties among themselves.

The (long term) monitoring of ES can contribute significantly to a more forward looking integrated sustainable management of the marine environment , since the analysis of ES makes it possible to determine – and become earlier aware of, and therefore offer the opportunity to implement measures to prevent – potential degradation of the marine ecosystem, caused by human activities, resulting in further losses of ecosystem services and economic impacts.

6.2 Application of ES and NC

There are many methods to assess ES and apply the results. Many case studies have been conducted and many approaches have been proposed (Table). Each of these approaches has advantages and disadvantages. In order to investigate the potential role of ecosystem approaches to support decision making at OSPAR level, it was necessary to determine which framework might be the most relevant for the North East Atlantic ocean and its marine services. In this report, five approaches were analyzed in more detail, illustrated by descriptions of case studies in which these methods were applied, and an overview of the advantages and disadvantages of each of the approaches.

The approaches can be divided into 3 groups, each with their own advantages and disadvantages:

<u>Approaches that are designed for monitoring (e.g., NCA)</u>

In case studies that apply this type of approaches, the list of ES is often determined by data availability. Services that are relatively easy to evaluate are often done so on an ongoing basis. The methods used for evaluation are often relatively simple, which makes it possible to provide a regular assessment, and thus to monitor trends in the state of the marine ecosystem.

<u>Approaches that can provide enhanced vision of what occurs in the socio-environmental system (e.g., ES list and Comparison approach)</u>

These approaches are more difficult to apply. The objective of these assessments is often more global. Often, a variety of methods is used including quantitative and monetary evaluation and expert judgment. In addition, this type of approaches are characterized by a large demand for input data, for which many data sources may have to be used.

<u>Approaches that are aimed at solving a specific problem in management (e.g., Spatio-economic modeling of ES and IES).</u>

An important characteristic of this group of approaches is the adaptation of the approach to a specific task in management or project. The various steps of the assessment therefore depend on – and are therefore tailor made to – the purpose of the study. They typically include modeling, CBA, and scenario development. A large amount of data is required, both on the spatial distribution of the ES, and for conducting the CBA or other monetary valuation.

Conclusions

Despite the fact that the implementation of the approach presents certain difficulties, as well as the fact that there are many views on the definition of ES, assessment methods and classifications of ES, it is likely that the application of this approach in the future may bring significant benefits for OSPAR, especially since (long term) monitoring of ES can contribute significantly to a more forward looking integrated sustainable management of the marine environment. ES and NC approaches can offer the opportunity to implement measures to prevent potential degradation of the marine ecosystem, caused by human activities, resulting in further losses of ecosystem services and economic impacts.

The first steps, should be aimed at collecting joint data for a narrow range of ecosystem services. The choice of services should be determined by the availability of data, as well as the relevance of these data for OSPAR activities. Therefore, the list of economic sectors mentioned in the economic chapter of the OSPAR Intermediate Assessment could be a good starting point for this. It will be necessary to ensure regular data collection. Such an accounting can be gradually improved and expanded, and these data will undoubtedly find their application over time.

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