Future Science Brief

Nº 5 April 2019

Valuing Marine Ecosystems

Taking into account the value of ecosystem benefits in the Blue Economy

European MARINE BOARD
Advancing Seas & Ocean Science

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This future science brief is a result of the work of the European Marine Board Expert Working Group on Valuing Marine Ecosystems (WG VALMARE - see list of WG members on page 35).

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Foreword

Since the launch of the Blue Growth Strategy in 2012 appreciation for of the value of marine ecosystem products and services has grown. Understanding the mechanisms and ways by which humans utilize marine resources and space directly or indirectly is essential for an integrated assessment and management of the coasts, seas and oceans, and requires an innovative interdisciplinary research approach. As marine research has traditionally focused more on physical, chemical and biological processes, a publication on the socio-economic aspects of the marine environment was timely.

In May 2013 an EMB working group on "Valuing Marine Ecosystem Services" (VALMARE) was established to analyze the development of different valuation tools for marine ecosystem services and their benefits, and how these tools can help to facilitate decision-making for sustainable environmental management. Even though the European marine science policy community increasingly recognized the benefits of marine ecosystems for society throughout the course of this working group, their effective implementation is often still lagging behind. With the development of natural capital accounts, including for the marine environment, mainstreaming the understanding and implementation of marine ecosystem valuation approaches and applications should be further developed.

On behalf of the EMB membership, I would like to extend my sincere thanks to the members of the EMB working group on Valuing Marine Ecosystems (Annex 1) and reviewers for their dedication and hard work in producing this document. My thanks also go to the members of the EMB Secretariat, past and present, who have been involved in this publication, in particular to Veronica French and Niall McDonough, who established the launch of this working group and guided the initial draft, and to Joke Coopman, Paula Kellett, Ángel Muñiz Piniella, Kate Larkin, Christine Rundt, Cláudia Viegas and Sheila Heymans who helped to complete the final publication.

Jan Mees
Chair, European Marine Board
March 2019

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Executive summary

This publication highlights current thinking in ecosystem service valuation for the marine environment. Valuation of the direct and indirect benefits (for either societal welfare, health and economic activities) stemming from marine ecosystem services, can help to assess the long-term sustainability of blue growth, support policy development and marine management decisions, and raise awareness of the importance of the marine environment to society and in the economy. Recommendations are made on how to incorporate outputs from valuation studies into the traditional analyses used in resource and environmental economics and into the European marine policy landscape and related management and decision making choices.

The publication is primarily aimed at stakeholders interested in valuation of marine ecosystem services and natural capital accounting, spanning diverse roles from commissioning, managing, funding and coordinating, to developing, implementing, or advising on, marine ecosystem service and natural capital programmes. Such programmes will have strategic and policy drivers but their main purpose may vary from predominantly research driven science to provision of valuation data and reporting to legally-binding regulations or directives. The main focus is on European capabilities but set in a global context with the various actors spanning a variety of geographical scales from national to regional and European. Key stakeholder organizations include environmental or other agencies; marine research institutions, their researchers and operators; international and regional initiatives and programmes; national, regional and European policy makers and their advisors. It will also be of interest to the wider marine and maritime research and policy community.

The publication recommends

1. *Include ecosystem valuation in marine management decision models.* Ecosystem valuation has advanced significantly over the past decade, however, the results are rarely used for marine management and policy decisions. Making ecosystem valuation an integral part of marine management decision models would advance their application and increase the available results;
2. *Promote the harmonization of ecosystem service frameworks.* The plurality of existing Ecosystem Frameworks and classification systems has led to different interpretations in the meaning of biophysical structure, ecosystem functions and services. Agreement on a standardized framework based on a holistic approach would improve the usages and comparability of ecosystem service assessments at global and national scales;
3. *Develop a set of indicators for ecosystem services that can be included under existing monitoring programmes.* In order to advance the understanding of the relationships between biodiversity, ecosystem functions, services and benefits, suitable ecosystem indicators that can link ecosystem components to ecosystem services need to identified and included in existing monitoring programmes, e.g. under the MSFD;
4. *Create open databases that contain the data, meta-data, applied methodology and results of marine ecosystem valuation studies (monetary as well as non-monetary).* Making valuation data and results available in open databases will increase their comparability and usability. Additionally, the used methodology could be checked according to best practice standards and suitability checklists; and data can be input into bio-economic models that can link (dynamic or static) natural science models with economic and social science models;

5. *Enhance trans-disciplinary connections by incorporating fundamental marine science, social science, economic and public health approaches.* Ecosystem valuation studies do not only require fundamental marine science and economics but also understanding of the potential health benefits and cost, and the social context and interpretation of the outcomes: who will benefit or bear the costs, what trade-off should be made between which ecosystem services, etc.;
6. *Set the right scale and boundaries.* As the beneficiaries of the ecosystem services under consideration might lie outside the administrative boundaries, cooperation on local, regional and international scale might be necessary to make robust assessments in trade-off analyses; and
7. *Develop the Natural Capital Approach and Natural Capital Accounting.* Enhance and standardize existing marine asset and valuation data sets, assessment methods and results and addressing issues such as scale, aggregation and ecosystem degradation to facilitate their inclusion in Natural Capital Accounting, and then develop financing mechanisms (e.g. payments for ecosystem services) to improve the sustainable use of marine natural capital.

1 Marine Ecosystem Valuation: the key to sustainable Blue Growth?

Marine ecosystem services are the services provided by the processes, functions and structure of the marine environment that directly or indirectly contribute to societal welfare, health and economic activities. A pluralistic valuation that includes the monetary and non-monetary valuation of all benefits stemming from these ecosystem services can help to assess their long-term sustainability.

The EU Directorate-General for Maritime Affairs and Fisheries 2018 Annual economic report on the EU Blue Economy[1] found that the European Blue Economy, which includes all economic activities related to the ocean, seas and coastal areas of Europe, is thriving. The overall aim of the European Commission's Blue Growth Strategy is to further harness the potential of Europe's marine environment for jobs, value and sustainability. The economic data, expressed in Gross Domestic Product (GDP), might suggest that we are on the right track. However, GDP data is a limited measure that does not give information about all of the impacts of economic growth on the marine environment (the environmental externalities) and how these in turn affect society. GDP can capture net financial and physical assets, some aspects of human capital (e.g. intellectual property) and up to a point the market component of natural capital (e.g. for fish or timber). However, it has difficulties in capturing and measuring the underpinning biophysical aspects of natural capital and flows of ecosystem services, or of non-market economic values. Hence it is still questionable whether Blue Growth will be sustainable or beneficial in net terms.

Ecosystem valuation can help to assess the sustainability of Blue Growth. Focussing on sustainability means that we take into account the environmental limits of marine ecosystems, their spatial distribution (who benefits and where the ecosystem services are provided) and their potential to provide sustained benefits in the future. By evaluating the impacts of human activity on ecosystem services and their social and economic consequences we can highlight the trade-offs between actions to reverse the declining trends in marine biodiversity and ecosystem health, and possible competing economic interests. A wide array of methods and techniques for ecosystem valuation exist, but are only occasionally implemented in policy decisions. Adding to the existing policy objectives defined in the EU Marine Strategy Framework Directive (MSFD) and the Biodiversity Strategy, the outcomes of ecosystem valuation studies can help to guide future targets and objectives and improve current GDP focused economic reporting, for example via natural capital accounting.

This document highlights current thinking in ecosystem valuation for the marine environment. It makes recommendations on how to incorporate outputs from valuation studies into the traditional analyses used in resource and environmental economics; and into the European marine policy landscape and related management and decision making choices.

> "Choices between promoting GDP and protecting the environment may be false choices, once environmental degradation is appropriately included in the measurement of economic performance."
>
> (Stiglitz, Sen, & Fiutoussi, 2009)

Credit: Dídac Perales

Aquaculture in Killary Harbour (Ireland), an example of a provisioning ecosystem service.

[1] https://publications.europa.eu/en/publication-detail/-/publication/79299d10-8a35-11e8-ac6a-01aa75ed71a1

2 A sustainable blue management tool

As intensified human activity causes increasing pressures on marine ecosystems, their ability to provide benefits such as food, energy, recreation and tourism, transport and communication, etc. might decrease. Recent figures from the IPBES regional assessment[2] show negative biodiversity trends for all available marine indicators for all sea basins in Europe (Fig. 1). As the state of biodiversity and ecosystems are correlated, these trends indicate that Blue Growth might not be sustainable into the future. In order to optimize and maintain flows of benefits stemming from the ocean's natural capital, the external costs associated with marine activities will need to be fully included (internalized) into our accounting. It is also important to understand the interactions between different ecosystem services and the impact they have on each other's benefits. Ecosystem valuation can help to show trade-offs between reversing the declining state of marine ecosystems and possible competing economic interests.

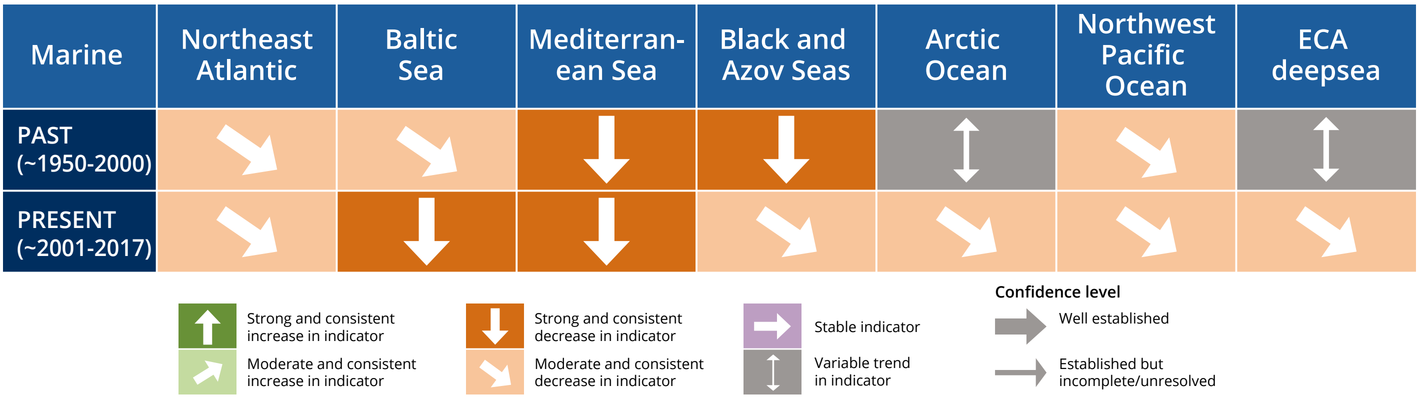


Figure 1 Past and present trends in marine biodiversity status (IPBES 6th session report IPBES/6/15/Add.4)

Ecosystem valuation should not be seen as a goal in itself, but as an addition to existing policy objectives and targets (e.g. achieving Good Environmental Status (GES)), as the outcomes could help to guide future targets and objectives for the evaluation and effective planning of diverse ocean activities. Due to their open character (many marine organisms disperse throughout their lifecycle over vast spatial distances) and higher variability on a shorter timescale, marine ecosystems tend to be more difficult to protect than terrestrial systems (Carr *et al.*, 2003; National Academy of Science, 2001). Approximately 60% of the ocean lies outside the borders of national jurisdiction and even within the borders, rules and regulations for the exploitation or protection of marine resources are often highly fragmented and non-enforceable. Additionally, there is an almost universal lack of visibility of the importance of the seas and global ocean. In a recent survey[3] of 3,500 leaders from developing countries, Sustainable Development Goal (SDG) 14 – "Life below water" was considered the least important of the United Nations' 17 SDG's.

Ecosystem valuation can help to highlight the often unrecognised benefits to society, such as recreation or carbon sequestration and their direct and indirect human health benefits. There is currently an increased effort in Europe to explore the links between physical and mental human health and wellbeing and the marine environment (e.g. by the SOPHIE[4] project). Expressing the value of these benefits in a commonly understood unit (e.g. monetary or health values) raises awareness of the importance of the marine environment to society and in the economy.

The outcomes of ecosystem valuation studies can help to support marine management decisions and conservation policies by: enabling analysis of the trade-offs between competing interests for natural resources; supporting establishment of compensatory schemes (e.g. in the aftermath of an oil spill); calculation of payments for environmental services (PES) and rates for the use of an ecosystem such as user fees for Marine Protected Areas (MPA) by assessing costs of ecosystem degradation (Lopes & Villastante, 2018) and by allowing a more complete cost-benefit analysis of marine policies and projects. As Europe's long-term Blue Growth Strategy progresses, the need to apply effective marine ecosystem valuation tools will intensify.

[2] https://www.ipbes.net/event/ipbes-6-plenary
[3] http://docs.aiddata.org/ad4/pdfs/Listening_To_Leaders_2018.pdf
[4] https://sophie2020.eu/

> “Well-being may be enhanced today by depleting some of the capital stocks essential for maintaining future production and future wellbeing.”
>
> (OECD, 2018)

Figure 2 gives an idea of how marine ecosystem services can by classified. Many different classification systems exist, e.g. as established by The Economics of Ecosystems and Biodiversity (TEEB) or the Common International Classification of Ecosystem Services (CICES)[5]. For the purpose of this paper, we will focus on 3 broad categories:

- **Provisioning services** that provide tangible, harvestable goods such as as fish, shellfish and seaweed for food, raw materials, algae and minerals;
- **Regulating services** such as coastal protection, prevention of erosion, water purification and carbon storage;
- **Cultural services** including the non-material benefits derived from nature such as recreation and tourism, beauty, as well as spiritual, intellectual and cultural benefits.

Figure 2 Ecosystem services from the Sea

[5] For a comparison between the different ecosystem services categories set by international groupings such as the Millennium Ecosystem Assessment (MEA); The Economics of Ecosystems and Biodiversity (TEEB); and the Common International Classification of Ecosystem Services (CICES) see: https://biodiversity.europa.eu/maes/ecosystem-services-categories-in-millennium-ecosystem-assessment-ma-the-economics-of-ecosystem-and-biodiversity-teeb-and-common-international-classification-of-ecosystem-services-cices)

3 Setting the framework for valuation

Ecosystem valuation is a powerful tool when used to answer clear policy questions. It requires analysis of the contribution of ecosystems to human well-being, both directly and indirectly. Various frameworks have been developed to facilitate and support such analysis e.g. by the Millennium Ecosystem Assessment (MEA)[6]; The Economics of Ecosystems and Biodiversity (TEEB)[7]; and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)[8]. Ecosystem service frameworks link the biophysical structures, processes and functions, via ecosystem services, to social or economic benefits for humans. Natural capital accounting systems use the ecosystem service framework concept, but with accounting terminology to facilitate inclusion of ecosystem values in national accounts. Economic valuation frameworks such as the Total Economic Value (TEV) framework help to identify the multiple values that can be derived from ecosystem benefits. Implementation of these frameworks requires input, cooperation and mutual understanding of economists, natural and social scientists, and policy makers. An Interdisciplinary approach is a prerequisite for any ecosystem valuation study (e.g. on integrated valuation (Jacobs *et al.*, 2016)).

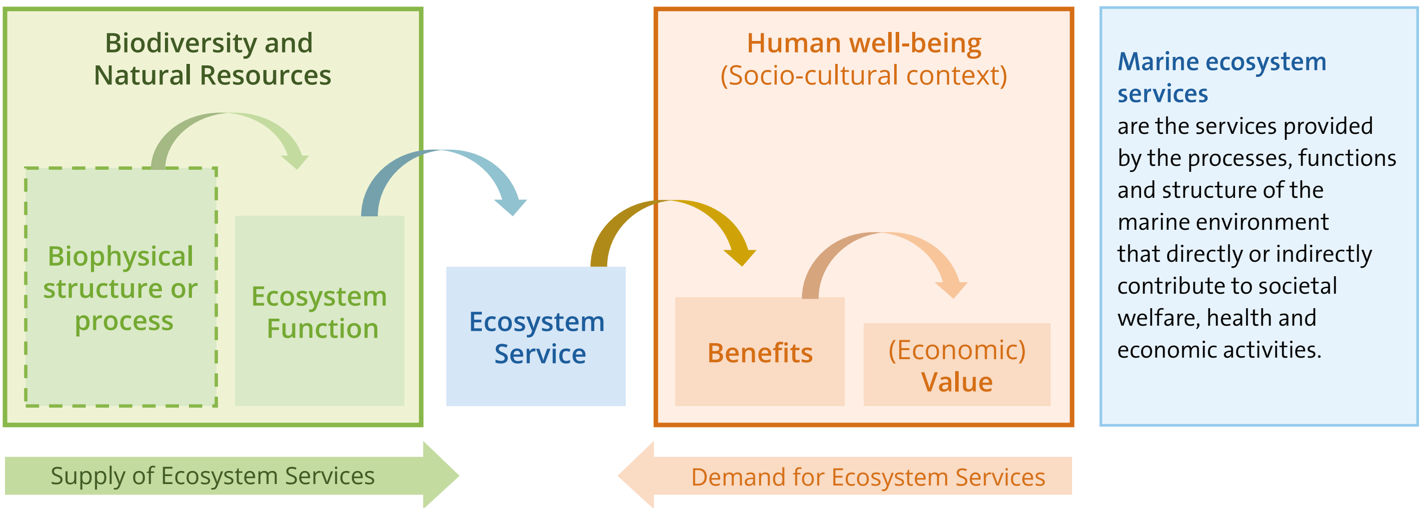


Figure 3 Example of an ecosystem framework: The Ecosystem Service Cascade Framework adapted from (DeGroot *et al.*, 2010 and Haines-Young & Potschin, 2010). The cascade framework, one of the many existing ecosystem frameworks, links ecological (biophysical) processes with elements of human well-being (from socio-cultural to economic) following a pattern similar to a production chain, requiring multidisciplinary cooperation between natural scientists, economists, and social scientists. This figure focuses mainly on the benefits, while the original figure also refers to pressures on ecosystems. As there is no universally agreed framework, many different interpretations exist in the meaning of biophysical structures, biological functions and ecosystem services and their benefits.

[6] https://www.millenniumassessment.org/en/index.html

[7] http://www.teebweb.org/

[8] https://www.ipbes.net/

3.1 Ecosystem service frameworks

Ecosystem service frameworks link the biophysical structures, processes and functions, via ecosystem services, to social or economic benefits for humans. To facilitate ecosystem valuation and to avoid double counting, biophysical structures and ecosystem functions are considered separately from, but as required inputs to, ecosystem services (Fig. 3). In earlier classifications (as in Fig. 2) they were referred to as supporting services. In more recent natural capital accounting frameworks these inputs are termed natural capital assets and functions, to acknowledge that they still need to be quantified and maintained as ecosystem service flows (Fig. 4).

Several concepts of classifications of ecosystem services have been developed at the national (e.g. the UK National Ecosystem Assessment), European (e.g. Mapping and Assessment of Ecosystem Service[9] (MAES) and international level (e.g. the MEA, TEEB and IPBES, including their assessment of Nature's Contribution to People). One of the pitfalls of the creation of a plurality of ecosystem service frameworks and classification systems is that it has led to different interpretations in the meaning of biophysical structure, ecological functions, and services. Agreement on a standardised framework based on a holistic approach would improve the usages and comparability of ecosystem service assessments at global and national scales.

For the purpose and simplicity of this paper, we will focus on the current grouping of ecosystem services into three categories, covering both biotic (living) and abiotic (non-living) items: provisioning services (e.g. food, oil and minerals), regulating services (e.g. climate change, waste absorption) and cultural services (e.g. spiritual enrichment, recreation and aesthetics). Supporting services, which were originally included as an additional group in the MEA, are less commonly referred to now, to avoid the danger of double counting in valuation.

From ecosystem services, goods and benefits are obtained that improve human welfare and wellbeing, and hence from which value can be derived. Goods and benefits can be valued in quantitative terms using metrics such as monetary value or health value or in qualitative terms, which will always be non-monetary and usually have some consideration of health, socio-cultural or conservation value.

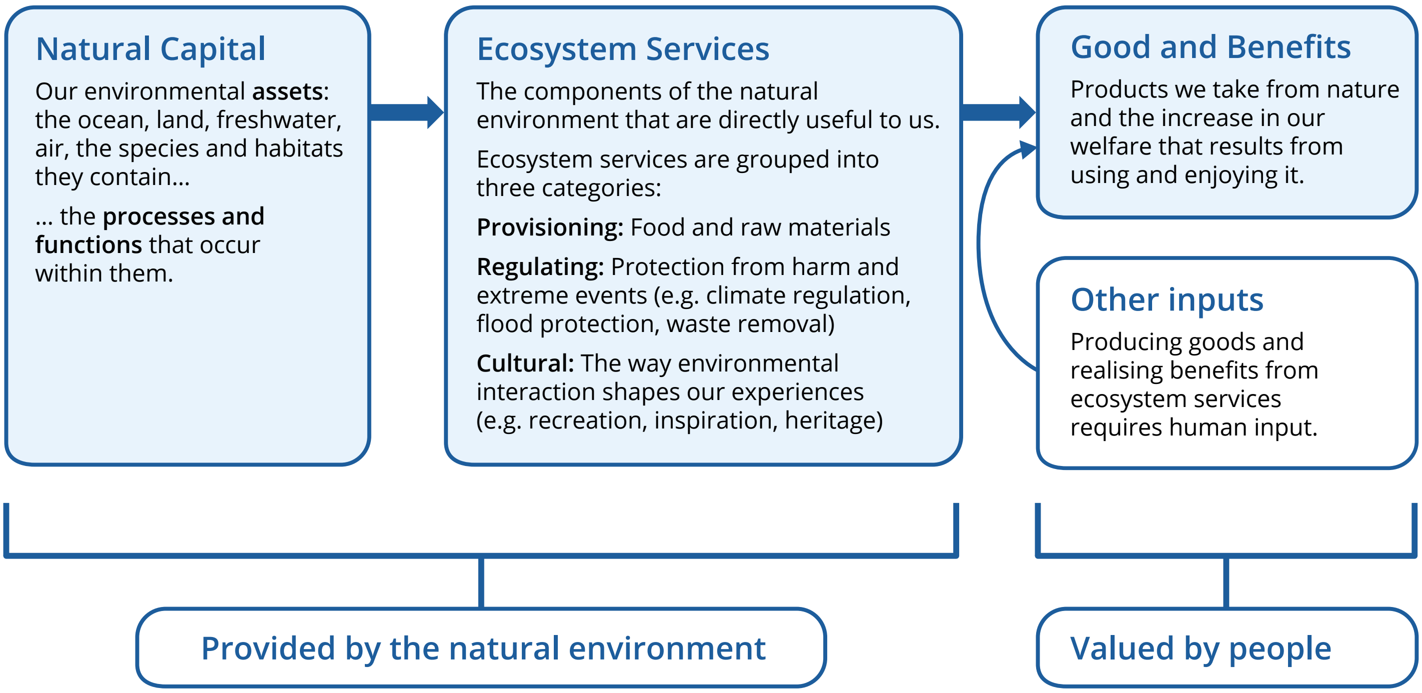


Figure 4 Benefits can be derived from final ecosystem services

[9] https://biodiversity.europa.eu/maes

3.2 The Natural Capital Approach and Natural Capital Accounting

Recommendations for member states to implement a system of integrated environmental and economic accounting to complement traditional national accounts were originally contained within Agenda 21 of the United Nations Conference on Environment and Development held in Rio in 1992. In addition, action 5 of the in 2011 adopted EU Biodiversity Strategy to halt the loss of biodiversity and ecosystem services in the EU by 2020, acts as one of the main drivers behind the push for ecosystem valuation studies. It requires European member states to assess and map the state of ecosystems and their services, to assess the economic value of their benefits, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.

In 2013, the Common International Classification of Ecosystem Services (CICES) was developed from the work on environmental accounting undertaken by the European Environment Agency (EEA) to address the lack of standardization in the way ecosystem services are described. The CICES classification is used by the EU MAES working group, which was set up to support implementation of the EU Biodiversity Strategy. The CICES classification also aims to be a common international classification system for natural capital accounting such as the United Nations' (UN) System of Environmental-Economic Accounting (SEEA)[10]. Natural capital accounts constitute a key instrument to harmonize data on the condition of ecosystems and to improve integrated data collection and assessment. Adopting the natural capital approach provides an opportunity to re-think and re-focus data collection beyond what is required through regulations and directives such as the MSFD, and to think more broadly about why we are interested in monitoring and assessing natural capital assets. It encourages links between environmental and economic concepts and policy areas including health and education. The approach has the potential to facilitate communication across jurisdictional boundaries in, for example, marine spatial planning and supports thinking about shared resources. This includes the recognition that benefits may flow to areas that are distant from their production.

There are still considerable issues with the implementation of UN's System of Environmental-Economic Accounting concerning spatial scale and boundaries and aggregation of data. Due to the open and variable character of the marine environment, there may also be a mismatch between where ecosystem services are supplied and the location where the demand or the benefits arise for them. The spatial scale to take into consideration might therefore not fit with the existing administrative boundaries (or data availability). Considerable additional information as well as sharing available information between countries, and between different levels (national, regional, local) will be needed in changing the scale of an assessment. Additional research is needed on how accounting for ecosystem services and ecosystem degradation can be used to augment National Accounts. Implementation of national accounting frameworks paves the way for the development of financing mechanisms that could be used to restore marine natural capital and ecosystem services.

3.3 Economic valuation framework

While standardisation of ecosystem service classifications is still underway, the concept of Total Economic Value (TEV), which considers the full range of different types of value of natural resources, has been in existence for some time (e.g. Pearce and Turner 1990). More recently the taxonomy of values underlying TEV is used to account for the different types of ecosystem values. The breakdown and terminology may vary slightly depending on the source but generally the concept includes two core categories: use values and non-use values, and often a further special category: option values. Use values are placed on marine resources that are either consumed or used directly (e.g. fisheries, recreation) or indirectly (e.g. bioremediation of waste, climate regulation, storm prevention); and they can be either consumptive (e.g. the consumption of fish) or non-consumptive (e.g. marine recreation). Non-use values refer to the existence of a value even though individuals do not intend to use the resource but feel a 'loss' if it was not available or disappeared completely (Krutilla, 1967). Option values include a premium placed on preserving marine resources for potential future uses (e.g. new antibiotics or therapeutic applications derived from marine organisms).

While use values best correspond to the traditional economic concept of benefits, the non-use components reflect people's preferences, including altruistic motives such as concern and care for nature (Subade, 2007). Widely used economic performance indicators like GDP tend to only consider consumptive use values.

Although the TEV framework encompasses a range of different value categories, because these values are determined via various valuation methodologies, they are not aggregated into one value, i.e. the 'total' economic value. It is rather a conceptual framework to consider different value dimensions and to acknowledge that individuals hold values for a good or service because of different reasons. In general, direct use values, such as for products from fisheries and aquaculture, are the easiest to estimate since they involve defined quantities of products for which prices are available in market transactions. Other direct use values such as leisure activities (e.g. bathing and diving), often do not have a direct market value, but prices could be derived using standard economic valuation techniques.

Measuring indirect use values (e.g. coastline protection) is often more difficult, as the contribution to wellbeing or the 'quantities' of the service being provided – such as the carbon stored in marine organisms – are hard to assess. Additionally, most of the benefits they provide are rarely traded directly or considered by economic markets, so their values are more difficult to establish. Non-use values are the most complex to estimate since they are not reflected in people's behaviour posing some challenges to their quantification on a monetary scale. They can however be estimated by assessing indirectly the costs of degradation.

[10] https://seea.un.org/

4 Applying valuation in the marine environment

Ecosystem service frameworks have mostly been developed and implemented in terrestrial ecosystems. Their application has lagged behind in the marine environment, mainly due to a lack of data both on the supply side of the ecosystem service framework (data and indicators on the state of ecosystem services, production trends and flows, pressures, tipping points and threats) and on the demand side (monetary and non-monetary valuation data for benefits), which has arisen partly because there is little bespoke methodology to collect these data in marine systems. The costs to develop and apply such methodology contribute to the paucity of marine applications and inhibit widespread political will to address the lack of data.

To be able to analyse the potential supply of marine ecosystem services, we need to understand: how ecosystems function, what components they are based on, how and why they change, and importantly, the relationships between these aspects of natural capital and the supply of different ecosystem services. We also need more understanding about how use of different ecosystem services can interact with, and impact, use of other services with consequences for the value of their benefits. An important issue for the marine environment, possibly even more than in terrestrial ecosystems, is that the relationships between biodiversity and ecosystem functions have not been fully identified and mapped. The biological components of the ecosystem play a clear role in the provision of ecosystem services. However, suitable ecosystem indicators that can link ecosystem components to ecosystem services still need to be identified, monitored, and the data needs to be made available in open and accessible datasets.

Based on several of the existing environmental directives (Marine Strategy Framework, Water Framework, Habitats and Birds, Bathing Water) core indicators for marine ecosystem pressures and ecosystem conditions (physical, chemical and biological quality) required for delivery of ecosystem services have been proposed (Maes *et al.,* 2018) e.g. by Bönhke-Henrichs *et al.* (2013); Hattam *et al.*; Atkins et. al. (2015) and Lillebø *et al.* (2016). For instance, Broszeit *et al.,* (2017, appendix B) identified 247 biodiversity indicators proposed for the monitoring of "Good Environmental Status" (GES) that could potentially also be useful ecosystem service indicators. The table below provides some selected examples that have been identified as useful (yes) or not useful (no) for the assessment of the selected ecosystem services. However, there are still many gaps in these indicators, poor spatial coverage in monitoring programmes for them, and little understanding of potential threshold effects or tipping points.

Marine ecosystems have few indicators of their condition, often with low data quality and poor spatial coverage compared to terrestrial systems (Maes *et al.,* 2016). Provisioning services mainly depend on data from fishery landing statistics, reflecting the benefits that have been extracted (sustainably or otherwise) rather than the quality and quantity of the available fish and shellfish (the stocks) and the amount and type (quality) of fish that can be sustainably harvested (the ecosystem service). Regulating services depend on water quality observations or modelling, and cultural services have few consistent or continuous datasets, especially in comparison to their terrestrial equivalents. Much of the data that is collected for the marine environment is very habitat or location specific, which limits its ability to be transferred or used in other places.

Ifremer - Olivier DUGORNAY

Underwater biodiversity (Echinus Esculentus) in Bretagne (France)

BIODIVERSITY INDICATOR	FOOD PROVISION	CLIMATE REGULATION	DISTURBANCE PREVENTION OR MODERATION	BIOREMEDIATION OF WASTE	BIOLOGICAL CONTROL	LEISURE AND RECREATION	AESTHETIC EXPERIENCE
Abundance of selected (coastal) fish species	no	no	no	no	no	yes	no
Trends in arrival of new non-indigenous species	no	no	no	no	yes	no	no
Areal extent of dead *Posidonia oceanica* meadows	no	no	yes	yes	no	yes	yes
Biomass of cephalopods	yes	no	no	no	no	yes	no
Biomass of phytoplankton	no	yes	no	no	no	no	no

Table 1 Examples of biodiversity indicators that have been identified as useful (yes) or not useful (no) for the assessment of the selected ecosystem services (Broszeit *et al.*, 2017, Appendix B)

Credit: European Space Agency

A regulating ecosystem service: the formation and melting of vast amounts of ice floating on the Arctic Oceans' sea surface plays a central role in polar climate and the global ocean circulation pattern.

5 Values are not just prices

Economic valuation is not equivalent to placing a 'price tag' on a species e.g. a dolphin or a coral reef. The main purpose of economic valuation is to assess changes in the net benefits derived from ecosystem services, or when comparing possible outcomes of scenarios of changes in human activities, for instance under different policy interventions. The distinction between things that have monetary value, and things for which it is either unethical or too complex to ascribe a monetary value, is an important guidance for the choice of appropriate economic valuation methods.

5.1 Valuation in complex social and ecological systems

Values from ecosystem services can be derived in multiple ways. Benefits from provisioning services, such as seafood, marine aggregates and blue energy, have an identifiable monetary value because they are often traded in markets. Benefits from many cultural and regulating services have few or no direct market values, but there are, to a certain extent, ways that monetary values can be derived for them. These are called non-market values.

Ecosystem services that can, *in principle*, be replaced by or exchanged for something else are said to have an instrumental value (whether whatever the entity is instrumental in can actually be provided by something else depends on the complexity of the system). For instance, electric energy from a wind farm has an instrumental value as it generates a specific service, but it could be replaced by other forms of electricity generation to provide the same service.

Some people argue that not all nature's contributions can be expressed in terms of instrumental values. Some have intrinsic or non-instrumental relational values (Chan *et al.*, 2016; Himes & Muraca, 2018). Because they are valuable for their own sake and not for any services or utility they deliver, they should be considered irreplaceable and incommensurable. Accordingly, applying monetary valuation methods could be ethically problematic and practically misleading when assessing complex ecological systems which are not reducible to single, discrete entities to which a specific service can be attributed, or within complex social systems characterized by deep ethical-cultural plurality of convictions (Schröter *et al.*, 2014; TEEB, 2010). To address these cases, alternative valuation methods which do not imply monetization, have been developed. For example, multi-criteria, integrated valuation or participatory multi-criteria analysis aim at capturing different and incommensurable values (Gómez-Baggethun & Martín-Lopez, 2015; Martinez-alier, Munda, & Neill, 1998) and can be very useful to support decision making when faced with complex systems.

5.2 Monetary valuation techniques and their applications

Economic valuation is more sophisticated than just price-tagging nature. It assesses change, usually caused by human activities, in the benefits derived from ecosystem services, or when comparing possible outcomes of scenarios of changes in human activities i.e. under different policy interventions. The scenarios are often only considered in theoretical and abstract terms in the analysis (for example what would people be willing to pay – hypothetically – for the seabed not to be trawled).

When assessing the value of a beach, economists may employ the travel cost method which assesses the effort and the costs incurred that tourists are actually willing to make in order to visit the beach. Although the tourists may personally say that they don't want to give the ecosystem 'beach' a direct economic value, their behaviour can indicate what they are willing to pay to use the ecosystem services of the beach in its current condition.

However, this type of valuation is not often included in decision making processes. Extending the example of the beach, when a planner wants to build a marina at the coast, the decision making is generally based on a traditional cost-benefit-analysis. This mostly only captures the direct financial and economic values for the developer, the home owners, and the economic activity in the near area of the marina. Any other value losses (e.g. potential loss of biodiversity) or benefits (for persons who used to visit the beach before it was developed) from this beach ecosystem, are not included or set to zero without any economic assessment. This makes for poor decisions.

Different valuation techniques can be used to assign monetary values to ecosystem services. These can be based on: market value (e.g. the production function approach which calculates how a change in the ecosystem might affect production of services and cost of production of benefits); revealed preferences through observed surrogate market behaviour (e.g. the effect of sea view on property value); imputed value (how much does it cost to replace an ecosystem service); stated preferences (using questionnaires

Credit: EMB

Aggregate dredging increases sediment suspension, reducing water quality and biodiversity with short and longer term effects on fish populations and on the fisheries that depend on them. Ecosystem service valuation could quantify costs and benefits for the dredging and fisheries sectors, and inform policy decisions.

to assess people's Willingness To Pay (WTP) to use a specific ecosystem service); or via benefit transfer (estimated values from one specific setting are used for other locations). Table 2 provides an overview of the most common monetary valuation techniques.[11]

When undertaking and reviewing the results from ecosystem valuation studies, ecosystem valuation practitioners have to take into consideration some common pitfalls and methodological issues in order to make a best practice valuation study. Indicative examples include:

- Considering motives when applying a travel cost valuation method in order to reveal why people have gone to the beach and which ecosystem service(s) (if any) they have used. For example, they may simply have been spending time with friends or relatives.

- Taking into account that the willingness to pay for a specific conservation measure puts the respondents into a theoretical market situation (what amount of money is a person willing to give up to conserve the good(s) in question) and not into a real market. Moreover, the answers depend heavily on the understanding that respondents have of the magnitude of monetary values, and their understanding of the environmental good in question and the hypothetical change to this good.

- Indicating and accounting for the different environmental (e.g. sea view, air quality) and non-environmental components (number of rooms, quality of the building) that influence house prices in a hedonic pricing method.

Decent valuation studies also carefully consider discounting rates to evaluate short-term versus long-term effects. Efforts by the present generation to achieve sustainable blue growth have associated costs but will be of benefit to future generations. An example is the costs, which are experienced today, of mitigation measures to prevent future catastrophic climate change (as avoided costs). To compare the short-term costs with long-term benefits, economists discount future benefits to today's value, under the assumption of economic growth and short term preferences. Costs and benefits can be discounted by a constant or declining discount rate and thus lower values are attributed to future benefits. Hence, for example, climate change mitigation measures are often seen as too costly compared to the current benefits (TEEB, 2010).

[11] The technical Recommendations (table 6.1) of the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA) framework also provides a summary of valuation techniques and their use and suitability for valuation in ecosystem accounting.

Finally, it should be noted that values are generated for different services using different techniques and these may not necessarily be commensurate. For example, for fisheries the value may be measured as revenue, for recreational use as a net economic contribution, and for coastal defence it may be measured using a cost-based approach. It is important to note that aggregating these different values and their beneficiaries in an effort to give a single figure for the value of total marine ecosystem services would probably misrepresent the TEV, as the values are not always comparable.

CATEGORY	TECHNIQUE	DESCRIPTION	MARINE ECOSYSTEM SERVICE EXAMPLE WHERE USED
Revealed WTP (direct market)	Market price	Market prices stemming from a normal production process.	Capture fisheries, seaweed harvesting
	Production function	Values how changes in the quantity or quality of the ecosystem affects ES and ultimately the costs of production of the final benefit.	Water quality in an estuary, filtration services provided by oyster reef in a bay
Revealed WTP (surrogate market)	Travel cost	Inferred from the cost of travel to a site (i.e. expenses and value of time incurred).	Marine and coastal recreation use
	Hedonic pricing	Value of goods is based on the value of individual components	Sea view premium in property prices
Imputed WTP	Damage cost avoided	Value of an asset is equivalent to the value of the economic activity or assets that it protects (e.g. the value of damage that is avoided by maintaining a coast protection function).	Protection of coastal property from storm surges
	Replacement cost	Value is based on the cost of replacing the environmental function.	Coastal defence
	Substitute cost	Value of a non-marketed product is based on the market value of an alternative product providing the same or similar benefits.	Waste water treatment
Stated WTP	Contingent valuation	Survey technique asking a representative sample of individuals how much they are willing to pay to prevent loss of, or to enhance, an environmental good or service.	Protection of a marine species or habitat, marine non-use values
	Choice experiments	Asking respondents to select their preferred package of environmental attributes at different prices and then inferring specific component values.	Climate regulation, potential use of marine genetic materials
Transfer of values	Benefits transfer	Values estimated in one context and location are used to estimate values in a similar or different context and location.	All of above

Table 2 Examples of monetary valuation techniques to estimate values of benefits stemming from ecosystem services (based on (Silvis & Van der Heide, 2013) Key - Willingness to pay: WTP

5.3 Alternative valuation approaches

If the methods are applied carefully, monetary valuation can help to guide sustainable use of ecosystem services in a way that is sensitive to the conditions and implications of the different methodologies. Alternative methods that do not necessarily imply monetization can also be employed where appropriate and may broaden the perspective and help policy decision making. For example, multi-criteria-analysis or participatory multi-criteria analysis aims to capture an aggregate of different and incommensurable types of value held across different stakeholders (e.g. monetary values, health indices, happiness indices, employment, effectiveness). In a novel approach to address non-use values, advanced stated preference methods have recently been developed that involve information-focused deliberation on the complex services from ecosystems and a focus on the public rather than individual good (Kenter *et al.,* 2016).

Instead of employing cost-benefit analysis to guide political decision making, there are many cases in which society decides to conserve ecosystems, species, habitats, etc. on the grounds of political deliberation. Economists can then provide a cost-effectiveness analysis to assess the most cost effective path to reach the objective. In this case, it is not necessary to assess benefits, and the costs are generally easier to assess. However, the cost estimation should also include opportunity costs, and this requires an understanding of the value lost due to the change in ecosystem services. Cost-effectiveness analysis may also follow on from cost-benefit analysis. For example, a decision to restore an ecosystem within a bay may be made by weighing this up against alternative uses of the area using cost-benefit analysis. The costs of alternative methods to restore would then be considered using cost-effectiveness analysis.

5.4 Overcoming limitations of valuation

Although research to further develop valuation methods has been undertaken, there are still some methodological issues to tackle. Being aware of these limitations and working to overcome them is much more important than not including economic values of environmental costs and benefits in a cost-benefit-analysis.

One of the main methodological issues, which is not unique for valuation studies but touches upon the wider fields of ecology and economics, is the problem of irreversibility. It is difficult to determine ecological thresholds (or tipping points) and equally difficult to account for them in valuation studies. While it might be possible to restore a mangrove or a beach after they were effected by e.g. the building of a marina, total extinction of a rare species caused by the marina would not be reversible.

Valuation studies (like ecological studies) are often time-consuming, and therefore sometimes viewed as not easily applicable for fast policy making decisions. Several issues have been identified within current ecosystem valuations (e.g. by Börger *et al.,* 2014; Hanley *et al.,* (2015); Grêt-Regamey *et al.,* (2017); and Beaumont, Mongruel, & Hooper, 2018). These issues include: simplistic approaches allowing the identification of general trends but limiting spatially explicit applications and the formulation of site-specific policy recommendations; failure to address precision, accuracy and related uncertainties; and not including an integrated disciplinary approach to carry out valuation studies, which may lead to substantial differences in outcomes when considering different value dimensions (from biophysical to socio-cultural or economic).

Furthermore, significant amounts of data, which are sometimes not readily available, are necessary to make an accurate valuation. In order to develop integrated valuation approaches Jacobs *et al.,* (2018) examine the pros and cons of different monetary and non-monetary techniques to evaluating ecosystem services and found that '*...every method has blind spots, which implies risks of biased decision-making.*'

Continuous development, implementation and validation of the ecosystem valuation techniques and approaches in the marine environment will be vital if we want to better use and manage marine resources to ensure sustainable Blue Growth.

Credit: EMB

Capturing the value of cultural marine ecosystem services. Breeding storks at the coast of Portugal form a tourist attraction.

Financing Marine Ecosystem Service Delivery

The development of market mechanisms whose aim is to finance initiatives to maintain and improve ecosystem services has become an important agenda item for many government, non-profit and private sector stakeholders. The valuation of ecosystem service benefits is an important element that facilitates the functioning of these market-based mechanisms. There are now a number of mechanisms by which ecosystem service finance has been applied[12], including debt-for-nature swaps, conservation trust funds, biodiversity offsets, parametric ecosystem insurance schemes and payment for ecosystem services (PES). The main challenges for using these mechanisms to financially support marine ecosystem conservation and restoration activities, are to overcome the "public good" nature of the services and inducing individuals or society to invest in ecosystem management, demonstrating the linkages between the processes and functioning of marine ecosystems and the delivery of services, and dealing with the lack of clearly established property rights, especially in international waters.

An example of a Marine Ecosystem Service Conservation Trust Fund and Insurance Scheme

The Coastal Zone Management Trust (CZMT)[13] was developed by the government of Quintana Roo, Mexico in partnership with a multi-sectoral group of federal and local governments, hoteliers, research centres and The Nature Conservancy. The trust was developed in recognition of the fact that the coral reefs in the area protect some of the most important tourist destinations in Mexico. As well as providing economic value through tourism and fishing, the coral reefs also provide vital habitat, recreation, storm surge prevention, protection from beach erosion and aesthetic services to local communities. CZMT receive taxes, collected by the hotel and tourism industry that can be used to fund science-based maintenance and restoration efforts for 60 km of reef and beaches in Cancun and Puerto Morelos. In addition to funding ongoing conservation work, the Trust also pay the premium to buy an insurance policy on this designated stretch. The insurance is triggered when severe weather hits the reef. Therefore, when a major hurricane hits the area the insurance policy is immediately activated, paying for the trust to clean up debris from the storm and nurture and replant broken coral. Stated preference valuation approaches could be used in these cases to help ascertain the correct level of tax or fees to charge tourists and/or residents.[14]

The development of these financial instruments is likely to increase in the future as we continue to move from thinking about conservation to the restoration of marine ecosystems. Such financing approaches are seen as being vital to support rebuilding of ocean ecosystems (Oceano Azul Foundation, 2018[15]). In a European context, the use of these financial instruments to fund marine ecosystem restoration is currently being explored through the EU Horizon 2020 project MERCES[16].

Credit: Ifremer - Séverine Tourbot-Paul

Fishermen in the Golf of Gascogne, France (2016)

[12] For a more in-depth discussion on ecosystem service finance mechanisms the interested reader is directed to Aylward, B., R. Hartwell, S. Lurie, and S. Duncan (2009). Financing Ecosystem Service Markets: Issues and Opportunities. Institute of Natural Resources Report, Oregon State University available at: https://ir.library.oregonstate.edu/concern/defaults/4m90dw28f

[13] https://www.iyor2018.org/news/launch-coastal-zone-management-trust/

[14] https://www.under2coalition.org/news/protecting-quintana-roos-coastal-infrastructure-insuring-nature

[15] Oceano Azul Foundation (2018). Summary of the Lisbon Workshop on Blue Natural Capital: 3-4 October 2018. Blue Natural Capital Bulletin Vol. 228 No. 6

[16] http://www.merces-project.eu/

6 Making ecosystem valuation relevant for policy making

One of the recommendations of the G7 "Future of the Ocean and its seas" report[17] was to assess sustainability by including the loss of natural capital in all cost-benefit analyses, and match it against the growth of economic capital. Even though the number of marine and coastal valuation studies is increasing, this rise in research activity has not been matched by an increase in the use of valuation in management decisions. Ecosystem valuation is currently mainly used to increase public awareness of the importance of preserving these ecosystems. An important next step in ecosystem valuation is to operationalize an integrated valuation framework that endorses value pluralism to better support global policy initiatives in ecosystem-based management (Garcia-Rodrigues *et al.*, 2018).

One reason for lack of inclusion of valuation in decision making is that valuation has not been incorporated in the models that link natural environments with human use and management. These models are usually single-service focused and seldom include non-use values. Here valuation has a lot to provide. But just assessing values is not enough.

All stakeholders, decision-makers and researchers need to be aware of some key enabling conditions that would improve the use of valuation studies to support policy-making:

- **A clear policy question:** what is the goal that needs to be achieved (economic growth in a specific sector, installing a Marine Protected Area, calculation of a compensation scheme after an environmental disaster, etc.);
- **Establishing a multidisciplinary team;**
- **A strategic choice of the study area:** what temporal and spatial scales and which thresholds will be taken into consideration;
- **Identification of data gaps and needs:** integrate locally relevant data into the appropriate scientific and socio-ecological approaches;
- **Strong engagement among all stakeholders and decision-makers** to understand how a specific location contributes to providing ecosystem services and their benefits and where they are accrued;
- **Further development of Decision Support Systems and tools** for the marine environment such as InVEST[18], ARIES[19], or ValuES[20]; and Ecopath with Ecosim[21];
- **Transparency in reporting results:** empirical evidence in marine valuation studies is scarce, so all data provided through valuation studies should be monitored and accounted for so that it can be used in benefits transfer techniques.

If the results from ecosystem valuation are placed into a decision making context or model, then they are more likely to impact marine management and policy decisions. Pendleton *et al.,* (2015) provide an example of such an approach based on 9 clearly defined steps from the UK and France (Fig. 5).

Ideally there will also be feedback loops to optimize the system: policy and management interventions affect the functioning of marine ecosystems, thus impacting the ability of the marine environment to deliver ecosystem services; the impact of interventions can then be determined through ecosystem valuation.

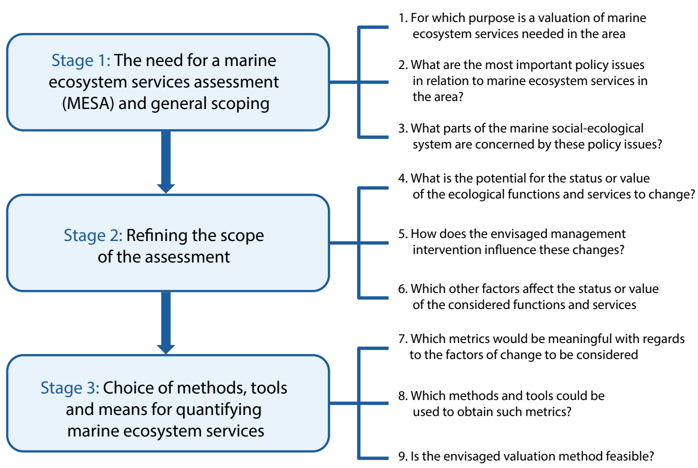


Figure 5 Stages of the triage approach to marine ecosystem services assessment (Pendleton, Mongruel, Beaumont, & Hooper, 2015)

17 http://www.iugg.org/policy/Report_FutureOcean_G7_2016.pdf
18 https://www.naturalcapitalproject.org/invest/
19 http://aries.integratedmodelling.org/
20 http://aboutvalues.net/
21 http://ecopath.org

7 Ecosystem valuation in practice: some examples

7.1 Ecosystem valuation informing national and regional marine policies in the Baltic Sea region and in Belize

7.1.1 A case study in the Baltic Sea region

The Marine Strategy Framework Directive (MSFD) calls for economic analyses to: assess the cost and benefits of measures to achieve Good Environmental Status (GES); estimate the forgone benefits if GES is not achieved; and analysing the social and economic impact of the use of marine waters. As a response, pragmatic approaches for ecosystem valuation have been developed and applied since the adoption of the directive in 2008 (Oinonen *et al.*, 2016; van der Veeren *et al.*, 2018).

The initial Finnish 'cost of degradation' analysis, measuring the economic benefits forgone if GES is not reached, was based on a Contingent Valuation study (Ahtiainen *et al.*, 2014), focusing only on the economic benefits of reducing eutrophication (one of the 11 GES descriptors). The economic benefits lost due to eutrophication were estimated at €200 million per year. Despite covering only eutrophication, the results were used as the national costs of degradation estimate in the Finnish Marine Strategy.

To support a review of the Finnish Marine Strategy in 2018, a fit for purpose primary valuation study, again using the Contingent Valuation method, was conducted (Nieminen, *et al.*, 2019).

The study covered all 11 GES descriptors and calculated that failure to achieve GES would cost the Finnish society €432–509 million annually. The underlying valuation survey indicated that the Finns give high importance to cultural ecosystem services, and valued a healthy marine environment irrespective of how far from the coast they live, and if they use the sea themselves or not. The results, implemented in the review of Finnish Marine Strategy, show that public funds used for Baltic Sea protection measures are largely accepted by Finns. Furthermore, existing valuation studies (Ahtiainen & Ohman, 2014; Kosenius & Ollikainen, 2015) together with a cost-effectiveness analysis (Oinonen *et al.*, 2015) were used to estimate the economic benefits of the Programme of Measures to achieve GES in Finland (Börger *et al.*, 2016).

The HELCOM - Baltic Marine Environment Protection Commission, formed by the 9 littoral countries[22] in the Baltic Sea region, included regional use of marine waters and cost of degradation analyses (Fig. 6) in the HELCOM 2nd holistic assessment of the status of the Baltic Sea. The analyses used a mix of different monetary valuation methods to assess the contribution that economic sectors using the sea make to the national economies and how GES contributes to citizen's well-being.

USE OF MARINE WATERS ANALYSIS	**COST OF DEGRATION ANALYSIS**
Contribution of selected **activities** on regional and national economies	Contribution of the **good environmental status** on citizen's well-being
Approaches 1. Marine water accounts 2. Ecosystem services	**Approaches** 1. Thematic 2. Ecosystem services
Activities & services 1. Fish and shellfish harvesting 2. Aquaculture 3. Tourism and leisure 4. Energy production 5. Transport	**Themes & services** 1. Eutrophicatoion 2. Recreation 3. Biodiversity (underwater meadows and foodwebs)
Main indicators 1. Cross value added 2. Employment 3. Consumer surplus	**Indicators** 1. Willingness to pay 2. Consumer surplus

Figure 6 HELCOM HOLAS II uses mixed approaches for the use of marine waters and cost of degradation analyses (HELCOM, 2018)

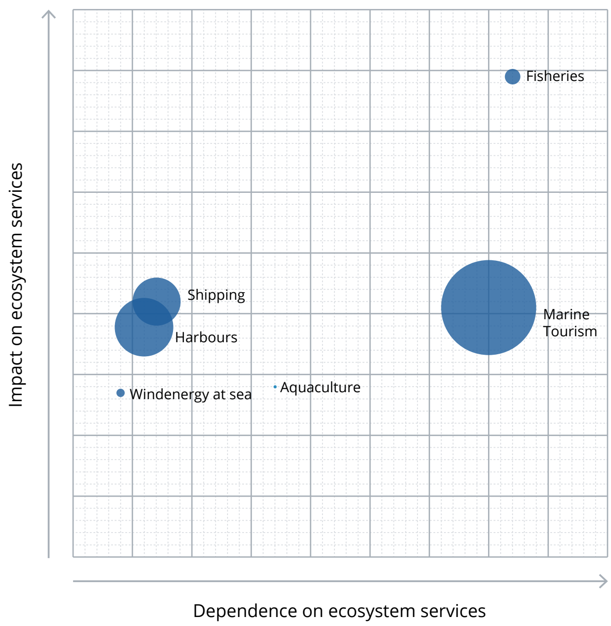


Figure 7 The bubble sizes represent the value added by each activity. The vertical axis represents the total environmental impact of human activities on the ecosystem services, and the horizontal axis represents the activity's dependency on the state of ecosystem services. Economically and ecologically sound marine management would sift the location of the bubbles downward and increase the size of the bubbles (HELCOM, 2018).

[22] Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Sweden and the Russian Federation

In this case, benefit transfer supported estimates of costs of degradation. Expert knowledge on the impact of economic sectors on the marine environment (and *vice versa*) together with existing statistical information on the economic performance of the sector was used to illustrate the marine environment-economy linkages (Figure 6). These examples show how existing data can be applied in a regional context, but also demonstrate the need for international valuation studies and how the development of ecosystem accounting could help in informing national and regional marine policies.

Credit: Tapio Heikkilä

Tourists enjoying beach activities in Finland.

7.1.2 Informing Coastal Zone Management in Belize

In 2015 the government of Belize used a suite of ecosystem service models and metrics to develop a national scale Integrated Coastal Zone Management (ICZM) Plan. Through an iterative process of stakeholder engagement, mapping, modelling, and review by scientists and policymakers, a preferred spatial plan that met multiple planning objectives was developed and approved.

The final version of the preferred plan improved expected coastal protection by more than 25% and more than doubled the revenue from fishing, compared with earlier versions based on stakeholder preferences alone. Including outcomes in terms of ecosystem-service supply and value allowed for explicit consideration of multiple benefits from oceans and coasts that typically are evaluated separately in management decisions.

The outcome of the study is described by Arkema *et al.,* (2015). The study started by identifying the country's three main economic and cultural marine ecosystem services: catch and revenue from the spiny lobster fisheries, visits and expenditures by tourists, and land protection and avoided damages from storms. A classic risk-assessment approach was used to identify the location and type of activities that pose the greatest threat to the three habitats that deliver these services: coral reefs, mangrove forests, and seagrass beds. To quantify future returns from ecosystem services, the expected change in area of functional habitat was calculated based on the results of the habitat risk assessment for three 2025 ICZM scenarios: conservation, development, and informed management. By accounting for spatial variation in the impacts of coastal and ocean activities on benefits that ecosystems provide to people, these models allowed stakeholders and policymakers to refine zones of human use.

Figure 8 shows the main economic results for the 3 policy scenarios compared to the current situation, suggesting that the "informed Management Plan" will lead to greater returns from coastal protection and tourism than outcomes from scenarios oriented toward achieving either conservation or development goals.

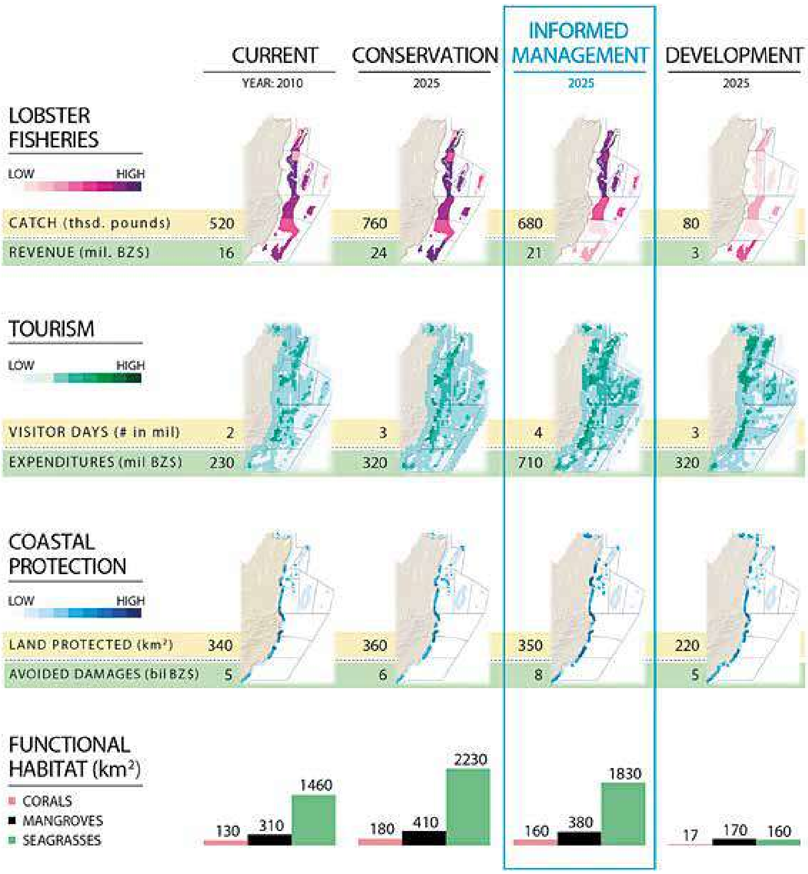
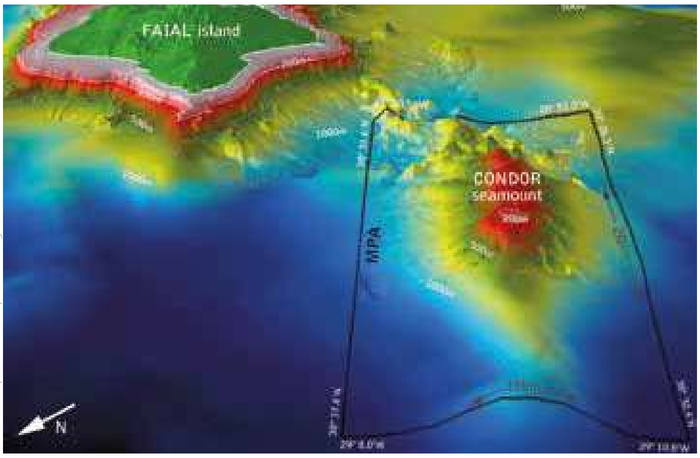


Figure 8 Biophysical and economic values for three ecosystem services and the area of habitat capable of providing services under the Current and three future scenarios for the ICZM Plan for Belize (Arkema *et al.,* 2015)

7.2 Analysing trade-offs between uses of marine ecosystem services in the Azores and in Argentina

7.2.1 Finding support for the preservation of MPAs in the Azores

Condor (Fig. 9) is a shallow seamount located southwest of Faial Island in the Azores archipelago. Once a commercial fishing ground for local fishers, Condor was designated as a temporary marine protected area (2010-2020) in June 2010 for the purpose of marine research.



Credit: Graphics: F. Tempera ©ImagDOP

Figure 9 Perspective of Condor Seamount (Faial, Azores) showing the limits of the fishing closure, source Morato *et al.,* 2010 in Oceanography (Bathymetry data credits: EMEPC, DOP-UAz, Project STRIPAREA/J. Luís/UAlg-CIMA, Lourenço *et al.,* 1998)

Activities such as demersal fisheries were banned, but marine recreational activities and tuna-fishing were allowed to continue. Estimates of the benefits generated by current and past uses of Condor seamount demonstrated that it supported a wide range of uses yielding distinct economic outputs through time.

The most significant resource use of the marine ecosystem was the demersal fishery, which until 2009 was generating a mean-annual direct output[23] of approximately € 0.5 million, albeit with a downward trend. Since the fishing closure in 2010 the range of uses supported by the ecosystem diversified, opening the way for the development of marine ecotourism, e.g. shark diving and big game fishing, as well as research activities (Table 3).

MARINE ACTIVITY	TIME PERIOD	DOI(€)
Demersal fisheries	1998 - 2009	431 723
Scientific research	2009 - 2014	290 435
Shark diving	2011 - 2014	173 701
Big-game fishing	2009 - 2014	80 847
Tuna-fisheries	1998 - 2014	51 867

Table 3 Mean annual direct outputs impacts (DOIs) of marine activities operating at Condor seamount

The economic importance of non-extractive uses on Condor is currently comparable to that of commercial fisheries, highlighting the importance of these uses as alternative income-generating opportunities for local communities (Ressurreição *et al.,* 2017; Ressurreição & Giacomello 2013).

These valuation results were used to inform stakeholder workshops in which the preservation of the MPA status of the Condor Seamount had to be decided. Combined with the results of other biological and ecological assessments, it was decided to extend the MPA status of the Condor Seamount first to 2014, than 2017, and recently again up to 2020. This shows that well established valuation studies can indeed be relevant for policymakers and to build support from the wider stakeholder community.

7.2.2 Assessing trade-offs in wildlife and waste management in Patagonia

In Península Valdés, (Patagonia) Argentina, the consequences of poor waste management and an overpopulation of kelp gulls has led to gulls feeding on living southern right whales, potentially causing losses to the tourism industry through loss in coastal quality and suboptimal right whale viewing experiences. Despite local progress in closing waste disposal sites and culling gulls, both waste and pest problems persist. This problem could impact the long-term viability of the site as a whale watching destination and present conservation concerns.

Stefanski & Villasante, (2015) used a contingent valuation survey to assess the trade-offs between the different management and conservation strategies. They interviewed 650 tourists about their willingness to pay to manage the gulls versus the waste in order to reduce the gull population and remove the risk to the whales. The study found that the interviewed tourists favoured addressing the human-driven component of the problem (the waste), over culling the natural component of the problem (the kelp gulls). Tourists' willingness to pay for additional entrance fees, in exchange for conservation of the site's wildlife and aesthetic qualities, can be incorporated into a cost–benefit analysis to estimate the potential net benefits of financing wildlife and waste management.

Credit: Stephani F. Stefanski

Kelp gull feeding on the skin of a southern right whale calf

[23] For the Direct Output of Investment, the gross revenues for fisheries and marine ecotourism were used, and for the financial investment in marine research was used as a proxy of the direct output value for science.

7.3 Valuing Ireland's coastal, marine and estuarine ecosystem services

Following from a recommendation in the Integrated Marine Plan for Ireland (2012) "Harnessing our Ocean Wealth", Norton *et al.*, (2018) described the contributions from provisioning, regulation, and cultural marine ecosystem services to Irish society. This report was developed to complement previous work on the direct economic value of Ireland's ocean economy because services such as carbon sequestration, waste assimilation, coastal defence, aesthetic services and recreational opportunities had mostly been invisible in marine management decisions. This first attempt to provide a full overview of the economic contribution of marine ecosystem services was based on the CICES classification system, but also took into account abiotic (non-living) items. It was estimated that recreational services have an annual economic flow value of €1.6 billion; fisheries and aquaculture are worth €664 million, carbon absorption services are valued at €819 million, waste assimilation services €317 million, scientific and educational services €11.5 million, coastal defence services €11.5 million, seaweed harvesting €4 million and the added flow value per annum to housing of being close to the shore (aesthetic services) is valued at €68 million. Even though not all of the ecosystem services provided by the marine environment can be monetized, this report indicates that the value of those that can be is substantial. Estimates from the report are being used by the relevant Irish authorities to inform the second round assessment required under the EU Marine Strategy Framework Directive.

7.4 The Blue Gym: Valuing the impact from oceans on human health in the UK

The 'Blue Gym' concept, which gained visibility from economic evaluation, refers to the use of the coastal environment specifically to promote health and well-being by increasing physical activity, reducing stress, improving mental health and building stronger communities. Valuing the non-market health benefits of physical activities in the marine environment is necessary if they are to be included in marine spatial planning and management decisions. For example, including the healthcare savings and societal benefits of physical activities in impact assessments alongside the need for local economic growth in the marine environment, could influence marine spatial planning in terms of improving coastal access and water quality. A recent study, (Papathanasopoulou *et al.,* 2016) estimated the monetary and non-monetary contribution of physical activities to quality adjusted life years (QALYs) in the UK. They found that physical activities undertaken in aquatic environments provide a total gain of 24,853 QALYs nationally, worth ca. £176 million.

Credit: EMB

Big data as an enabler for valuation questions?

One of the main issues with marine ecosystem valuation is the lack of data. New valuation opportunities arise with advances in data analysis technologies that are able to combine different types of datasets (biophysical and economic) stemming from different locations and times. Spalding *et al.,* (2017) used big data applications to map the global value and distribution of coral reef tourism. Global data from social media (including pictures) and crowd-sourced datasets were used to estimate and map on-reef values (diving, snorkelling and glass-bottom boat tours) and reef-adjacent values (the role of reefs to generate clear calm waters and beach sand, outstanding views, fresh seafood and use in advertising, all of which help to draw people to coral reef regions). Applying and using these new sources of data requires a new paradigm of cross-disciplinary training and professional evaluation to increase capability to fully exploit big-data analytics in a way that is sustainable and adaptable to emerging disciplinary needs (LaDeau, *et al.,* 2017).

Furthermore, ecosystem modelling and simulation of ecosystem change is likely to play an increasingly important role in ecosystem valuation. When coupled to economic models, these ecosystem models can provide useful output for policy makers. For more information on the newest ecosystem modelling approaches see EMB Future Science Brief No. 4.

Credit: EMB

8 Recommendations and key actions

The overarching goal of this document is to apply the outcomes of marine ecosystem valuation studies to assess and ensure the long-term sustainability of the Blue Growth Strategy, support policy development and marine management decisions, and raise awareness of the importance of the marine environment to society and in the economy. The purpose of ecosystem valuation is not to price-tag nature, but to help answer clearly defined marine policy questions, as it can help visualize and quantify (in monetary or non-monetary terms) the diverse direct and indirect contributions of ecosystems to human well-being. Ecosystem valuation studies need to take the specific context, knowledge and spatio-temporal scale into account with the appropriate level of complexity. This requires a transdisciplinary approach and the inclusion of socio-economic drivers. Arising from the issues discussed and described in the previous chapters a series of overarching high-level recommendations, which address some of the most important next steps are given here:

1. Make ecosystem valuation studies an integral part in decision models for specific marine management decisions (e.g. in Marine Spatial Planning, Coastal Zone Management) and conservation policies (e.g. implementation of MPA's, fishing bans, etc.);

2. Promote the harmonization of ecosystem service frameworks and classification systems through international initiatives such as the MEA, TEEB, IPBES and ICES, and agree on an international standardized framework to improve the usage and comparability of ecosystem services assessments;

3. Improve understanding of the role of marine biodiversity and ecosystem processes in providing services and benefits by:
    a. Identifying and mapping the relationships between biodiversity, ecosystem processes, and services, including mapping the external factors that affect the relationship between them, at all the relevant spatial and temporal scales. Furthermore production-function relationships between biodiversity or ecosystem processes and values of ecosystem benefits should be developed where feasible;
    b. Agreeing on a set of ecosystem service indicators that can be monitored under existing and continuous monitoring programmes, which should be optimised to increase the usability of the collected data for marine ecosystem valuation studies; and by
    c. Identifying potential ecological thresholds (tipping points) in order to indicate the environmental limits of the marine ecosystem.

4. Improve the quality and availability of monetary and non-monetary valuation data through:
    a. Creating open databases that contain the data, meta-data, applied methodology and results of marine ecosystem valuation studies (monetary as well as non-monetary) to increase comparability and usability of the gathered information;
    b. Establishing best practise and suitability checklists for ecosystem valuation studies and techniques, to address methodological issues, such as context dependency, sensitivity and uncertainties;
    c. Including the breadth of social science and public health approaches in marine ecosystem service and benefit assessments and quantifying health benefit (and cost) values for marine ecosystems;
    d. Developing further understanding and quantification of the non-monetary and shared values held for cultural ecosystem services; and through
    e. Creating bio-economic models by linking (dynamic or static) natural science models with economic and social science models.

5. Set the right scale and boundaries for each valuation study, focussing particularly on those areas that provide the services and those where the benefits occur. As the beneficiaries of the ecosystem services under consideration might lie outside the administrative boundaries, cooperation on local, regional and international scale might be necessary to make a robust assessment in the trade-off analysis; and

6. Set up interdisciplinary teams of scientists including ecologists, economists, other social scientists, and policy makers to develop concrete policy questions and answers, as the understanding of the social context of the interpretation of the valuation results (who will benefit or bear the costs, what trade-off should be made between which ecosystem services, etc.) will gain increasing importance.

7. Develop the Natural Capital Approach and Natural Capital Accounting by enhancing and standardizing existing marine asset and valuation data sets, assessment methods and reporting of results. Issues such as scale, aggregation and ecosystem degradation should be further addressed to facilitate their inclusion in Natural Capital Accounting. Based on natural capital approaches, develop financing mechanisms (e.g. payments for ecosystem services) to improve the sustainable use of marine natural capital

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List of Abbreviations and Acronyms

CICES	Common International Classification of Ecosystem Services
CZMT	Coastal Zone Management Trust
EEA	European Environment Agency
EU	European Union
GDP	Gross Domestic Product
GES	Good Environment Status
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
ICZM	Integrated Coastal Zone Management
IPBES	International Platform on Biodiversity and Ecosystem Services
MAES	Mapping and Assessment of Ecosystem Services
MEA	Millennium Ecosystem Assessment
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
PES	Payments for Environmental Services
QALYs	Quality Adjusted Life Years
SDG	Sustainable Development Goal
SEEA	System of Environment Economic Accounting
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UN	United Nations
WTP	Willingness To Pay

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