Lars Berger (Ed.)

Marine Ecosystem Services

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Editor
Lars Berger

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Cover picture: Selection of Marine Ecosystem Services around the globe (F. Schillaci)

Editor‘s address:

Dr. Lars Berger | Bundesamt für Naturschutz
Konstantinstr. 110
53179 Bonn
E-Mail: lars.berger@bfn.de

Scientific Supervision:

Dr. Lars Berger | Division I 2.1 “Legal Affairs and Economics”

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List of Abbreviations

BAC	Background Assessment Concentrations
BNatSchG	Federal Nature Conservation Act (Bundesnaturschutzgesetz)
BSH	Bundesamt für Seeschifffahrt und Hydrographie
CBA	Cost-benefit analysis
CBD	Convention on Biological Diversity
CEA	Cost-effectiveness analysis
CEMAT	European Conference of Ministers responsible for Regional Planning
CES	Cultural ecosystem services
CICES	Common International Classification on Ecosystem Services
CMR	Clyde Marine Region
DFG	German Research Foundation (Deutsche Forschungsgemeinschaft)
EA	Ecosystem approach
EBA	Ecosystem based approach
EEZ	Exclusive Economic Zone
ESS	Ecosystem services
EU	European Union
GDR	German Democratic Republic
GES	Good environmental status
HELCOM	Baltic Marine Environment Protection Commission
ICZM	Integrated Coastal Zone Management
MEA	Millennium Ecosystem Assessment
MAES	Mapping and Assessment of Ecosystems and their Services
MARUM	Centre for Environmental Science
MESAT	Marine Ecosystem Service Assessment Tool
MSEG	Member States Expert Group on Maritime Spatial Planning
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
MSPD	Marine Spatial Planning Directive
OECD	Organisation for Economic Cooperation and Development
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic

RES	Recreational ecosystem services
RIA	Regulatory Impact Assessment
ROG	Federal Regional Planning Act (Raumordnungsgesetz)
TCM	Travel cost method
TEEB.de	The Economics of Ecosystems and Biodiversity (Naturkapital Deutschland)
UN	United Nations
UNEP	United Nation Environment Programme
WFD	Water Framework Directive

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1 Marine Ecosystem Services: a means of conserving marine biodiversity

Lars Berger, Axel Kreutle and Carla Kuhmann
(Federal Agency for Nature Conservation)

Introduction

The decline in biodiversity is the most pressing and serious problem that our society has to deal with in the interaction of natural and social systems. Conserving nature means protecting biodiversity (i.a. Ceballos et al. 2015). Efforts in nature conservation predominantly focus on terrestrial ecosystems. Given the fact that oceans cover more than 70 percent of the planet's surface, there is a considerable need to expand the range of arguments for the protection of marine biodiversity. The concept of ecosystem services (ESS) bears the potential to better integrate marine nature conservation objectives in processes and decisions of public policy making.

Biodiversity and ecosystems are closely related concepts. Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes which they are part of: this includes diversity within species, between species and of ecosystems (UN 1992). Diversity is a structural feature of ecosystems, and the variability among ecosystems is an element of biodiversity (Alcamo 2003). In the 1990s, the parties of the Convention on Biological Diversity (CBD) agreed that the ecosystem approach should be the primary framework of action to be taken under the Convention. The CBD defines an ecosystem as a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Humans are understood as an integral part of many ecosystems which can be a functional unit at any spatial scale. The Convention recognises the often unpredictable nature of ecosystem responses and the incomplete understanding of ecosystem functioning (SCBD 2001). Based on this understanding, the members of the CBD derived operational guidelines for applying the ecosystem approach (EA) in nature conservation.

According to these guidelines, the maintenance of ecosystem services is a priority target of conservation of ecosystems. Ecosystem services are broadly understood as the benefits people obtain from ecosystems. Their utilization should appropriately balance between and integrate the conservation and use of biological diversity, involving all relevant sectors of society and scientific disciplines (ibid.). The EA links biological, ecological and broader environmental questions to the sphere of social actors with differing interests and world views. Implicitly, conflicting forms of ecosystem use are taken into account (Garrelts and Flitner 2010). But changes in ecosystems do not only affect humans but countless other species as well. The objective of conserving nature and in a broader sense, shaping the institutional structure[1] of interactions between natural and social systems favouring nature conservation, can be supported by the consequences of ecosystem changes for humans. On equal terms is still the intrinsic value of nature and its biological diversity as a human life support, considering also our responsibility towards future generations (compare Article 1 paragraph

[1] Institutions are defined as "conventions, norms and formally sanctioned rules of a society. They provide expectations, stability and meaning essential to human existence and coordination. Institutions support certain values, and produce and protect specific interests." (Vatn 2015: 78)

1 of the Federal Nature Conservation Act).

Ecosystems and their services

The benefits people obtain from ecosystems are not taken into account adequately in public and economic decisions because (among other reasons) these services are freely available as public goods. They are not part of market transactions and their value is neither known, quantified nor assessed appropriately. For the integration of nature conservation objectives in processes of public decision-making it can be worthwhile that nature's values are identified and insofar as possible quantified, so that these benefits and values can be increasingly considered up to their full extent. Such considerations might have very different applications. Valuation can for example be used to assess the total contribution that ecosystems make to human well-being, to understand the incentives that individual decision-makers face in managing ecosystems in different ways, or to evaluate the consequences of alternative courses of action (Alcamo 2003).

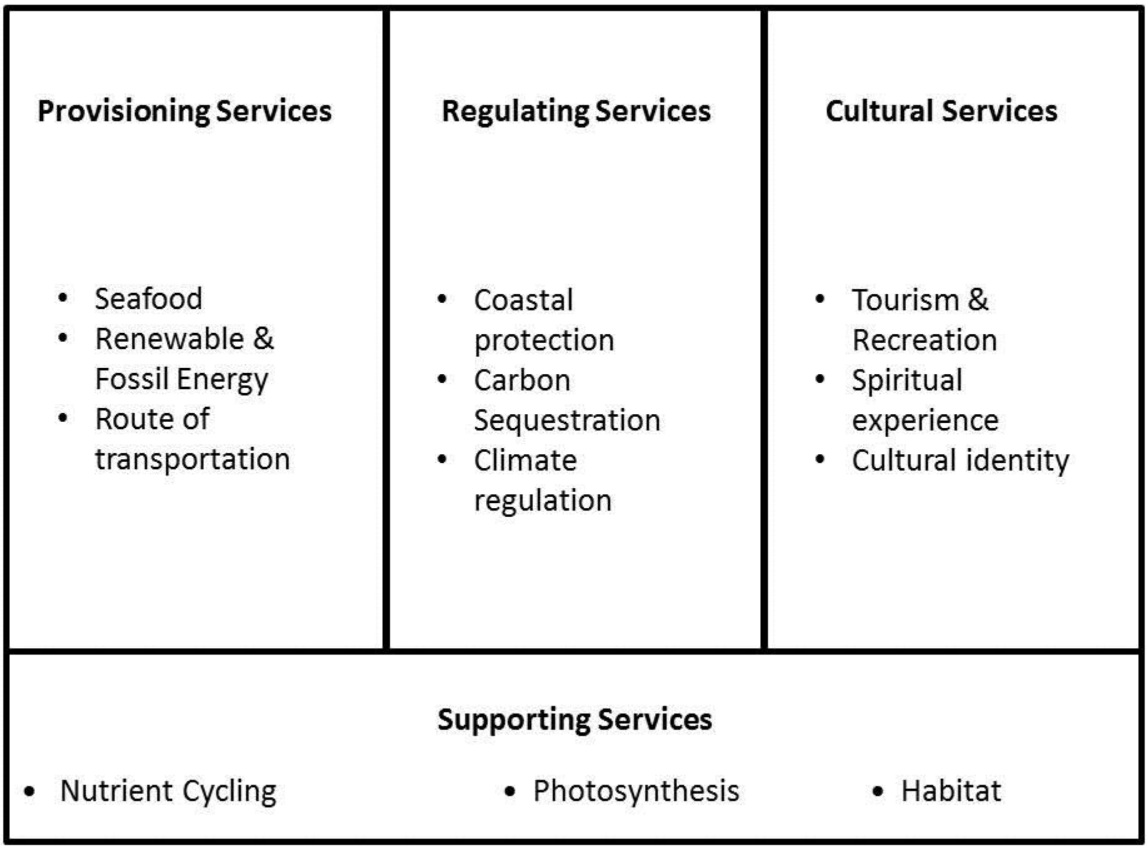

Figure 1: Marine ecosystem services

Ecosystem services can be clustered in provisioning services such as fish; regulation such as flood control; support such as nutrient cycling; and cultural services such as recreational and other non-material benefits (see Fig.1). This typology is mainly used as a way of structuring information and does not reflect the inherent complexity where, for example, a provisioning service like fish does not just represent any diet, but also carries a strong cultural dimension related to harvesting techniques, preparation, symbolism and so on. To place cultural values in a separate cluster is thus underestimating the cultural dimension of many of the services in other clusters (Kumar 2010). Cultural values can also be described as non-use values. People ascribe value to knowing that a resource exists even if they never use that resource directly. Examples are the international financial support for the Australian Great Barrier Riff or the protection of Malaysian mangroves by people who will never visit the site. Slightly easier is the valuation of use-values.

The main goal of valuating ESS is NOT to assess these values in monetary units. It is rather the objective to explicitly demonstrate the importance of fully taking into account the qualitative and quantitative dimension of benefits that humans gain from nature and the consequences we have to bear in case of inaction in protecting nature. Monetization is only one method among many (Ifuplan et al. 2017). The assessment of ESS involves not only the quantitative dimension, but also the identification of the impact of a measure, project or environmental change and ascertaining the impact of such elements through the use of suitable indicators or metrics. Identifying the features of the natural system as well as systematically and comprehensively documenting environmental change can matter as valuation itself. Moreover, to know who has to bear certain consequences and how these consequences unfold is more important for decision making than knowing the pecuniary benefits of a particular element. In other words, the purpose of a valuation is not to hang a price tag on the 'features' of nature. The objective is to raise awareness for the multi-functionality of various ecosystems; identifying, determining, and fully taking into account all services that come into play; and analysing how the costs and benefits of these services are distributed to all concerned. And indeed, expressing the value of the benefits of keeping ecosystems intact in a metric other than money may ultimately provide greater clarity than would be the case if only monetary value is used (ibid.). The conservation of biodiversity is certainly motivated by its existence value, but applying the concept of ESS can strengthen the argument for conserving marine biodiversity.

Biodiversity and ecosystem services

Various studies suggest that a reduction in biodiversity not only impairs the ability of marine ecosystems to feed a growing human population (productivity) but also sabotages their stability and recovery potential in a rapidly changing marine environment (resilience) (i.a. Donovaro et al. 2008, Hooper et al. 2005, Kumar 2010, Worm et. al. 2006). High-diversity systems consistently provide more services with less variability. The buffering impact of species and habitat diversity on the resistance and recovery of ESS generates additional insurance value.

This robust causal chain not only implies a proportionate relation between biodiversity and ESS, but often exhibits an inversely proportional relation. Worm and his colleagues (2006) understood in their analysis of long-term regional time series that rates of resource collapse increased and recovery potential, stability, and water quality decreased exponentially with declining diversity. Restoration of biodiversity, in contrast, increased productivity fourfold and decreased variability by 21 % on average. Likewise, Donavaro and his colleagues (2008) state that biodiversity loss in deep-sea ecosystems might be associated with exponential reductions of their functions. High (or not adversely affected) biodiversity plays a central role in the delivery of many services. Ecosystems and their functioning need to be considered and managed to deliver multiple services sustaining human well-being.

To our understanding, two paths of arguments valuing biodiversity and thus shaping the institutional structure favouring nature conservation can be pursued. Primarily it is the intrinsic value of nature, which should drive the motivation to protect it. Second are the benefits people obtain from ecosystems (respective the consequences societies have to bear in case of inaction), subdivided in non-use and use values. From a valuation perspective, environmental problems and conflicts are the consequences of trade-offs between values held by different groups of stakeholders. The valuation of nature is nothing new. As a current scientific field, it has emerged from traditions in ecological, as well as environmental economics, environmental justice, and ecosystem service assessment practice (Jacobs et al. 2016). Based on the ecosystem approach the valuation of nature to foster nature conservation efforts can be found in various legal frameworks.

Ecosystems in the legal framework

The world's oceans belong to the ecosystems of the earth that are used intensively, but at the same time are only weakly protected. Also a large number of human activities overlay the protection interests in the German North and Baltic Sea (ARGE BLMP Nord- und Ostsee 2011).

The EU has already integrated the ESS concept in several directives and management actions (Bouwma et al. 2016). As for example the management agreement, action 2 of the Biodiversity 2020 Strategy (European Commission 2011) asks Member States (MS) to maintain and restore their ecosystems as well as their services. An Ecosystem Approach (EA) has been integrated in various fields of marine policy and management in recent years, Marine Strategy Framework Directive and Marine Spatial Planning Directive being good examples.

The EU Marine Strategy Framework Directive (MSFD, 2008/56/EC and 2017/848/EC) laid down that it is evident that pressure on natural marine resources and the demand for marine ecological services are often too high. The Community needs to reduce its impact on marine waters regardless of where their effects occur. To meet this challenge, all Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest.

For this purpose, marine strategies shall be implemented with an ecosystem approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations (Art 1 (3) MSFD).Thereby, an application of EA – describing and taking into account ecological contexts in management and planning – is closely connected to the importance of securing ESS.

In principle, the MSFD programme of measures (BLANO 2016a) aims to implement the ecosystem approach as a controlling instrument for human activities to achieve a good environmental status. This is evident, among other things, for the protection of migratory species (BLANO 2016b). The implementation itself will show if these measures are a positive example for the EA, as today there are not many indications how EA is implemented or integrated in real life.

Moreover, in the sense of the MSFD, this Directive and the achievement of good environmental status should promote integration of environmental considerations into all relevant policy areas and deliver the environmental pillar of the future maritime policy for the European Union (Weiß 2017). Furthermore, in the MSFD Annex VI, there are examples to establish a programme of measures. Among others, this includes Spatial and temporal distribution controls: management measures that influence where and when an activity is allowed to occur. This refers clearly to the directive on Maritime Spatial Planning (MSP, 2014/89/EU). However, the achievement of MSFD objectives and good environmental status is merely only one goal among others when implementing MSP, next to the strong emphasis on economic growth.

Ecosystems and spatial planning

With reference to the integrated marine policy, EA should also be seen as a holistic and comprehensive principle in marine spatial planning. Meaning that the spatial organisation of human activities in marine waters has to ensure that the use of marine areas is limited to an extent the ecosystem's carrying capacity allows for; i.e. the Biological Diversity is not affected by anthropogenic pressures (MSFD 2017/848/EC).

Although the EU Maritime Spatial Planning Directive is, compared to the MSFD, not geared to the protection of marine ecosystems (but rather analyses and organises human activities in marine areas to achieve ecological, economic and social objectives), Art. 5 (1) clearly sets the obligation to Member States to consider EA – as defined by the MSFD – when developing marine spatial plans. Spatial plans have to ensure that good environmental status in marine waters can still be reached.

Considering the interlinkage between economical utilization and changes in regulating and providing services in planning can support the comparison of effects of different planning scenarios on the environment. Thereby the focus is drawn to the decision making in the planning process and indicates the contribution of the ecosystem to prosperity of society. The application of EA in planning provides ecological, social and economic information by the concept of ESS to be transformed into spatial planning options. Integrating maps of ESS and the costs of not taking up measures in planning process can therefore support decision making process and steer sustainable development of human activities.

Germany as well as littoral states of North Sea and Baltic Sea are committed to the EA and comprehensive protection of marine waters by international agreements such as OSPAR and HELCOM. OSPAR and HELCOM define EA as „the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity" (HELCOM & OSPAR-Commission 2003). This common definition of EA shifts the focus from managing ecosystems towards the management of human activities, what makes this interpretation suitable when dealing with steering development of uses taking into account ecological demands.

Particularly for MSP this definition is further specified by HELCOM / VASAB[2] in „Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area" (HELCOM / VASAB 2016), which also includes the concept of ESS as a key element for spatial planning in the Baltic Sea region, showing the close linkage between different approaches to marine management.

The policy framework for the application of EA in marine waters is still in place and should be considered seriously to push forward a set of integrative measures which leads to the

[2] HELCOM / VASAB – Helsinki-Kommission & Visions And Strategies Around the Baltic Sea

improvement of ocean ecosystems.

Conclusion

The concept of Marine Ecosystem Services allows to better inform processes and decisions of public policy making. It supports arguments to better visualize the urgent need to conserve biodiversity. In other words, it helps to integrate environmental concerns in various other policy domains. Thus, an environmental strategy can be effective only if it also influences policies in other domains (Jordan and Lenschow 2010). By no means, it can substitute the acknowledgement of nature's intrinsic value, but it can serve as a tool for communicating and mainstreaming biodiversity into various marine sectors. Anchored in the European legal framework, in various international treaties and spatial plans it helps to balance different demands by various groups of stakeholders

It can be concluded that two pivotal characteristics of MESS will determine the future path of progress in this field: first of all, the lack of sound and credible arguments in favour of nature conservation. Research on ESS has grown exponentially during the last decade (Liqete et al. 2013). Still, data and methods to assess the provision of MESS are much more limited when compared to terrestrial assessments. Secondly, besides the quantitative limitations of data and methods available, there is also the normative issue of valuation to be considered. The valuation of MESS leaves considerable room for interpretation. Decisive steps of the assessment that determine the construction of values and therefore, the outcome of assessment are:

- the choice of types of values or the value language to use,
- the selection of social actors to engage in the process,
- the decision of which methodological tools and measurement units to use,
- or even the choice of which MESS or benefits to include (Vatn 2009).

These characteristics were reason to conduct an "International workshop on Ocean Ecosystem Service" on the island Vilm in July 2018. Participants from different countries and various disciplines, such as biologists, economists, spatial planners, legal professionals and ethicists seized the opportunity to present research results (Kruse & Kruse, Döring, Robbe et al., Ahmerkamp, Mayer), to identify the linkages of legal requirements and practical application (Sauer & Marggraf, Janßen, Janssen & Werner, Altvater) and critically discuss theoretical and ethical foundations of the general concept (Leibenath, Bachmann & Willemsen). Please find their contributions in the following.

One influential critic on the concept of ESS is that the design and implementation of the concept is dominated by knowledge from the natural sciences and economics and that this predominantly stock-and-flow framing of people-nature relationships largely failed to engage a range of perspectives from the social sciences, or those of local practitioners including indigenous people (Diaz et al. 2018). As a reaction to this, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), a joint global effort by governments, academia, and civil society, established the concept of Nature's Contributions to People – one further step to expand the range of arguments for the protection of biodiversity.

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2 Assessment and mapping of Marine Ecosystem Services: the case study of the German Baltic Sea

Marion Kruse & Tim Kruse (Kiel University)

Introduction

The assessment and mapping of ecosystem services has become an important and necessary task, not only in a scientific context but also for decision-making and policy. Due to the integrative nature of the concept, several current environmental and societal challenges and problems could be tackled by applying this concept. So far, there are different conceptual frameworks available with (slightly) different viewpoints regarding the scope of the concept (e.g. economic vs. non-economic valuation). However, in recent years, great effort has been undertaken to bring the core ideas, methods and information together (e.g. Maes et al. 2018; Haines-Young & Potschin-Young 2018). For example, in the European Union this has been done by developing and preparing databases and guidelines for a comparable and unified assessment of ecosystem services in Europe (e.g. ESMERALDA Project; Santos-Martin et al. 2018). This is also driven by the integration of ecosystem services into Target 2 Action 5 of the EU Biodiversity Strategy to 2020 which states: "Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020."

In the scientific literature, the assessment of marine ecosystem services has begun to come under greater and greater focus due to the strong emphasis initially placed on terrestrial studies as the development and application of the ecosystem services concept first got underway.

The Baltic Sea is an essential case study area, due both to its location and to the fact that it has been heavily used by humans for thousands of years. The limited water exchange in the Baltic Sea, due to bathymetry and the Danish straits, combined with its shifting water characteristics (e.g. salinity, temperature), have led to a diverse and fragile ecosystem. Therefore, several reports from environmental agencies and workshop proceedings, among others, have been published for the Baltic Sea and its adjacent countries in recent years. However, many reports only give a general description of the ecosystem services in the area. Specific case studies with detailed data and information are restricted to the assessment and mapping of 1-3 ecosystem services and are limited in space.

For the German Baltic Sea and Coast, the assessment and mapping of ecosystem services is of high importance due to the increasing pressure on the limited area from tourism, housing/industry, shipping traffic and the need for coastal protection and conservation areas.

In this article, a conceptual idea on the combination of the assessment of ecosystem services with mapping and its advantages for policy-making and knowledge improvement is presented together with a short discussion on the challenges of the approach for the practical case study.

Assessment and mapping approach for ecosystem services

Case study area

The case study area of the German Baltic Sea is delineated as the German Exclusive Economic Zone and, in order to integrate the terrestrial-coastal-marine gradient, the adjacent municipalities along the coast. Due to the large spatial extent of the case study area, the marine ecosystem characteristics range from Förde areas with higher salinity, to brackish inner coastal lagoons, as well as to freshwater inflow zones and offshore areas.

In addition, a diachronic assessment of the most important ecosystem services is integrated into the framework. With the temporal assessment, the hope is to get insight into the effects of environmental changes on human society and associated changes in valuation. For example, the removal of (larger) stones for coastal protection from the seabed until the 1960s (Steinfischerei) incurred the long-term consequence of the loss of important hard-bottom substrate-based habitats and their connected ecosystem services (e.g. regulating services). Another issue related to the disturbance of sediments results from certain heavy fisheries equipment and techniques (e.g. harvesting wild mussels in the Flensburger Förde), which has been discussed in science and practice for years. Integrating the information in management and spatial planning will hopefully help to reduce the negative effects on the marine environment in the future.

Framework and data requirements

The applied key concept is based on previous studies developed by Kandziora et al. (2013) on the categories of ecosystem services and the necessary indicators and methods for quantification, as well as a spatially-explicit mapping approach by means of biogeophysical units suitable for the ecosystem services categories and indicators (Burkhard et al. 2014). The adaptation to the marine context was carried out by deleting ecosystem services that do not occur in the case study area or specifically adding marine compartments in more detail.

The main idea is based on the distinction of the three different kinds of ecosystem services:

- Potential ecosystem services are services that are supplied by a specific area, but which are not currently used or perceived as services by humans. This is an important aspect in distinguishing the ecosystem functions from ecosystem services.
- Ecosystem service flows are the ecosystem services currently being used and perceived as services.
- Demand for ecosystem services by the society.

Table 1 lists the applied ecosystem services for terrestrial, coastal, and marine ecosystems for which some relate only to one part of the ecosystems (e.g. timber for terrestrial ecosystems) whereas others, especially regulating services, are supplied by different parts of the ecosystems. Marked (* and #) ecosystem services are not always considered to be ecosystem services as such due to the fact that they are not generated by ecosystems (rather, they are generated e.g. on longer geological timescales, or by abiotic processes). In today’s management and planning, however, it is necessary to include these features for a holistic assessment and in order to consider synergies and trade-offs in the consequences of human activities. The example of beach wrack is emphasized because of how perspectives towards it changed in coastal regions. In former times it was used for multiple purposes (such as insulation or fertilizer), whereas today it is considered to be negative for tourism, which can be referred to as an ecosystem disservice. Currently, some studies assess the (recent) changes in coverage and condition of seagrass and macrophytes and a more sustainable and less costly use of the material from the (touristic) beaches.

Table 1: Applied ecosystem services for the German Baltic Sea and Coast (adapted from Kandziora et al. 2013 and Burkhard et al. 2014).

Ecosystem service	Definition
Provisioning services	
Fish and seafood	Commercial catch of fish, seafood/algae for human consumption incl. aquaculture.
Wild food	Harvest of berries, mushrooms, (edible) plants, hunted wild animals, fish catch from recreational fishing.
Fibers	Cultivation and/ or harvest of natural fibre (e.g. cotton, jute, sisal, silk, cellulose, seagrass) for e.g. cloths, fabric, paper, or insulation.
Fodder	Cultivation and/or harvest of fodder for domestic animals (e.g. grass, fish, and mussel meal/oil).
Biomass for energy	Plants used for energy conversion (e.g. sugar cane, maize, macrophytes)
Crops (human nutrition)	Cultivation of edible plants and harvest of these plants on agricultural fields and gardens used for human nutrition.
Livestock	Production and utilization of domestic animals for nutrition and use of related products (e.g. dairy, wool).
Timber	Wood used for construction purposes.
Wood fuel	Wood used for energy conversion and/or heat production.
Drinking water	Consumed freshwater for drinking.
Beach wrack#	Organic material from submerged macrophytes (e.g. seaweed and algae) which is accumulated regularly along the coast.
Ornamentals*	Collection of natural ornaments (e.g. seashells, stones/amber, leaves and twigs for ornamental or religious purposes).
Abiotic energy*	Sources used for energy conversion (e.g. solar power, wind power, water power, and geothermic power)
Minerals*	Minerals excavated close from surface or above surface (e.g. sand for construction, lignite, gold)
Regulating services	
Global climate regulation	Long-term storage of greenhouse gases in ecosystems.
Local climate regulation	Changes in local climate components like wind, precipitation, temperature, radiation due to ecosystem properties.

Flood protection /Coastal protection	Protection and mitigation of storm surges.
Erosion regulation / Sediment stabilization	Soil/sediment retention and the capacity to prevent and mitigate soil erosion, landslides, coastal erosion and seabed sediment transport.
Nutrient regulation	The capacity of an ecosystem to recycle nutrients, e.g. N, P.
Water purification	The capacity of an ecosystem to purify water, e.g. from sediments, pesticides, disease-causing microbes, and pathogens.
Groundwater recharge, water flow	Maintaining of water cycle features (e.g. water storage and buffer, natural drainage, irrigation, and drought prevention).
Air quality regulation	Capturing/filtering of dust, chemicals and gases.
Pest and disease control	The capacity of an ecosystem to control pests and diseases due to genetic variations of plants and animals making them less disease-prone, and by actions of predators and parasites.
Pollination	Bees, birds, bats, moths, flies, wind, non-flying animals contribute to the dispersal of seeds and the reproduction of lots of plants.
Cultural services	
Recreation and tourism	Outdoor activities and tourism relating to the local environment or landscape, including forms of sports, leisure, and outdoor pursuit.
Landscape aesthetics + inspiration	Visual quality of the landscape/ecosystems or parts of them which influence human well-being and the need to create something, esp. in art, music, and literature. The sense of beauty people obtain from looking at landscapes/ecosystems as ecosystems provides a rich source of inspiration for art, folklore, national symbols, architecture, advertising, and technology.
Knowledge systems	Environmental education based on ecosystem/landscape, i.e. out of a formal schools context, and knowledge in terms of traditional knowledge and specialist expertise.
Cultural heritage	Values that humans place on the maintenance of historically important (cultural) landscapes and forms of land use (cultural heritage).
Regional identity	Elements or processes of ecosystems that contribute to a person's individual identity (sense of belonging) or strengthen people's group identity.
Natural heritage	The existence value of nature and species themselves, beyond economic or human benefits.

All relevant ecosystem services in the case study area are valued by available data from various previous research projects, literature, monitoring data, modelled data, and statistical data. Data availability is not equal for all ecosystem services. Especially in the case of cultural services, quantification is difficult due to a lack of detailed studies on the perception of marine ecosystems. For the mapping approach, spatially explicit data is processed in a geographic information system to create ready-to-use maps of ecosystem services.

Fig. 2 shows the application of available data for two examples: one provisioning service and one cultural service. It is clear that in particular the quantification of “food” from fisheries is covered by statistical data for a longer time scale. Unfortunately, the data is not spatially explicit, meaning that a map would result in a rather uniform distribution of few value which changes every year (e.g. due to quota). Additionally, the data availability needed to distinguish potential ecosystem services from the actual flow and demand is incomplete. Only information on selected key species (e.g. cod or herring) is available. Seasonal changes in the abundance of migratory species or temporal closure of fisheries and quota regulations make the mapping approach rather complex; so much dense information is not easily displayed in one single map. The demand for fish as food in Germany is furthermore not identical to the actual supply from the Baltic Sea. The example for the cultural service highlights the limited available spatial and temporal data as well. Since cultural ecosystem services such as recreation and tourism are quite different over the seasons, the ecosystem services maps must reflect the seasonality as well.

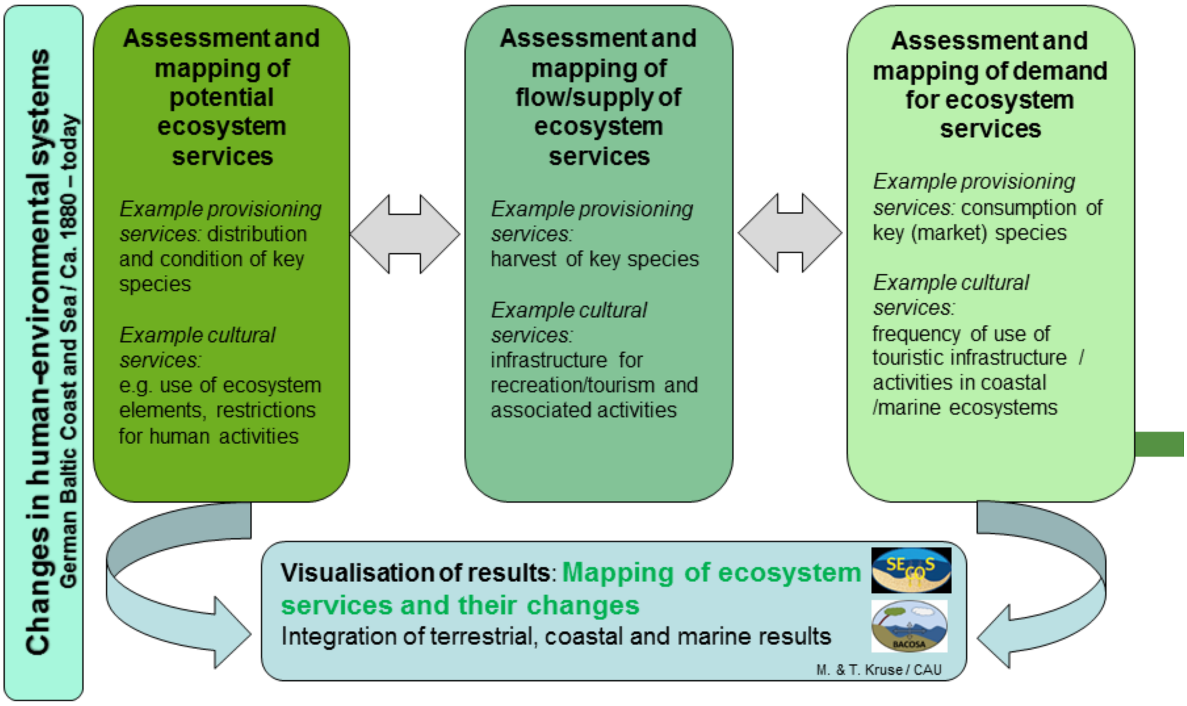

Figure 2: **Mapping approach with examples from the German Baltic Sea case study**

Discussion

The current application of the ecosystem services concept for the German Baltic Sea is still in progress. It is part of a methodological case study to test the applicability of a previously developed assessment and valuation framework that is now being extended to the coastal and marine context (Kruse et al. 2014). In most cases, there is a strict separation of marine ecosystems from terrestrial ecosystem assessments. This is also reflected in data availability. The listed ecosystem services in Table 2, however, show a clear interaction and should in the best case be assessed as a set rather than only focusing on one or few key ecosystem services.

However, the first results reveal several advantages that are applicable not only for this case study, but also in general when discussing ecosystem services.

Advantages in the application of the ecosystem services concept for all ecosystems include:

- Although the concept of ecosystem services includes the challenge of individual interpretation, it also has the advantage of visualizing the current condition of ecosystems and their services and the connected consequences of human activities;
- The interdisciplinary set-up leads to manifold perspectives in methods, data, and values;
- The holistic approach of integrating the marine-coastal-hinterland gradient is a suitable information source for sustainable management; and
- Maps are often perceived as an appropriate communication tool for all parts of society to make unseen or unknown issues visible.

Due to the complexity of human-environmental systems in general and the specific goals for decision-making and management, several challenges persist in the assessment and mapping of ecosystem services.

These challenges include:

- For the marine ecosystem, especially in the case of regulating services, a clear separation between ecosystem functions and ecosystem services remains difficult;
- Unclear or understudied marine processes (e.g. within habitats) hinder a full assessment;
- The selection of key species and processes (e.g. macrophytes; nutrient regulation) must be carefully elaborated and discussed to prevent overestimation or underestimation of marine ecosystems;
- Data availability and quality does not always match the spatial and temporal scale on which ecosystem services act;
- The selection of indicators is often driven by data availability rather than by the required clear indicator-indicandum relationship;
- The localization of demand is still under discussion (e.g. where do people live or how fast / slow can an ecosystem service be consumed; is a spatial localization possible at all?);
- Some conceptual aspects like the demand for certain ecosystem services (e.g. recreation/tourism, or landscape aesthetics) are difficult to describe in a single indicator or easy assessment method;
- Although maps are perceived as a good communication tool, not all results and values are spatially explicit enough to mean that the map is providing improved/better information;
- The shift in values from individuals, social groups, or society over time makes a one-to-one valuation of past to present ecosystem services difficult or even impossible; and
- A shift within the categories of provisioning, regulating, and cultural ecosystem services (e.g. fisheries as both food provider and as cultural symbol for tourism) suggests further caution is necessary in assigning values.

In general, it is challenging to value the changes through diachronic assessment. For example, some former ecosystem services are no longer in use (e.g. use of eel skin for making shoes), but the knowledge and tradition is maintained in museums, which in turn provide a cultural service. The question is whether this provides an equivalent, greater, or lower value, or whether it provides another value altogether, which is not comparable. Still, this keeps the development and adaptation of ecosystem services assessments active to improve data sets and methods.

Conclusions

The assessment of ecosystem services helps to improve the comprehensive knowledge needed to analyse human-environmental-systems. The German Baltic Sea is an important supply area of ecosystem services; increasing demand is placed on these services due to increasingly high human pressures. Assessment methods must be suitable for valuing the multiple ecosystem services and benefits delivered by marine and coastal areas. Due to the complexity and uncertainty inherent to the assessment, it is essential that, from an interdisciplinary approach, methods and data are shared and adapted in order to match the information needed to valuate ecosystem services and to close current data and knowledge gaps, especially in the valuation of marine ecosystem services.

The elaborated framework shows that marine ecosystem services depend on interactions with terrestrial and coastal ecosystems and are strongly influenced by human activities, which must be assessed and valued in a holistic manner.

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3 Marine Ecosystem Services within the project 'Natural Capital Germany - TEEB.de'

Ralf Döring
(Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Braunschweig)

Introduction – Project ‚Natural Capital Germany'

In 2013 the German Federal Environmental Ministry launched the project 'Natural Capital Germany – TEEB.de'. The project applied the research questions and approaches of the international study "The Economics of Ecosystem Services and Biodiversity" to the conservation of biodiversity and ecosystem services in Germany. A research group at the Centre for Environmental Research in Leipzig coordinated the project with the contribution of a large group of authors.

The main objective of the project was to demonstrate the societal relevance and value of intact nature and its services. It was intended to provide additional economic arguments for strategic decisions in favour of protecting the climate, biodiversity, etc. The three main thematic reports (climate policy, ecosystem services in rural areas and, the third one, ecosystem services in cities) are in German but summaries are available in English (UFZ o.J.).

In the following text I give a short overview on the application of the concept of ecosystem services in marine ecosystems in Germany by using the implementation of the Marine Strategy Framework Directive (MSFD) as an example. Secondly, I describe some of the contents of the two reports on climate policy and rural areas regarding marine ecosystem services. In a third part I present some background on spatial planning as the main instrument to show the sectors using space in the German EEZ (and with that exploitation of and influencing the provision of ecosystem services). The text finishes with a short summary and conclusion.

Marine ecosystem services (MES) – e.g. MSFD in Germany as an example

Thus far there were very limited applications of economic valuation of ecosystem services in Germany. In a few research projects some conceptual work was integrated (e.g. SECOS (https://deutsche-kuestenforschung.de/secos.html)). The MSFD requires an initial economic assessment and cost-benefit or cost-effectiveness analyses for measures to restore or preserve the good environmental status. The MSFD demands a socio-economic analysis of the uses of marine waters and of the costs of degradation of the marine environment (Art. 8 (1c). EU Member states have delivered reports to the European Commission. The Commission has analysed the reports and summarised the covered sectors and the applied methods (see Fig. 3 & 4).

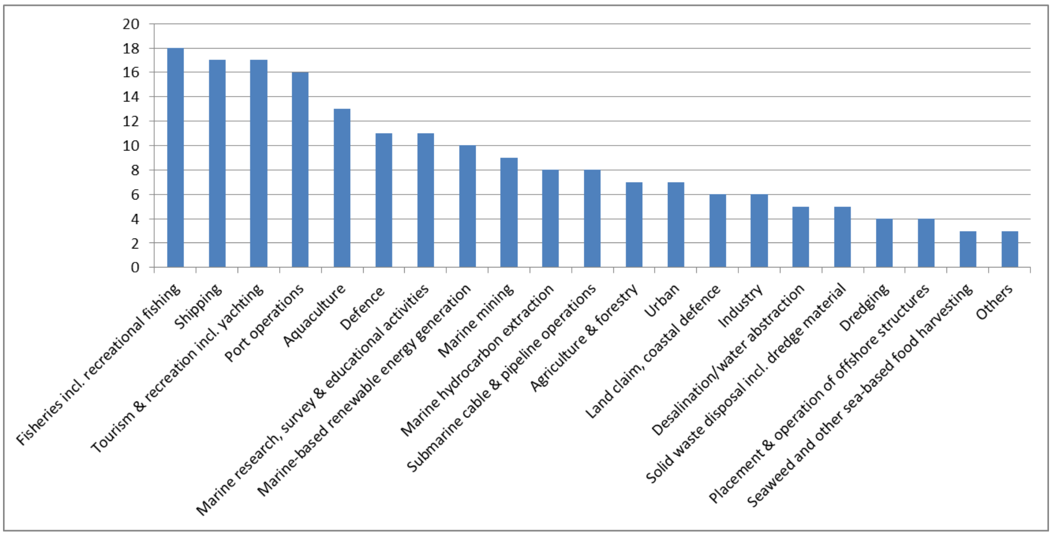


Figure 3: **Summary of which uses and activities were most reported in the economic analysis (European Commission 2014, p. 61)**

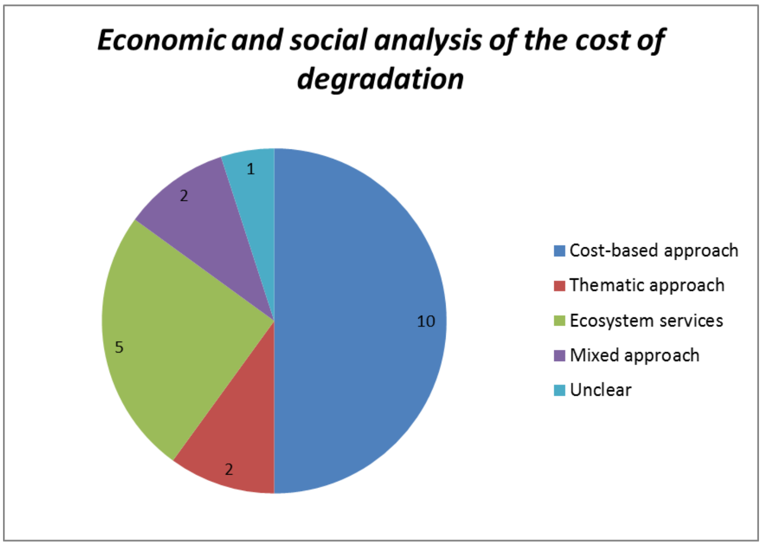


Figure 4: **Fig. 2: Summary of which methods were most often used in the analysis of the cost of degradation (European Commission 2014, p. 62)**

The Ecosystem services concept was applied in 5 of the overall 20 countries.

Also Germany has not covered all the marine sectors listed in Figure 1. The German Working Group decided to cover 7 sectors, which directly operate in the marine environment (e.g. fishing or sand and gravel removal) and 3 sectors that negatively influence the status of the ecosystem (e.g. inflows of nutrients). The report includes basic economic figures on the sector, e.g. employment or gross value added. There was only very limited information on the costs of degradation in Germany. Thus, the working group decided to list possible sources like research projects to cover this topic. In the meantime the working group has issued several studies to assess the socio-economic effects of the proposed measures to keep or reach the good environmental status.

The project Natural Capital Germany did not include a systematic economic assessment either. The objective was only to describe the value of applying the MES concept by describing specific cases, results of research projects etc.

MES Report 1: Natural Capital and Climate Policy: Synergies and Conflicts

The participants of ‘Natural Capital Germany’ decided to start with a report on climate policy as a considerable amount of research has been undertaken in Germany over the last years on adaptation and mitigation measures regarding climate change. Some of the mitigation measures and energy policy instruments, e.g. increasing production of energy by offshore windmills, have an impact on habitats, species and ecosystem services in marine ecosystems.

A chapter on coastal and marine ecosystems described the knowledge about marine ecosystems and identified costs and benefits of climate change adaptation measures. In this analysis the authors identified a number of cost-effective and near-natural solutions for selected sites on the Baltic Sea. Prior to the analysis they agreed on a categorisation of ecosystem services for the report.

Provisioning services

- Uncultivated marine plants, algae and animals for food
- Plants and animal resources
- Genetic resources and pharmaceutical ingredient

Regulating and supporting services

- Regulation of pollutants and waste through biological and ecosystem processes (Extraction, Filtration, Fixing and Dilution)
- Gas- and Climate regulation (local and global)
- Protection from storms and erosion control

Cultural services

- Recreation and leisure activities
- Aesthetic and nature experience
- Natural heritage and identity
- Spiritual and symbolic meaning
- Science and education
- Existence value and legacy to future generations

Figure 5: List of identified categories of ecosystem services in coastal/marine ecosystems (Naturkapital Deutschland – Teeb.de 2015, p. 184 own translation).

In a concrete example – dyke removal on the Sundische Wiese - the authors illustrated the usefulness of the ecosystem service concept for an adaptation and mitigation measure at the coast, which in addition would restore a rare ecosystem and protect biodiversity.

The Sundische Wiese is the Eastern part of the peninsular Fischland Darß-Zingst at the Southern Baltic Sea Coast of Germany, and is part of the National Park ‘Vorpommersche Boddenlandschaft’ and a protected area with a limited, low input agricultural production system (mother cows). In 2009 the dyke at the waterfront was sliced and a new dyke was erected in the middle of the peninsular. This means a regular flooding of the lower parts of the meadow with salty seawater. There was a long discussion before the dyke was removed regarding possible negative effects on houses and small villages in the area. It was also predicted that the developing salt meadow is less productive and, therefore, revenues for the farmer would be reduced. As the meadow is part of the National Park a farmer raises cattle in a low intensity production system. Energy contents of the fodder would be further reduced and that meant less meat production from the area.

Before the dyke removal a cost-benefit-analysis was issued to show the economic effects of a dyke removal and the establishment of a rare coastal ecosystem – a salt meadow (see table 2).

Table 2: Cost-Benefit Analysis dyke removal on the Darß (own translation)

Project effect	Results for 806 ha (Tsd. €/a)		
Scenario	with Salt Meadow	without Salt Meadow	Difference
Water Management	-116	-148	32
Agriculture	-122	-210	88
Balance 1	-238	-358 Proportion with/without 1:1.5	120
Willingness to Pay	+185	0	185
Balance 2	-52	-358 Proportion with/without 1:6.8	305

The Water Management is cheaper with the dyke removal, agricultural production will be reduced, but this does not mean an increase of the deficit as this would mean a reduction in subsidies for the meat production (at that time the European Union agricultural subsidies were paid to support certain production systems, today farmers receive a payment per hectare). Therefore, the new production system with the salt meadow is favourable for society. Balance 1 (see Table 1) shows that the new salt meadow is less costly (-238 € vs. -358 €) as going on with the removal of the water from the area behind the old sea dyke and the payment of the high public subsidies for agriculture. Those are reduced due to the lower level of agriculture.

During the time of the discussion of the dyke removal a study on the willingness to pay for the reestablishment of salt meadows in the area of the Southern Baltic Sea revealed a sum of 185 € on average per ha per year. Including this in a second balance calculation would improve the proportion to 6.8:1 compared to 1.5:1 before (-52 € vs. -358 €). This case study showed a positive cost-benefit ratio for the dyke removal.

MES Report 2: Ecosystem Services in Rural Areas: Basis of Human Well-being and Sustainable Economic Development

The second report of TEEB Germany is on ecosystem services in rural areas (Naturkapital Deutschland – TEEB.de 2016). The main aim is to strengthen the recognition of our natural capital in rural areas as decisions systematically underestimate the economic importance of ecosystem services for economic activities. The report shall reveal that investing in Natural Capital is worthwhile doing e.g.

- Reduction of nitrogen intake into marine ecosystem (Ahtiainen 2013),
- Preservation of small structures in agricultural landscapes,
- Restoration of wetlands for carbon sequestration and fixing of nutrients,
- Etc.

For marine ecosystems we have only a few examples of measures that improve biodiversity and preserve ecosystem services (see for example the dyke removal above). On land we have many examples of benefits of investments, cost-effective measures or benefits of nature conservation.

The problem is that it is harder to draw the link between conservation and preservation of ecosystem services which then results in benefits for society as ecosystems/habitats below the surface are not that easily visible and many ecosystem services, especially provisioning services, are not assessed. For the report on ecosystem services in rural areas we looked at the cultural services of e.g. whether fishing vessels and landings of fresh fish in small harbours are attractive for tourists.

The North Sea shrimp fishery

The most important fishery at the German North Sea coast today, the brown shrimp fishery, was originally carried out using trap-nets with the overall fishing effort being extremely low. Reason for that was that the Wadden Sea is very shallow and with only few areas were larger ships could operate (today the main shipping lanes). However, with rapid technological development during the 19th century, new fishing techniques developed quickly. Steamboats were able to employ effective bottom trawling and dredging techniques. Later, when beam trawling was introduced, a large fishery targeting brown shrimp developed (Schnakenbeck 1953, 49ff.). The shrimp trawlers are still small vessels that are located in the small harbours along the coast (see Fig. 4).

Over the last two decades, the number of vessels has been decreasing constantly, although the economic situation is favourable compared to other small-scale fishers. The main reason for the economic success of the shrimp fisheries is that brown shrimp (*Crangon crangon*) can be marketed as a unique regional product for a relatively high price. It is a typical Wadden Sea species, which cannot be substituted with any other product.

Figure 6: Shrimp beam trawler (© Thuenen-Institute of Sea Fisheries)

The shrimp vessels in the small harbours yield recreational services, as they have substantial positive effects on tourists (Schmücker & Schmüdderich 2010), while at the same time shrimp trawlers harvest a provisioning service (shrimps plus some fish catches). On the other side they have negative impacts on bottom habitats (Kratzer 2012). There is no possibility to measure those effects and, therefore, no further elaboration of costs and benefits has been undertaken.

Spatial planning in the German EEZ

The German Bundesamt für Seeschifffahrt und Hydrographie (BSH) is responsible for spatial planning in the German EEZ. Fig. 7 shows a map of the North Sea displaying the areas occupied by different sectors. This includes e.g. windparks (red), nature conservation areas (green), shipping lanes (blue) and cables (red lines).

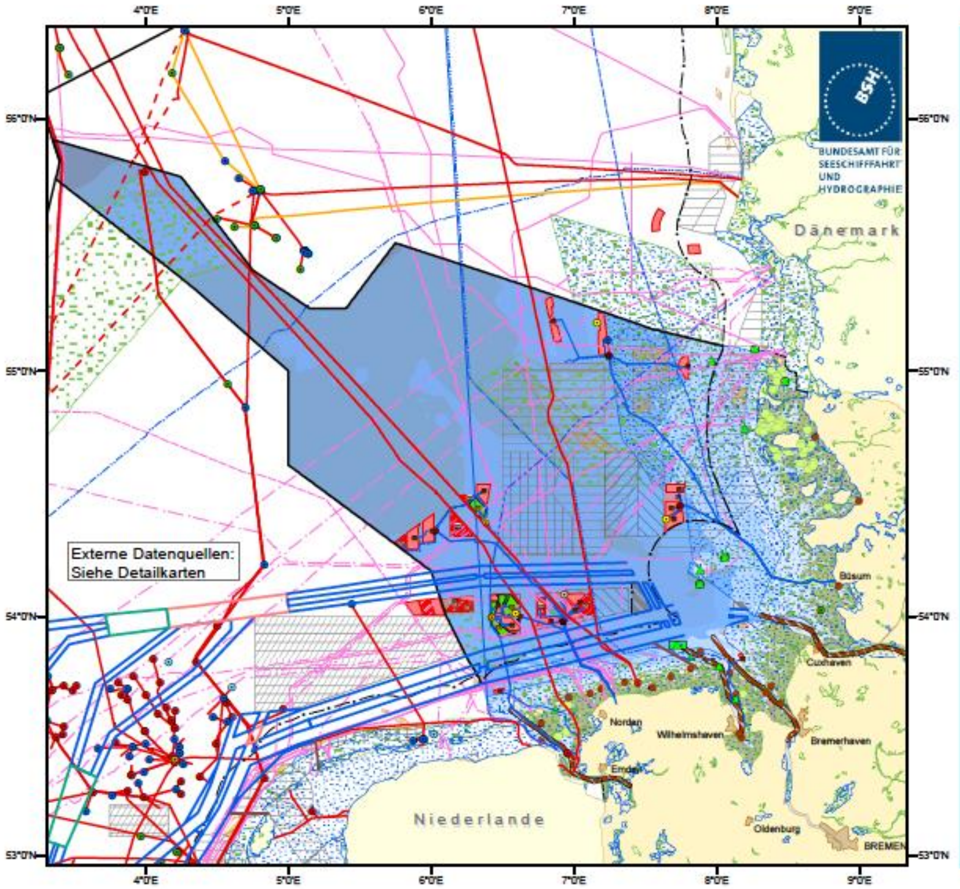


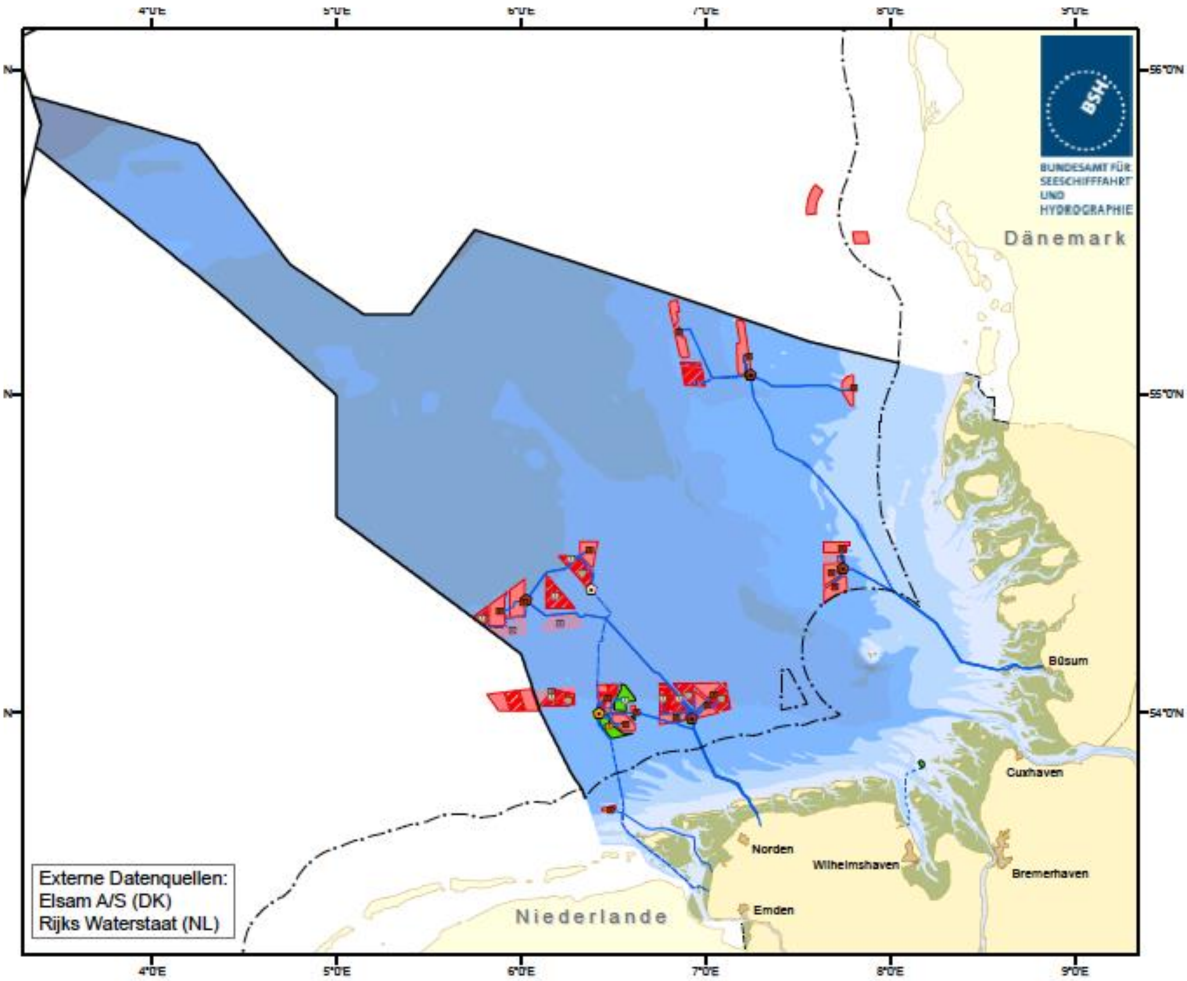
Figure 7: Spatial plans in Germany for the North Sea (© BSH)

Not all of these sectors have strong rights to exclude other economic sectors from using that space. Fisheries are regulated via input and output rights but fishers don't have a specific area right. Therefore, they can easily be excluded from an area if other users have clear rights on that area (as owner of windfarms or claims for sand and gravel removal).

For the BSH it is complicated to assess the economic consequences of the different activities including positive or negative impacts on ecosystems and the provision of ecosystem services. Regarding the ongoing installation of offshore windfarms it may be beneficial if an assessment of the values of ecosystem services could close some of these knowledge gaps.

The development of offshore windfarms in the German EEZ

Nearly two decades ago the German government decided to move energy production from fossil sources to renewable energy. A part of this change should be the construction of offshore windfarms in the North and Baltic Seas. The following map shows the current situation in the German EEZ in the North Sea.



The areas occupied by windfarms are increasing and meanwhile cover a substantial part of the German EEZ in the meantime. At the moment it is not allowed to enter the windparks with fishing vessels or to install equipment for the production of plants or fish in aquaculture facilities.

Figure 8: Windpark development in the German EEZ (© BSH)

Summary and Outlook

The project 'Natural capital Germany' was a project to show the current situation and possible effects of applying economic valuation of ecosystem services into decision-making processes. Two of the three final reports include chapters regarding coastal and/or marine ecosystems and give a good overview on the status quo of applying the ecosystem service concept. There are, so far, only a few studies on the economic valuation of marine ecosystem services in Germany. Most of the studies focus at terrestrial ecosystems and a reason for that could be that submersal marine habitats are not visible at first glance. The reports show, however, that the application of the concept of economic valuation can support the preservation of biodiversity, marine habitats and species.

There are no systematic assessments of economic values in the North or Baltic Sea so far. Most of the assessments done in the Baltic Sea are on effects of nutrient inflows. In several EU research projects the assessment of economic values of ecosystem services were included (e.g. FP 7 VECTORS). However, it is unclear how far the economic valuation will be part of the decision-making processes in the future. As the German example regarding the implementation of the MSFD shows there is only very limited application at the moment and so far it is also no regular part of marine spatial planning.

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4 Assessment of Coastal and Marine Ecosystem Services and its importance within Environmental Policy Implementation

Esther Robbe, Gerald Schernewski and Miguel Inácio
(Leibniz Institute for Baltic Sea Research Warnemünde [IOW])

Introduction

Ecosystem services are defined as the benefits humans obtain from ecosystems directly or indirectly (Costanza et al., 1997). Thus, the well-being of humans strongly depends on the provision of ecosystem services. Due to worldwide population growth up to 9 billion people till 2050 and urbanization processes, the demand for ecosystem services is constantly increasing, especially in coastal areas. Strong anthropogenic pressures on ecosystems (e.g. waste water discharge by agriculture and municipalities) lead to an overall degradation and decreasing provision of ecosystem services. This is also accelerated by other future threats like climate change (e.g. flooding). Especially coastal and marine ecosystems that are ever since intensively used by humans (e.g. fisheries, tourism, maritime industries) are degrading and losing its ability to support humankind with its services being pivotal for their well-being and survival.

As the ecosystem service concept allows for an anthropocentric and holistic perspective on ecosystems and its benefits to humans, there was an ongoing increase of interest in ecosystem services both in science as well as in policy during the last decade. The concept evolved from early concerns about environmental degradation and was institutionalized mainly from the disciplines economics and ecology (Chaudhary et al., 2015). In order to prevent and stop ecosystem degradation, multiple institutions, initiatives and projects emerged during the last 15 years (e.g. Millennium Ecosystem Assessment, Ecosystem Services Partnership). Also, several European Union policies (e.g. Water Framework Directive, Marine Strategy Framework Directive, Biodiversity 2020) aim to protect, restore and manage coastal and marine systems in a sustainable way within the ecosystem approach. Even tough, the quality of European water bodies has been improved over the last few decades, more than half of the surface water bodies in the EU hold less than good ecological status or potential (Tsakiris, 2015).

The last 30 years of ecosystem service research are dominated by studies focusing on terrestrial ecosystems (Liquete et al., 2013) and mostly on monetary valuations (Costanza et al., 2017). Some recent publications also study coastal and marine ecosystem services, e.g. on estuaries (Jacobs et al., 2015), on lagoons (Newton et al., 2018), and on marine protected areas (Jobstvogt et al., 2014). However, there is still a clear need for further ecosystem service research on coastal and marine waters. Another urgent challenge and need already identified in Daily et al. (2009) is to operationalize the concept. The awareness of the value of ecosystem services in management and policy issues may help to use research results to find solutions for sustaining natural capital and ecosystem services (Burkhard et al., 2012).

By means of two approaches for coastal and marine ecosystem service assessments we seek to fulfil the practical needs and research gaps mentioned. The overarching objectives of the approaches are: 1) to operationalize the ecosystem services concept by presenting and applying a computer aided assessment tool (e.g. within monitoring, policy implementation, urban planning), 2) to assess changes in the provision of coastal and marine ecosystem services on different temporal (past, present, future) and spatial scales (e.g. inner and outer estuary) through two different approaches - quantitative and qualitative - , and 3) to provide information by visualizing the benefits and/or costs of certain measures (e.g. achieving a good ecological state) in order to support sustainable management strategies. In this article we give a short summary of the methodology of the approaches by the exemplary case study of the Warnow Estuary in order to show their potential within environmental policy implementation in coastal and marine areas.

Coastal and Marine Ecosystem Service Assessment

The assessments can be carried out within a data-based and/or an expert-based approach. Both are based on the assumption that changes in ecosystem structures and functions influence the ability of ecosystems to provide services to humankind. The ecosystem service provision for coastal and marine waters are assessed through the relative changes of two different ecological states over time, and thus in non-monetary terms. Initially the Marine Ecosystem Service Assessment Tool (MESAT) (Inácio et al., 2018) was developed to compare a former good ecological state with the present (often degraded) state. Nevertheless, the approach also allows for different application possibilities and can be adapted to diverse purposes (e.g. future scenarios).

Classification and indicators are adapted from the Common International Classification on Ecosystem Services (CICES V.4.3) according to Haines-Young and Potschin (2013) and from the EU project Mapping and Assessment of Ecosystems and their Services (MAES) (Maes et al., 2016). Accordingly, ecosystem services are divided into three categories: 1) provisioning (e.g. food, water), 2) regulating and maintenance (e.g. flood protection, climate regulation), and 3) cultural services (e.g. aesthetics, recreation). Further, they are organized hierarchically into divisions, groups and classes. In total 31 ecosystem service classes are included that can be assessed by 54 indicators (see Fig. 4). Besides, the assessment results are given in eleven classes of change with non-linear class boundaries (Fig. 9). For the calculation of the score, the indicator value of the present situation is divided by the value of the status of the earlier periods in time. The allocation into scoring classes allows for assessments even without concrete values, and thus, also for scenario assessments based on expert valuations.

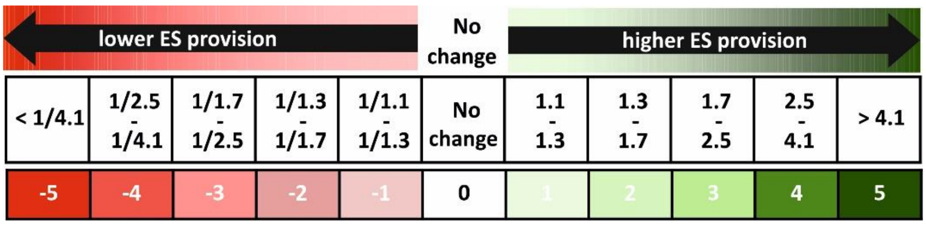

Figure 9: **The relative scoring system of MESAT.**

Several coastal and marine ecosystem service assessments have been done so far within these approaches - both quantitatively and qualitatively. Therein comprehensive data and information on transitional and coastal waters were collected and case studies were applied. Among others Szczecin Lagoon (Schernewski et al., 2018a), Curonian Lagoon (Inácio et al., 2018), Pomeranian Bay (Benz, 2016), Schlei Estuary (Paysen, 2017) and Warnow Estuary (Robbe, 2018) have been assessed.

Data-based Assessment

The Marine Ecosystem Service Assessment Tool (MESAT) (Inácio et al., 2018) allows for a (semi-) quantitative, data-based assessment. It compares the present ecological state with the past or initial state (usually around 1960) and is carried out by one single evaluator (user of the tool).

For practical relevance, the tool builds on the Water Framework Directive´s (WFD) typology (spatial definition of assessment units) and guidelines (reference conditions). The Directive´s aim is to achieve good environmental status (GES) for all European surface water bodies. Reference conditions describe a high ecological status, which was defined for the time around 1880 in Germany. The good ecological status, or desirable target conditions, was derived for most of the German coastal waters around 1960. Strong eutrophication levels were only known after 1960 leading to severe degradations of the ecological status (Schernewski et al., 2015). Using the WFD typology, the assessment results can be easily compared and/or extrapolated and/or transferred to other water bodies of the same type or system. Using the WFD´s reference conditions results can show the effect of achieving GES and visualize its benefits. This is only one option to apply the tool, as also other past or future states can be compared.

The application of the tool consists of four steps: 1) definition of the study area, 2) definition of two time periods representing different ecological statuses (initial and present state), 3) assessment of ecosystem services, and 4) visualization of results (for more details see Inácio et al. (2018)). The implementation through Microsoft EXCEL enables automated calculations, score averaging (see Fig. 1), data aggregation, and visualizations (see Fig. 4). Application guidelines and an assessment of data quality are included. A single evaluator with broad knowledge of the study area applies the tool quantitatively. Preference is given to observational and crisp data (from datasets and databases), followed by literature-based information, other data (modelling), and lastly using expert judgment. The data is categorized according to its reliability into “very high (1)”, “high (2)”, “moderate (3)” and “low (4)”. The tool can be freely downloaded from the BONUS BaltCoast website (http://www.baltcoast.net).

Expert-based Assessment

The second approach is a pure qualitative, expert-based assessment comparing different ecological states, e.g. past with present state or present with a future, hypothetical state.

The assessment consists of the following steps: 1) definition of the study area, 2) definition of two time periods representing different ecological statuses (past, present and/or future states), 3) definition of future, hypothetical state(s) (scenario development), 4) carrying out an expert workshop for the assessment of ecosystem services. In this way, the subjective perceptions from different stakeholders can be gathered and used for an assessment of future scenarios and/or possible management and planning measures.

This was done, for example, on management level (different scenarios for mussel farming) for the Szczecin Lagoon concerning Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) (Schernewski et al., 2018a). Also, this was done on policy level in the context of the Water Framework Directive (i.a. improved water quality) for the Schlei Estuary and the Warnow Estuary (Schernewski et al., 2018b - submitted), as well as for the Curonian Lagoon (Inácio et al. 2018).

Case Study: Warnow Estuary

The Warnow Estuary (including Breitling) is located at the German Baltic coast, surrounded by the city of Rostock and covers an area of 12.6 km^2 with a total length of 14.4 km. This case study was chosen due to its urban and industrialized character and history. It can be used as an exemplary, representative case study in the realm of coastal urbanization and population growth causing biodiversity loss and ecosystem degradation. According to the German WFD typology, the estuary is classified as a mesohaline inner coastal water (type B2) and since 2013 defined as a heavily modified water body (HMWB). For the purpose of this study the water body was further subdivided into the Northern and Southern Warnow Estuary.

In a first step, three quantitative, data-based assessments have been carried out comparing past and present ecological states: 1) a comparison of the historic state around 1880 (where a high ecological state is assumed) and the present state, 2) a comparison of the historic state in 1960 (where a good ecological state is assumed) and the present state in the Northern Estuary, and 3) a comparison of the historic state in 1960 and the present state in the Southern Estuary. In a second step, a qualitative, expert-based assessment has been carried out comparing the present state with a hypothetical future scenario of the Warnow Estuary for 2040 (Fig. 3). The objectives of this case study were, among others, 1) to test the tool suitability for an assessment in coastal, urban and industrialized areas (subdivided in the Northern and Southern Estuary), 2) to assess the ecosystem services of the study area for the historic situations in 1880 and 1960, and 3) to show the effects of developed scenarios (including planning and management measures, and policy implementation) on overall provision of ecosystem services.

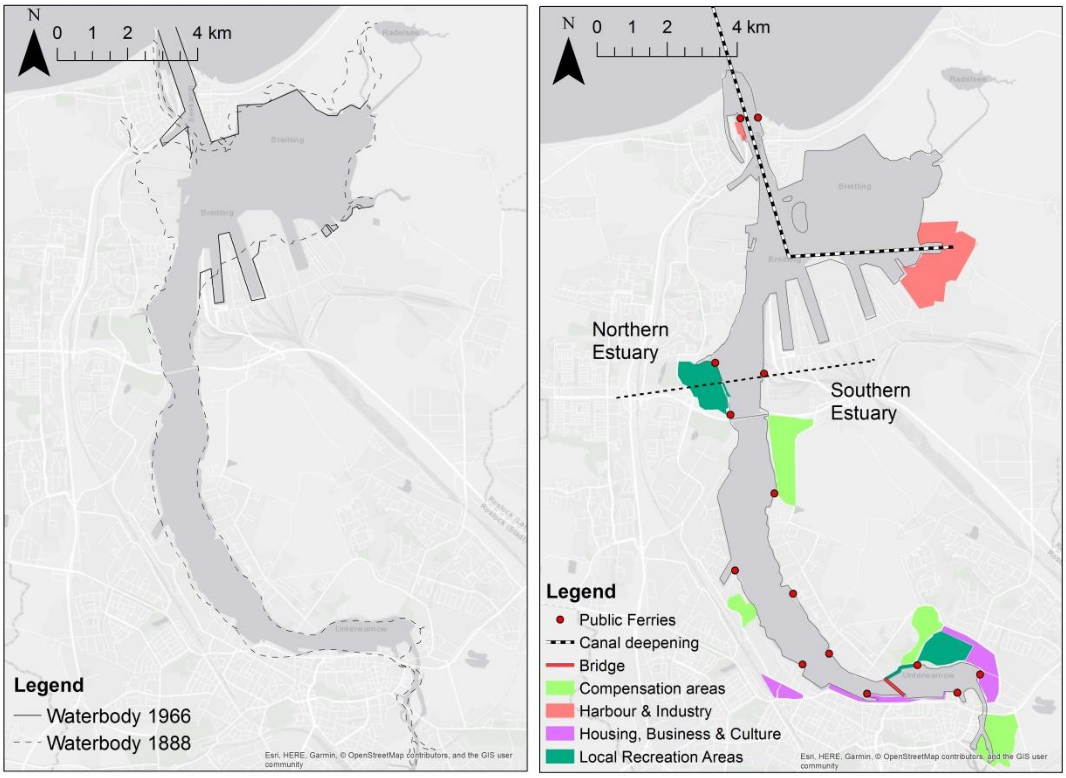

Figure 10: Reconstructed historic map for the data-based assessment (left) & Future scenario map for expert-based assessment (right)

The data-based assessments (see Fig. 11) reveal three major influencing factors on ecosystem service provision (apart from water conditions). These are 1) the socio-economic environment, 2) the political settings, and 3) hydromorphological changes. First, the study results show that a historical comparison is extremely difficult with regard to the given classes and indicators. It becomes clear that several indicators, especially the cultural ecosystem services, are not suitable for a comparison on this historic temporal scale. Most indicators are applicable and suitable for present state evaluations and also for the state around 1960, but they show major difficulties for the time around 1880. Such problems, especially when assessing cultural ecosystem services, are also found in recent literature (Chan et al., 2012). Besides, as there was also a shift of preferences with regard to recreation and aesthetics over time, the perception of ecosystems and its uses changed significantly due to the socio-ecological co-evolution, industrialization and globalisation (Kemp and Rotmans, 2005). Second, another problematic aspect when it comes to comparability, is the changing political setting over time. For this case study this is of special importance for the historic state around 1960, as the German Democratic Republic (GDR) was significantly shaping the human use of ecosystems and their perception of nature. GDR philosophy was more focused on physical experiences in nature promoting hiking and fitness. There was mainly local tourism, as the borders were closed and only few options existed to go abroad for vacations. Thus, most touristic activities were concentrated at the Baltic coast. Third, the results also show the significance of morphological and physicochemical changes of the system with regard to the provision of ecosystem services. In the 19th century, high freshwater inflow from the Warnow river and only a low salt water inflow from the Baltic led to a very low salinity gradient almost at freshwater level. Some of the morphological and physicochemical indicators actually do not really reflect the changes in provision of ecosystem services, but only of the system itself, for example, salinity, water residence time, and water depth. They only indicate that there have been changes, but not whether they affect the provision in terms of increase or decrease, e.g. different types of flora and fauna. The results also show that the water area is a crucial factor influencing the provision of ecosystem services. The very same indicators are also affected by changing water depth as a crucial morphological parameter.

Besides, the results also show that the assumptions about the ecological status of the water body for the historic periods of time were partly incorrect. On the one hand, the reference conditions around 1880 were chosen due to its assumed high ecological status. According to the results this assumption seems to be true, as they show a severe degradation of the ecosystem with regard to the provisioning services as well as to the regulating and maintenance services. Nevertheless, the hydromorphological character of the water body has changed significantly (e.g. salinity, bathymetry, anthropogenic influences, modifications, and water residence time). Therefore, it is difficult to compare this state with the present one even though the assumption of a high ecological status holds true. On the other hand, for 1960 a good ecological status of the water body was assumed. However, the results confirm that the state around 1960 is not a suitable reference condition for the good ecological status in case of the Warnow Estuary. The water body was already degraded significantly and actually in worse conditions than nowadays. This is, for example, due to poorly filtered waste water, harbour construction and increasing industry.

Concerning the expert-based assessments, the scenario for the Southern Estuary is characterized by the urban development plans like national garden show, seaside housings, local recreation areas and development of a maritime harbour city. Thus, the results show that the cultural service provision clearly dominates and increases in the South. These are for example bathing and sunbathing, aesthetic experience, and culture and heritage. Compared to the scenario for the Northern Estuary that is characterized mainly by harbour and industry, here it is noticeable that the focus lies on the increasing provision of provisioning services, for example navigation and waterways, harbours and maritime industries, and water discharge. The expert-based assessment results show that this approach can be suitable for depicting possible future scenarios and its effects on ecosystem service provision. Besides, misunderstanding among stakeholders can be discussed and cleared up. The integration of ecosystem services and its assessment bear huge potential for different steps and processes of measure implementations within policy, management, planning, and wherever decision-making is involved, which was also already stated by Daily et al. (2009) and de Groot et al. (2010).

Summarising, the case study presents opportunities (e.g. measure implementation) and threats (e.g. misleading results) as well as strengths (e.g. broad understanding) and weaknesses (e.g. comparability) of ecosystem service assessments when applying both the data-based and expert-based approach. Using the ecosystem service approach for understanding the complexity of socio-ecological systems can show the consequences of certain changes on the provision of ecosystem services. In this way, it allows a non-monetary visualization of costs and benefits of certain measures (like environmental policies, coastal protection, spatial planning) and hence their communication to a broader audience for better understanding and acceptance.

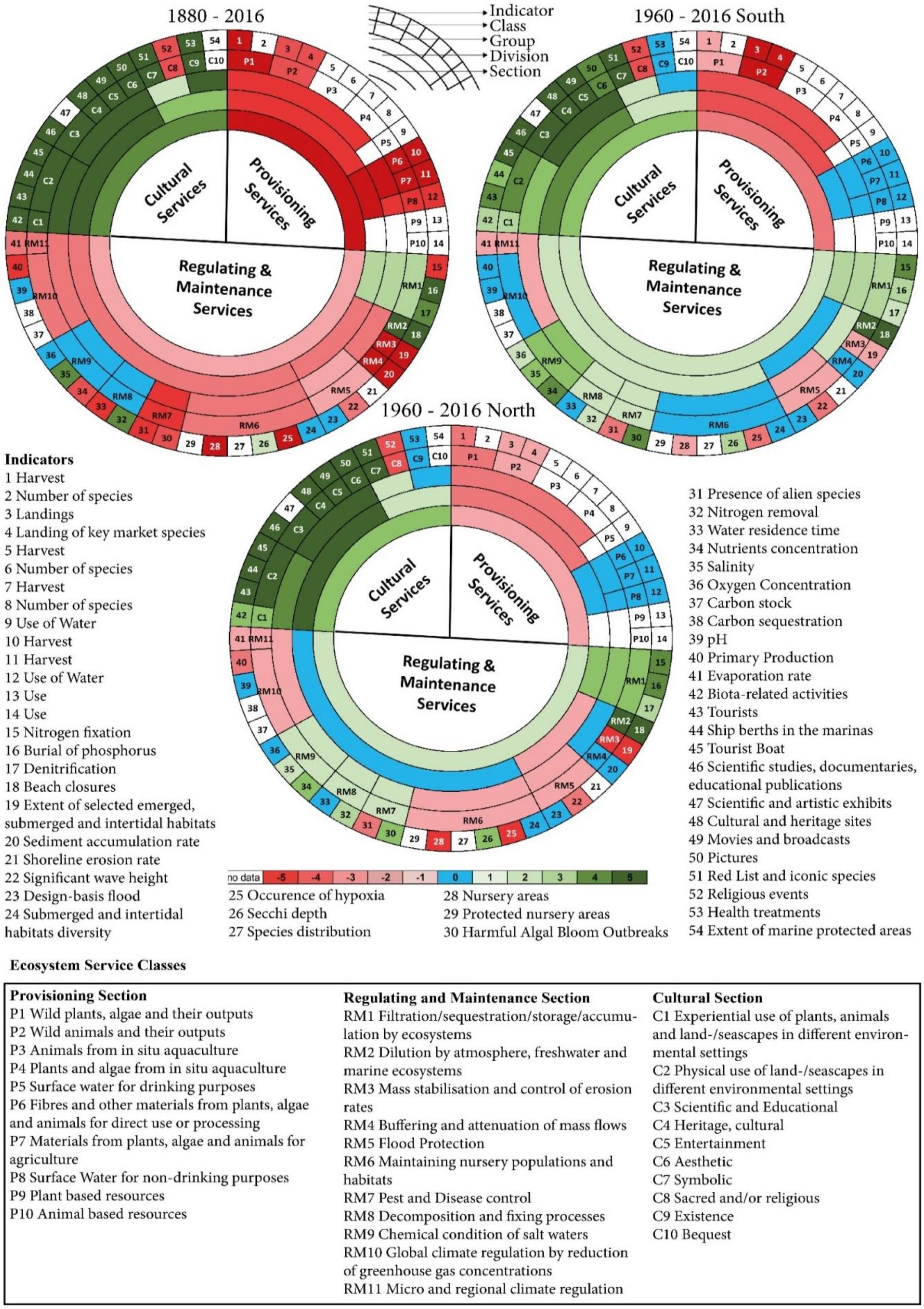

Figure 11: Assessment results of the (Northern and Southern) Warnow Estuary (Robbe, 2018)

Discussion & Conclusion

In contrast to previous studies, this article presents two non-monetary approaches that serve as tools for the assessment of coastal and marine ecosystem services. The case study shows some potential of these approaches within environmental policy implementation in coastal and marine areas. The assessment approaches have the capacity and benefit of being able to assess the impact of temporal dynamics and thus to compare different ecological states of coastal waters related to their ecosystem service provision. The main advantage of the approaches is the use of relative change classes instead of absolute values following the recommendation for non-monetary assessments by Newton et al. (2018). In this way, the standardized comparison between ecosystem services, water body types, data types and study areas are possible.

One of the main weaknesses of the assessment of ecosystem services is its pure anthropogenic perspective widely neglecting the inherent value of nature. The expert-based assessment is of strong subjective character, because the results are highly influenced by the experts´ individual perceptions. Nevertheless, acknowledging this subjectivity can also being used as an advantage. Especially when working with stakeholders and/or the broad public this can support awareness raising and consensus building by eliminating misconceptions, and by increasing understanding and acceptance of certain decisions and measures, e.g. mussel farming in the Szczecin lagoon (Schernewski et al. 2018a).

Current research focuses on the expansion to the coastal sea, thus the entire German Baltic waters, on improvements when assessing cultural ecosystem services, and on including abiotic ecosystem services by adaptations according the new CICES V5.1 (Haines-Young and Potschin, 2018). For further research it is recommended to test the tool with different stakeholder groups within measure implementations for environmental policy (e.g. ecological enhancement), management (e.g. coastal protection) and planning (e.g. urban development). A possible extension of the assessment could be at river basin level with the aim to project changes in ecosystem service provision due to certain inland measures on coastal areas (Schernewski et al., 2018b – submitted). Further research on suitable indicators is necessary, especially for cultural services (Chan et al., 2012).

In conclusion, results of the case studies that have been applying the approaches (both the data-based and expert-based) imply that the assessment of coastal and marine ecosystem services can play an important role in the planning and management of coastal and marine areas (Inácio et al., 2018; Schernewski et al., 2018a; Schernewski et al., 2018b - submitted). It is of high practical relevance, as federal agencies and departments, institutions and other practitioners can apply the tool and can support measure implementations of environmental policy (e.g. Water Framework Directive), management (e.g. Integrated Coastal Zone Management) and planning (e.g. Marine Spatial Planning). The approaches turned out to be suitable for application within environmental policy implementation in coastal and marine areas, as it allows for a relative comparison of ecosystem service classes, is spatially expandable and transferable and enables a relatively fast assessment. The tool is applicable, for example, for stakeholder involvement, consensus building, decision-making, and monitoring and controlling mechanisms.

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5 The role of sandy sediments for the North Sea ecosystem

Soeren Ahmerkamp
(Max Planck Institute for Marine Microbiology, Bremen)

Introduction

Continental Shelves and the North Sea

Continental shelves are submarine terraces connecting the continents to the open oceans. With maximum water depths of less than 200 m, continental shelves extend on average 65 km from shore. The total occupied area of all continental shelves encompasses $30 \cdot 10^6$ km^2, representing 7.5% of the total ocean area (Jahnke, 2010). Despite their relatively small area, continental shelves are highly productive ecosystems and essential for marine life (Walsh, 1991). In fact, the primary production fueled by river runoffs, aeolian inputs, groundwater discharge and upwelling accounts for 15-21 % of the global production (Jahnke, 2010).

During the last glacial period water levels were 120 m lower then today and most of the shelves were exposed. Roughly 22,000 years ago, after the last glacial maximum, sea level started to rise and the terrigenous material was eroded leaving behind relict silica sediment. The shallow water depths on continental shelves tie the sediment distribution to the strong hydrodynamic forcing. Observations of surface waves have shown that 40% of the shelf sediments are potentially eroded and reworked (George and Hill, 2008). This is enhanced by tidal currents which alone have the potential to mobilize the coastal seafloor (McCave, 2002). The mobilization of sediments leads to a re-suspension of fine material leaving behind coarse grained sands. These finer sediments are redeposited in regions of weaker hydrodynamic forcing, i.e. the outer continental shelves. On average sands constitute approximately 50 % of all shelf sediments with the remaining fraction mostly composed of rock and gravel, and to a small extent silt and clay (Emery, 1968).

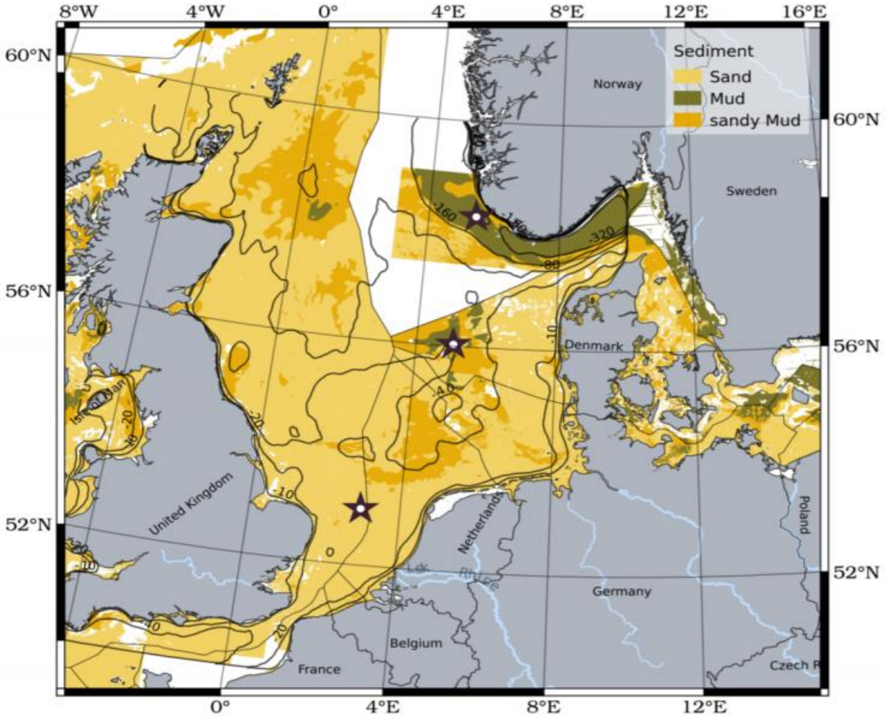

Figure 12: **The North Sea sediment is depicted in colors while the black lines indicate the bathymetry. The map reveals that the seafloor of the North Sea, including the German Bight, is mostly covered by sandy sediment and to a lower extent by muddy sand and mud (Data provided by EMODnet** *http://www.emodnet.eu/****, from (Ahmerkamp, 2016)*****.**

One example of a strongly eutrophied continental shelf is the North Sea. The North Sea covers a total area of 575000 km^2 and as a marginal shelf is encompassed by France, Belgium, Netherlands, Germany, Scandinavia and Great Britain. The seafloor is mostly composed of relict silica and silt sediments (Figure 12) transported during the last glacial period. Exposed to the strong tidal and wave forcing the sediments undergo frequent re-distribution and sorting, which leaves behind coarser grained sediments and forces finer sediments into regions with reduced hydrodynamic forcing such as the Skagerrak in between Denmark and Norway, where the North Sea reaches down to more than 700 m (De Jorge and Van Beusekom, 1995).

The southern part of the North Sea is mostly composed of the so-called German Bight water. As a result of the low water depth the German Bight water is characterized by strong riverine discharges mainly induced by Rhine (2900 m^3s^{-1}), Elbe (870 m^3s^{-1}) and Meuse (350 m^3s^{-1}) leading to anthropogenic nutrient enrichment fueling high productivity (Lenhart and Pohlmann, 1997). In terms of inorganic nitrogen the total export into the North Sea by rivers equals in average 300 kt y^{-1} but is also highly variable as estimates range from 1271100 kt y^{-1} (Johannsen et al., 2008). These riverine runoffs coincide with strong primary productivity with an estimated annual carbon fixation rate of 31 mol m^2 y^{-1} (Wollast, 1998). The high primary production within coastal waters reduces nutrients from coastal waters towards the open seas which are than exported within organic matter to the sea floor.

The high primary production in the water column in combination with shallow water depth indicates that there is a strong biogeochemical cycling within the sandy shelf sediments. Despite this fact little is known on the role of sandy sediments for the global nutrient and carbon cycles.

Biogeochemical Cycling in Shelf Sediments

For the global biogeochemical cycles ocean sediments play a decisive role because they inhabit a high number of microorganisms (~10^9 cells per milliliter) which contribute significantly to the turnover of organic carbon and nutrients. A large part of the microbial activity is associated with the consumption of oxygen which, as the energetically most favorable oxidant, is a good indicator for the microbial activity and overall intensity of the carbon turnover. However, it is especially the anoxic processes in the sediment, such as denitrification, that determine the global nutrient cycle. The interaction of microbial activity and transport of reactive substances in the sediment is therefore a focus of biogeochemical research. In cohesive muddy sediments, which are mainly found in the deep sea and other areas with low water currents, mass transport in pore water is limited by diffusion. The transport reaction conditions are well understood in these diffusively regulated sediments and can therefore be considered in global models. This is not yet possible for another category of sediments: permeable Sands.

The mass transport in permeable sandy sediments is order of magnitudes higher due to the advective pore water flow than in diffusively regulated sediments (Huettel et al., 2014). The increased oxygen flow allows the organic carbon to be 'burned' more effectively. Advective pore water flow in permeable sands occurs when bedforms (ripples: wavy structures at the sea floor) interact with the currents above, creating pressure gradients at the surface that continuously pump bottom water through the sediment and thus supply benthic organisms with organic carbon and dissolved substances from the water column. Although the theoretical significance of sandy sediments has been known for two decades (Huettel et al., 1998), investigations were almost exclusively experimental performed under laboratory conditions. Neither strongly varying tidal currents nor sediment transport were considered - both characteristic features of the continental shelf. Thus it was not known how biogeochemical processes can be regulated, quantified and predicted under real conditions.

Ecosystem Function of Sandy Sediments

Methodological Approach

In a cooperation project between the Max Planck Institute for Marine Microbiology and MARUM – Centre for Marine Environmental Science the ecosystem functioning of sandy sediments in the German Bight, North Sea was investigated. The strong wave and tidal forcing in North Sea required the development of new methods. Therefore, the lander system ‘LanceALot’ (Figure 13) was constructed to monitor concurrent measurements of bottom water currents, bed surface topographies and oxygen penetration depths, as well as their temporal variability. The response of benthic oxygen penetration and net fluxes to tidal currents, waves and events of sediment mobilization could be described and quantified for various sediment types, bottom water velocities, and microbial respiration rates. For a better mechanistic understanding the in situ measurements were complemented by numerical models and laboratory experiments.

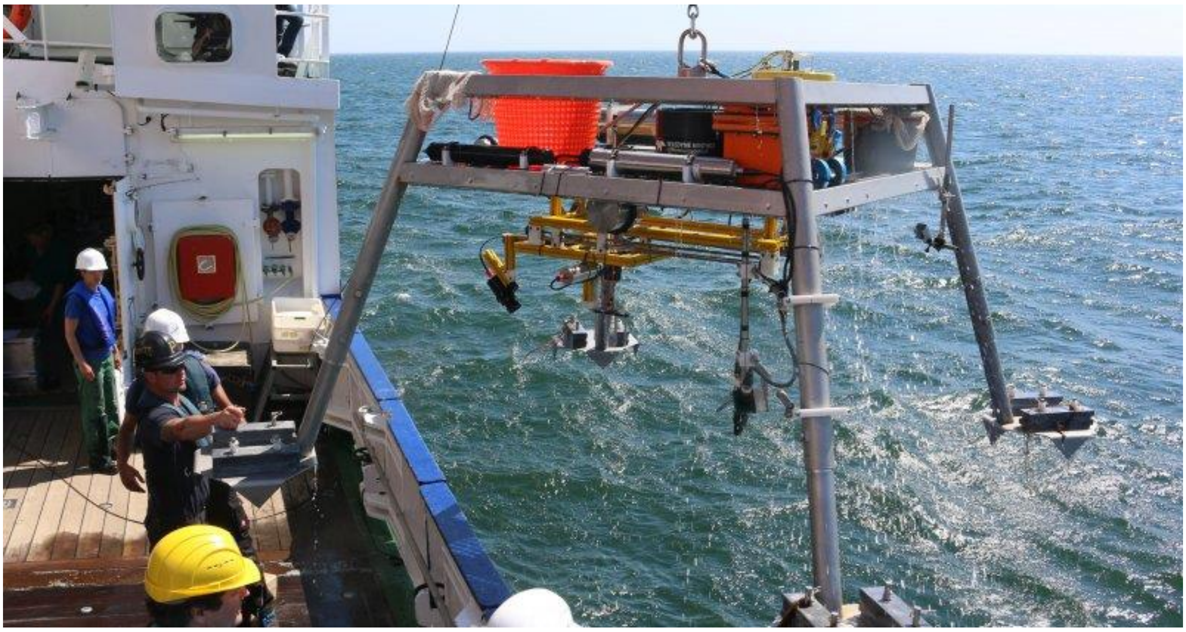

Figure 13: **The benthic observatory "LanceALot" after retrieval from the sea floor of the North Sea.**

Sandy Sediments - a dynamic microbial habitat

For a long time sandy sediments have been ignored as biogeochemical desert (Boudreau et al., 2001). The reason is that measured carbon contents are typically low; however, this is in strong contrast to the high productivity as found in the coastal ocean. In a traditional view, sediment and water column have been seen as two separated systems where the sediment is the receiver of the organic material from the overlying water column. The microbial activity is therefore directly triggered by the total amount of organic carbon. However, this paradigm was overturned as our understanding has grown of advective porewater flow, which transports particles and solutes directly into sandy sediments enhancing the bentho-pelagic coupling (Huettel et al., 2014). In fact, the mass transport is accelerated by several orders of magnitude and the microbial communities are so active, that a large portion of the received organic carbon is remineralized (Santos et al., 2012).

The in situ measurements show that oxygen dynamics and exchange fluxes are regulated by a complex interplay of rapidly changing transport rates and microbial activity. This implies that changing current velocities, wave heights and in general tides influence biogeochemical processes in sands. Sandy sediments, therefore, represent an environment where chemical conditions vary strongly in time and space (Ahmerkamp et al., 2017). A single sand grain is colonized by 10.000 – 150.000 microorganisms (Probandt et al., 2017) which have to face this challenging conditions as the organisms must withstand a variable and fluctuating supply of oxidants and reductants. Only recently it was shown that such conditions promote unique metabolic adaptations, such as denitrification in the presence of oxygen (Marchant et al., 2017).

Sandy Sediments - a biocatalytic filter that protects the open oceans from anthropogenic nutrient inputs

The strong variability of solute distributions and gradients within sandy sediments complicates the quantification of biogeochemical processes; therefore, biogeochemical datasets for sandy sediments are few. Further, a parametrization that accounts for the combined effects of porewater advection and microbial activity in biogeochemical models has been lacking. Employing a numerical model that covers the full complexity of exchange fluxes, a simplified mechanistic model was derived which allows for an order of magnitude scaling of benthic fluxes for sandy sediments (Ahmerkamp et al., 2015). This model is largely controlled by grain size, current velocities and microbial respiration rates and is able to well predict in situ measurements (Ahmerkamp, 2016).

In a first approach, the model was used to investigate carbon cycling and nitrogen-loss processes within the German Bight (exclusive economic zone of Germany). The results show, that roughly 10 % of the organic carbon which is produced in the water column is mineralized in the sandy sediments (Figure 14). The remaining 90 % are mineralized in the water column indicating that shelf sediments are neither a sink nor a source for organic carbon. However, the high organic carbon supply in combination with the efficient microbial communities in sandy sediments trigger nitrogen loss process that remove more than 30 % of the total nutrient inputs. This underpins the important role of sandy sediments as a biocatalytic filter protecting the open ocean from anthropogenic nutrient inputs. The estimates are conservative as additional exchange processes like bioturbation and bioirrigation might strongly enhance solute fluxes.

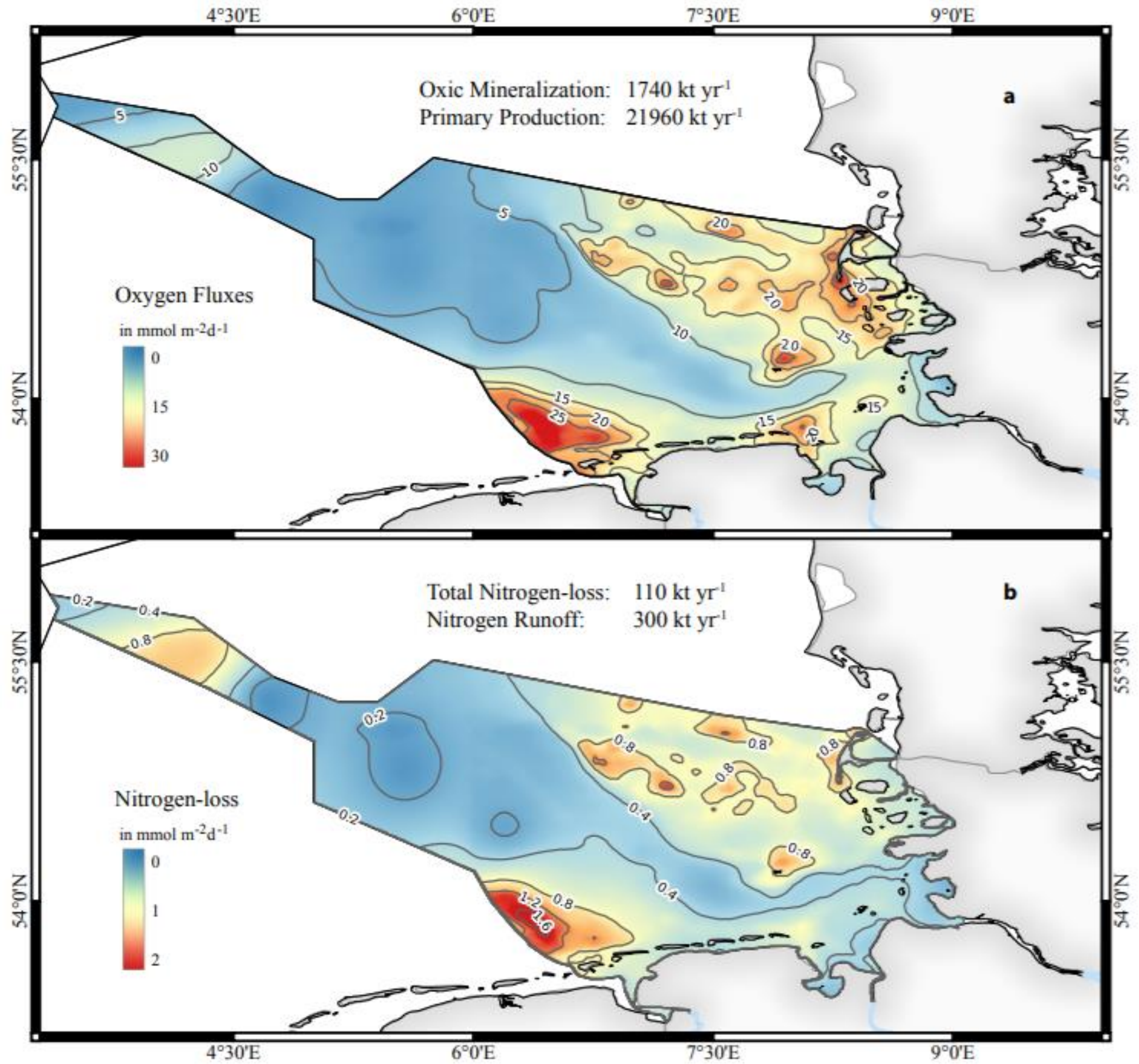

Figure 14: **Modelled oxygen fluxes in the German Bight as indicator for the carbon mineralization. Roughly 10% of the produced organic carbon is mineralized within the sandy sediments. b The high turnover rates trigger processes like denitrification that remove a large fraction (30 %) of the riverine nitrogen inputs (Ahmerkamp, 2016).**

Vulnerability of the ecosystem function

Despite the increasing knowledge of the important ecosystem function of sandy sediments, little is known on the vulnerability of the key mechanism as biocatalytic filter. Disturbances range from fish trawling, exploitation as mineral commodity to increasing nutrient loading. The tracks of fish trawling are a ubiquitous phenomenon at the sea floor. The bottom trawl gear penetrates more than 30 mm into the sediment, strongly affecting benthic life (Jones, 1992). While there is an increasing number on studies investigating the effects on macrofauna, the extent of disturbances on microbial communities and the associated biogeochemical cycling is not understood.

In 2018 Germany was sued as a consequence of alarming nitrate levels. Elevated nitrate concentrations in groundwater typically lead to an increased nutrient supply to coastal waters (Santos et al., 2012). Consequently, primary production is increased which might have severe impacts on ecosystems. While the plankton bloom itself might be already harmful (Anderson et al., 2002) also indirect impacts should not be underestimated. Enhanced plankton blooms might increase organic carbon export towards the sea floor. As the filtration function of sandy sediments is likely to be limited, the increased intake of organic carbon might clog pore spaces and reduce the efficiency of sands as a biocatalytic filter. However, data is still missing and further research has to be done to make concise statements.

Conclusions

Sandy sediments cover more than 50% of all continental shelf areas and 90% of the North Sea seafloor. Research of the last decade has shown that these permeable sands play an important role in the biogeochemical cycling of carbon and nutrients on continental shelves. The interaction of microbial reaction rates with transport processes such as advective porewater flow and sediment transport leads to a microbial realm characterized by large variations in chemical gradients. Therefore, a unique microbial community is formed that is highly efficient in the removal of critical nitrogen inputs. Inhabited by this unique microbial community, coastal sands play a vital role in buffering the open oceans from anthropogenic eutrophication. However, the increased number of anthropogenic disturbances such as fish trawling, exploitation as mineral commodity and increasing nutrient loading might have severe impacts on their ecosystem functioning. Even though the impacts and vulnerabilities are not fully understood, it is of importance to consider an extended protection of the sand habitat.

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6 Cultural Ecosystem Services of coastal areas – the case of tourism and recreation in the German maritime national parks

Marius Mayer
(Universität Greifswald)

Introduction

Oceans and coastal areas generate very important ecosystem services (ESS) for mankind (Martínez et al. 2007). These include also relevant cultural ecosystem services (CES) like tourism and recreation, spiritual enlightenment, identity or place attachment which can be attributed to water and coastal areas (Liquete et al. 2013, Hynes et al. 2018). However, the operationalization and quantification of CES is far from straightforward, especially for more qualitative aspects like the spiritual, aesthetic and identity dimensions of ecosystems, while tourism and recreation are often used as the most straightforward CES in quantification and valuation studies (Milcu et al., 2013; Hynes et al. 2018), as long-established valuation methods like the travel cost method (TCM) exist (Ward and Beal, 2000; Hanley and Barbier, 2009). Therefore, the literature highlights tourism and recreation as one of the most valuable CES provided as they are more directly linked to human well-being which may motivate public support for protection efforts (Hynes et al., 2018). Thus, it seems appropriate to explicitly assess recreational ecosystem services (RES) considering the widely-acknowledged role of nature and ecosystems as attraction factors for tourism and recreation (Deng et al., 2002). Consequently, we refer to RES as “the natural environment’s contributions to the range of leisure and recreational opportunities and experiences enjoyed by human societies” (Hermes et al., 2018, p. 290) while Liquete et al. (2013, p. 6) generally define them as “opportunities that the natural environment provide for relaxation and amusement”.

However, even though the TCM as a means to estimate recreational values of natural sites is well-established and widely-criticized for several years, its application requires site-specific visitor numbers and at the same time detailed visitor surveys including information about covered distance from home, the mode of transportation etc. (Ward and Beal, 2000). Due to the relatively high effort to obtain these data in high qualities, the RES of coastal and maritime areas in Germany can only be estimated for parts of these areas for which these data are existing. Therefore, this contribution uses the potential to analyze RES of the four German maritime national parks (NLP), Lower Saxony and Schleswig-Holstein Wadden Sea, Jasmund and Western Pomerania Lagoon Area (Europarc, 2011), using TCM based on earlier economic impact studies of NLP tourism (Job et al. 2009, 2016; Woltering 2012; Mayer et al. 2010; Mayer & Job 2014).

Cultural ecosystem services in coastal and marine environments

CES are defined as the “nonmaterial benefits people obtain from ecosystems” (Millennium Ecosystem Assessment (MEA), 2005, p. 40) and entail “cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism” (MEA, 2005, p. 40). However, ES and especially CES are not produced ready-made by ecosystems, but benefits from ecosystems arise because of humans’ engagement with an ecosystem (Fischer & Eastwood, 2016). In other words, “most services are actually co-produced by a mixture of natural capital and various forms of social, human, financial and technological capital” (Palomo et al., 2016, p. 246). Humans can be (1) involved in the production of ecosystem structures, (2) play a crucial part in the production of (ecosystem) benefits and (3) attribute meaning to a service or benefit, i.e. they construct ESS and benefits (Fischer &

Eastwood, 2016). This co-production and co-construction of ESS holds especially true for CES (Daniel et al., 2012; Fischer & Eastwood, 2016), and, as we argue, even more for RES due to the inherent nature of tourism and recreation. Consequently, Costanza (2008) and Paracchini et al. (2014) classify recreation as "user movement-related". Fish et al. (2016, p. 211), do not regard CES (including RES) as "*a priori* products of nature… but as relational processes and entities that people actively create and express through interactions with ecosystems". Therefore, our approach to estimating the RES of German maritime NLP relies on actual (not potential) recreational use, considering: i) physical structures of ecosystems (landscape amenities like the Wadden Sea); ii) accessibility (created by humans in terms of roads, train tracks, ferries etc.); iii) the distribution of potential recreational demand (population density and settlement structure, "produced" by people); iv) destination image (constructed by people as NLP might be more well-known than comparable landscapes); and v) the *uno-actu* principle in tourism, i.e. the simultaneity of production and consumption in services. This final aspect sustains that an area cannot have RES *value* if no visitors go there, but only a RES *potential* influenced by the other features cited (Gee and Burkhard, 2010; Carius, 2013).

Liquete et al. (2013) summarize in their review about the state-of-research of marine and coastal ESS that the most important classification schemes of ESS all include CES and more specifically (opportunities for) recreation, leisure and (eco)tourism. Examples of the CES of marine and coastal areas besides attractive beaches for tourism and recreation purposes could include inspiration for art and culture (e.g. Caspar David Friedrich's famous paintings of the chalk cliffs on the Island of Rügen, Germany), spiritual experiences (such as a burial at sea), cultural heritage, myths and arts (such as the legend of the Flying Dutchman turned into a romantic opera by Richard Wagner) or knowledge, sense of place, heritage and education (like the traditional knowledge about coastal protection and dyke building at the German North Sea coast). More specifically, the marine/coastal specific component of tourism and recreation is defined as follows: "The appeal of marine ecosystems is usually linked to wilderness, sports, or iconic landscapes and species. It can be related to coastal activities (e.g. bathing, sunbathing, snorkeling, scuba diving) and offshore activities (e.g. sailing, recreational fishing, whale watching)." (Liquete et al. 2013, p. 6). Tourism and recreation rank fourth among 14 marine and coastal ESS in terms of frequency of analyzed indicators, while the other CES, symbolic and aesthetic values and cognitive effects, rank much lower; ninth and tenth respectively (Liquete et al., 2013).

Methods and materials

The materials and methods used for the TCM of the German maritime NLP are described at length and full detail in Mayer and Woltering 2018 and Mayer 2013. Therefore, only the most important information is provided here.

The TCM are based on existing economic impact studies conducted between 2007 and 2012/13 in the German maritime NLP[3] (Job et al., 2009, 2016; Mayer and Job, 2014; Woltering, 2012). Because these representative on-site studies used the same methodology, we were able to use 7,557 detailed interviews (after data preparation and cleaning) to compile the database required to estimate travel distances between visitors' places of resi-

[3] The very small Hamburg Wadden Sea National Park is included in the two other much larger Wadden Sea parks for methodological reasons (Job et al., 2016). In the newest German NLP, Hunsrück-Hochwald, designated in 2015, there has not been done a visitor survey so far.

dence and the NLP, including information on the means of transportation used, trip length, visitors' characteristics, and sociodemographic variables. Also culled from these surveys were data on trip motivation and the role of NLP in destination choice (NLP affinity). As German NLP do not charge entrance fees which leads to scarce visitation data, economic impact studies include extensive visitor counts to estimate the number of visitor days per year. We used these available data to extrapolate the consumer surplus per visitor day to the total number of NLP visitor days, though this required extensive data preparation (see Mayer and Woltering 2018 for details) because the original studies were not designed to estimate RES.

Table 3 shows the travel cost rates for the maritime NLP ranging from EUR 0.060 to 0.118 per person per km, which equals the rank places 1, 2, 7 and 8 among all German NLP.

Table 3: Modal split to German maritime national parks, car group size, raw data on travel cost and mean weighted travel cost rates

National Park	Car	Train/Public transport	Coach/ Bus	Ferry*	Diverse without travel costs (on foot, bike, horse…)	Mean group size car users	Mean weighted travel cost rates per person and km in EUR***
Jasmund 2013/14	90.6% (0.136 €/km)	5.2% (0.213 €/km)	2.4% (0.073 €/km)	0.0%	1.8%	2.63	0.060
Lower Saxony Wadden Sea 2007	80.5% (0.115 €/km)	14.7% (0.180 €/km)	3.1% (0.060 €/km)	0.5%	1.2%	2.56	0.113
Schleswig-Holstein Wadden Sea 2012	82.4% (0.141 €/km)	10.6% (0.207 €/km)	2.4% (0.077 €/km)	0.9%	3.7%	2.94	0.118
Western Pomerania Lagoon Area 2013/14	91.9% (0.136 €/km)	4.7% (0.213 €/km)	0.5% (0.073 €/km)	0.1%	2.8%	2.57	0.062

* Ferry costs (for persons and cars) and train shuttles to Sylt island (for people and cars) are included in the average travel cost rate per person and kilometer. Incorporating these additional costs was complex: first, visitors taking ferries/train shuttles must be identified and differentiated by the different islands, means of transportation, and whether they took their cars. Second, each visitor incurred additional absolute travel costs for ferry/train shuttle rides. This value was averaged over the user group and calculated per kilometer. Third, the weighting procedure for the overall travel cost rate was repeated, but including the additional ferry/train shuttle costs per kilometer for the respective visitor groups. Parking fees on the mainland or islands are not included because data was not available. Future studies should ask respondents about these issues.

Source: Mayer and Woltering 2018, p. 374, 384 adapted

We dealt with multiple-destination trip bias by assigning the full consumer surplus to the visitors with high NLP affinity (Woltering, 2012); *i.e.*, the share of visitors with high national park affinity for whom the NLP was the primary reason for visiting the region, and half of the consumer surplus to the group of visitors partly motivated by the park. The share of visitors with high NLP affinity was defined as the percentage that answered three successive questions affirmatively (Mayer et al., 2010). Visitors not motivated by the parks were excluded from the consumer surplus aggregation, where multiple-destination trip bias was considered

(Bennett, 1996).

Using the simpler, but nevertheless reliable and defensible zonal TCM, we estimated the reaction functions for each park for the 30-km zones under three different model specifications: linear, semi-log, and double-log:

Linear model: $VR_{estz} = \alpha + \beta_1 \times TC_z$ (1)

Semi-log model: $LN\ (VR_{estz}) = \alpha + \beta_1 \times TC_z$ (2)

Double-log model: $LN\ (VR_{estz}) = \alpha + \beta_1 \times LN\ (TC_z)$ (3)

where VR_{estz} is the estimated visitation rate per 10,000 inhabitants from zone z, depending on the respective travel costs, TC_z. To validate, we estimated non-zonal TCM; *i.e.*, models in which each county/urban district served as a zone on its own.

The estimated visitor numbers for the different zones were calculated as follows (see Ward and Beal, 2000; Driml, 2002):

Semi-log model: $V_{estz}= [(e^{(\alpha - \beta 1(TC_z + E_i))}) \times P_z)] \times 10{,}000^{-1}$ (3)

Double-log model: $V_{estz} = [(e^{\alpha} \times (TC_z + E_i)^{\beta 1}) \times P_z)] \times 10{,}000^{-1}$ (4)

where V_{estz} is the number of estimated visitors from zone z, depending on the respective travel costs, TC_z, plus the i-th fictional entrance fee, E_i; P_z denotes the population in zone z, divided by 10,000; α is the constant; β_1 is the regression coefficient; and e is the base of the natural logarithm. For the best double-log zonal and non-zonal models for the four maritime parks see Mayer and Woltering (2018, p. 375).

A specific characteristic of log models is the need for cut-off points, since logarithmic functions, by definition, never reach zero. Thus, the function is truncated at some fictional entrance fee price levels, following Driml (2002) (EUR 1000, 500, 200 and 100), though this affects the estimated consumer surplus. The estimated consumer surplus of recreation in the German maritime NLP corresponds to the area under the demand curves so identified (Bennett, 1996; Driml, 2002). With the precautionary principle in mind, and in seeking to not overestimate RES values, only the results of the EUR 100 and 200 truncations, plus the net opportunity costs of time, are presented. To ensure comparability of results, all consumer surplus values were adjusted for inflation to 2016 values using the Destatis consumer price index (2017).

Results

Table 4 provides an overview of the German maritime NLP, their size, visitation and visitor structure. Size, absolute visitor numbers, share of visitors with high NLP affinity, and share of foreign visitors all vary considerably among the maritime NLP, while the visitor structure is quite similar. The maritime NLP represent holiday destinations with high shares of overnight visitors.

Table 4: Characteristics of the maritime national parks compared to all German national parks

	Jasmund	Lower Saxony Wadden Sea*	Schleswig-Holstein Wadden Sea	Western Pomerania Lagoon Area	All maritime NLP	All German NLP***	Share of maritime NLP
Area [ha]	5,738	345,000	441,500	78,600	870,838	1,041,457	83.6%
Area [ha], without water and tideland surface	2,395	22,772	10,155	13,362	48,684	219,303	22.2%
Designation Year	1990	1986	1985	1990			
Survey Year	2014	2007	2012	2014			
No. of (raw) interviews	1471	2830	2725	2355	9381	24,548	38.2%
Valid cases (visitor structure, weighted)	1245	2827	2191	2066	8329	22,879	36.4%
Valid cases TCM	1126	2503	2011	1917	7557	20,999	36.0%
Visitor Days [Million]	0.68	20.65	18.64	28216	44.74	53.10	84.3%
Share of Overnight Visitors [%]**	91.8	84.0	77.2	86.0			
Share of Non-Local Day-Trippers [%]**	3.5	11.9	18.8	6.2			
Share of Local visitors [%]**	4.7	4.2	4.0	7.8			
Share of Foreign Visitors [%]	7.6	1.5	1.8	7.0			
Share of Visitors with High PA Affinity [%]	27.5	10.9	17.1	31.5			

* Due to its small size, and for methodological reasons, Hamburg Wadden Sea National Park is included in the much larger Lower Saxony Wadden Sea National Park (Job et al., 2016, p. 5).

** Values refer to TCM data sets and are therefore not directly comparable to results in Job et al. 2016

*** size measures including Hunsrück-Hochwald 10,230 ha

Source: Mayer and Woltering, 2018, p. 376, adapted

Table 5 presents the average distances travelled to the maritime NLP, differentiated by visitor groups. With an average distance of 526.2 km, Jasmund takes the lead among all German NLP for all visitors and overnight visitors (567.4 km). In general, the distances travelled to the maritime NLP are quite high. For all visitor groups, the top distances are to be found in the maritime NLP.

Table 5: Mean distance between maritime national parks and visitor domiciles in km, differentiated by visitor groups (descending order of all visitors' distances) [rank places in squared brackets] (Source: Mayer and Woltering, 2018, p. 378, adapted)

Park	All visitors	Overnight visitors	Non-local day trippers	Local day trippers
Jasmund	526.2 [1]	567.4 [1]	188.1 [2]	40.1 [1]
Western Pomerania Lagoon Area	438.0 [3]	494.3 [3]	203.2 [1]	27.3 [4]
Schleswig-Holstein Wadden Sea	380.8 [4]	469.8 [4]	97.4 [8]	6.5 [11]
Lower Saxony Wadden Sea	311.7 [6]	342.9 [9]	178.7 [3]	24.4 [5]

Table 6 shows the main results of the TCM for the German maritime NLP. In what follows, scenarios I and III always include the lower-limit values (cut-off point: EUR 100), while scenarios II and IV show the upper-limit scenarios (cut-off point: EUR 200). Also, scenarios I and II consider multiple-destination trip bias, but III and IV do not. Thus, scenarios I and II account for the role of the NLP in trip decisions because they do not assign RES to those visitors who would have come to the survey area regardless of the existence of the parks. Consequently, the results for scenarios III and IV are higher throughout.

Table 6: Consumer surplus of recreation in German maritime NLP (2016 values, inflation-adjusted): (a) per visitor day; (b) per hectare of land surface in the parks; and (c) aggregated for all park visitors; rank among German NLP in square brackets

Name	(a) Consumer surplus per visitor day in EUR*			
	I	II	III	IV
Jasmund	13.2 [3]	21.5 [2]	36.8 [1]	59.7 [1]
Lower Saxony Wadden Sea	5.3 [12]	8.7 [10]	34.5 [2]	56.1 [2]
Schleswig-Holstein Wadden Sea	7.7 [6]	13.0 [6]	32.9 [3]	55.8 [3]
Western Pomerania Lagoon Area	11.8 [4]	18.8 [4]	31.4 [5]	50.0 [5]
	(b) Consumer surplus in EUR per hectare of land surface*			
	I	II	III	IV
Jasmund	3756.3 [4]	6099.7 [4]	10,419.7 [4]	16,920.1 [4]
Lower Saxony Wadden Sea	4826.6 [2]	7854.5 [2]	31,239.9 [2]	50,837.9 [2]
Schleswig-Holstein Wadden Sea	14,060.0 [1]	23,824.3 [1]	60,473.3 [1]	102,470.2 [1]
Western Pomerania Lagoon Area	4208.2 [3]	6699.9 [3]	11,191.9 [3]	17,818.9 [3]
	(c) Aggregated consumer surplus (millions of EUR*)			
	I	II	III	IV
Jasmund	9.0 [8]	14.6 [8]	25.0 [7]	40.5[7]
Lower Saxony Wadden Sea	109.9 [2]	178.9 [2]	711.4 [1]	1157.7 [1]
Schleswig-Holstein Wadden Sea	142.8 [1]	241.9 [1]	614.1 [2]	1040.6 [2]
Western Pomerania Lagoon Area	56.2 [3]	89.5 [3]	149.5 [3]	238.1 [3]
SUM maritime NLP	317.9	524.9	1500.0	2476.9
SUM all German NLP	385.3	621.8	1690.1	2750.6
Share of maritime NLP	82.5%	84.4%	88.8%	90.0%

* Opportunity costs of time per net wage rate

(I) Lower-limit CS (100€ cut-off) including multiple-trip bias

(II) Upper-limit CS (200€ cut-off) including multiple-trip bias

(III) Lower-limit CS (100€ cut-off) without multiple-trip bias

(IV) Upper-limit CS (200€ cut-off) without multiple-trip bias

Source: Mayer and Woltering, 2018, p. 378, adapted

We first analyze the consumer surplus of recreation per visitor day (Table 4a). The lower-limit values of maritime NLP vary from EUR 5.3 to 13.2 per visitor day with Jasmund and Western Pomerania Lagoon Area reaching rank three and four among all German NLP. These parks are all situated in peripheral areas, so they require long-distance travel from the main source areas. They are dominated by overnight visitors and have high shares of visitors with high park affinity. In contrast, Lower Saxony Wadden Sea has one of the lowest CS per visitor day (rank 12) because of its low share of visitors with high park affinity.

The two model specifications without multiple-destination trip bias show considerably different results with higher national ranks of the maritime NLP. As they incorporate all visitors, the CS values per visitor day rise to EUR 31.4-36.8 and EUR 50.0-59.7 for Scenarios III and Scenario IV, respectively, with identical ranks. Lower Saxony Wadden Sea jumps forward in these rankings compared to Scenarios I/II because it’s very low share of visitors with high NLP affinity (10.8%) is not relevant, but its importance as a holiday destination with a high share of overnight visitors that incur high travel costs (ferries) gains weight. The same holds true for Schleswig-Holstein Wadden Sea, while Jasmund reaches the national top rank.

The next step shows the results of the aggregated CS values for recreation in German maritime NLP; that is, the CS per visitor day multiplied by absolute visitor day numbers and then corrected for the multiple-destination trip bias and the net opportunity costs of travel time (Table 4c). The lower-limit CS (scenario I) lies between EUR 9.0 (Jasmund) and 142.8 million (Schleswig-Holstein Wadden Sea). While the CS per visitor day showed a nearly linear increase between the lowest and highest values, the aggregated values are predominantly driven by the number of visitor days. Thus, all aggregated scenarios show a sharp difference between the maritime parks and the others, with the exception of Jasmund which reaches the national ranks 8 and 7. If we do not consider the multiple-destination trip bias in scenarios III and IV, then the highest aggregated CS is generated by the Lower Saxony Wadden Sea NLP, which has even higher visitor day numbers, but lower NLP affinity than Schleswig-Holstein Wadden Sea. In sum, the total lower-limit CS of recreation in Germany's maritime NLP (Scenario I) amounts to EUR 317.9 million, while an upper-limit value (Scenario II) reaches EUR 524.9 million. In contrast, aggregated CS values without multiple-destination trip bias are 4.72 times higher; *i.e.*, EUR 1,500.0 million (lower-limit, Scenario III) and EUR 2,476.9 million (upper limit, Scenario IV) (Table 4c). The share of the four maritime parks increases from 82.5% (Scenario I) to 90.0% (Scenario IV).

In terms of RES mapping, the per-hectare CS values of German maritime NLP provide interesting insights (Table 4b) as they occupy all top ranks in a nationwide comparison because they have relatively small terrestrial areas in relation to the number of visitor days. In addition to the variation introduced by the different scenarios, the CS per ha values also differ considerably from one park to another. For the lower-limit scenario I, this varies between EUR 3756.3 (Jasmund) and 14,060 per ha (Schleswig-Holstein Wadden Sea). Thus, the CS per ha is between 3.7 (Scenario I) and 6.1 times (Scenario IV) higher there. However, the differences between the maritime parks and the other German NLP are much larger.

Based on the zonal double-log reaction functions, we were able to estimate recreation demand curves for the German NLP. They show how visitors would react to higher travel costs; for instance, the hypothetical introduction of entrance fees. These demand curves illustrate visitors' WTP for recreation in the NLP, such that the more L-shaped the curves, the lower the CS and the higher the visitors' sensitivity to rising travel costs. All maritime NLP have rather flat demand curves which entail the highest WTP to visit them. Assuming a fictional entrance fee of EUR 10, Jasmund would still record 83.7% of its current visitor days, followed by Schleswig-Holstein Wadden Sea (80.3%), Lower Saxony Wadden Sea (78.0%), and Western Pomerania Lagoon Area (74.4%).

Discussion and conclusions

The four German coastal and maritime NLP and their ecosystems generate important RES for their visitors and thus for the German society as a whole by providing highly valued recreational opportunities. The highest RES per hectare values of German NLP occur in the maritime parks. In terms of per visitor day RES values, these parks take the ranks one to three and five among 15 German NLP. Depending on the scenarios, the aggregated consumer surplus of recreation varies from EUR 317.9-524.9 million (considering multiple-destination trip bias) and EUR 1.500-2.477 billion (without multiple-destination trip bias), respectively. Compared to the remainder of the German NLP the maritime parks are strongly dominating with a share of 82.5 to 90.0% of the aggregated consumer surplus. This can be explained by the following reasons:

- The high number of visitor days per NLP: the maritime NLP in the Wadden and Baltic Sea with their long sea-and-sun tourism tradition have considerably more visitor days than the smaller forest NLP, which usually have a weaker tourism orientation.
- The high mean distance to visitors' residences: this factor is influenced by the visitor structure (*i.e.*, the attractiveness of the destination for vacationists) and the geographic location in Germany, such that the coastal peripheries entail higher travel distances compared to more centrally-located destinations.
- Travel costs: The ferries required to access islands plus high shares of railway users led to higher travel costs compared to destinations with high shares of car transport, larger travel party sizes, and higher shares of day-trippers who arrive by bicycle or on foot.

Without doubt, the RES values generated by German maritime NLP constitute very important elements in the economic value of the CES offered by the German NLP system. Thus, our results strengthen arguments in favor of NLP because they reflect societal benefits not expressed in monetary flows. This underscores the fact that neglecting the consumer surplus of recreation and tourism in maritime NLP would lead to a significant underestimation of the CES, and necessarily of all ES of these NLP but also of the coastal and marine areas in Germany of course.

As the maritime NLP cover only parts of the German coastal and marine areas, the question arises whether these results can be generalized for and transferred to the RES of all coastal and marine areas of Germany. The answer is "no", for several interrelated reasons. First, we emphasize the evident difference between potential and actual RES; the latter only occurs when people actually visit an area for recreational purposes (Carius, 2013). A complete and compelling visitor counting in marine areas is most likely an extremely challenging task – but without proper visitor-counting and monitoring, RES assessment is not feasible. Potentially, social media meta-data sets could contribute to solve this methodological problem in the future as, for instance, pictures uploaded to hosting platforms like Instagram or Flickr are geotagged and often allow to identify the exact location where pictures have been taken and where the photographer has his/her permanent residence, which makes it possible to use these data for TCM approaches (see Sinclair et al., 2018). Closely related to this methodological issue is the debate whether a visual impact of marine/maritime areas is sufficient for the generation of RES. If we take, for example, a beach visit/vacation where the sea is not entered except for ten to 25 meters of shallow waters for limited time during bathing. Do the RES generated attribute to the ocean as a whole? Or only to the exact area of visitation or, in a bit wider perspective, at least to the area of the visual horizon? However, in a strict understanding of RES these services can only exist if the areas are frequented by recreationists. Without visitors, such areas have the *potential* to provide RES, but do not *generate* them. That means, if spatial units (like hectare-sized parcels for instance) of the vast mudflats and tidelands of the Wadden Seas or the open oceans of North and Baltic Sea are not explicitly visited by recreationists, we technically cannot attribute RES to these areas in benefit transfer approaches. However, in this strict sense this critique also applies partly to our own research as we just assess whether respondents have entered a NLP but not analysed which areas of the park were actually visited. This issue holds especially true for the coastal and maritime NLP where the mentioned mudflats and tidelands are most likely only visited by a very small fraction of the millions of visitors in both Wadden Sea parks and only on very small shares of the overall area (which is positive, of course, in terms of ecological integrity of these sensitive areas). To conclude, there are still further theoretical clarifications necessary concerning the spatial attribution of RES.

These considerations are also linked to the nature of tourism and recreation, and to the complex, multi-faceted issue of individuals' trip/destination choice. People do not choose areas for recreational activities based only on the characteristics of the ecosystem; indeed, they may not even be familiar with those features when deciding. However, some conditions must be met: 1) people need to be aware of the area and its recreational potential; 2) the area must be accessible; that is, located within a reachable spatial and temporal distance (which is not the case for the real "wilderness" areas of the maritime NLP); and 3) the area must differ notably from other places, for example, by specific features or attractions. Consequently, we argue that the RES values estimated in our study do not reflect inherent characteristics of the respective ecosystems in the German NLP (like the Wadden Sea), but unique combinations of the values that humans attribute to elements of these ecosystems that are specifically designated and marketed as NLP. This corresponds to the notion of ES co-production/co-construction of Fischer and Eastwood (2016). Thus, it would be misleading to transfer our results to other areas with similar ecosystem characteristics, for they would not have the same prominence as the NLP, nor generate the same image among potential visitors (e.g., the chalk cliffs at Jasmund NLP are an emblematic landscape of Romanticism depicted by painters like Caspar David Friedrich). Finally, they do not have the same visitor frequency given they are frequented at all, as discussed above. In other words, RES values, like other ES (Palomo et al., 2016), do not depend solely on the different ecosystems, but are co-produced and co-constructed by humans, in this case by the visitors (Fish et al., 2016; Palomo et al., 2016) and depend, among other factors, on people's preferences in terms of landscape and leisure, the areas' image, peoples' awareness of them, and, not least, on the elements of location and accessibility (see Kirchhoff, 2012 for a fundamental critique of the inclusion of cultural and symbolic values in the ES concept). This leads to the final recommendation to treat RES values derived from benefit transfer approaches with caution.

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7 Socioeconomic Assessment Scheme for measures to protect the marine environment

Uta Sauer & Rainer Marggraf
(webod.gbr, Göttingen)

Introduction

Before implementing new measures within the Marine Strategy Framework Directive, the member states of the European Union (EU) have to carry out an impact assessment including cost-benefit analysis (MSFD 2008, MSFD 2014). In the Directive it is not specified what these analyses imply. Therefore webod.gbr developed a Socioeconomic Assessment Scheme including a cost-effectiveness analysis and the compulsory impact analysis with a cost-benefit analysis. It is based on recommendations for Regulatory and Law Impact Analyses – both given by the European Commission and the German Federal Government.

The impact analysis of measures to achieve a Good Environmental Status of the EU's marine waters comprises a description of socioeconomic impacts and an evaluative cost-benefit analysis. All relevant expected effects on economy and society are determined and evaluated in terms of costs and benefits. The developed Scheme has a procedural structure of detailed questions to gain all necessary information, and a primed basis of official data and calculation assistance (webod.gbr 2015).

Regulatory Impact Assessment and Impact Analysis of Laws

In the 1970s, the German Federal Ministries set out the Joint Rules of Procedure (GGO) for integrating provisions on Regulatory Impact Assessment (RIA). Thereby proposals should include a description of the anticipated impacts on consumers, prices and the environment (Federal Interior Ministry 1987). At the end of 1984, guidelines for legislation were adopted known as the Blue Checklist using criteria such as costs and benefits. In fact all major industrialised countries have legal provisions on RIA.

In Europe, the EU Commission has a leading position in formalising procedures for assessing the impact of policies. Applied checklists for projects were developed into comprehensive guidelines on impact assessment which are updated regularly (European Commission 2009). In 1995, the Council of the Organisation for Economic Cooperation and Development (OECD) adopted a recommendation that member countries should institute a ten-point checklist of management techniques to ensure the quality and transparency of government regulations and laws. The checklist systematically analyses the expected effects on the social and economic welfare. The revised version of the GGO in 2000 also contains a new integrative RIA procedure which prescribes that Federal government draft legislation must undergo an ex-ante assessment of its impacts. Both main intended effects and unintended secondary effects of the legislation must be considered.

With regard to the requirement for socioeconomic evaluations of suggested MSFD-measures particularly three main issues of the RIA are of relevance: an assessment of total costs and benefits – including those for industry, citizens, and administrations – are crucial for decision-making. Especially it is important to make sure that costs of government action are justified by its benefits before taking action.

Another point is to make the distribution of regulatory costs and benefits transparent across social groups, and to consider disproportionate effects on particular groups, e. g. for potential compensations. The success and effectiveness of a measure depends critically on the compliance and adoption of the affected social groups.

Socioeconomic Assessment Scheme

Among legal and political provisions, especially prior work such as the economic section of the initial assessment of the German North and Baltic Sea (Marggraf et al. 2012) provided the basis for the Socioeconomic Assessment Scheme. Various separate cost-benefit studies (e. g. UBA 2013) supported its development.

The Scheme is embedded into the implementation process of MSFD-measures. Central elements are the two analysing methods – the required cost-effectiveness and impact analysis. The impact analysis consists of a description of socioeconomic impacts and an evaluative cost-benefit analysis. All relevant expected effects on economy and society are determined. The description of socioeconomic impacts represents a positive analysis which describes all real consequences of an action whether the consequences are desirable or not and makes clear which of them are considered relevant for the public budget, industry and private households.

The following cost-benefit analysis (CBA) – as a normative analysis – goes even further, as it considers potentially lost economic possibilities (opportunity costs) as well as economic and non-economic benefits. The CBA evaluates in terms of costs and benefits and compares these values for decision. Part of the scheme is a detailed list of questions within a procedure to gain the required information, and a primed basis of data and calculation instructions. The provided data is primarily based on official statistics. If no official data is available, the needed information has to be gathered from scientific publications and experts responsible for the measures.

In general, the Socioeconomic Assessment Scheme is strongly connected with the existing measure fact sheets and could be seen as supplemental to these. The structure of the Scheme is shown in the following figure.

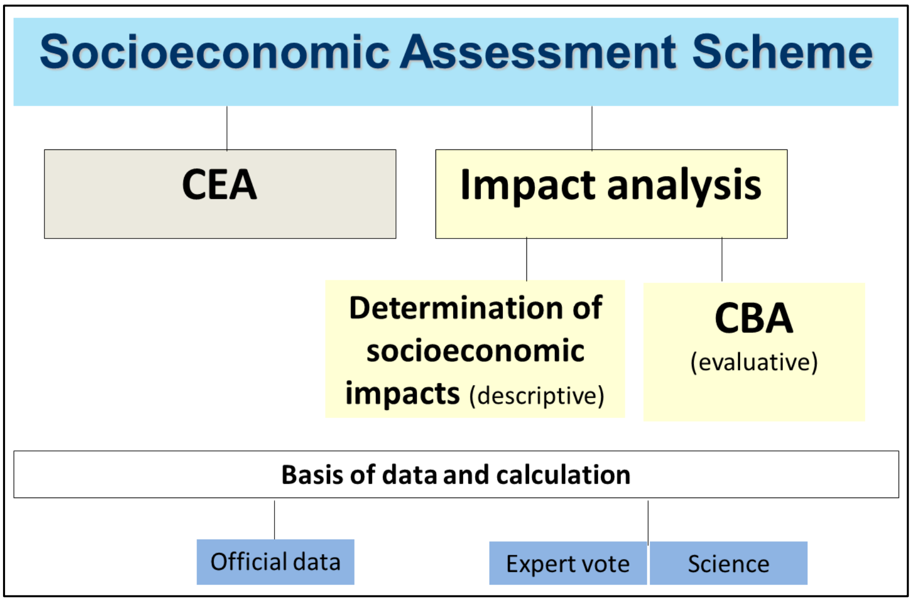

Figure 15: Socioeconomic Assessment Scheme, source: webod.gbr 2015

Cost-effectiveness analysis

The cost-effectiveness analysis (CEA) comprises four steps:

(1) The theoretical effectiveness is the effectiveness under controlled conditions. One of the key questions to be answered is: Is the selected measure useful? The response should highlight why it is necessary to implement the particular measure. As evidence of effectiveness scientific studies have to be cited which verify that the measure achieves the desired effects. Considering alternative measures is part of the first step: Were alternative measures considered earlier, and how is their effectiveness or the effectiveness of further possible alternatives compared to the effectiveness of the measure in question?

(2) In contrast to the theoretical effectiveness, the effectiveness in practice focuses on how effective the measure is once implemented. This is also called “compliance and adoption“. The relevant questions are: Can implementation lead to problems which hinder the effectiveness of the measure and if so, what was undertaken in advance to reduce the probability of these problems? Such problems particularly arise if several institutions are involved in implementing a measure and when certain social groups have to alter their behavior. This leads to the need for consultation to clarify cooperation and competencies and to allocate responsibilities and costs. Furthermore, flanking measures and strategies such as advisory services, awareness raising and timely information should be used to make sure that the public agrees and complies.

(3) The next step determines the administrative compliance costs connected with the measure. This takes into account both personal and material costs for development, adoption, coordination and implementation of the measure.

(4) In a last step of the CEA the financing of the measure has to be specified, detailing the funding sources and their respective contributions. Alternative funding options have also to be reviewed.

Impact analysis

Determination of socioeconomic impacts

As mentioned before, the impact analysis consists of two components: a socioeconomic assessment and a cost-benefit analysis. The descriptive socioeconomic assessment focuses on relevant economic and social factors and describes the economic and social impacts. It considers the consequences arising from the compliance costs of the measure on administration/ public budget, industry and society. Key parameters are administrative costs, personal and material costs for development, implementation, coordination and performance of the measure. Compliance costs to industry include costs or changes in turnover arising from charges, information requirements or other obligations. The consequences for the economy and society include changes in public spending, in gross value added, employment and prices. The consequences of the effects of improving the marine environment on the economy and population are described in changes of these welfare economic key figures as well.

1. Impacts of administrative costs on public expenditures

2. Impacts of compliance costs on the economy
on gross value, employment, and prices

3. Impacts of improving marine environment on the economy and population in the German cities and districts directly bordering the seas

Figure 16: Socioeconomic assessment, source: adapted from webod.gbr 2015

Cost-benefit analysis

Costs to the national economy arise from the administrative compliance costs and their associated consequences. The compliance costs to industry also lead to costs to the national economy. To value the costs to national economy the changes in public expenditures, factor income, employment, and prices have to be identified. With regard to the economic benefits the improvement of the marine environment is to be quantified. The valuation of the benefits has to consider both the economic and non-economic values. Whether the non-economic value is examined qualitatively or in monetary terms must be determined on a case-by-case basis. In doing so the availability of data is a deciding factor. Therefore a comprehensive table of willingness-to-pay studies structured according to the different environmental MSFD-targets is part of the data and calculation basis. If a study fits all relevant conditions, a benefit-transfer is carried out.

1. Annual cost to national economy arising from administrative costs (changes in public expenditures)

2. Annual cost to national economy arising from costs to industry (changes of factor income, employment and prices)

3. Annual benefit to national economy arising from improvements to the marine environment

4. Total cost and benefit of the measure for national economy in present values

Figure 17: Cost-benefit analysis, source: adapted from webod.gbr 2015

For the total economic assessment of the measure, the calculated economic costs and benefits are adapted to the project duration and in the majority of cases beyond that, because the impacts of the measure occur generally over years and arise in different time periods. So the future costs and benefits have to be discounted to their present values and compared with each other. The net present value of the measure equals the difference between the present value of costs and the present value of benefits. The basic decision rule for a single measure is: adopt it, if its Net Present Value is positive.

Discussion

The Socioeconomic Assessment Scheme meets all economic requirements of the Marine Strategy Framework Directive and is built as a practical guide for water managers, especially due to the primed basis of data and calculation instructions. The Scheme provides the opportunity to evaluate the direct measure costs due to the government expenditures as so called "simple financial criteria" with a simultaneous check for their ability to pay. Furthermore, it contains comprehensive cost-benefit valuations including macroeconomic effects. These meet the needs of societal interests and attempt to avoid potential conflicts in respect to measure implementation. The Scheme collects and structures the decision-relevant information. There is no decision-making criterion. In this way the decision-making autonomy of the responsible authority remains unchanged. The Socioeconomic Assessment Scheme is rather decision-supporting.

In 2016, Germany reported the Scheme to the European Commission as the basis to fulfill the socioeconomic assessment requirements for new MSFD-measures. Furthermore, in the meantime webod.gbr gained expertise due to the assessment of 12 MSFD-measures. These valuations contain specific measures of all seven environmental targets like UZ2: Preventing and combating marine pollution through improving maritime emergency preparedness and response; the results of which were already published (Sauer et al. 2015).

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8 Ecosystem Services and the Ecosystem Approach in Maritime Spatial Planning – experiences and thoughts from the Baltic Sea Region

Holger Janßen
(Ministry of Energy, Infrastructure and Digitalization Mecklenburg-Vorpommern.)

This paper reflects the opinion of the author and does not necessarily represent government policy.

The use of the ecosystem approach (EA) as a framework for a sustainable and also holistic way of planning and management has been promoted, among others, by the 1992 United Nations Convention on Biological Diversity (CBD). Early traces of the EA lead back to the beginning of 20th century, e.g. the theories of Sir Patrick Geddes according to which ecological issues lay a basis for spatial planning (Allen, 1976). One may therefore argue that spatial planning and the EA emerged from one common concept and that EA thinking has since long been an inherent part of spatial planning. This becomes visible also by comparing two basic definitions of spatial planning on the one hand and the EA on the other. The European Conference of Ministers responsible for Regional Planning (CEMAT) defined spatial planning as:

“Spatial planning gives geographical expression to the economic, social, cultural and ecological policies of society. It is at the same time a scientific discipline, an administrative technique and a policy developed as an interdisciplinary and comprehensive approach directed towards a balanced regional development and the physical organisation of space according to an overall strategy."

Based on the 12 Malawi Principles the fifth Conference of the CBD Parties (COP5) defined the EA as follows (COP5 decision V/6, May 2000):

“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. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organisation, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.”

The Helsinki and OSPAR Commissions later refined the CBD definition for use in a marine context during their first joint ministerial meeting in June 2003 (HELCOM & OSPAR, 2003) and clarified that “achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity” are among the objectives of the EA.

Maritime spatial planning (MSP) relies on integration for achieving many of its stated aims and aspirations. Delivery of greater coherence in marine management, achieving a “fair balance of interests”, or reducing fragmentation and uncoordinated decision-making in favour of positive synergistic effects all suggest a pivotal role of some form of integration. The integration of environmental concerns is part of these integration processes. Gee et al.

(2019) identified four interrelated dimensions, along with associated benefits of successful integration. The first is policy and sector integration, which is a key prerequisite for MSP as an inherently crosssectoral approach and can be defined as the temporal and spatial synchronisation of concerns, objectives and interests across policy fields and sectors. The second dimension – closely related to the first – is stakeholder integration, meaning the formal and informal involvement of relevant individuals, groups and organisations in processes that lead to the production and implementation of maritime spatial plans. Closely related to this is the third dimension of knowledge integration, referring to how and to what extent diverse types of knowledge are included in MSP processes and reflected in the outputs. Last not least, given that MSP has an international dimension, there is a need for multi-scale and transboundary integration, defined as collaboration and coordination between governmental levels across multiple scales and different types of borders, as well as the interrelation of different layers of regulations, norms and practices vertically within a country. Naturally, the EA plays a role in each of these integration challenges as these often directly contribute to its implementation in MSP.

The above mentioned definitions of both, spatial planning and the EA, understand the sea as a coupled social-ecological system; the sea becomes ‘peopled’, with human beings considered as much a part of the sea as any other component. According to this thinking, the sea is a legitimate setting for multiple interests and that it is the role of MSP to manage competing demands, as advocated by the MSP community generally. Within this framework, the EA does not aim to make activities conform to strict ecosystem requirements, but is more of an ameliorative pressure, by which higher environmental standards are sought within a complex of activities; the EA is subservient to the wider needs of planning (Jay et al., 2016).

This is also the setting for the integration of ecosystem services in MSP. Designations on ecosystem services are nothing new to MSP. The State Development Plan 2016 of Mecklenburg-Vorpommern, for instance, includes spatially explicit designations on ecosystem services as follows:

Tab. 7: Examples for ecosystem service designations in the State Development Plan 2016 of Mecklenburg-Vorpommern

Designation	Ecosystem service	Category
Priority Area for maritime transport	Space and waterways	Provisioning services
Reservation Area for maritime transport	Space and waterways	Provisioning services
Priority Area for wind energy	Renewable abiotic energy	Provisioning services
Priority Area for wind energy testing	Renewable abiotic energy	Provisioning services
Reservation Area for wind energy	Renewable abiotic energy	Provisioning services
Reservation Area for tourism	Inspiration and recreation	Cultural services
Priority Area for nature conservation	Habitat, genetic resources, resilience, nutrient buffering, food webs, primary production, biologic regulation, biological diversity	Supporting and regulating services
Reservation Area for nature conservation	Habitat, genetic resources, resilience, nutrient buffering, food webs, primary production, biologic regulation, biological diversity	Supporting and regulating services
Reservation Area for fisheries (including spawning)	Food, habitat, genetic resources, resilience, food webs, biological diversity	Supporting and provisioning services

While the consideration of ecosystem services and the integration of the EA are already ongoing practice, there is, as always, room for further improvement. In both cases, the implementation is currently impeded by too little, too narrow, or too local knowledge about an ecosystem. A UNEP (2014) analysis of 73 MSP processes worldwide identified that maritime planners have a strong need for more and better spatio-temporal, qualitative and quantitative data e.g. on distribution and status of species, habitats and ecological functions, ecosystem services, interdepencies with human activities, cumulative impacts, environmental limits et cetera. To be used for MSP designation such data have to be available for the whole planning region and the data quality has to be good enough to stand a court hearing.

According to Jay et al. (2016), another challenge seems to be, that the needs for ecological management by MSP might not always be fully clarified yet. As outlined above, spatial planning gives geographical expression to policies of society. This requires, as input to MSP processes, management concepts or objectives that are coordinated or agreed at least within the respective policy sector. At the same time, it should be noted that MSP as a holistic instrument must not replace individual policies. This also means that MSP designation must always be different in form and content from nature conservation regulations. However, MSP and conservation have in common that they aim for a balanced and sustainable development, which includes maintaining and improving the quality of ecosystem services as well as making use of their goods and services for human wellbeing.

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9 Marine Ecosystem Services in the Maritime Spatial Planning Directive (MSPD) and the Marine Strategy Framework Directive (MSFD)

Gerold Janssen & Marius Werner
(Leibniz Institute of Ecological Urban and Regional Development Dresden)

Background

One of the key issues in the implementation of the Maritime Spatial Planning Directive 2014/89/EU (MSPD) are the consequences of implementing the "ecosystem approach" to spatial planning. The significance of this new approach should have had to be answered by law in the course of the implementation of the Marine Strategy Framework Directive 2008/56/EG (MSFD), but there is no specification in the German Water Resources Act (Wasserhaushaltsgesetz, WHG) apparent. In the MSFD (and further legal acts) some criteria are mentioned. According to Article 1 para. 3 of the MSFD, to which the MSPD refers directly, it should be ensured that "marine strategies … apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations."

In addition, the MSPD added, that an ecosystem-based approach (EBA) should be applied in a way that is adapted to the specific ecosystems and other specificities of the different marine regions and that takes into consideration the ongoing work in the Regional Sea Conventions (e.g. by HELCOM and OSPAR). This holistic approach will be of particular importance to the implementation of the guiding principle of sustainable spatial development within the meaning of Section 1 para. 2 Spatial Planning Act (Raumordnungsgesetz, ROG), whereby the social and economic demands on space have to be in line with its ecological functions or services. In this article the legal aspects should be investigated.

Ecosystems in Marine Spatial Planning

Main task of spatial planning is to spatially arrange and develop current and future uses while minimizing conflicts through coordination of uses and safeguarding of free space. General principle in German planning is a sustainable spatial development which harmonizes the social and economic demands on the region with its ecological functions. For sustainable spatial development the use of marine areas must not endanger the basis of existence of marine biodiversity and has to be limited to an extent the carrying capacity of the ecosystem allows.

Marine and coastal waters are under high pressure of multiple uses in the North Sea Region and the Baltic Sea Region. Additionally the marine environment is characterized by an endless number of complex and extensive ecological interactions, such as large scale migrations and food webs, also across administrative borders. These developments call for overarching and comprehensive solutions to protect ecological functions and features in marine spatial planning. The development of such solutions is also supported by the consideration of an ecosystem-based approach in planning regulations.

However, the question for planners remains how to deal with the new requirements set by the introduction of ecosystem-based approach with regard to the planning process as well as the content of marine spatial plans. Which steps are necessary to provide profound argumentation for the consideration of ecological demands in planning and to handle those in planning process? Different research projects has shown, how to implement the ecosystem-based approach in marine spatial planning.

Research Findlings

In this context two research and development projects were carried out by Leibniz Institute of Ecological Urban and Regional Development and Leibniz Institute if Baltic Sea Research Warnemuende together with various research partner and supported by the Federal Agency for Nature Conservation with funds of the Federal Ministry for the Environment, Nature Conservation and Nuclear, aiming at finding ways to translate requirements of an ecosystem-based approach into concrete marine spatial planning measures.

In this way the projects evaluated concrete options of how to consider ecological demands and nature conservation aspects through spatial planning tools. As all riparian states of the North Sea and the Baltic Sea have their own legal system and therefore also differences in the respective planning systems the projects especially focused on the legal system of Germany.

The first project is called MSP-INT ("Developing scientific basis for the consideration of the environmental concerns in the maritime spatial planning, with a special regard to the international requirements"). The project investigated among other issues the role of marine spatial planning in marine nature conservation, the levels planning and marine space, legal aspects of the consideration of environmental concerns in marine spatial planning, the management of different uses under consideration of an ecosystem-based approach and the development of a concept for the implementation of an ecosystem based approach in marine spatial planning. In the context of this concept design for the implementation of the ecosystem-based approach the „HELCOM – VASAB Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area" plays a significant role. The project developed specific recommendations for the implementation of the ecosystem-based approach on the basis of a comparison between the "key elements for applying the ecosystem-based approach in MSP" (HELCOM-VASAB Guideline) and their status of implementation in German MSP.

The second project is called MSP-FABENA ("Contribution to conservation in Maritime Spatial Planning"). Its task is to determine and compile information and a scientific basis of measurement for the integration of environmental concerns in marine spatial planning processes. It also developed a version of a planning contribution to the German Exclusive economic zone (EEZ) from the viewpoint of nature conservation. The focus of this project was the identification of spatial claims and the sensitivity towards marine uses of endangered and representative species and habitats (in particular habitats according to Section 30 Federal Nature Conservation Act (Bundesnaturschutzgesetz, BNatSchG), Habitat and Birds Directive and Red List species) to translate those into concrete planning options for the German EEZ.

Ecosystem services in relevant regulations

In recent years the importance of considering marine environment in spatial planning has strongly increased by introducing an ecosystem-based approach to marine spatial planning through different regulations and guidance documents. Research findings of the mentioned projects have shown, that these regulations set new requirements on European, regional as well as national level for developing marine spatial plans, not only in terms of the content of the plan but also regarding the planning process. The following selection of relevant regulations is orientated towards the relation to marine ecosystem services.

a) EU MSF Directive (2008/56/EC)

The European Marine Strategy Framework Directive (MSFD 2008/56/EC) requires economic and social assessments but does not directly mention "marine ecosystem services".

But a definition what ecosystem service means is given in the Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (IAS-REG).4 According to Article 3 No. 6 IAS-REG

"ecosystem services means the direct and indirect contributions of ecosystems to human wellbeing".

However, the legal term "ecosystem" is not defined here, either in the MSFD. Although the framework and requirements of the MSFD make clear the links to the concept of ecosystem services. Article 1 para. 3 MSFD lays down, that "marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations."

For determining a good environmental status qualitative descriptors in Annex I of the MSFD referred to Article 3 para. 5, Article 9 para. 1 and 3 and Article 24 MSFD are applied, which for example include populations of all commercially exploited fish and shellfish according to Annex I No. 3. According to Annex I No. 6 the sea-floor is also addressed. Its integrity should be at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. Futhermore according to Annex I No. 9 contaminants in fish and other seafood for human consumption are not allowed to exceed illegal levels.

These examples are showing, that ecosystem services are already included into the regulations of the MSFD. Sometimes the directive addresses this namely by the term "services", sometimes obliquely by the word "functions". The function of an ecosystem is at least, among other things, to serve as a source of food for humans.

b) EU MSP Directive (2014/89/EU)

The EU MSP-Directive (MSPD 2014/89/EU) obliges the Member States for the first time to establish and implement maritime spatial planning while applying an ecosystem-based approach. The MSPD links to the Marine Strategy Framework Directive (MSFD) for defining criteria of an ecosystem-based approach and takes guidelines etc. developed in conventions for the protection of marine environment into account. In this directive, neither the term "ecosystem services" nor the term "ecosystem" is defined by law. Therefore the relevance

[4] Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (OJ 04.11.2014 L 317 S. 35).

of ecosystem services has to be determined along the ecosystembased approach.

Article 4 para. 1 MSPD says, that each Member State shall establish and implement maritime spatial planning. According to Article 4 para. 4 MSPD the maritime spatial planning shall aim to contribute to the objectives listed in Article 5 MSPD and fulfil the requirements laid down in Article 6 and 8 MSPD. Article 5 MSPD listet up the objectives of maritime spatial planning: when establishing and implementing maritime spatial planning, member states shall consider economic, social and environmental aspects to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach, and to promote the coexistence of relevant activities and uses.

The framework character of the MSPD leaves range to the way the Member States implement the ecosystem-based approach. However, as stated above with reference to the MSFD concrete criteria have to be fulfilled while applying an ecosystem-based approach.

Insofar, maritime spatial planning should apply an ecosystem-based approach as referred to in Article 1 para. 3 MSFD in order to promote the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources, with the difference, not enabling but contributing to the sustainable use of marine goods and services.

In addition to the regulation of the MSFD, Recital 14 of MSPD says, that “an ecosystem-based approach should be applied in a way that is adapted to the specific ecosystems and other specificities of the different marine regions and that takes into consideration the ongoing work in the Regional Sea Conventions, building on existing knowledge and experience. The approach will also allow for an adaptive management which ensures refinement and further development as experience and knowledge increase, taking into account the availability of data and information at sea basin level to implement that approach. Member States should take into account the precautionary principle and the principle that preventive action should be taken (…).”

It should be emphasized that certain "levels" are not be exceeded and the “capacity” of marine ecosystems is not affected. These aspects are adressed by both the MSPD and the MSFD where reference is made to marine goods and services. Even if the term “marine ecosystem services” does not appear by name in the guidelines is to be noted, that the MSFD and the MSPD strongly links to the concept of ecosystem services.

These new requirements for marine spatial planning show the need for appropriate concepts and tools of actually implementing an ecosystem-based approach while drawing up marine spatial plans. In the view of above the MSPD introduces a balance of marine conservation and different uses with the aim to support blue development but only within green borders.

c) Federal Regional Planning Act (ROG)

The legal requirements of the MSPD do not impose a significant adaption in the German law position, because there have already been legal regulations to marine spatial planning. However, the opportunity of the legislative amendments has not been used sufficiently to reform the Federal Regional Planning Act (ROG) according to an appropriate attention to marine conservation and to specify implementation of the ECOSYSTEM-BASED APPROACH. Although the transposition of the EBA in the principles of the Federal Regional Planning Act (Section 2 para. 2 ROG) strengthen the position of nature conservation as well as the interpretation of the Leitbild of a sustainable development in spatial planning .

The following figure (figure 18) shows the Leitbild of a sustainable development in spatial planning in the sense of Section 1 para. 2 Federal Regional Planning Act. Social and economic demands on areas shall be reconciled with its ecological functions. “To reconcile” these conflicting demands means at least to stay within limits of carrying capacity of an ecosystem and to maintain its ecological functions. That does not mean that ecological functions have an absolute priority to economic and social demands in the weighting. But uses can only be realized within the limit of carrying capacity that’s given by an ecosystem. Therefore weighting criteria have to be defined, such as the “Limit of carrying capacity”, which is closely linked to GES (Good Environmental Status) of the MSFD and the MSPD.

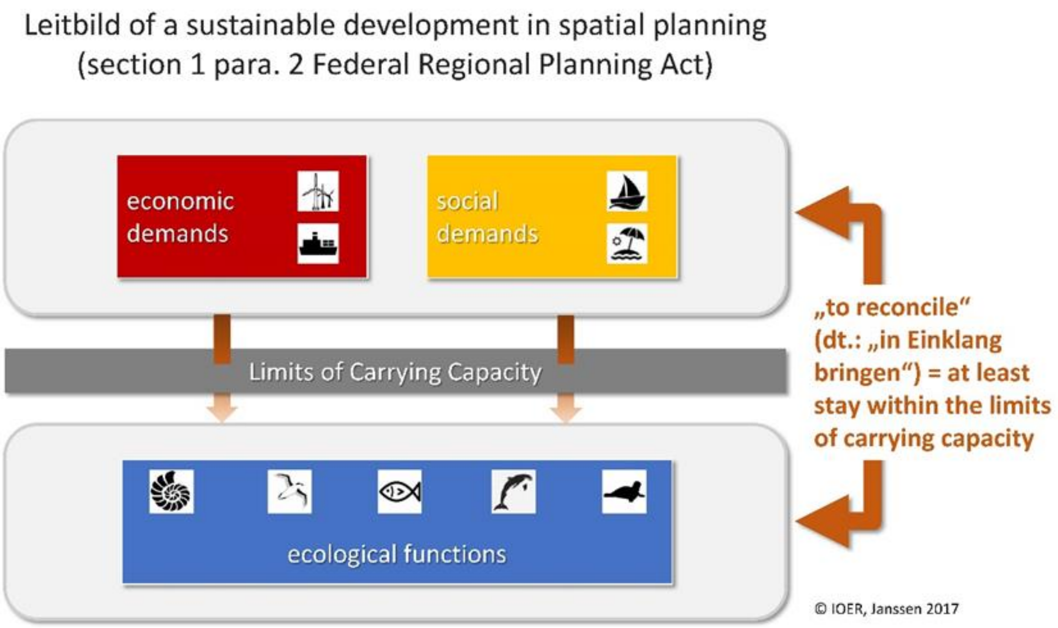

Figure 18: Leitbild of a sustainable development in spatial planning

The central task of spatial planning is to receive and coordinate the content of sectoral planning. According to section 7 para. 4 Federal Regional Planning Act (ROG), the regulations on spatially significant plans and measures by private law authorities and persons are to be included in the spatial planning plans, which are suitable for spatial classification plans and for the coordination of space requirements necessary and which can be secured by spatial planning objectives or principles. These include specifications of the water law measures according to section 45h WHG and the Natura 2000 management plans according to section 32 para. 5 Federal Nature Conservation Act (BNatSchG). The latter can also be an integral part of a spatial plan (Section 32 para. 5 second alternative Federal Nature Conservation Act).

The content of sectoral plans contained in spatial plans is to be treated as objectives or principles and priority or reserve area of spatial planning. Therefore, these are direct components of the spatial plans and stress the need of sectoral planning for nature conservation in marine waters to strengthen ecological components in planning.

d) HELCOM / OSPAR

This importance of the ecosystem-based approach is also underlined by the MSPD, when stating that ecosystem-based approach should be applied in a way that takes the ongoing work in the Regional Sea Conventions into account (Recital 14 MSPD). HELCOM and OSPAR (2003) 5 define the ecosystem-based approach as: “the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity”. The application of the precautionary principle is equally a central part of the ecosystem approach.

For the Baltic Sea Region the „Regional Baltic Maritime Spatial Planning Roadmap“ (2013-2020) was developed with the goal to make every effort to draw up and apply maritime spatial plans throughout the Baltic Sea Region by 2020 which are coherent across borders and apply the ecosystem approach. To meet the Roadmap´s obligations HELCOM and VASAB developed the „Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area”. This guideline with its key elements for applying the ecosystem-based approach in MSP (Best available Knowledge and Practice, Precaution, Alternative development, Identification of ecosystem services, Mitigation, Relational Understanding, Participation and Communication, Subsidiarity and Coherence and Adaptation) works in the sense of a common understanding on how the ecosystem-based approach can be applied in drawing up a spatial plan for a sea area in accordance with spatial planning legislation in force in the Baltic Sea countries.

Ecosystem-based approach in Marine Spatial Planning

The relevant regulations show the need to implement an ecosystem-based approach in marine spatial planning. Against this background it is important to make clear, that an implementation of an ecosystem-based approach can effect two aspects of planning: the planning process itself and the content of plan. Therefore an implementation of an ecosystem-based approach should result in changes of both of these aspects. This requires a need for modification in the different aspects of MSP, that will be shortly described in the following.

a) Ecosystem-based approach in planning process

To consider an ecosystem-based approach in planning procedural aspects are to be applied before and during the process of developing spatial plans. First, these include strengthening knowledge of a holistic view on ecosystems which considers processes, functions and interactions of ecosystem components as well as connectivity and functional networks. Taking into account of cumulative effects as well as the precautionary principle when ecological knowledge seems not sufficient are key elements. Second, for an holistic planning process the development of planning alternatives and the examination of their effects on the environment as well as national and international cooperation for cross border issues are essential. In the third place competent authorities and stakeholders have to be involved timely. Finally, to apply an ecosystem-based approach in planning ecological functions and components have to be strengthened in spatial plans. This can be done through a variety of options:

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[5] Joint Meeting of the Helsinki & OSPAR Commissions 2003, Record of the meeting, Annex 5.

The establishment of priority areas for nature conservation can keep areas which are of ecological importance to ecosystem components and their functions free of conflicting uses. These areas can represent existing MPAs but can also be located outside of MPAs and thereby support coherent networks. Buffer zones can also be used depending on the sensitivity of protected goods.

Use related determinations in spatial plans can steer development in marine areas in a way which is compatible with nature. These determinations can include the use of best available techniques, temporal regulations of uses as well as regulations of operation of anthropogenic structures.

To keep marine areas free of human uses and thereby protect ecological processes spatial plans can also define free spaces.

b) Contents of Plan

Despite being closely interlinked with the planning process, the ecosystem-based approach is also to be applied in terms of the scientific content of plans. Using best available data to introduce sectoral planning for nature conservation can provide profound argumentation for the weighting of maritime uses and activities during the planning process in such a way, that requirements of ecosystem-based approach are met. Therefore three essential steps should be followed to consider ecological knowledge in MSP.

At a first step the spatial distribution and ecological spatial requirements of protected features should be identified and visualized. Protected features thereby can include species and habitats according to Habitats and Birds Directive as well as MSFD or HELCOM and national red lists. It is important to consider that not only species can be relevant but also interactions between ecosystem components – such as birds and benthic communities they use for feeding – and ecosystem functions like migration routes.

Example: Bird migration

Migrating birds need large areas for migration between i.e. wintering and breeding grounds, although this migration is often limited to certain times of the year and has different intensities. In the German Baltic Sea two areas of special importance can be defined: Fehmarn Belt as the shortest connection between land masses in western Baltic Sea presents an important hub for bird migration. In addition, the area between Sweden and Germany north of the Isle of Ruegen is highly important for bird migration, as especially crane populations of Sweden and Norway cross this area twice a year.

Second step is to identify and localize causes of endangerment to these species and habitats.

Example: Bird migration

Offshore wind parks can cause collision of migrating birds and present a barrier for birds during migration over the sea. However, the reaction of migrating birds towards offshore wind parks differs between species and varies from large scale avoidance to attraction. Additionally, sensitivity of migrating birds towards offshore wind parks is also related to weather conditions during migration

Finally, building on this knowledge spatial protection requirements should be defined for the species and habitats as well as ecosystem functions and finally translated into planning language. These concrete formulations can follow the options mentioned above and be –

depending on the availability on data – defined either as planning objectives or principles.

Example: Bird migration

If the need is shown to keep migration routes free of offshore wind parks the following planning principle can be defined: “Areas of special importance for bird migration are to be kept free of effects impairing the bird migration, especially in order to preserve continuous migratory corridors.”

However, also determinations can be defined which regulate wind park operation to ensure the function of bird migration. Possible planning determinations could be: “For the protection of bird migration wind power plants in areas of special importance for bird migration have to be shut down in events of high migration” and “Best available techniques / concepts are to be used. Adequate lighting of power plants has to be used. “

c) Assessment

The question is whether the consideration of ecosystem services leads to the effect, that the arguments of the nature protection in the assessment gain more weight and lead to more nature-friendly decisions. This could ensure the internalisation of external costs of natural destruction into the sectors causing them. This assumption applies in particular to the monetization of ecosystem services: If the actual costs and benefits can be quantified in euros, then "ecological" arguments are competitive with economic arguments. In addition, the positive effectiveness of ecosystem services in financial terms is based on the assumption that monetary values are taken into account identically in administrative and political decision-making and weighing processes.

However, power relations and interest-driven influences are always reflected in practice. Financial interests of individuals or small groups prevail over financial interests of public welfare - even if they have a higher monetary value. The interests expressed by ecosystem services are predominantly of general interest, in some cases even of the "global general public". A wind energy investor will not forego the use of an area of the sea from which he benefits significantly, even if the monetary benefits of an ecosystem services, like eg. a bird migration route should be higher. Firstly, this benefit serves public welfare and, secondly, its contribution remains relatively negligible. In other words, many EES are subject to the commons problem or ecological-social traps.

At least, short-term interests usually prevail over long-term goals. This also applies to the example chosen: The benefits of using wind power are obvious in the short term, and the benefits for bird protection are often only long term.

Conclusions

Ecosystem services are already part of the MSPD and the MSFD. Within the MSFD, the inclusion of marine ecosystem services can contribute to achieving or maintaining good environment status (GES) while within the framework of the MSPD sustainable spatial development in the marine area can be ensured.

Ecosystem services can contribute to ensure, that the carrying capacity of the ecosystem will be considered. That efforts a holistic perspective on ecosystems which is one of the central tasks of spatial planning. Requirements of the ecosystem services in connection with the ecosystem-based approach are shown in different aspects of Marine Spatial Planning e.g. in the planning process and in the contents of plans. This requires a better translation of ecological demands into planning language.

The research and development projects have shown that the implementation of requirements of the ecosystem services and the ecosystem-based approach sets new challenges for competent authorities and stakeholders regarding the planning process and the content of marine spatial plans. Still concrete implementation concepts remain vague. Therefore explicit guidelines (e.g. HELCOM-VASAB Guideline for the implementation of ecosystem-based approach in marine spatial planning in the Baltic Sea area) are very useful for the implementation process. They provide relevant information especially on the planning process towards ecosystem based spatial plans.

10 Challenges to link the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive and practical application of the Ecosystem Service Approach in European Maritime Spatial Planning

Susanne Altvater
(s.Pro – sustainable projects GmbH)

Introduction

Historically, the marine environment and its resources have been managed through fragmented and sectorial approaches (Kelly et al., 2018). This approach, which only considers individual sectors, fails to incorporate the complexity and interconnection of marine ecosystems and the cumulative pressures that different human activities have on species and habitats. Sectorial approaches that do not consider the connections between ecosystems contribute to the degradation and decline of ecosystems goods and services, as shown by the increasing marine pollution and decline of fish stocks, among other ecological trends (Long et al., 2015; Veidemane et al., 2017). Additionally, this negatively impacts human well-being and food security. Furthermore, the growing competition between different sectors for the use of marine areas highlights the need to better regulate and organise human activities (e.g. shipping, oil platforms, offshore wind farms, fishery) in order to reduce conflicts and protect the marine environment (Veidemane et al., 2017).

In response to the need for new management approaches, concepts such as the Ecosystem Based Approach (EBA) and Maritime Spatial Planning (MSP) were developed. These integrated, area-based management approaches are underpinned by science and intend to support sustainable development. In the European Union, both concepts are integrated in a number of EU policies, such as the EU Marine Strategy Framework Directive (MSFD)[6] and the Maritime Spatial Planning Directive (MSPD)[7].

The ‘ecosystem services’ are seen as part of the EBA principle. The following provides some answers to these questions, which are linked in practice: first, which opportunities exist to use synergies between the MSFD and the MSPD to support administrative work? Second, are ecosystem services (ESS) relevant for maritime spatial planning (MSP) or - in other words - how can planners practically implement socioeconomic aspects into MSP? Answers may also help to implement the two directives in a more consistent way.

The MSFD and the MSPD: challenges, opportunities and synergies

The MSFD supports the implementation of EBA since it matches a number of the EBA principles as defined by the Convention on Biological Diversity (CBD Secretariat 2004).

For instance, Rouillard et al. (2017) note how the MSFD includes concepts of “ecological diversity”, “biodiversity”, “resilience”, and “ecosystem services”, which are part of the EBA. The MSFD also calls for a multi-disciplinary assessment (EBA principle 3), provides a framework for considering social-ecological interactions (EBA principle 4), and explicitly incorporates adaptive management (EBA principle 6).

EBA is at the core of the MSFD since it is considered necessary to achieve good environ-

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[6] 2008/89/EU

[7] 2014/89/EU

mental status (GES) and it is explicitly described in the Article 1(3) of the Directive.[8]

As with the MSFD, the MSP Directive indicates that to promote sustainable development, blue growth[9], and sustainable use of the marine and coastal resources, maritime spatial planning should be based on EBA (Borja et al., 2013; Directive 2014/89/EU). Marine Spatial Planning (MSP) is about planning when and where human activities take place at sea – to ensure these are as efficient and sustainable as possible. However, EBA is only mentioned in the MSP directive's preamble, which is not legally binding: in Preamble 14 of the MSP Directive it is noted that EBA within MSP should be adapted to specific ecosystems and should be based on an adaptive management approach, taking into account the availability of new data as well as the precautionary principle (Directive 2014/89/EU).

Nevertheless, EBA plays a vital role in MSP because it has the potential to "set boundaries for a management approach" (Schernewski et al., 2018) as it bases the planning on the best available scientific data and other principles. At the same time, implementing MSP can contribute to the achievement of GES (Suárez de Vivero et al., 2012) since MSP approaches implemented by Member States need to be based on EBA (HELCOM, 2016). EBA can also create a framework for transparent evidence-based decision-making processes (Long et al., 2015).

However, the application of the EBA still entails some difficulties as to merge environmental quality management (e.g. MSFD) with MSP and Blue Growth initiatives. *The main challenge remains on how to maintain and protect ecological structure and functioning (MSFD) while at the same time allowing the system to produce sustainable ecosystem services from which we derive societal benefits (MSPD).* Furthermore, uncertainty still exists on cumulative and in-combination effects, footprints of activities and footprints of both Directives (spatial and temporal). Although both legislative instruments work towards the realisation of the UN Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development)[10], the different frameworks did not integrate such aim consistently. An immanent limit to which MSP can manage certain issues is that Member States have no baseline to evaluate if their plan is within the boundaries of EBA. Moreover members of the Member States Expert Group on Maritime Spatial Planning (MSEG) were not necessarily negotiating the MSFD and hence did not play a role in establishing targets for those individual sectors. Similarly, it is not the responsibility of planners to identify supporting targets.

However, especially Spain, Portugal and France are currently fostering strong cooperation

[8] Article 1(3) of the MSFD clearly states that marine strategies "shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations" (MSFD, 2008/89/EU). This shows that the implementation of EBA is strongly advocated in the MSFD since it is considered a necessary approach to achieve the Good Environmental Status (GES) of the European marine environment.

[9] https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

[10] https://sustainabledevelopment.un.org/sdg14

between the MSFD and MSPD and are eager to integrate these efforts into their marine policy. These countries start with the definition of the boundaries of EBA and how data collected under both directives could be merged to use synergies.

During an inter-active session of the MSEG in Slovenia, March 2018 (see Figure 19), some lessons-learned are that planners have quite precise needs, which are necessary to be delivered by the MSFD community (researchers and stakeholders working in relevant administrations).

Figure 19: World Café rounds during the MSEG meeting, March 2018; source: MSP Platform

Several questions have been put forward to the members who are all coming from national MSP authorities and have to balance combating interests of sectors. For instance, when looking only at those qualitative descriptors (QD) that are most negatively impacted by a sector, the members had to select those indicators where they believed that could benefit from data and information input from the sector: What indicators? What data/information? Who has that data/information?

For the sector of tourism participants said that those indicators related to QD1 (biodiversity) require data from environmental agencies. MSP planners can benefit from that data as to determine what thresholds or carrying capacities the environment has.

A general comment from the table was a lack of knowledge how much data and indicators are collected under the MSFD. They expressed that knowing about these indicators could help them better planning for their areas, especially if some of those impacts may benefit from actions that require spatial answers such as allowing (not allowing for certain activities, temporal allowances, spatial allowances, co-uses, etc.).

The MSP Directive could cross-feed with MSFD by helping to gather the data on human activities and uses occurring in the maritime space in order to build an information basis for those pressure indicators much needed for the MSFD. Pressure indicators are especially needed as independent verification of the cause of a problem as the presence of an activity cannot be assumed to cause a pressure.

More precisely, the following opportunities become immanent when working on the topic:

- Ensure competent authorities are the same for MSFD and MSPD or ensure good coordination if they are different
- Resolve jurisdiction areas (e.g. Directive limits, land planning to low water)
- Ensure within and between Member States (MS) trans-border coordination - with other MS and third countries
- Implement using Regional Seas Conventions and harmonise assessments
- Determine if each activity affects each descriptor in different ways and has different spatial and temporal footprints
- Determine cumulative and in-combination pressures and impacts
- Take land-sea interactions into account (e.g. erosion and dredging)
- Determine whether Blue Growth or the achievement of GES takes precedence

As a positive message how to use synergies and how to reconcile the objectives of the MSFD and the MSPD, the following findings can be recommended to stakeholders:

- Monitoring is adequately designed, coordinated within the same eco-region and using adequate resources
- Any activity at sea is subjected to adequate evaluation of pressures and impacts produced, together with an investigation of its interaction with other activities
- Adequate targets are set for indicators of good environmental status
- Integrative assessments are undertaken regularly, based upon the best knowledge available (e.g. NEAT, a nested environment status assessment tool)
- If marine ecosystems are considered in a holistic way, including humans as part of the system

Why are ecosystem services important for MSP?

Ecosystem Based Approach and Ecosystem Services

As outlined above, the EBA is a central principal of MSFD and marine spatial planning. ESS fit into the broader concept of the EBA to environmental management. The EBA is often described as a holistic approach, which considers the needs of all users and attempts to balance these with sustainable development and exploitation of the ecosystem*, including its goods and services.*

There are many definitions of the term ESS but in general it can be intended as the benefits people obtain from nature.[11]

It is important to keep in mind that ESS is a concept that humans created and ecosystem functions are not equal to ecosystem services. Ecosystem functions and processes are

[11] Ecosystem are divided and classified in different groups according to different methodologies. The most known Millennium Ecosystem Assessment (MA) classifies services along functional lines into the categories of: provisioning, supporting, regulating, cultural (see UK National Ecosystem Assessment website http://uknea.unep-wcmc.org/EcosystemAssessmentConcepts/EcosystemServices/tabid/103/Default.aspx); Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis, World Resources Institute.

biological processes that occur in nature regardless of our presence. However, certain ecosystem functions and processes benefit people and these are called ecosystem services. Therefore ecosystem services as intended with this term exist only if humans obtain (directly or indirectly) the benefits and this view is the basis for the following considerations about the implementation of ES into MSP.

Pro and contra 'ecosystem services'

As a side note, table 8 shows different criticisms of the ES underway to provide a better overview of the concept:

Tab. 8 Criticism of the concept of ecosystem services and counter-arguments

Criticism	Counter-argument
Criticism 1: **ESS is an anthropocentric concept** • ESS concept excludes intrinsic values of natural ecosystems (Schröter et al., 2014). • ESS concept is strictly utilitarian and it shows as if nature exists to serve humans (McCauley, 2006).	• The concept of ESS becomes anthropocentric only if it would deny that nature has an intrinsic value (Davidson, 2013). • Humans are simply another species of animals that uses natural resources to survive (Schröter et al., 2014). • The concept of ESS shows that the whole system matters and not only humans (Costanza et al., 2014).
Criticism 2: **ESS conflict with biodiversity** • ESS are used as a conservation goal at the expenses of biodiversity (Schröter et al., 2014). • Strategies based on protecting ESS provision might not safeguard biodiversity but divert attention instead (Schröter et al., 2014).	• Biodiversity and ESS are complex concepts. • ESS frameworks such as the TEEB and MEA account for certain components of biodiversity (e.g. migratory species, genetic diversity) (Schröter et al., 2014). • Biodiversity support ecosystems functions and processes that influence ESS provision (Verburg, 2017).
Criticism 3: **ESS valuation** • The ESS concept is criticised because it comprises economic framing (Hannis, 2014). • Economies exist inside ecosystems, not the other way round (Hannis, 2014). • The term value is usually employed in a monetary sense but not all ecosystems deliver tangible benefits (e.g. aesthetic value delivered by a landscape) (Schröter et al., 2014).	• Valuation of ESS helps to raise awareness regarding the importance of ES for human well-being (Costanza et al., 2017). • Monetary valuation provides additional arguments, which help policy makers make more informed decisions (Schröter et al., 2014). • Monetary valuation of ESS is not the only method to valuate ESS. Non-monetary evaluations can also be used (Schröter et al., 2014).
Criticism 4: **ESS lead to the commodifica-**	• ESS can help policy-makers design-

tion of nature • Valuating ESS and thus estimating their value in monetary terms leads to the commodification of ecosystems (Mccauley, 2006). • Commodification of ecosystem services results in the commercialisation of ecosystem services (Gómez-Baggethun and Ruiz-Pérez, 2011). • Communicating the value of ESS in monetary terms is not the best way to influence people's behaviour (Hannis, 2014).	ing measures which incentive the protection of ecosystems and disincentive behaviours that damage them (Schröter et al., 2014). • Protecting nature for its intrinsic value is itself an implicit valuation (Davidson, 2013
Conclusion: • Critical debates are essential for improving the science behind the concept of ESS. • Different critics have been adequately addressed but critics of ESS still have a point regarding some of the ESS pitfalls. • Ultimately, the conservation of ecosystems is in the interest of everyone and disagreements on the concept of ESS appear to be semantic for certain aspects.	

Managing change to a system

Understanding ecosystem services can help to understand or predict the implications of changes in ecosystems, and allow us to consider this in terms of their impact on humans. Ecosystem services therefore provide a method to monitor the impacts of ecosystem change and can also be used to identify triggers for intervention in management.

Supporting better management and planning choices

Considering the value of ecosystem services is relevant to governance and planning purposes, as it allows more informed management choices, and allows for the influence of human behaviour.

It also assists in setting planning priorities. It can be utilised in policy, project and programme appraisal and can help determine liability and compensation in environmental litigation. For example, the associated ecosystem services provided by Marine Protected Areas and Priority Marine Features (such as improved system quality and local-scale provisioning) can play an important role in guiding their implementation.

Supporting an Ecosystem Based Approach to management

The ecosystem approach is a central principal of marine planning, and integrates the management of human activities with knowledge of ecosystem dynamics to achieve sustainable use of ecosystem good and services, while maintaining the health and resilience of an ecosystem.

Some practical implementation approaches of the ecosystem service concept related to maritime spatial plans in Europe

Country approaches of how to integrate ES into MSP

So far socioeconomic data used in MSP is mainly related to the value of sector, employment figures and number of companies. To a certain extend it also considers dynamics and drivers how business is developing. What is missing so far, is a better understanding as well as methods, how to valorise the maritime space for each sector; the land-sea interactions and the effects of planning decisions.

Scotland

In the Clyde Marine Region, Scotland, the implementation of an ESS is at an early stage. The region is framing their approach to MSP using the ESS concept. As a first step in the formal marine planning an assessment of the region has been undertaken. Several questions have been addressed when conducting the approach:

- What is the current status of the environment in the Clyde; what are the primary issues of concern?
- As part of an Ecosystem-Based Approach (EBA), how can ecosystem services be applied at a regional level?
- What are the key knowledge and data gaps in relation to understanding the condition of the Clyde marine region?

A report (Mills, F. et al., 2017) presents the results of the assessment of the condition of the Clyde Marine Region (CMR), documenting a summary of the significant pressures and the impact of human activity. It provides a more detailed analysis at regional level of the broad assessment undertaken through the development of Scotland's Marine Atlas an assessment of Scotland's seas, which informed the first draft of Scotland's National Marine Plan[12]. Also results of the guidance document: "Initial principles for developing assessments to support Scottish Regional Marine Plans"[13] were used for the report.

Structured around Scotland's Vision for the Marine Environment ("'clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of people and nature"), the report presents an assessment of the current condition of the CMR, based on available data. Each aspect is presented in terms of a trend, either 'Improving', 'Static' or 'Deteriorating', and with 'Many concerns', 'Some / local concerns', 'Lack of evidence / robust data' or 'Few or no concerns'. Acknowledging the limited quality / lack of data in some cases, it includes indication of the confidence (High, Medium or Low) in the data informing the assessment, and relates this to identification of key research and knowledge gaps. The planning administration responsible for the CMR also aimed to incorporate an Ecosystem-Based Approach (EBA) by relating the assessment of the region to relevant ecosystem services where possible.

For instance, for hazardous substances and their biological effects, results of various studies on the health of the marine environment and its biological effects have been compiled. The aim was to produce an overall assessment of the condition of the regions marine, coastal and river basins, developed in line with the EU Water Framework Directive (see Figure 20).

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[12] https://www.msp-platform.eu/practices/scotlands-national-marine-plan

[13] https://www.msp-platform.eu/practices/initial-principles-developing-assessments-support-scottish-regional-marine-plans

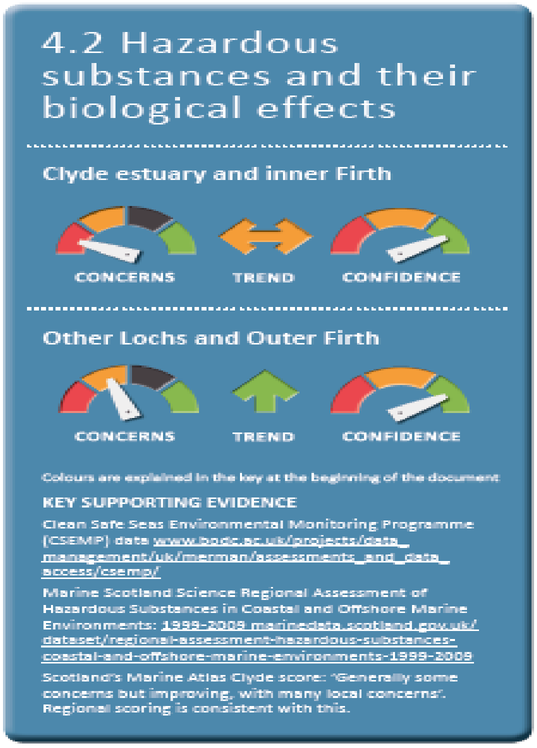

Figure 20: Assessment of hazardous substances and their biological effects in the Clyde

Outputs show that sediments and metals concentration and the biological effects of hazardous substances on living marine organisms were present in the marine waters. The concentration of enzyme 7_Ethoxyresorugin-O-deethylase (EROD) in male fish livers across same species were all above Background Assessment Concentrations (BAC) at all sites.

Latvia

The country follows a three-step approach to implement EBA in MSP: 1) Analysing best knowledge and practice and identification of ecosystem services, 2) Finding alternative developments to assess impacts on marine ecosystems, and 3) Applying precaution and mitigation when using an impact matrix. During the assessment of ecological impacts, Latvia performs a spatial assessment of impacts on special ecosystem features and ecosystem services provision as well as a semi-qualitative assessment of impacts against selected criteria and indicators.

Germany

The Federal State Mecklenburg-Vorpommern combined various approaches to implement EBA; first by identifying provisioning and cultural ecosystem services, which were then taken up in programme designations. Similarly, important areas for nature conservation and protection were designated as reservation or priority areas for marine conservation. Additionally, a comprehensive Strategic Environment Assessment was carried out to investigate potential impacts of the State Development Programme (cf. Janssen, H. in this volume).

Tools and studies to support socioeconomic aspects in MSP

The relation between MSP and socioeconomic aspects is multi-faceted and not yet fully explored. MSP aims to reduce or avoid conflicts between a variety of economic and non-economic functions and pressures. At the same time, it is also a tool to allocate space for new and emerging uses while respecting marine nature protection targets. MSP can potentially open new economic potentials by fostering synergies between different uses. It can be seen as a way to organise the spatial distribution of economic sea uses for sustainable economic growth and to support the EU Blue Growth Strategy (2012)[14].

Socioeconomic aspects are therefore important to be considered in MSP. The terrestrial economic development and land-sea interaction are also highly related to the economic benefits of maritime spatial plans and the importance of given maritime uses covered by these plans for the economic development of the region / country. Decisions in MSP change the opportunities of marine sectors as much as structural changes in economic sectors change the context and needs for MSP decisions. In a way, it is even up for debate if MSP could be used as a strategic tool for regional economic development.

Currently, the number of tools developed to analyse socioeconomic aspects and to integrate those more strongly into the MSP process is limited. However, the need for these tools is recognized and the interest to work on new tools has increased. Until now socioeconomic data used in MSP is mainly related to the value of sectors, employment figures and numbers of companies. To a certain extent, it also considers dynamics and drivers of economic development. What is missing so far is a better understanding as well as methods on how to valorise the maritime space for each sector, the land-sea interactions and the effects of planning decisions.

Which tools and studies are available, showing the spatial allocation of costs and benefits of marine sectors across a country?

The Spatial Economic Benefit Analysis[15] tool of the BONUS BALTSPACE project provides first approaches for the offshore wind and shipping sectors, analysing and mapping the geographical distribution of benefitting companies and industries throughout the whole country and beyond. The tool is based on a value-chain approach. The collected data is presented in the form of easy to read maps. These maps reveal the share of benefitting enterprises located in the coastal region as well as the geographical scope of the maritime economy.

Which tools and studies are available, showing the socioeconomic impacts of marine sectors on coastal regions?

- The BEA-APP project analyses the offshore wind power in Sölvesborg[16] (Sweden) with regard to its regional creation of jobs. The approach differentiates between jobs created in the context of construction versus jobs related to operation and maintenance. Furthermore, the approach calculates for each year of the Sölvesborg wind park the number of new and total jobs created.

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[14] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0494&from=EN

[15] https://www.msp-platform.eu/practices/spatial-economic-benefit-analysis

[16] https://www.msp-platform.eu/practices/socio-economic-aspects-offshore-wind-power-swedish-municipality

- The Plan4Blue[17] project deals with indicators to be used to assess the current effect and potential for Blue Economy in coastal areas on the regional and municipal level. The analysis[18] includes indicators such as population and employment, industry turnover and number of employees, productivity, company locations and density, R&D and high technology investments as well as maritime patents. The regional focus of this study is on the Gulf of Finland as well as the Archipelago Sea.
- In a separate but related effort, the Plan4Blue project[19] is using descriptive statistics[20] to analyse productivity and efficiency of blue sectors in coastal regions. Six financial indicators are used for an input-output analysis. The results allow for a benchmarking of different Finnish and Estonian coastal regions in terms of productivity and efficiency in blue economy.

Which tools and studies are available to assess the value of marine sectors?

- The study economic valorisation of Polish sea space[21] in relation to fishing and its implication for the Polish MSP combines economic and spatial data. It includes the fishing effort, the variable and total costs as well of the number of vessels fishing in the same segment. Data is collected per sea-square and afterwards used within a mathematical formula to calculate the fishing intensity. This result has then transformed in easy to read maps to show the spatial distribution of fishing intensity within the polish coastal waters.
- A methodology[22] developed at the University of Naples allows for the estimation of the monetary value of marine space related to various maritime activities occurring in a specific area (see Figure 21).

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[17] https://www.msp-platform.eu/projects/plan4blue-maritime-spatial-planning-sustainable-blue-economies

[18] https://www.msp-platform.eu/sites/default/files/presentation_6.pdf

[19] see fn 10

[20] https://www.msp-platform.eu/practices/economic-potential-maritime-regions

[21] https://www.msp-platform.eu/practices/economic-valorization-polish-sea-space-related-fishery

[22] https://www.msp-platform.eu/practices/new-approach-assess-marine-opportunity-costs-and-monetary-values-use-spatial-planning

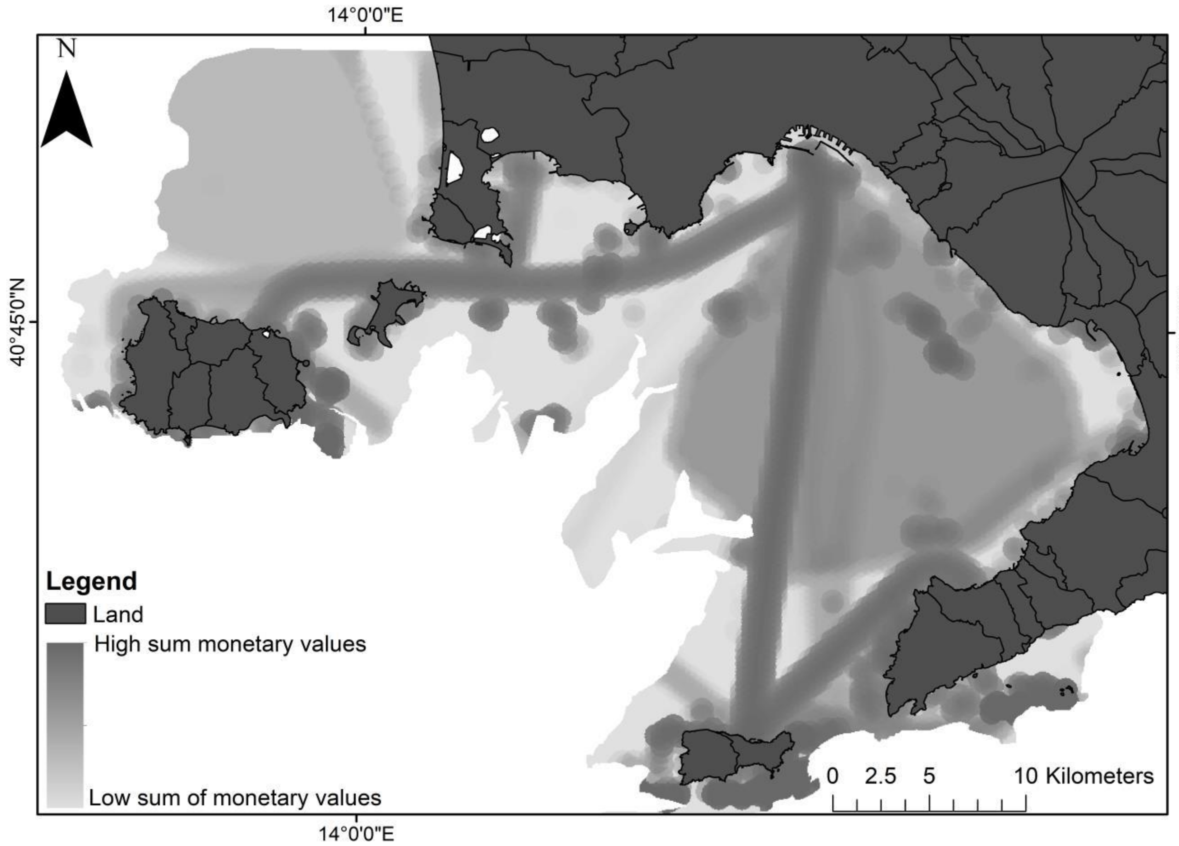

Figure 21: **Map illustrating the monetary values estimated in each CU for all the activities considered in the study area (Source: L. Appolloni, R. Sandulli, G. Vetrano, G. Russo. A new approach to assess marine opportunity costs and monetary values-in-use for spatial planning and conservation; the case study of Gulf of Naples, Mediterranean Sea, Italy. Ocean & Coastal Management, Volume 152 (2018), 135-144)**

Its results can help marine planners to recognize zones with higher socioeconomic importance and consequently adapt the zonation process in order to fulfil conservation objectives.

What is the benefit of cross-border cooperation and networks in terms of socioeconomic aspects?

- The Plan4blue project analyses economic and social networks[23] in the Gulf of Finland and the Archipelago Sea area to find out which networks exist and estimate their maritime value. The study is based on an online survey, face-to-face interviews and a social network analysis. The results show that cross-border cooperation is experienced as very important and should thus been improved.
- HELCOM as Baltic Marine Environment Protection Commission has established an expert network on economic and social analyses[24] to acknowledge the strong interlinkage of socioeconomic and environmental aspects and to learn more about the

[23] https://www.msp-platform.eu/sites/default/files/presentation_8.pdf

[24] https://www.msp-platform.eu/practices/socio-economic-work-helcom

contribution of the use of marine waters to the economy in the Baltic Sea region per year. In parallel, the 2nd holistic assessment of ecosystem health[25], initiated in 2017, investigates the costs of degradation caused by human activities in the marine area to find comprehensive answers.

- Understanding and Applying Ecosystem Services in Transboundary Maritime Spatial Planning[26] is one part of the SIMCelt project. In this context a tool was developed as part of a case study to understand the concept and application of Ecosystem Services for MSP in a transboundary context by using existing and readily available datasets. The tool seeks to help marine planners understand and apply Ecosystem Services in a practical way. It therefore uses three types of data sets to map ecosystem services including provision, regulatory and cultural services in a transboundary context (Celtic Seas). It also illustrates how different data sets can be used to map ecosystem services for decision making in transboundary MSP.
- The BalticAPP project focus is on the supply and demand of marine ecosystem services in the Baltic Sea region and foresees a time frame of the next 80-100 years. In their study existing state-of-the-art modelling tools and recently collected data were combined. The models create links between nutrient loading, fishing, human wellbeing and the marine ecosystem. Furthermore models help evaluating the effects of agriculture and fisheries policies on human welfare. In addition, the project identifies long-term strategies to safeguard the various ecosystem services the Baltic Sea provides us with. Anticipated climate and socioeconomic developments are taken into account for those strategies. The project applies the concept of 'Citizen Science' as well as recent developments in information technology to test innovative, low-cost methods for collecting data on the demand of cultural ecosystem services like recreation.

  The project pilots a mobile application throughout the region, targeting stakeholders from different Baltic Sea region countries: local people can use to share their specific insider knowledge with researchers. The application provides researchers and policymakers with valuable information on the consumption patterns and geographical hotspots of recreation in the Baltic Sea region.[27]

Take home messages

The increasing use of marine resources and the development of coastal areas will exacerbate the number – as well as the magnitude – of pressures on marine ecosystems, which will also negatively impact social and economic dimensions. Consequently, maritime planners, managers, and governments should properly collaborate to implement EBA in MSP and other environmental management decisions - not only because it is required by a growing number of maritime policies; but also because of the added economic value given by the protection of important ecosystem services, which provide vital goods and services.

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25 http://stateofthebalticsea.helcom.fi/wp-content/uploads/2017/07/HELCOM_State-of-the-Baltic-Sea_First-version-2017.pdf

26 https://www.msp-platform.eu/practices/understanding-and-applying-ecosystem-services-transboundary-maritime-spatial-planning

27 See https://blogs.helsinki.fi/balticapp/

For future work, some take home messages are:

- Planners have data needs, which obviously cannot be provided for all data by the MSFD. This is due to different aims of the two directives and timelines of the MSFD and MSPD cycles. However, planners have to proof on political and legal level that everything was considered in a balanced way and why, for example, a use was excluded in a planning zone. Therefore, more consistency in data collection and provision is needed.
- The concept of ecosystem services can be a vehicle to include the ecosystem-based approach into both directives. Again, efforts to meet this aim can also foster more coherent data collections.
- Discussions about ecosystem services of marine ecosystems and socio-economic benefits of their uses can positively support the dialogue with stakeholders - even with those working outside coastal waters (e.g. in the Exclusive Economic Zone)
- Of course, there exist sharper instruments to protect nature than the ecosystem service concept – however, it can be an additional way explaining politicians, industry and the broad public what value nature has.
- The stronger collaboration between those responsible for the MSFD and MSPD can be achieved by linking work during the evaluation cycles for both directives and can reduce data gaps.

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11 The Ecosystem Services Concept and its relation to national biodiversity policies: The case of ‘Natural Capital Germany – TEEB DE’

Markus Leibenath
(Leibniz Institute of Ecological Urban and Regional Development, Dresden)

Political science and Ecosystem Services

In recent years the Ecosystem Services (ESS) concept has evolved into a key term in national as well as international debate on nature conservation and landscape management. In particular, German scientists and policy-makers make such frequent use of the term that it can be described as ‘naturalised’: nature and landscape are today commonly conceived in terms of ‘ecosystems’ that provide ‘services’ to humans. However, many questions and doubts still surround the ESS concept (cf. Chaudhary et al. 2015; Dempsey & Robertson 2012; Haber 2014; Jax et al. 2013; Kronenberg 2014; Schröter et al. 2014). These are – inter alia – related to:

Definitions, i.e. the meaning of ‘ecosystems’ and ‘services’ themselves as well as derived notions such as ‘cultural ESS’. Further, critics have voiced concerns about the relation between ESS and biodiversity or the treatment of abiotic elements such as wind, which is essential for the pollination of many agricultural plants.

Methodological issues **related to various ways of classifying, assessing and evaluating ESS.**

Ethics (cf. Bachmann and Willemsen in this volume)

Adequacy for purpose, for instance, because the increasing reliance on ESS and its utilitarian perspective may jeopardise the efforts of conservationists to protect habitats and species irrespective of their value or ESS approaches may conflict with existing policy instruments.

Some political scientists and policy analysts regard the growing salience of the ESS concept as an indicator of a “reorientation of biodiversity policies [...] in an economic vein” (Bundestag 2015, 12)[28]. However, we basically do not know how the increased currency of ESS is changing policy-making in Germany. Furthermore, some critics have pointed out that concepts such as ESS and ‘natural capital’ are linked to a neoliberalisation of nature and landscapes (cf. McAfee 1999; McCauley 2006; Sullivan 2014). Against this background, the present paper is guided by two overarching questions: (1) How are nature and landscape policies changing in Germany under the influence of the ESS concept? (2) How can the approach of ‘Natural Capital Germany – TEEB DE’ be characterised in political terms? Empirical findings are drawn from the ongoing project “Governing (with) Ecosystem Services: Changing problematisations and rationalities of governing in German nature and landscape policies”, which is funded by the German Research Foundation (*Deutsche Forschungsgemeinschaft* – DFG)[29].

The paper is structured as follows. First I introduce the analysed case ‘Natural Capital

28 All quotations from sources in German have been translated by the author.

29 Project number 401342127 (GZ 2255/6-1).

Germany – TEEB DE' (henceforth 'TEEB-DE') and its background (section 2), before I turn to my theoretical framework, analytical terms and methodology (section 3). This provides a technical background for the presentation of results of the empirical inquiry (section 4). Finally I draw conclusions on further research needs as well as on perspectives for potential follow-ups of TEEB-DE (section 5).

The analysed case (TEEB-DE) and its background

TEEB-DE follows a lineage of policy initiatives related to ESS that goes back at least to 2005 when the UN published their Millennium Ecosystem Assessment (MEA). In 2007 the then G8 countries followed suit with the project 'The Economics of Ecosystem Services and Biodiversity', also known as TEEB. In 2011 the EU determined to "map and assess the state of ecosystems and their services" as part of its Biodiversity Strategy 2020 (European Commission 2011, 12). In addition, some nation states have initiated ESS programmes of their own, such as the United Kingdom in 2009 and the Netherlands in 2011.

TEEB-DE was launched in 2012 and officially ended in 2016, although the final report is still pending (as of August 2018). Supported and coordinated by the Federal Agency for Nature Conservation (*Bundesamt für Naturschutz* – BfN), the aim of TEEB-DE was to "present [...] the economic case for nature conservation as a complement to ethical and ecological arguments" and to "uncover the hidden value of biological diversity and ecosystem services – the value of 'natural capital' – for society" (UFZ 2016, without page numbering).

TEEB-DE had a sophisticated governance structure, at the heart of which was the study leader from the Helmholtz Centre for Environmental Research – UFZ and his coordination team. They consulted with the funding agency BfN as well as with a Stakeholder Committee that included representatives of civil society organisations and an Advisory Board. The project yielded three thematic reports on climate policies, rural areas and cities as well as two introductory brochures. A large number of experts was involved in preparing these publications either as authors or reviewers, presumably totalling several hundred individuals (UFZ 2016, without page numbering).

Theoretical framework and methodology

My theoretical framework draws chiefly on the work of Michel Foucault (1926-1984), the French historian and philosopher. Foucault was interested in a wide range of issues such as the penal system, the economy, medicine, or social aspects of sexuality. A productive and unorthodox thinker, he was always ready to overthrow and reformulate his ideas. In this regard he is a good source of inspiration, although his works should always be read with a critical eye.

One Foucauldian concept is 'government', which he understood somewhat differently from ordinary language use. For him, government is not limited to the activity of ministers, parliaments or kings. Instead, he subsumed under this heading "all practices of government of self or others" (Dean 2010, 27), all attempts to "act upon the possibilities of action of other people" (Foucault 1982, 221), or simply "the conduct of conduct" (Gordon 1991, 2). Foucault stressed that in order to govern and to exert power, one needs certain knowledge about the objects and objectives of governing. By the same token, the creation of knowledge requires us to define categories, select 'facts' and distinguish legitimate from illegitimate forms of knowledge. Hence he regarded power and knowledge as being mutually constitutive.

Foucault also popularised the term 'governmentality' for an approach to studying historically contingent forms of governing. More precisely, governmentality is “a way of thinking about how we conduct ourselves and others, and how we think about ourselves and others when we are doing this”; it “removes the ‘naturalness’ and ‘taken-for-granted’ character of how things are done” (Dean 2010, 48 f.).

So how can historically contingent forms of governing be studied? – Two categories are helpful in this regard: ‘problematisations’ and ‘rationalities’. Problematisations are descriptive statements by means of which objects of governing are constituted. When something is problematised, it is construed as a problem and thereby rendered visible. By contrast, phenomena that are not problematised do not exist as problems of governance and receive little or no attention. For this reason Dean (2010, 41) compares problematisations to “fields of visibility”. The second category, rationalities, refers to

“changing discursive fields within which the exercise of power is conceptualized, the moral justifications for particular ways of exercising power by diverse authorities as well as notions of the appropriate forms, objects and limits of politics” (Rose & Miller 1992, 175).

Consequently, Foucault does not assume the existence of a universal rationality but rather the co-existence of a multitude of different rationalities, which are always related to specific contexts.

Foucault further distinguishes between different governmentalities or arts of government, meaning constellations of certain types of problematisations and rationalities. An art of government is a discursive formation that produces – at a given time and in a given context – certain problems, strategies and actors as well as spaces and landscapes. Because they may overlap, such governmentalities are not to be confused with clear-cut historical phases. Here I employ a threefold classification of governmentality, based on Foucault’s writings. These are *sovereignty*, *discipline* and *neoliberalism* (Castree 2011; Fletcher 2010; Foucault 2007 [1977-1978], 2008 [1978-1979]; Oels 2005), and can be described as follows:

Sovereignty focuses primarily on “obedience to the law, either to the earthly sovereign’s law, or to the law of the absolute sovereign, God” (Foucault 2007 [1978], 98).

Discipline relies on educating people to become disciplined individuals who behave in standardised ways and who have internalised certain rules and moral demands.

Neoliberalism implies the adoption of economic enterprise and the principles of the market as models for state and society. The point here is not to apply economic thinking to specific fields such as running a business or devising sectoral policies, but to take economic principles as a measure for all spheres of the state and social life. In particular, neoliberalism considers the market as “a sort of permanent economic tribunal confronting government” (Foucault 2008 [1979], 247).

The differences between these three arts of government can be illustrated with regard to problematisations and rationalities of governing. Typical problems or challenges to which policy-making is supposed to respond are:

a lack of compliance with existing rules under sovereignty,

grievances, which are evaluated morally in terms of good and bad, in a disciplinary art of government, and

excessive costs as well as insufficient markets in a neoliberal view.

Turning to rationalities of governing, the prime objectives of governing in a sovereign governmentality are regulation and litigation; in a disciplinary art of government they are control and surveillance as well as moral suasion and awareness-raising; in neoliberal governing the aim would be to measure and compare performance and to create economic incentives.

As regards recent research into governmentality, a number of studies have linked ‘ecosystems services’ and ‘natural capital’ to a neoliberalisation of nature (e.g., Turnhout et al. 2014; Wynne-Jones 2012). Other scholars have emphasised the importance of contextual factors (e.g., Dempsey & Robertson 2012). Kull et al. (2015, 122) observe that “ecosystem services, as an idea and tool, are mobilized by diverse actors in real-life situations that lead to complex, regionally particular and fundamentally political outcomes”. Considering this state of the art, the present paper addresses three specific research questions: (1) Which problematisations and rationalities of governing have so far been produced in the context of TEEB-DE? (2) How can these be characterised in the light of different arts of government? (3) How does TEEB-DE engage with existing policy approaches and how does it redefine them?

In methodological terms, the core of the study is a document analysis. Following an initial survey of German publications on ESS and the TEEB-DE process, I selected 14 key texts. These included the two TEEB-DE brochures and the three thematic TEEB-DE reports (or parts thereof) as well as some accompanying texts (cf. Leibenath 2017 for further details). These texts were carefully read and then analysed with regard to a set of heuristic questions concerning problematisations and rationalities of governing. This was combined with a discourse analysis intended to uncover certain systems of meaning (or discourses) in the selected texts. By ‘discourse’ I refer to a set of relations between elements such as words but potentially also those objects and practices which are regularly articulated and thereby transformed into moments of a specific discourse. A discourse is further characterised by an inside and an outside. The inside consists of one or several central elements (or nodal points), which can be political claims or demands, and a number of other elements that support these claims and are hence equivalent in relation to the core element(s). By contrast, the outside of a discourse includes elements contrary to the inside and which are hence articulated negatively or in a relation of contrariety. Inside and outside are separated by an antagonistic frontier. The identity of a discourse is often shaped by those elements which are rejected and articulated as being antagonistic. For this reason, Staten (1984, 16) adopts the term “constitutive outside” (see Fig. 22; cf. Leibenath 2017 for further details).

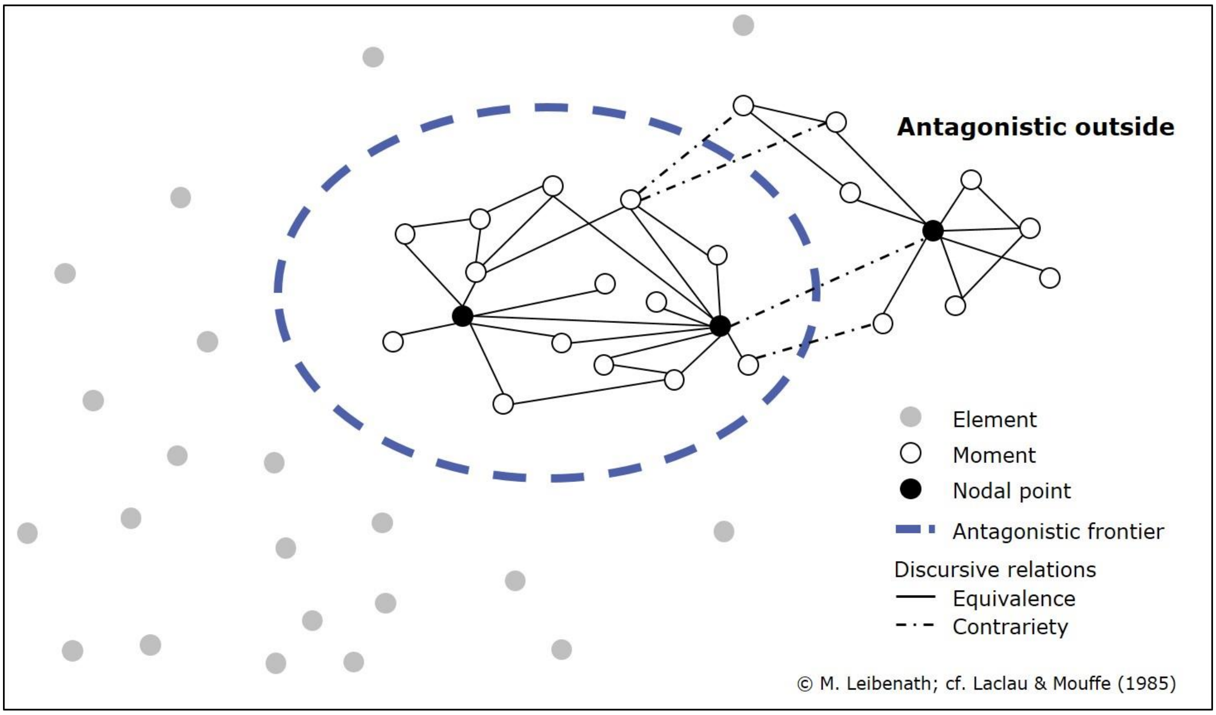

Figure 22: Discourse theoretical categories for analysing selected documents related to TEEB-DE

Empirical results

Problematisations in TEEB-DE

The analysed documents display a rather straightforward discursive structure as regards problematisations of governing. One of the nodal points in the TEEB-DE discourse's outside is "depletion of natural capital", which is related to "deficits in economic knowledge", "environmental problems", "severe economic problems" and "wrong priorities of decision-makers". The elements "high societal costs" and "wrong incentives" are also central, the latter being related to "shortcomings of markets", "no price has to be paid" and others. – All of these elements are articulated in relations of contrariety to the inside of the discourse, where "natural capital" and "ecosystem services" figure as nodal points. They are articulated in equivalential relations with "capital stock", "basis of human well-being", "win-win situations", "synergies" and others (see Fig. 23).

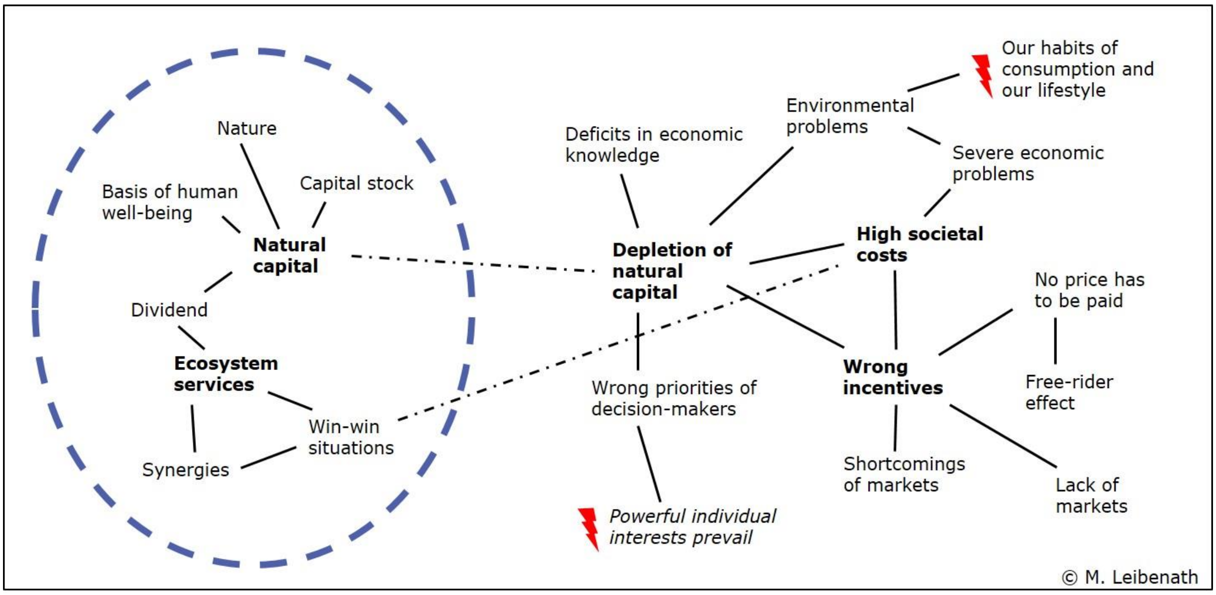

Figure 23: Problematisations in TEEB-DE
[The thunderbolts symbolise unexpected discursive articulations; see Fig. 22 for an explanation of the different types of lines]

Although some elements such as "our habits of consumption and our lifestyle" and "powerful interests prevail" are indicative of a disciplinary governmentality, the discursive structure basically fits neatly to a neoliberal art of government. Hence it seems fair to say that TEEB-DE conveys a typically neoliberal set of problematisations. But what about rationalities?

Rationalities in TEEB-DE

It is perhaps unsurprising to learn that a project coordinated by economists such as in the case of TEEB-DE frames environmental problems as economic problems. However, the picture is considerably more multi-faceted with regard to rationalities. Here I found a relatively coherent pattern of articulation in the discourse's inside: The nodal points "economic approach", "environmental policy integration", "awareness-raising" and "utilising economic incentives" are mentioned again and again. These are positively related to "ecosystem services", "economic assessment", "efficiency" and "synergies" as well as to "expertise of economists", "human self-interest" and "prudence" (see Fig. 24).

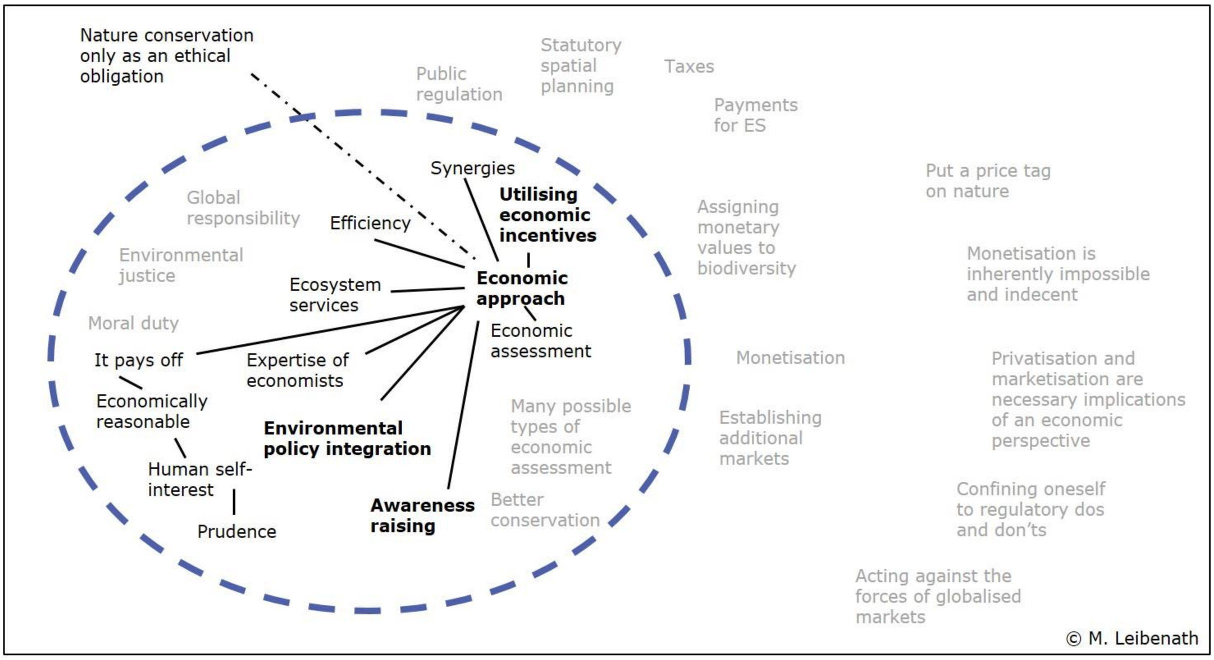

Figure 24: **Core rationality in TEEB-DE**
[See Fig. 22 for an explanation of the different types of lines]

Beyond this relatively stable core, there is one variant in which the elements "monetisation", "put a price tag on nature", "establishing additional markets" and "privatisation and marketisation" are rejected and thus articulated as part of the antagonistic outside, while "economic approach" and "ecosystem services" are positively related to "many possible types of economic assessment" and "better conservation". Apparently, those who produce this strand of discourse advocate an economic approach that does not merely imply an extension of the market sphere or an assessment of ESS in monetary terms.

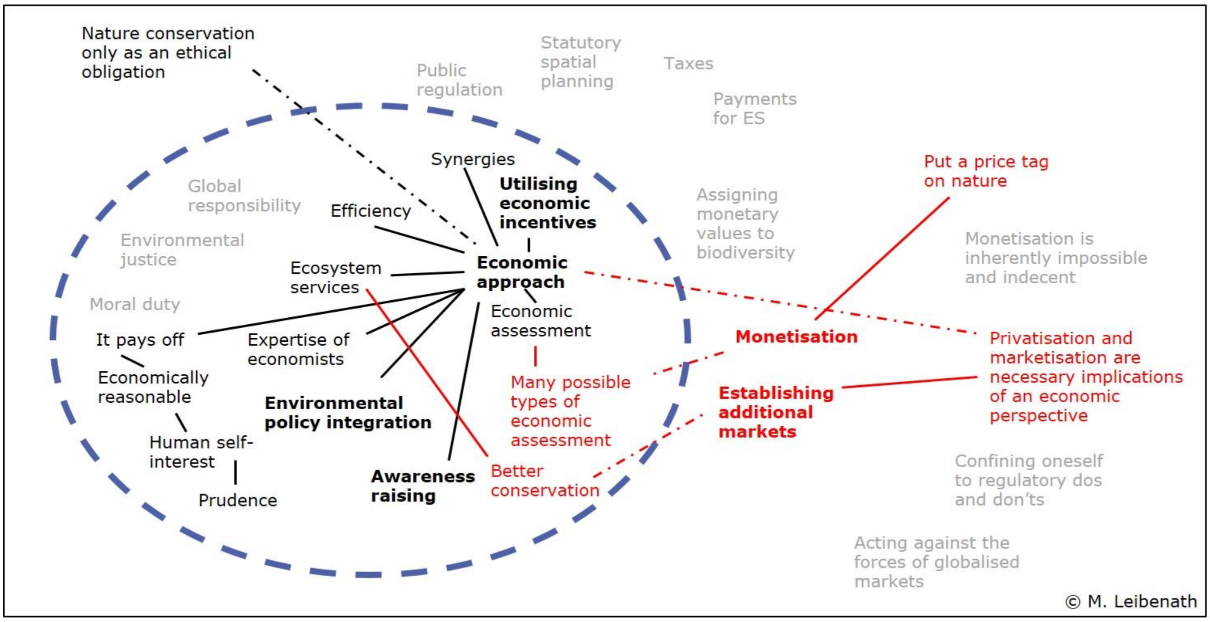

Figure 25: **Rationalities in TEEB-DE – variant 1**
[See Fig. 1 for an explanation of the different types of lines]

In another variant, however, “establishing additional markets” and “monetisation” are positively related to “economic approach”, while the elements “confining oneself to regulatory dos and don’ts” and “acting against the forces of globalised markets” are articulated in relations of contrariety (see Fig. 25). Other variants establish equivalential chains between “utilising economic incentives”, “taxes”, “statutory spatial planning” and “public regulation” or between “economic approach” and elements such as “global responsibility”, “environmental justice” and “moral duty”.

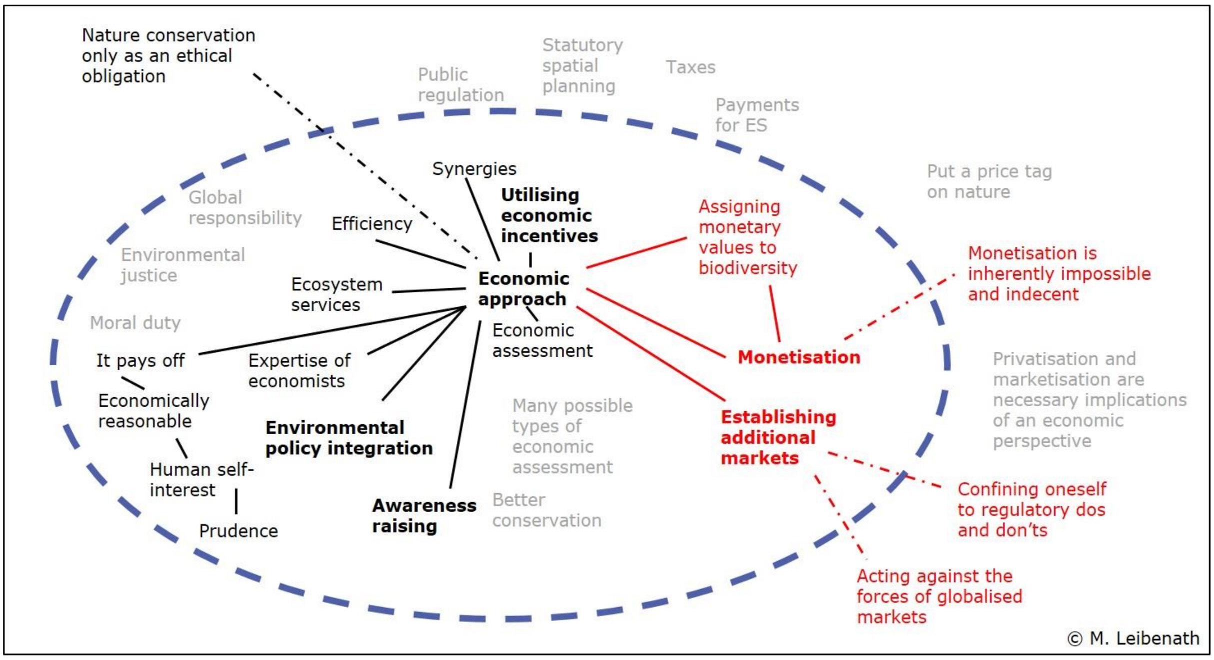

Figure 26: **Rationalities in TEEB-DE – variant 2**
[See Fig. 22 for an explanation of the different types of lines]

It is difficult to ascribe this discourse and its variants to any of the three arts of government introduced above. What we see instead is an interweaving of different rationalities, some closer to a neoliberal governmentality (e.g. variant 2 in Fig. 26) while others allude to sovereign or disciplinary arts of government. This also illustrates the general assumption that any discourse is a contingent construct that fixes meaning only temporarily and can always be articulated differently.

Conclusion

The analysis revealed a coherent set of neoliberal problematisations. By contrast, the findings regarding rationalities of governing are more nuanced: TEEB-DE includes highly divergent strands of discourse about objectives and instruments of nature conservation and, more broadly, environmental policy-making. Compared to the status quo in Germany, TEEB-DE nevertheless marks a shift towards neoliberal governmentality by strengthening an economic framing of environmental problems, based on the notion of ecosystem services. Yet it is also apparent that – in distinction to other countries such as the UK or the USA – sovereign and disciplinary rationalities are still very influential in Germany. At present it is an open question whether a more neoliberal take on policy-making in the field of nature and landscapes will complement or rather cannibalise other views.

The present study shows that TEEB-DE does not offer any clear roadmap for policy-makers. Indeed, it is difficult to grasp the main impact of TEEB-DE: What is its message and to whom is it addressed? While TEEB-DE brought conflicting views on nature, environmental policies, etc. to the surface, it seems as if the initiators failed to establish robust mechanisms to resolve these conflicts (cf. Kowarsch et al. 2017 for an overview of possibe approaches). Furthermore, the close interweaving of politics and science in TEEB-DE is potentially problematic. At times it is unclear to what extent a specific statement expresses scientific knowledge according to the standards of peer-review or rather a political viewpoint. If the ultimate goal is to halt the loss of biodiversity and to facilitate policies for the better protection of natural resources, then we probably need more political, more straightforward and more radical approaches than TEEB-DE.

With regard to future research, it would be worthwhile to undertake more fine-grained analyses of the TEEB-DE process and to scrutinise counter-discourses as well as competing knowledge claims and policy prescriptions in Germany. Furthermore, the development of German nature conservation policies should be investigated over the long term in order to deepen our understanding of how problematisations and rationalities of governing evolve.

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12 Ethical considerations on the relevance and regulation of Marine Ecosystem Services

Andreas Bachmann & Ariane Willemsen
(Bundesamt für Umwelt BAFU, Bern)

Introductory remarks

Target 2 of the EU 2020 Biodiversity Strategy focuses on maintaining and restoring ecosystems and their services. Action 5 states that with the assistance of the Commission, Member States shall "map and assess the state of ecosystems and their services in their national territory". This applies to terrestrial as well as maritime areas. Regarding the latter the Marine Strategy Framework Directive (MSFD) states in article 3 that "the marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive." Article 8 determines the approach to be chosen in order to reach these objectives: "By applying an ecosystem-based approach to the management of human activities while enabling a sustainable use of marine goods and services, priority should be given to achieving or maintaining good environmental status in the Community's marine environment, to continuing its protection and preservation, and to preventing subsequent deterioration."

In the following, we will tackle the question how this strategic and legal approach regarding the protection of terrestrial and maritime biodiversity by maintaining and restoring ecosystem services is to be evaluated from an ethical perspective. We will focus on two questions:

1. What is the moral significance of ecosystem services in general, marine ecosystem services in particular?
2. What does that imply regarding the use and legal regulation of these services?

Before answering these questions, however, the central concepts need to be defined. Furthermore, a clarification of the normative assumptions underlying these concepts is required. These preliminary steps are necessary since an ethical evaluation presupposes a clear understanding of the object to be evaluated.

What is ethics?

Ethics is the science of morality. It aims at a rational justification of moral judgements and moral norms. A rational justification is a justification based on reasons that are comprehensible and acceptable to all persons, irrespective of their cultural background or religious allegiances. Moral norms refer to what ought or ought not to be done or to what may or may not be done. Three features characterize them: 1) Universality: They claim to be valid for everybody; 2) Unconditionality: They claim to be valid regardless of desires or interests; 3) Sanctions: In case of non-compliance, they are associated with specific sanctions (guilt, shame, indignation etc.).

The relationship between ethics and the law is complex. Suffice it to say that many legal norms especially those enshrined in the constitution (and in many international conventions and treaties) are based on moral norms. At the same time, state action, at least in democratic states of law, should be based on legal regulations, not on moral beliefs. That does not mean, however, that in this context ethical reflection is irrelevant. There are two main reasons why this kind of reflection remains essential: first, because it can help interpret and clarify legal concepts such as dignity or sustainability that contain moral aspects; second, because it is an efficient tool to examine the justification of legal regulations and, if necessary, criticise current regulations in a way that can contribute to improving these regulations.

Definitions

The concepts to be defined are: ecosystem, ecosystem services (ESS) and marine ecosystem services.

- Ecosystem: According to article 2 of the Convention on Biological Diversity (CBD) an ecosystem is a "dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". This definition seems to be universally accepted. That is why in this context no further discussion is needed.
- Ecosystem services (ESS):
  Generally speaking ESS are "benefits people obtain from ecosystems" (Millennium Ecosystem Assessment). More specifically, they are "direct and indirect contributions by ecosystems to human wellbeing, i.e. goods and services which offer direct or indirect financial, material, health or psychological benefits for humans." (TEEB.DE (2016), Ecosystem Services in Rural Areas. Basis for Human Well-Being and Sustainable Economic Development, p.86).
- According to the standard classification as set out by the Millennium Ecosystem Assessment, there are four types of ESS: supporting services (soil formation, nutrient cycling, primary production), provisioning services (food, freshwater, fiber, genetic resources), regulating services (climate regulation, water regulation) and cultural services (aesthetic, recreation and ecotourism, cultural heritage, spiritual and religious). This classification is still widely used even though some modifications have been proposed. For our purposes, however, these modifications are not relevant since the anthropocentric approach essential to the original conception of ESS has not changed. The aim is still the same: "to maintain or enhance beneficial contributions of nature to a good quality of life for all people" (Diaz et al. 2018:270). And this still implies that nature is considered instrumental with regard to human well-being.
- Marine ecosystem services: These services also include ESS of coastal areas. Oceans and coastal areas provide a broad range of ESS. To give some examples: Provisioning services such as fish (food) or energy production; regulating services such as climate regulation or CO2 sinks: cultural services such as the recreational value of the underwater world or coastal landscapes; or supporting services such as the contribution of marine organisms to global primary and oxygen production.

Normative assumptions underlying the conceptual framework of ESS

The conceptual framework of the ESS approach is based on the idea that ESS are of instrumental value with regard to human wellbeing, which is intrinsically valuable. The key normative assumption seems to be that there is a duty – coinciding with rational self-interest – to protect and enhance human wellbeing (as the target value) by protecting and enhancing ESS. At the same time according to the self-understanding of this approach, nature is also inherently valuable. What is distinctive is only its specific emphasis: it focuses on the relationship between nature and human wellbeing. In this vein the Millennium Ecosystem Assessment (MA) states that "the conceptual framework for the MA places human well-being as the central focus for assessment, while recognizing that biodiversity and ecosystems also have intrinsic value and that people take decisions concerning ecosystems based on considerations of well-being as well as intrinsic value." (Alcamo et al. (2003), Millennium Ecosystem Assessment, Ecosystems and Human Well-Being. A Framework for Assessment, p.7). A very similar view can be found in the influential reports of the global initiative "The Economics of Ecosystems and Biodiversity TEEB". In one of these reports issued by TEEB.DE it says: „Nature is inherently valuable, which should be reason enough to preserve it. In addition, the many and varied services that nature provides for human wellbeing (…) have a significant economic value. (…) They enhance our quality of life and form the basis for numerous economic activities, and are therefore vital for our prosperity and wellbeing." (TEEB.DE (2015), Natural Capital and Climate Policy, p.18)

Human wellbeing, inherent value, instrumental value, and morality

These normative assumptions are highly problematic, and this in several respects. There are strong arguments against the view that nature is inherently valuable, i.e. valuable in itself, irrespective of its instrumental value e.g. for human wellbeing. However, even if it were inherently valuable, that would not necessarily entail that there is "reason enough to preserve it" – at least if 'reason' means 'moral reason'. Furthermore, this way of thinking is based on the tacit assumption that morality mainly or even exclusively refers to inherently valuable objects and their protection or preservation; whereas it is irrelevant with regard to instrumental values. This is not plausible. Many instrumental values are of great moral importance – as is the case with ESS. It is wrong to tie instrumental value exclusively to economic value. To make this clear and to better understand the moral status of ESS we have to take a closer look at the pertinent moral "protection goals" as seen from an ethical point of view and the way they are linked to human wellbeing.

What is the status of ESS from an ethical point of view?

Ethics as a science is characterized by a theoretical pluralism. There is no single theory accepted by all experts active in this field to be the right or true or best theory. Among the competing theories (which are few in number) two play a dominant role: Consequentialism and deontology.

Consequentialism and deontology exclude each other. They cannot be combined. There is no third 'super-theory'.

Consequentialism

According to consequentialism, the moral rightness of an act (or rule) depends solely on its expected consequences. The action (or rule) must be chosen that presumably has the best consequences for all those being affected. The best-known consequentialist theory is utilitarianism. On this approach, the action (or rule) must be chosen that presumably results in most happiness for all those being affected. There is just one moral duty: maximize happiness.

What is the connection between utility and happiness? Utility does not refer to social or economic utility. It is just another word for happiness. Happiness, in turn, means the same as wellbeing. And wellbeing refers to what is called 'intrinsic goodness'. In our context it is important to understand that what counts from a utilitarian perspective, is not individual wellbeing, but rather the (greatest possible) net benefit, i.e. "the greatest happiness of the greatest number".

Deontology

In deontology, consequences of action are also important. However, there are situations in which they do not matter. Actions of a certain type such as, for instance, lying, the intentional killing of innocent persons or torture must not be performed, irrespective of the consequences that may occur. Such acts are prohibited even if they would increase or maximize net benefit. On the other hand, actions of a certain type such as helping a drowning person are morally obligatory.

From a deontological perspective, moral norms (duties, rights) do not directly refer to 'human wellbeing' or a good (human) life. Deontologists distinguish between moral norms (duties, rights) that are in everyone's interest and that must be respected as a precondition of a good life and the good life itself. There is no moral right to a good life and its components. No one has a moral duty to see to it that a good life for all is guaranteed.

Utilitarianism and ESS

Utilitarians argue that ESS of any kind must be preserved (in the long run) according to their importance with regard to the maximization of happiness (locally, regionally and globally). There is no other criterion regarding the value or significance of different (types of) ESS. This also applies to marine ESS. What this means in concrete terms, is an empirical question.

Utilitarians do not reject the monetization of ESS outright. However, they would question the concept of total economic value as an adequate way of determining net benefit – even if they agree that net benefit is to be measured in terms of preference satisfaction (as opposed to the surplus of pleasure over pain). Furthermore, they would argue that if a utilitarian approach is chosen then the consequences accruing from this decision must be accepted, even if this means that some – or maybe even many – people (or other sentient beings) suffer great harm.

Finally, they would demand caution with regard to long-term evaluations of ESS. The longer the time period under consideration the more difficult it gets to compute the net benefit.

At the same time, utilitarians think that we do have to take future generations into account. In this situation, it may seem plausible to prioritize certain ESS (likewise with regard to their mapping and assessing according to Action 5 of Target 2 of the EU 2020 Biodiversity Strategy and given the limited human and financial resources). To the extent that a computation is not possible due to lack of data regarding long-term developments it seems rational first, to do what is required to protect the ESS necessary for long-term survival and secondly, to protect those ESS necessary to retain as many options for action as possible.

The same criteria apply for the risk assessment of impacts of new technologies on ESS such as e.g. for energy production, ocean mining or climate mitigation projects. The corresponding chances and risks have to be netted. The expected benefit has to be maximized. Every risk has to be taken if this increases the expected net benefit. How these risks and chances are distributed is irrelevant. Each person has to accept to be exposed to a risk, no matter how high, as long as it is connected to the highest expected net benefit.

Deontology and ESS

According to deontologists those ESS that are of vital interest for all human beings (or all inhabitants of a country) must be preserved irrespective of their economic (monetary) value and irrespective of the costs of preservation. In other words: ESS required to safeguard moral rights (for instance, to health, to access to adequate food or water) must be preserved. Other ESS (e.g. cultural ESS) may be less significant with regard to moral rights. Thus, there is no duty to protect them. The significance of marine ESS must be evaluated accordingly

In a deontological risk assessment of the impact of new technologies on ESS the acceptability of risks depends on the extent to which each person is affected. While we have no moral claim to be exposed to zero risks, we have a moral claim not to be exposed to risks that exceed a threshold to be defined. Every person has to accept being exposed to risks as long as the level of risk is beneath the threshold. Deontologist do not accept to net risks against chances. Chances are morally irrelevant as long as the risks are above the threshold.

Summarising the above, it can be said that in both ethical theories the decisive moral point of reference is not human well-being as such, but:

- net benefit (maximization of happiness) in utilitarianism
- safeguarding moral rights and/or meeting one's duties in deontology.

When lacking risk information on the impact on ESS, both utilitarians and deontologists demand to generate risk data on possible impacts on ESS in order to be able to adequately assess the risks, i.e. information on damage scenarios and data on probability of occurrence.

Utilitarians need these data in order to calculate chances and risks and the greatest net benefit of an action. However, getting more information has a price. Utilitarians will include this price into their calculations. At a certain level of costs utilitarians will act. But in a utilitarian logic one will do so cautiously, step by step.

The reference point for deontologists is the duty to protect and restore ESS that are of significance to moral rights. In this respect, it is forbidden to base decisions on chance/risk-calculations. What is required is to clarify the threshold for acceptable risks and to reduce risks to a level that the occurrence of a morally relevant damage becomes (highly) improbable. Where feared damage scenarios are 'severe' and not implausible (i.e. not logically impossible), and the probability of the damage occurring cannot be determined due to lack of data, both ethical approaches demand to take precautionary measures in order to avoid occurrence of a severe damage on ESS. Adequate step by step procedures, expansion and continuous update of risk knowledge as well as systematic accompanying research on risks and systematic monitoring to detect unexpected damage is needed.

It is the state (or other political entities, such as the EU or the UN) that has (have) the moral duty to see to it that the corresponding ESS are protected according to their moral importance.

Conclusions for the use and regulation of ESS

Summing up we can say that ESS are not on a par. They do not all have the same importance. From a(n) (act-)utilitarian point of view no general statements regarding the comparative importance of the different kinds of ESS can be made. Generally, it depends on the context, on the concrete case at hand. It may be that cultural services can be neglected or on the contrary must be given priority. However, especially with regard to long-term decisions utilitarians would urge to give priority to the maintenance of those ESS that are indispensable for human survival and a minimally decent life (i.e. mainly the satisfaction of basic needs). Secondly, to those that helps to keep options for actions of future generations as open as possible (since it is impossible at the present point in time to calculate the net benefit of these generations). Since we do have a moral duty with regard to future generations utilitarians would tend to plead in favour of a legal regulation that is based on these two criteria.

As far as legal regulations are concerned deontologists would take a similar view – albeit for different reasons. Deontologically speaking cultural ESS are only relevant if there is a moral duty to see to it that these services exist. Whether such a duty exists towards these ESS, however, is questionable. Conversely, it is clear that the instrumental value of many of the other ESS regarding the protection of moral rights such as the right to adequate food or water is of such great importance that there is a moral duty to maintain and, if necessary, restore them. To the extent that these ESS are practically indispensable they ought to be regarded as non-negotiable and non-exchangeable. In this respect, deontologists would argue that it is advisable not to use concepts such as 'ecosystem services'. Since this way of talking suggests that the goods and processes in question are commodities that are monetizable and can be exchanged like any good as long as there is a market, i.e. supply and demand.

Although the legal documents on ESS are using an ambiguous language from an ethical point of view, the law, especially constitutional law, is based on fundamental rights, and the legal system is thus close to a deontological approach. Insofar as the protection of ESS affects these rights it seems preferable, therefore, to tailor the corresponding legal regulations to the deontological criteria delineated above.

Regarding access to and use of ESS the two approaches may come to the same conclusion despite the differences in their theoretical foundations. If the goods in question are abundant or non-limited (e.g. genetic information, understood as immaterial type as opposed to material token), both an open source model without any regulation as well as a model of private appropriation (e.g. based on patents) may be justifiable. If the goods are not abundant or limited, such as many ESS, understood as material tokens, and if these goods must be protected for moral reasons, neither unregulated open source nor private appropriation models seem admissible. This implies universal and free access. However, in order to avoid a 'tragedy of the commons', the use of these goods must be regulated accordingly.