The Missing Links in Ecosystem Service Research

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Abstract

The marine and coastal ecosystems of the Baltic Sea are exposed to an intensification and diversification of anthropogenic activities and related environmental pressures. Human interest in marine resources and space often overlap with environmental protection objectives, causing conflicts. Research can assist capacity building to enable knowledge-based decision-making in marine management and policy to help solve these issues. Three participatory systematic maps were carried out on marine and coastal ecosystem services (ES), monetary and non-monetary valuation methods applied to value them, and the interrelation of ES and human health and well-being in the Baltic Sea region. Policy advisors were engaged throughout the review process. The aim was to map existing

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scientific knowledge and identify knowledge gaps for the scientific community and to support the implementation and update of the key marine protection policies in the region. This chapter introduces the review methodology, provides an overview of knowledge gaps and missing links in ES research, and addresses future steps to connect the dots.

21.1 Marine Policies and the Ecosystem Approach

Marine policy and management decisions in the Baltic Sea predominantly target the condition of ecosystems in order to regulate anthropogenic pressures and meet the environmental objectives. The commonly used framework is the ecosystem approach adopted by the Convention on Biological Diversity (CBD) to support "integrated management of land, water and living resources", thus emphasizing the "intrinsic value" of biodiversity and ecosystems (UN CBD 1992).

Since 1974, the Baltic Sea Marine Environment Protection Commission (HELCOM) has coordinated the environmental protection objectives as well as environmental assessment and management goals of the nine littoral Baltic Sea countries and the EU. In 2007, HELCOM adopted the Baltic Sea Action Plan (BSAP) with the aim to reach good environmental status in the Baltic Sea by 2021. This plan included objectives on eutrophication, biodiversity, hazardous substances and maritime activities. To reach these objectives, HELCOM established the Group for the Implementation of the Ecosystem Approach (GEAR) dedicated to marine management and the sustainable use of marine environments. In addition, an expert network of economic and social analysts specializing in the use of marine waters and the cost of degradation was formed to provide recommendations and advice to the HELCOM GEAR group (HELCOM 2018a). The European Union Marine Strategy Framework Directive (EU MSFD) (Directive 2008/56/EU), however, is the key policy on environmental protection of marine ecosystems and was established in 2008. It extended the EU Water Framework Directive (WFD) to all European waters to achieve Good Environmental Status (GES) by 2020.

The BSAP and the European Union Maritime Policies, including the MSFD and the Maritime Spatial Planning Directive (MSPD) (Directive 2014/89/EU), apply the ecosystem approach for the integrated management of marine resources. Through the MSFD, 11 qualitative descriptors were established that describe the ecosystem condition when the GES has been achieved. Similarly, the goals and objectives of the BSAP represent its main aims by linking the environmental status and the impact of anthropogenic pressures to the environment. Due to the main target of policy objectives and management decisions to achieve and maintain GES of marine ecosystems, the research focus has been predominantly on ecosystem processes and functions (e.g. Lindh and Pinhassi 2018; Carstensen et al. 2020) and the development of assessment methods and environmental indicators to assess the environmental status of ecosystems (e.g. Borja et al. 2013, 2014; Lyons et al. 2017). The MSPD, and likewise the MSFD, require the maritime spatial plans and

the Marine Strategies of all EU member states to consider ES to achieve and maintain healthy marine ecosystems and to enable their sustainable use (Article 4 MSPD; Article 1, MSFD). While the official reporting has a mandatory requirement for the assessment of the environmental status, it makes the assessment of ES and the application of the ES approach obligatory only for the economic and social analysis. Due to these limited institutional requests, the application of the ES concept is not well-developed in marine and coastal ecosystem management and decision-making (Boulton et al. 2016; Drakou et al. 2017).

However, considering the manifold interrelations of human actions and the condition of nature, sustainable management cannot simply focus on the ecological status, but needs to analyze and integrate all aspects of the socio-ecological systems. Therefore, three participatory systematic literature syntheses on (1) marine and coastal ecosystem services research in the Baltic Sea, (2) monetary and non-monetary valuation methods used in the region, and (3) the relationship of the Baltic Sea ecosystem services and human health and well-being were carried out to provide an overview of the available scientific knowledge on marine and coastal ES research in the Baltic Sea region. In this way knowledge gaps were identified, and the available scientific evidence made more accessible for policy makers and the scientific community alike. This chapter constitutes a summary of the outcomes of the three studies (Håkansson et al. 2020; Kuhn et al. 2021; Storie et al. 2021).

21.2 Participatory Systematic Mapping of the Evidence Base

Systematic literature mapping is a method to review literature with the aim to identify, collate and describe the evidence base to a specific question and identify research gaps in a repeatable and objective manner. First applied in medical research, the Collaboration for Environmental Evidence (CEE) developed guidelines (CEE 2018; Haddaway et al. 2018) that set standards for synthesizing environmental scientific information for decision making. Literature is reviewed under transparent conditions and with pre-defined criteria to reduce bias. Stakeholder involvement is considered beneficial for the process of planning and conducting systematic maps, and to support the development of policy relevant outputs that enable decision-making with the best available knowledge (Haddaway et al. 2016, 2017).

Figure 21.1 gives an overview of the review questions and illustrates the screening process of the three participatory systematic maps. The search string development included test searches to validate the comprehensiveness of the search strings, composed of geographical keywords, ecosystem/ ES keywords and synthesis-specific keywords, against benchmark lists of publications that were previously defined as relevant through expert knowledge and snowballing. Searches were carried out in multiple bibliographic databases and search engines (e.g. Web of Science Core Collection, Scopus, BASE) and after duplicate removal, publications were subsequently screened for relevance on title, abstract and then at full-text level based on pre-established inclusion and exclusion criteria. All levels of screening and data extraction were carried out by teams of two or more reviewers and consistent

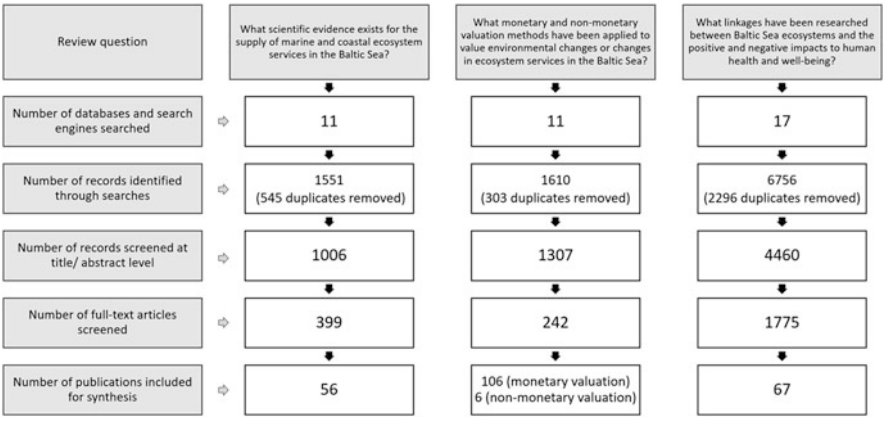

Fig. 21.1 Review questions and number of publications throughout the screening process

practice was ensured by double screening and coding a subset or respectively all publications to consolidate repeatability. After the collection and collation of publications, data was extracted and synthesized. Policy advisers from the HELCOM GEAR group were involved throughout the review process, e.g. to define the scope of the research, discuss the interim synthesis results and to clarify the policy relevant main messages from all syntheses (Kuhn et al. 2021). For more detail on the methodological approach and overviews of all relevant publications of the three syntheses, please see (Storie et al. 2020, 2021; Håkansson et al. 2020; Kuhn et al. 2021).

21.3 Ecosystem Service Research

Following the general trend in the past decade, research on marine and coastal ES has been a growing field in the Baltic Sea region. Studies have been mainly focussed on regulating ES (37.2%) with a special focus on the regulation of nutrients. Research on cultural ES (32.6%) and provisioning ES (30.3%) were predominantly represented by studies on the provision of fish and recreational aspects of the human interaction with nature. More than 80% of studies only considered ES supply and did not incorporate ES demand. 40.7% of publications focused on biophysical studies in comparison to social (18.5%), economic (18.5%) and management/ policy approaches (22.2%). Typical study designs were economic (17.8%) and biophysical assessments (16.8%), modelling approaches (16.8%) as well as surveys (15.8%) and expert assessments (10.9%) (multiple answers possible). Studies on the development and application of ES indicators and therefore publications that systematically apply ES assessment and mapping approaches, as requested by MAES (Mapping and Assessment of Ecosystems and their Services), Target 2 Action 5 of the European Biodiversity Strategy to 2020, are rare (5 studies) (e.g. Veidemane et al. 2017; Ruskule et al. 2018; Depellegrin et al. 2020). The understanding of how changes

in ecosystem properties and functions cumulatively affect the ability to supply ES is limited as studies mainly focus on specific aspects of the ES cascade model (Potschin and Haines-Young 2011). Neither do these studies necessarily link human actions, biophysical structures and processes via ecosystem functions with ES and the impact on the benefits humans gain for their health and well-being. This knowledge is crucial to assess the vulnerability of ecosystems to the numerous human activities associated with the Baltic Sea. Conversely the integration of the influence of drivers of change, like anthropogenic pressures as well as policy actions, on ES supply would be valuable. While there are a few publications that consider the supply of more than one ES (e.g. Troell et al. 2005; Ahtiainen et al. 2019; Viirret et al. 2019), studies on ES trade-offs and synergies or on the interactions within ES bundles are missing. ES research in the Baltic Sea is characterized by limited use of a classification system. 24.5% of publications applied the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin 2018), while another 7% of studies referred to the four ES categories established by the Millennium Ecosystem Assessment (MA 2005). The restricted application of systematic classifications in the scientific literature makes room for an inconsistent use of terminology and leaves space for misinterpretation.

The word clouds in Fig. 21.2 display synthesized the categorized terms of all provisioning, regulating and cultural ES mentioned as examples of ES in the publications. Word size resembles how often the respective category is used, e.g. larger words were mentioned more often or represent a category of word clusters. The main word clouds in the centre depict the categorized major findings, while the smaller word clouds on the right display a more detailed account of chosen categories. Comparison of word size and therefore the frequency of appearance is only valid within each cloud. The word clouds show, on the one hand, the plethora of terms for one ES, e.g. related to nutrient mitigation. On the other hand, they indicate the broad notion in which some ES, e.g. the provision of fish, are discussed. For example in the use of the term "fishery" as an ES, there is no consistent differentiation between the service supplied by the ecosystem and the human action to extract the resource. As for the application of CICES, the word clouds indicate that the classification is most often applied to identify regulating ES. In addition, space and biodiversity, which are not considered as ES in CICES, are often discussed as such. This analysis and the stakeholder involvement carried out during the review process indicated, that more emphasis should be given towards developing a more consistent terminology within the research community, as well as reconsidering how the communication towards stakeholders and the general public can be simplified.

21.4 Ecosystem Service Valuation

A systematic mapping of scientific literature of monetary and non-monetary valuation methods was set up to get an overview of which valuation methods have been used to value the benefits of an environmental/ES improvement in the Baltic Sea or the costs of not reaching the environmental protection goals of the Baltic Sea

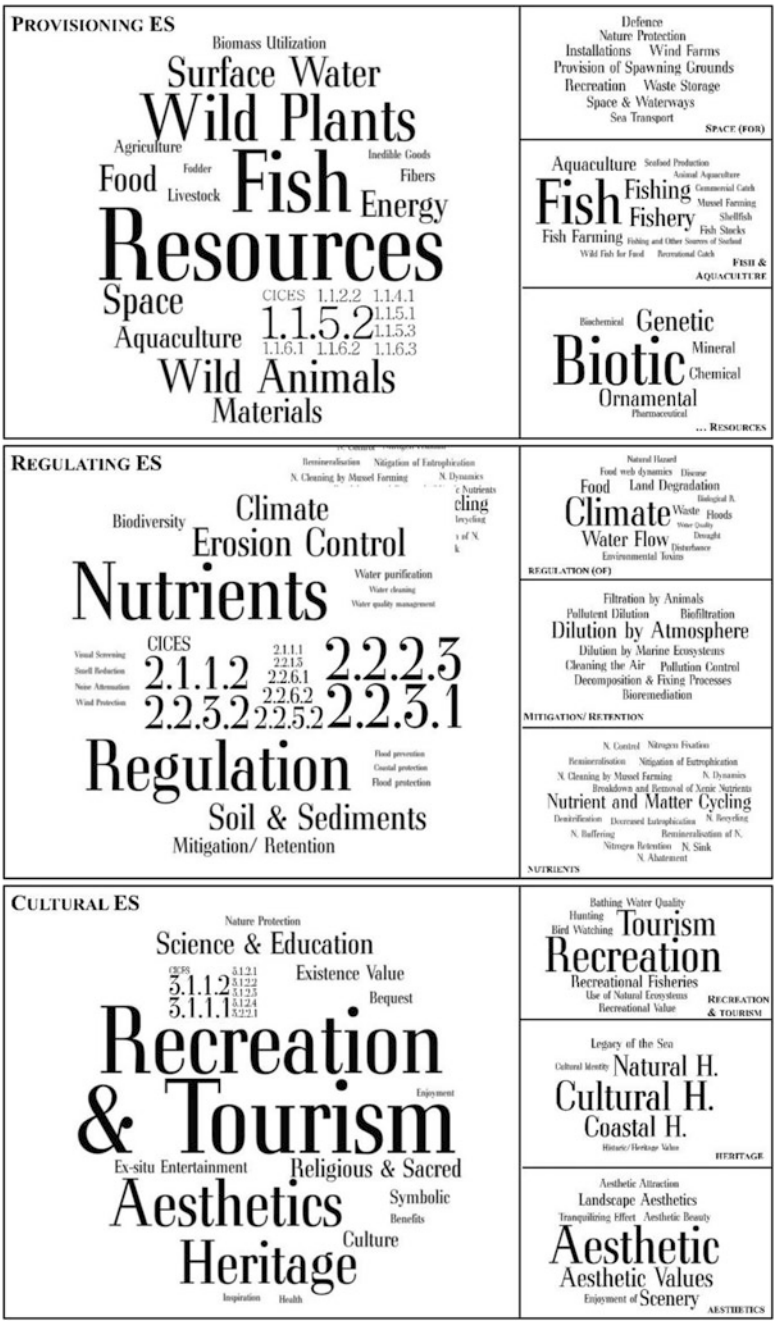

Fig. 21.2 Word clouds displaying the categorized findings of provisioning, regulating and cultural ecosystem services mentioned

(Håkansson et al. 2020). Monetary and non-monetary valuation methods capture people's preferences, perception and motivations and measure these using quantitative, semi-quantitative or qualitative value indicators (e.g. Ninan 2014). The choice of the right valuation method to be used depends entirely on the need for information, i.e. the question to be answered. So-called cost-based methods can be used if the aim is to find the cost of reaching/not reaching an environmental/ES improvement. However, if policy makers are particularly interested in getting to know how the citizens value the benefits of environmental/ES improvements, or avoidance of degradation, then methods that can capture people's preferences need to be applied (benefit-based methods). The most straightforward way of approximating how people's well-being is affected by a policy action is to use a method that is based on market prices (marked-based methods). (e.g. Hanley and Barbier 2009) The results from non-monetary valuation methods can be used for various purposes, without using monetary metrics, from solving conflicts between different stakeholders to assessing the acceptability of environmental programmes. (e.g. Santos-Martín et al. 2018).

Notably our results showed that, although a number of different valuation methods were available, the cost-based method abatement cost (44%), and the benefit-based method choice experiment (40%) dominated the applied monetary valuation methods to a large extent. Conspicuously only six applications of non-monetary valuation methods were identified. Two major gaps identified in our mapping were that valuation research did not apply the ES concept and they did not make the connection to marine protection or other marine policies. For example only 13% of the studies applying monetary valuation methods used ES as a keyword in their research article. Although the authors of the research articles did not seem to apply the ES concept in their study, the researchers conducting the systematic mapping were able to apply CICES to the existing studies and interpret which ES were valued. Nearly 60% of the monetary valuation applications studied cultural ES, whereas only 11% of the studies considered regulating ES. The MSFD, that is the policy explicitly calling for economic analysis and the use of ecosystem approach, was mentioned only in 16% of the studies.

As pointed out in Sect. 21.3 there is a lack of ES research, and evidently, if the impact of a marine policy to the marine environment is not known in biophysical terms, the basis for valuation is not solid. Increasing the number of marine ES assessments where the impact of a policy to the magnitude of the ES supply is studied would facilitate the valuation of the ES. Also, valuation studies considering single ES are probably less valuable for decision-making since they do not provide the basis for analyzing trade-offs between different ES. Further, it is important to point out that in order for the valuation results to be used in policy making it must be clear to the policy makers what has been valued (both in terms of ES/environmental change and in terms of what a valuation method can and cannot capture). Hence, we argue that an effective marine ES valuation requires interdisciplinary collaboration and science-policy dialogue.

21.5 Human Health and Well-being

Health and well-being have a range of definitions in the literature from the functional use of proxies, such as life expectancy, to a more holistic understanding that utilizes a range of factors (Storie et al. 2020). However, the knowledge of the ES that the Baltic Sea provides to the health and well-being of those who live in the region or visit it, is lacking. While human populations have had a significant negative impact on the Baltic Sea ecosystem, which are well documented (HELCOM 2018b), the positive and negative impacts of the Baltic Sea on human populations are not as well elaborated in the scientific literature, as the linkages are often vague and lack detail (Storie et al. 2021). For example articles may mention human health is negatively impacted by the ecosystem, but do not elaborate on the specific health impacts.

Society protects what it values but does not protect what it does not understand, therefore there is a need to understand the benefits that the Baltic Sea provides to human populations and the consequences of environmental degradation on human health and well-being. Literature suggests that improving the knowledge within society also improves the acceptability of the measures taken to restore and protect ecosystems (Pakalniete et al. 2017; Schernewski et al. 2018; Thomas et al. 2018; Hyytiäinen et al. 2019). Once people understand that a good environmental status is good for their health and well-being, they are often more supportive of the measures taken.

The systematic literature search showed there are articles focused on health issues arising from exposure to the Baltic Sea, such as cancers from eating fatty fish (Hagmar et al. 1992; Glynn et al. 2013) or infection from antibiotic-resistant organisms (Literak et al. 2010; Mudryk et al. 2010; Bier et al. 2015). Studies were also carried out that documented how degraded ecosystems are leading to poor health and well-being outcomes for society (Ahtiainen and Öhman 2014; Veidemane et al. 2017; Nieminen et al. 2019).

Few articles, however, bring these aspects together in any detail. Those that explicitly mention ES rarely provide examples of the health and well-being impacts of ES on people, they merely mention the potential for impacts. Those articles that do mention ES tend to focus on the benefits of cultural ES such as recreation (Czajkowski et al. 2015; Ahtiainen et al. 2019; Bertram et al. 2020) or the provision of fish for good nutrition (Veidemane et al. 2017). In addition, knowledge of the impacts of the Baltic Sea on health and well-being is scattered across multiple disciplines. For example detailed effects on health arising from exposure to the Baltic Sea ES are found primarily in the medical literature, however, these papers do not link to the ES concept.

There is a need for a common understanding of the benefits, not just health, but the full range of well-being benefits that the Baltic Sea ES provide. The benefits include economic and material contributions to living standards; healthy food; security and safety of users through coastal protection; social relations, governance and freedom of choice and action connected to how the Baltic Sea's resources are used and enjoyed; subjective well-being and culture related to the aesthetic and recreational opportunities the Baltic Sea provides and so on. There is a need to

understand these impacts on human health and well-being because they are not always obvious to society and therefore education is needed. For example, knowledge is limited on the multiple benefits provided by coastal wetlands, which include the provision of clean water, maintaining healthy beaches and reducing erosion. Often society thinks reeds by the beach are unaesthetic and do not understand the benefits. Society needs to see the beauty in the complexity of the ES provided by the Baltic Sea and thus be able to value the benefits.

21.6 Implications for Research to Support Environmental Management and Policy

The main marine policy focus and thereby the leading research emphasis has been on the GES of the Baltic Sea ecosystems and therefore significant knowledge gaps on ES exist. Our society is driven by limitless economic growth, while ecological resources are limited. Therefore, the management intention based on the ecosystem approach could obtain depth by involving the complex linkages and dynamic relationships between human pressures, biodiversity, ecosystem condition and the supply of ES. As environmental protection constitutes only one aspect of social decision-making and is not the highest priority, environmental management of ecosystems needs to balance the status of ecosystems with anthropogenic interests and importantly, underline the importance of healthy ecosystems for human existence. To support evidence-based decision-making that integrates environmental protection and human use of the marine environment, increased efforts are needed to assess and quantify ES and their synergies and trade-offs, that builds the foundation for ES valuation. The lack of a standardized terminology and classification within the research community was identified as source for misunderstanding, as well as an obstacle to develop a common approach for the communication towards policy makers. In addition, there is a need to communicate more effectively to the public to help them understand the value that ES provide for them. The involvement of a broader range of stakeholders (e.g. concerned citizens, ES users, funding agencies and policy makers) and a strong focus on transdisciplinary ES research that incorporates ecological assessments, environmental management, as well as medical and socio-economic research is needed to support sustainable development for the Baltic Sea.

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