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Hendrik Schubert · Felix Müller *Editors*

Southern Baltic Coastal Systems Analysis

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Foreword

Since two decennia, coastal research in Germany is promoted mainly through funding of the Federal Research Ministry. Since one decennium I am retired so I was honoured to be asked to give my comments on this substantial contribution to coastal research encompassing disciplinary studies on aquatic and marine habitats as well interdisciplinary studies including ecosystem services on such land–water transition areas. Globally coastal habitats are important areas for nature, as well as for humankind. Therefore interest in understanding these habitats is growing.

During and after reading through this immense complex matter, I was left with a series of impressions that I will present and discuss in a more or less arbitrary order. Coastal research has been strongly promoted since the early 2000s. ICZM (Integrated Coastal Zone Management) was the magic word. Most of the initial studies were disciplinary oriented (geology, marine and aquatic biology, etc.). Later on and impressively demonstrated in the BACOSA and SECOS projects interests changed from disciplinary to multi- and inter-disciplinary studies. In other words from the disciplinary natural science approaches to the human oriented ecosystem services assessment approaches, a major and risky activity.

Coastal research in Germany can be considered as fragmented, mainly due to the different institutions that are involved. Their main interest is natural science of the environment, e.g. the Baltic Sea, the North Sea and the Wadden Sea or the oceanic waters including Arctic and Antarctic waters. The main interference with the human dimension takes place in the coastal zone where human activities interact, mostly in a negative way (pollution, space claims) with the natural environment. This is well illustrated in several chapters of the book. Looking at a broader perspective, one would like to see a much more intensive cooperation between all the institutes involved through guiding activities of the KDM (Consortium of German Marine Research), where almost all institutes are represented. However, as far as I know, the KDM has not been involved in prioritization of research proposals or stimulated future research directions. Because of the large amount of expertise available, the establishment of a National German Institute for Coastal Research would have been a challenging idea. A department of coastal terrestrial studies should be included to cover all aspects of ecosystem services and human interactions.

The most challenging issue in this book is the attempt to construct a method for the assessment of ecosystem services. A long and intensive text is needed to explain

all the different aspects of ecosystem services, which comprise supporting, regulating, provisioning and cultural services. All four parts are well documented and discussed, new methods to assess them described.

What is missing is a financial evaluation method (see, e.g., Costanza et al. 1997, de Groot et al. 2010). An exception is the attempt to use willingness to pay in a context of touristic use of the coast. This could have been a useful extension towards policy makers and coastal managers. A future activity taken into account should be the application of the ecosystem services assessment in a concrete case with an environmental problem to be solved. I strongly suggest to come up with possibilities to simplify the type of presentation of results of such assessments to make them more understandable for a group of non-experts. This brings me to a déjà vu from my occupation in the Netherlands. In preparation of a new water strategy plan, we were asked to come up with a method to assess ecosystem health. We developed a method based on the occurrence of about 30 species from low to high in the food web. Their numbers or densities were compared between nowadays and a reference period (about 1930, if data available). The current data were expressed against the reference values in a radar plot which delivered an 'amoeba' type of diagram, very easy to understand to which extent numbers differed from the reference. The Minister of Infrastructure and Public Works herself presented the diagram at a symposium on the North Sea (see ten Brink et al. 1991).

In one of the last chapters, the role of the EU in setting coastal and marine policies is well illustrated through the complexity of coming up with new alternatives during a relatively short period. These policy issues are rather confusing.

Finally, the authors have done a brilliant job by starting with an overarching set of questions at the very beginning and answering them in a convincing way at the end. This book will be a milestone in discussion about the human interaction in the coastal zone.

Büsum, Germany
January 2022

Franciscus Colijn

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Preface

The specific smell of a harbour market, a mixture of tar, paint and fish, is regarded as an extremely attractive holiday element, but beach wrack is mostly seen as a nuisance—e.g. because of its smell. In- and out-coming cruise ships can gather large enthusiastic crowds of spectators, whereas others, mainly residents, are complaining about the exhausted pollution. Moreover, even within rather homogeneous groups the points of view about a specific aspect or a specific coastal structure may differ largely. For instance, high biodiversity is seen as a positive feature in general, but when it comes to the establishment of neozooans and neophytes, even in unsaturated ecosystems as the Baltic, other perceptions are arising quickly.

Faced with these different opinions, local and regional authorities must find balanced solutions in their multiple decision-making processes. They are exposed to a large, sometimes contrasting spectrum of judgements, expectations and interests of stakeholders, all of them highlighting their very specific target aspects and armed with their very specific arguments. During the respective debates, soon emotions come into play, stirred up by lobbyist groups and hampering constructive discussions. So where is the neutral ground for environmentally sustainable and at the same time socially accepted solutions? Searching for a solution and relying on the (still) high reputation of science as a source of objective knowledge, decision makers are asking for sound and intersubjective arguments to withstand the pressures from lobbyists.

Consequently, after several decades of intensive research along the German Baltic coast, funded by a broad spectrum of regional, national as well as international agencies, reliable and robust knowledge about all aspects of coastal ecosystems from economic aspects via cultural and societal approaches to natural sciences' results should be ready at hand. However, as seen during, e.g., the establishment of assessment schemes for the EU-Water Framework Directive or, later, for the Marine Strategy Directive, our knowledge is still fragmented. Discipline-related approaches have revealed many new details and have given rise to a bunch of new concepts and challenging hypotheses—but large gaps have been left open between the knowledge-related home ranges of the different disciplines. For example, we knew a lot about tourist behaviour at coastal holiday resorts, but almost nothing was known about their prevalence with respect to the beach appearance. Details of nutrient cycling and relations to ecosystem structure, irrespective of some extant

uncertainties, have been studied a lot at the terrestrial as well as the aquatic part of coastal systems—but the interactions between these two subsystems were at the very best regarded as input/output parameters, ignoring the enormous variabilities or the important feedback mechanisms.

In general, the lack of exchange between the disciplines resulted in a fragmented knowledge base where data provided by one discipline did not fulfil the requirements of the other; so no comprehensive concept for describing coastal ecosystem functionality in a holistic manner was available. In addition, to overcome this situation, during the past decades a series of truly interdisciplinary research projects tried not only to gather the existing knowledge and to fill in disciplinary gaps, but also to develop a concept for assessing the effects of various simultaneous anthropogenic impacts on the system's states.

For the German Baltic coast, this work was done, e.g., by the sister projects BACOSA (Baltic Coastal System Analysis and Status Evaluation) and SECOS (Understanding and Quantifying the Scope and Scale of Sedimentary Services in the German Baltic Sea) as parts of the KÜNO research program (Küstenforschung Nord- und Ostsee), aiming to analyse the interplay between anthropogenic pressures, ecosystem status and climatic factors. Both projects did not start at scratch, disciplinary parts of them just filled in remaining substantial knowledge gaps rather than developing brand-new concepts of ecosystem function. However, closing the gaps, thought to be proof of existing concepts, resulted in some surprising new insights, e.g. about limitation patterns of eutrophic coastal water bodies. But the main aim, and consequently also the red line of this book, was to develop an instrument bridging the gap between scientific results, gathered by disciplinary analysis, and societal demand for a comprehensive knowledge base for well-balanced management decisions. Consequently, writers and readers are facing the challenge to combine a brought arc of knowledge, from deep philosophy to, e.g., exact hydrochemistry.

In filling up this interdisciplinary bow, many colleagues and friends have been helpful in conceiving and realizing this book. Therefore, we wish to thank all of these persons for support, assistance and encouragement. Especially we wish to thank

- The colleagues and supporters from both sequences of the projects BACOSA and SECOS.
- The colleagues and coordinators of the KÜNO research programs between 2013 and 2019.
- The funding institutions from BMBF and PTJ, as well as the home-universities and institutions of the authors.
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Rostock, Germany — Hendrik Schubert
Kiel, Germany — Felix Müller
January 2022

Contents

Part I

Introduction

Southern Baltic Coastal Systems Analysis: Questions, Conceptions, and Red Threads

1

Hendrik Schubert and Felix Müller

Abstract

This chapter sets the frame for the book by introducing the reader into the motivation for coastal ecosystem research at the Southern Baltic Sea, a region under increasing pressure caused by anthropogenic impact. Especially the last decades transformed them to an extent, that serious concerns about their functionality raised requests for sustainable management schemes. This chapter outlines the societal demands behind these developments and the research programs conducted to solve the problems along the path to societally accepted management decisions.

The overall increasing *anthropogenic impacts* in the environment have not only been altering coastal systems, but have also resulted in a steadily increasing number of conflicts of interests. In this situation, the governmental bodies are asked for balanced decisions, respecting the individual interests of various stakeholders and interest groups. Doing this, the weighting of multiple arguments requires solid science-based reasons. And the decision makers need *interdisciplinary approaches* in order to respect the economic, cultural, ecological, and social aspects, which are intertwined in sustainable management strategies. Such comprehensive interdisciplinary studies have been conducted in the past for several terrestrial systems, but they are rather scarce with respect to *marine and coastal systems*.

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The respective modern terrestrial examples have demonstrated that *ecosystem services (ESS)* can be suitable instruments for integrating science with the social and economic aspects of sustainability for a balanced recognition of the various related aspects and requirements. ESS have therefore shown a promising potential for providing a platform for constructive discussions. However, in order to do so, ESS–assessments must be performed on a sound and broad knowledge base. To realize this requirement, all involved disciplines should provide the instrument with data reflecting a deep understanding of the *systems structures and functions* before analyzing interactions and feedback loops together. The resulting *forecast-potential* is the main focus which such instrument is asked for, e.g., to serve as a platform to assess anticipated changes. Climate change impacts, coastal protection measures, installations of windfarms, aquaculture, eutrophication, technical installations, or local development measures are examples for the rising management demands in coastal environments. The desirable local forecast scenarios can be developed by comparison with already existing sites; however, the knowledge base *of the historical status* in most of the cases is not complete, but restricted to specific aspects only. This especially applies to ecological data in the marine realm, where thorough analysis of ecosystem structure and function was not done before industrialization whereas data about economic circumstances, cultural as well as social aspects are at least existing. But "existing" does neither mean that they are easily available nor that they have been analyzed in a suitable approach. A comprehensive history of southern Baltic coastal regions, dealing with all aspects of cultural and economic developments during the past centuries is still missing irrespective of the large number of region- or town-specific publications. Summarizing, for *economic and cultural aspects data exist*, which needed to be analyzed whereas for *ecological aspects data deficiency* has to be substituted by in-depth analysis of the functionality of the recent system. This is what the two projects *BACOSA and SECOS* were aiming to contribute to, in order to improve the knowledge base for the development of an instrument for spatial planning, respecting all aspects of a sustainable use of coastal ecosystems.

Within that situation, this book documents some interesting parts of the outcomes of the German research program *KÜNO*, which has been following the target to "improve the scientific basis for ecosystem-oriented, sustainable management of coastal resources and to make its results available to practice-oriented users,"[1] referring to the German coastal ecosystems of the North Sea and the Baltic Sea. As components of that program, the two Baltic Sea projects *BACOSA* and *SECOS* are providing the main contents of this book. *SECOS* ('The service of sediments and the coastal sea in the German Baltic') has studied the "distribution and quantitative relevance of sedimentary services in the range of the German Baltic waters by measuring, mapping and modelling of future scenarios with the aim to advance the development of management tools." SECOS II[2] has aimed for "a better

[1] https://deutsche-kuestenforschung.de/

[2] https://www.io-warnemuende.de/project/141/secos_ii.html

understanding of transport, exchange and interaction processes between water and sediments, "..." providing mapping tools for areal quantification of structural and biogeochemical properties linked to sediment functions." To do so, SECOS II has aimed for the extension and application of a marine ecosystem-service-evaluation-framework, that covers the German Baltic Sea, spatially integrates natural scientific data, model simulation results and socio-economic aspects into an evaluation tool that visualizes the societal benefits and serves as an umbrella for the integration of marine policies.

The *BACOSA*-Project ('Baltic Coastal System Analysis and Status Evaluation')[3] has aimed "at analysing the quality and quantity of the functions of aquatic plants and has intended to identify and evaluate ecosystem services provided by coastal ecosystems of the Baltic Sea." The aim of *BACOSA II* was to characterize, quantify and value the historical development of ecosystem service supply in the German Baltic Coast region in order to determine the interrelations of ecosystem services with environmental, social, economic and ethical conditions."

The *target of this book* is to integrate important results of these projects and cooperating activities with a special emphasis on interdisciplinarity and linkages between human and environmental coastal sub-systems. We have structured the subsequent steps of knowledge description in this book in 31 chapters, which are each following certain research questions. These questions will be guiding the following introduction and you will find them again in the conclusions of this book. There are of course also *focal questions* concerning the whole contents of this book. These are as follows:

- *Q1: What can we learn from actual case studies of coastal ecosystem analysis in order to evaluate the actual condition of the ecosystems along the German Baltic Sea coastline?*
- *Q2: Is it possible to integrate the multiple aspects of social, ethical and environmental sciences in order to characterize, indicate and measure ecosystem service potentials and flows?*
- *Q3: Is such analyse a useful base for ecosystem management decisions and is it sufficiently significant, robust and applicable to serve as an instrument for sustainability policy?*

To find answers for these queries, we are attempting a *stepwise integration*, which cannot reach up to a total holistic overall view but to the proposal of an interesting pathway how the very different and diverging parts can be brought together. One branch of argumentation will be based on the cooperation of scientific disciplines; another one will be based on the environmental demands for integration and a third pathway will be shown through human-environmental systems approaches. An outcome of this level of integration will be demonstrated by indicator studies on ecosystem services. The basic structure of this conception can be seen in Fig. 1.1.

[3] https://www.ecosystem-management.uni-kiel.de/en/research/projects/bacosa

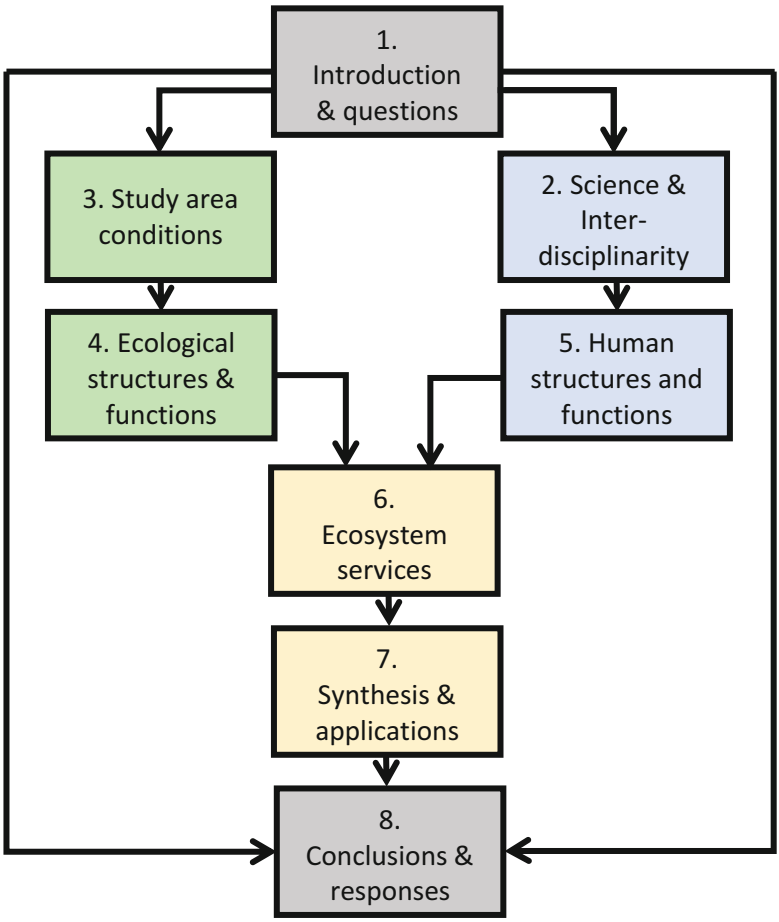

Fig. 1.1 General structure of the book and lines of argumentation

The *second chapter* of this book, nominated as **"Coastal ecosystems from a social-ecological perspective"** (Benkenstein et al., this volume) tries to introduce the different disciplinary viewpoints, which have been denoted before. It is therefore a conceptual text section, which tries to argue for the general integration of individual scientific approaches and starting points. Therefore, Chap. 2 can be understood as a formal and structural description of scientific positions and developments, including an expose of the process of interdisciplinary interaction. The focal guiding question of Chap. 2 is:

- *Q4: What are the demands of coastal research and management for cooperation between the involved scientific disciplines, and how has the attained interdisciplinarity been applied in this book?*

The tentative answers and comments on this question are ordered in the following textual sequence: After an introduction of the single topics, the basic necessity for interdisciplinary approaches in coastal analyses is underlined due to the demand side (Chap. 2) and due to general scientific issues, requirements and reasons for integrative approaches (Chap. 2). These arguments are followed by descriptions of the disciplinary, science-based starting points, their specific targets, demands, methodologies and potential contributions (Chap. 2). Hereby, the authors are discussing aspects from marine and coastal ecology, ecosystem ecology, environmental economics and ethics. Also social and legal aspects are briefly considered, but the focal philosophical approach is described comprehensively from multiple viewpoints, and finally, in Chap. 2 we try to show how this diverse information has been integrated to an interdisciplinary pattern in the framework of this book.

With the *third chapter* (named "**structures and functions of the research area"**), we are moving from theoretical considerations to a practical subject, getting to know the environmental conditions in and around the research area and enfolding the research question 5:

- *Q5: Which are the basic environmental conditions of the research area of the following chapters?*

Thus, here we can find the basic long-term features of the overall study area and the existing habitat types. In the beginning of this brief presentation of the study regions of this book, Chap. 3 (Schubert et al., this volume) demonstrates the abiotic conditions of the southern Baltic Sea. In Chap. 4, Papenmeier and Arz (this volume) provide an introduction of the "geological and sedimentary conditions and their developments." Thereafter Müller et al. (this volume) describe the ecological conditions of the terrestrial hinterland areas of the research region (Chap. 5). Jurasinski et al. (this volume) concentrate on the ecology of the direct coastlines in Chap. 6 and they add a detailed analysis of ecosystem conditions in the reed zones of the Eastern German coast. Finally, the sediment-based habitat structures and the ecological patterns in the marine zones of the Southern Baltic Sea are described by Zettler and Darr (this volume, Chap. 7). This information provides the ground for the more detailed analyses of Chaps. 9–18.

These investigations are described and summarized under a clear ecological focus in the following Chapter, nominated "**Ecological structures and functions of the coastal and offshore water body ecosystems**" by Blindow et al. (this volume). *Chapters 9–18* is targeted on a comprehensive analysis of structure-function links and their variability with respect to limitation patterns in time, ranging from seasonality aspects to decadal long-term trends. For the first time, a synoptical assessment for all sub-systems of a coastal ecosystem allows for direct analysis of interactions and feedback mechanisms. The respective research questions are:

- *Q6: Which are the basic ecosystem mechanisms, interrelations and patterns in the respective habitats and which is their seasonal and long-term variability?*

- *Q7: Can this knowledge help to provide a sound ecological data base for human-environmental systems analysis?*
- *Q8: How do the investigated ecosystems react after human modifications, which is their reactivity, resilience and adaptability?*

Related to these questions, the ecological analysis of the coastal ecosystems begins with an introduction in Chap. 9 (Blindow and Forster, this volume) before Blindow et al. (this volume) start to highlight the special characteristics of coastal lagoons as transient zones between terrestrial and marine influences in Chap. 10. This attitude is reinforced by describing the special study sites of the following paragraphs in Chap. 11 (Schumann and Blindow, this volume). Finally, in Chap. 12. Schumann et al. (this volume) demonstrate significant data about short-term variability, long-term trends and seasonal aspects in the Darß-Zingst Bodden Chain. These ecological items are accomplished by a special study on carbon fluxes and food webs and the effect of macrophytes on the lagoons' food web characteristics by Paar et al. (this volume) in Chap. 13.

In the following four texts, the habitats of the coastal zones of the open Baltic Sea are investigated. The sequence starts with a structural characterization of the benthic habitats by Gogina and Zettler (this volume) in Chap. 14. In the following Chap. 15, the matter fluxes are in focus of the descriptions. Forster et al. (this volume) analyze these functional components concentrating on the important exchange processes by bioturbation. Thereafter, seasonal aspects and short-term variabilities of the offshore ecosystems are discussed by Dutz and Wasmund (this volume) in Chap. 16. The long-term trends of the offshore ecosystems are contained in Chap. 17 (Wasmund and Zettler, this volume) and in the end of the ecophysiological analyses, Berthold (this volume) provides results about nutrient and limitation regimes in coastal water ecosystems in Chap. 18.

With these passages, some significant aspects of the ecological conditions in the coastal waters of the German Baltic Sea are introduced. Therefore, with the subsequent chapters, we are widening the scope and moving into socio-ecological systems. Therefore, in *Chap. 19* (Ott et al., this volume), the human factor is added to the analysis. This accomplishment starts with some theoretical considerations, whereby ethical aspects are playing a major role. Hereby, different approaches to merge the main contrasting lines of human demands by means of ethical and economic points of view are presented and discussed, followed by an introduction into the interdisciplinary approach of human-environmental systems. The respective research question related to "**The human factor—coastal social-ecological systems"** is this:

- *Q9: Which are the focal mechanisms, interrelations and patterns of the societal aspects in order to provide a sound knowledge base for human-environmental systems analysis?*

The resulting depiction of human-environmental systems by Ott et al. (this volume) starts with a short introduction in Chap. 5 and then highlights the systems

from an economic aspect in Chap. 5, stressing perspectives from behavioral sciences as a basis for economic environmental activities. These considerations are expanded by a detailed inception of philosophical arguments. The text introduces, discusses, derives and compares the human-environmental relations from different viewpoints such as environmental virtue ethics, eudaimonic theory, biophilia, religion, or inherent moral values in Chap. 5. These concepts are applied in Chap. 5 within the discussion of valuation strategies and methods, which includes a first introduction of the ideas of ecosystem services. Another approach is demonstrated in Chap. 5: here some basic arguments and concepts of general systems analysis and ecosystem analysis are used to discuss the basic outlines of human-environmental systems conceptions, which can serve as a level of integration bridging philosophical, economic, social, and scientific approaches. Finally, the major human-related geographical structures of the research area are mapped in Chap. 5 as a supplement to the ecological descriptions from Chap. 4.

Up to that position, the object of our studies has been described at different levels, from a pure aspect of *theory of science* and the concept of *interdisciplinarity* over an analysis of the spatial, structural and functional *ecological conditions*. It was ending in an application of the interdisciplinary basics from Chap. 2 in Chap. 19, where the *ecological fundament* has been built for a practical integration on the next, applicable level. That is the development of methods in order to indicate the potentials of the southern Baltic ecosystems to provide *ecosystem services*. Thereby, the following questions will be guiding the discussions in the following paragraphs:

- *Q10: Which are the most effective ecosystem services in the research areas, how can they be described and indicated and how can we derive them from ecosystem analysis linked with societal approaches?*

This task is carried out and demonstrated in some case studies of *Chaps. 20–26* of this book (“**Combining the aspects—Ecosystem service assessment”)**. It starts with a short introduction (Chap. 20) and a conceptual merging of the arguments discussed before. That is the basis for the review article of Kuhn et al. (this volume, Chap. 21), who are on the search for missing links in ecosystem service research related to the situation of the Baltic Sea. They are showing fields of problems, and one such field becomes obvious in the report of Ott and Berg (this volume) about the cultural services of the lagoons of Mecklenburg-Vorpommern (Chap. 22). Besides some illustrative examples of service provision, the authors express the statement that from an ethical viewpoint, a qualitative description of cultural services is sufficient, while attempts of quantification are connected with problems originating in philosophical attitudes. That this is a rather disciplinary viewpoint is shown by the following papers. Poser/Frank and Benkenstein (this volume) provide a report on economic valuations using conjoint analyses of coastal touristic areas in Chap. 23. A more comprehensive approach is developed by Schumacher et al. in Chap. 24. Here, a terrestrial matrix approach has been supplemented, adapted and applied to assess the ecosystem service potential of marine and terrestrial habitats. This is a new combination, which was applied to different scales of the German Baltic coastline. A

compatible approach is demonstrated by Inacio and Schernewski (this volume) in Chap. 25. Here, the authors are concentrating on the temporal dynamics of ecosystem service potentials in different Baltic lagoons by comparing recent and historical data. Also in Chap. 26, we are illuminating ecosystem service dynamics. In this last paper from Bicking et al. (this volume) the viewpoint is directed into the future, describing the potential outcome of some climate and land-use-based scenarios on ecosystem service budgets.

Chapters 27–30 completes the circle of arguments by presenting the feedback from the individual disciplines, demonstrating potential applications and identifying open questions and defining the limits of applicability of ESS. The title is "**Synthesis—valuation as a tool for managing coastal ecosystems"** and the respective questions are related to the overall outcome of this study and potential applications of the derived results and methods. The introduction of this first step of a synopsis (Chap. 27) sets the pace for three articles that try to provide elements of a synthesis of the preceding elaborations. In this sence, Blindow et al. (this volume) are applying the ecosystem service matrix technique to demonstrate the consequences of different ecosystem states in Chap. 28. Thereby it becomes clear how significant the role of macrophytes, phytoplankton and bioturbation can be for the overall capacities to provide ecosystem services. In Chap. 29, Schernewski and Robbe (this volume) are discussing the strategic and instrumental potential of the ecosystem service approach to find a suitable degree of application in coastal management and policy. Finally, Ott et al. (this volume, Chap. 30) discuss the role of ecosystem services for nature protection purposes and for the coastal sustainability concept in general.

In the end, *Chap. 31 ("Conclusions")* provides a brief summary, highlighting the progress achieved and describing fields for application as well as giving recommendations for future research in order to increase the robustness and reliability of forecast potentials within ESS assessments. A focus of the chapter is set on some tentative answers of the research questions, which have been listed beforehand.

Altogether, this volume is thought to offer a comprehensive insight into several aspects of coastal systems of the southern Baltic, ranging from the functioning of ecosystems via socio-economical aspects to ethical concepts. Basing on the obtained results of interdisciplinary research, it addresses transdisciplinary problems and can serve as a sound state-of-the-art knowledge base, stimulating further research as well as being used for the development of management scenarios and strategies with a broad societal acceptance.

Coastal Ecosystems from a Social-Ecological Perspective

2

Martin Benkenstein, Konrad Ott, Michael Rauscher, Hendrik Schubert, and Felix Müller

Abstract

This Chapter has the function of introducing the different starting positions of the authors and to provide a first list of viewpoints on social-ecological systems of the southern Baltic region. After a short general introduction, Chap. 2 describes the central role of human needs for the construction of a unified human-environmental model conception. It argues towards the approach of ecosystem services and gives a first impression on the demand for interdisciplinary and transdisciplinary integration. This strategy is generally deepened in Chap. 2, while in Chap. 2, the situation in different participating disciplines is described: It is shown from which state marine ecology, coastal ecology, ecosystem analysis, environmental economics, and environmental ethics have proceeded to cooperate on the attempt to better understand the coastal systems from a multidisciplinary

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point of view. Finally, the demand for interdisciplinary integration is illuminated in Chap. 2 with respect to the following contents and structures of this book.

2.1 Introduction

In "*The Sea Around US*," Rachel Carson wrote in 1951 about "man":[1] "He cannot control or change the ocean as, in his brief tenancy of earth, he has subdued and plundered the continents" (1951, p. 20). Retrospectively, this quotation echoes a final illusion of planetary infinity. Even if humans cannot "control" the ocean in its entirety, they have changed both the ocean and its coastal zones deeply.

Meanwhile, the ocean is warming due to climate change, ocean acidification has become an encroaching long-term problem, and the intake of substances implies pollution (heavy metals, plastics) and eutrophication. Oxygen-poor regions increase. Specific ecological systems, as coral reefs, are under threat. Some species of marine mammals (blue whales) and fish (tuna) are at the edge of extinction. Coastlines are transformed into human-dominated infrastructures (cities, harbors, tourist destinations, aquacultures, bridges). Many fish stocks are harvested at limits or are overfished. Shipping dominates global trade, adding to marine pollution and to submarine noise, disturbing marine mammals. Deep sea mining is an option of ongoing extractivism. Activities from naval forces add to human impacts upon the ocean. In addition to these degradation factors, we have to consider environmental burdens from the past, as ammunitions from World War II accumulated on the ocean grounds (as in the Baltic Sea) as well as dumping of hazardous substances, which was common in the past century.[2]

The ocean has now been reached by the forces of the Anthropocene. This is true *a fortiori* for the smaller "seas" which are connected to the ocean but are usually surrounded by civilized coastal zones (as the Baltic Sea, the Mediterranean Sea, the Black Sea, and others). Marine conservation and restoration efforts are to be located at different scales. There is planetary or biospheric scale on which we face only one ocean, but there are also continental, national, regional, and even communal scales on which we face specific seas, coastlines, and brackish waters. Environmental policy making also is situated within a multi-layered system: international regimes (as UNFCCC, CBD, CITES, OSPAR, HELCOM etc.), EU policies (as FFH, WRRL), federal state (national), regional, etc. On a global scale, the ocean has been represented in the Sustainable Development Goals (SDG). SDG 14 (misnamed "Life Below Water") has been interpreted from a theoretical "strong" sustainability perspective (Neumann et al. 2017). As Neumann et al. (2017) and Franke et al. (2020) argue the prominent SDG metaphor of "healthy ocean" should be conceived

[1] In 1951, male inclusion was usual in grammar even for a female author. Today, of course, all sex and gender are referred to within inclusionary speech. This is the case in this article.

[2] The dilemma is here that removing the rusted ammunition from the seabed might result in a sudden release of highly toxic substances into the marine environment.

in terms of a principle that one should promote the fertility/productivity, resilience, and richness/diversity of all land- and seascapes. It also holds with respect to the German Baltic coastlines. Under this normative principle, full attention can be devoted to the scope of ecosystem services. The full rationale is given in Chap. 19.

The ecosystem service approach has been applied to different scales in many case studies. Most environmental actions affect primarily but not exclusively minor scales. If we restore the Baltic Sea, we do not affect the Chinese Sea, the Pacific Northwest, and the Gulf of Mexico, but may provide benefits to the Danish North Sea. Minor scales gradually become historical-geological individuals which have proper names ("Wadden Sea," "Schlei," "Jasmund," "Darß"). The predicament of particularity is entailed in the famous slogan: "Think global, act local." Marine policies often also operate on national, or even federal and communal scales. Lieven (2020) has argued that national states and political entities as EU are indispensable for environmental policies. In any case, it makes good sense to create as many refugees and recoveries of nature on minor scales, hoping for beneficial up-scaling effects in the longer run.

Therefore, comprehensive studies on marine and coastal areas of smaller seas are needed. This is the aim of our study. Many general human impacts on marine systems are actual on smaller scales, as at the Baltic Sea. If so, the Baltic Sea can be seen as a "laboratory" for challenge and response, pressures, and outlooks for recovery in terms of ecosystem services at coastal zones. In 2004, the German Environmental Advisory Council published a report on marine environmental protection for the Northern Sea and the Baltic Sea (SRU 2004). This report relies on many HELCOM and OSPAR reports and documentations (see also WBGU 2013; MARE 2017).

A focus on ecosystem services must integrate scientific and social science perspectives as the ecosystem service approach wishes to bridge the gap between nature and human welfare. The approach as such requires inter- and even transdisciplinarity. Natural sciences can identify pressures on ecosystems, as on marine and coastal systems. Science can detect causalities, model complex interactions, and, with some caution, predict outcomes. Natural sciences can observe how ecosystem services change over time. Social sciences deal with dispositions of human behavior (psychology), opportunity costs (economics), institutions (law, political science), social stratification (sociology), and inclinations to react on incentives (behavioral economics). Social sciences are about empirical societal affairs, seen as matters of fact ("soziale Tatsachen"). Empirical sociology investigates how people factually value ecological services. They also may point to challenges, to which societies *should* be able to respond. In the sphere of academia, there are some normative disciplines as well: ethics, political philosophy, economics, and legal studies, which have some expertise in how matters should and should not be.

Ethics is about how people *should* (not) behave. Ethics wishes to substantiate moral yardsticks, as principles, ideals, and virtues. Economics as well has some prescriptive content as it is about "rational choice" and "efficiency." It can be based in an anthropology of human dispositions. Legal studies, which make some

suggestions "de lege ferenda," also belong to the scope of normative disciplines. Disciplines, which gather around the flag of "sustainability science" often, combine scientific and normative components (Ziegler and Ott 2011). Since our study belongs to this type of trans- and interdisciplinary inquiry including normativity, some reflective remarks are appropriate.

Since decades, there is a growing demand for interdisciplinary and transdisciplinary (some say: "post normal") science. Inter- and transdisciplinary modes of research are driven by real-world problems. Interdisciplinary science addresses problems not just from different scientific lenses, but wishes to integrate them. A close reflection on interdisciplinary validity claims is given in Gethmann et al. (2015). Transdisciplinary sciences involve lay persons, professional stakeholder, persons from administrative bodies, and local authorities. Such inquiries assume that scientific knowledge is only one body of knowledge among other ways of knowing. Thus, local, indigenous, and professional knowledge should be incorporated into problem perception and solution. Pohl et al. (2017) make a ten-step proposal of how to perform transdisciplinary science successfully.

Inter- and transdisciplinary approaches, however, presuppose disciplinary excellence. The contribution of each discipline should rest on high scientific standards. Other requirements are the separation of facts and values, the difference between predictions and scenarios, definition of the limits of science (uncertainty, unknown unknowns), and transparency of evaluation schemes (as Ecosystem Service Approach), and policy suggestions.

Environmental studies are a paradigm case for inter- and transdisciplinary inquiries, which include empirical and normative disciplines. In such studies, both epistemological and normative reflections are needed. If values and obligations are made fully explicit in discursive ways, scientific disciplines can be engaged in societal transformations, be it sustainability science, conservation biology, restoration ecology, environmental law, marine conservation, etc. Thus, the distinction between the "two cultures" (Snow 1959) of science and humanities should be complemented by a "third culture" of interdisciplinary environmental sciences (Ziegler and Ott 2011; Ott 2014). This investigation on the Southern Baltic Coast has been written presumptively out of the spirit of such "third culture."

Our inquiry rests on the commonly shared normative assumption that environmental degradation and the loss of ecosystem services should count a paramount challenge. Thus, we wish to bring together scholars from different sciences and we have to include environmental evaluations (for a philosophy of environmental evaluation see Ott and Reinmuth 2021). Comprehensive environmental evaluation can make use of different schemes, as Total Economic Value, Ecosystem Service Approach, and the universe of environmental ethical discourse (for overview see Ott 2020). In environmental evaluation, there is an interplay between sociology and ethics. While sociology informs how individuals or groups values ecosystem services, environmental ethics takes a normative perspective. We will deepen the environmental ethical dimension in Chap. 19.

2.2 Individual and Collective Demands for Marine Ecosystem Performance

People's well-being and life satisfaction ultimately depend on the extent to which their needs, aspirations, and desires, as well as the motivations underlying these, are fulfilled. Research has long sought to address these relationships. To do so, the field has primarily relied on work in motivational psychology, which considers the extent to which human behavior aims to fulfill needs and desires, and how these needs and desires arise.

As noted above, ensuring well-being is a central human need. Accordingly, people seek to bring about positive, emotionally beneficial experiences, and at the same time to avoid or prevent negative emotional experiences. Human behavior can therefore be said to be motivation-driven (Kroeber-Riel and Gröppel-Klein 2019, p. 157). It has been shown that motivations shape our behavior—both consciously and unconsciously.

Research in motivational psychology has primarily focused on the idea that individually distinct drivers can be understood in light of a small number of basic motives. For example, Rothermund and Eder (2011, p. 95 f.) stated that all human behavior can be traced back to and divided into three basic motives: striving for power, will to power, and desire for connection or attachment. The best-known classification of motivations is Maslow's (1975) hierarchy of needs. This hierarchy is based on three premises (Maslow 1970):

- All humans have a similar set of motivations.
- Some motivations are more basic or critical than others.
- The more basic motivations must be satisfied to a minimum level before other motivations become relevant.

Based on these premises, Maslow proposed his hierarchy of needs according to the pyramid shown in Fig. 2.1.

As shown in Fig. 2.1, physiological needs must be satisfied to a certain (individual) level before safety needs become relevant. In turn, once safety needs have reached a satisfactory level, belongingness, esteem, and self-actualization become dominant motivations (Schiffman and Kanuk 2007).

At a societal level, these individual motives and needs aggregate into collective needs. The basic (physiological and safety) needs have high priority in society; however, the satisfaction of higher, more hedonistic needs contributes significantly to life satisfaction of societies as a whole.

Against this background, many countries have sought to anchor collective needs in their state goals, often in a financial sense via growth targets for their gross national product, but occasionally via indicators such as the Gross National Happiness Index, in which the life satisfaction of society is determined not only financially, but also from human and psychological perspectives.

The satisfaction of the above-described motives and needs is influenced—at both individual and collective levels—by marine ecosystems. In the literature, services

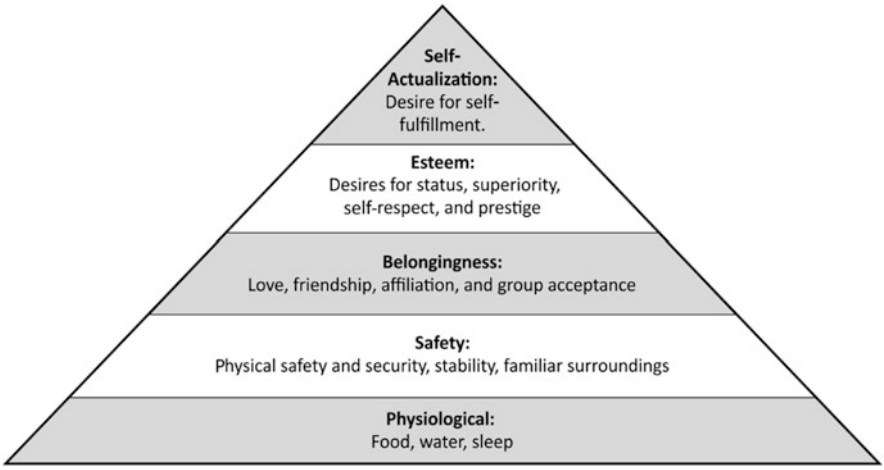

Fig. 2.1 Maslow's hierarchy of needs and ESS gratifying these needs (Mothersbaugh and Hawkins 2016)

related to these ecosystems have been divided into regulating, provisioning, and cultural services (Hernandez-Blanco and Costanza 2019). Regulating services of coastal maritime systems creates value by means of, for instance, flood control or climate control and in this way gratifies safety needs. Provisioning services of coastal ecosystems provide human beings with seafood or costal specific plants like seaberries and gratify physiological needs. Finally, cultural services yield spiritual, recreational, and aesthetic benefits and therefore gratify belongingness, esteem, and self-actualization.

Thus, maritime ecosystem services on both the individual and the collective levels contribute to the life satisfaction of both individuals and society. Regulating and provisioning services—according to Maslow's subdivision—are geared more towards physiological and safety needs, while cultural services primarily address hedonistic needs.

However, it remains largely unexplored as to how the services of maritime systems are created, and how the biological processes work together to produce regulating, provisioning, and cultural services. Likewise, there remains a gap in the literature regarding the interactions between marine ecosystem services and the life satisfaction of individuals and entire societies measured using gross national product or happiness indices.

Against this background, a wide variety of scientific disciplines, e.g., ethnographic research methods embedded in transdisciplinary assessment approaches must be drawn upon to investigate the interdependencies with respect to both the origin and the impact sides of marine ecosystem services. In particular, there is a need for interdisciplinary research between natural sciences, economics, social sciences, and psychology. The current study attempts to provide such an integrative, interdisciplinary view of marine ecosystem services.

2.3 Disciplinary Starting Points of the Analysis

2.3.1 Aspects of Marine Ecology

Compared to coastal, and even more drastically, terrestrial ecology, marine ecology until now can be characterized as a field where a few scientists, equipped with very expensive instrumentation and requiring huge resources try to get at least a glimpse into structure and function of the ecosystems occupying 71% of earth surface (e.g., Odum 1999). However, throughout the past decades, it became clear that not only coastal, but also offshore ecosystems are being drastically influenced and altered by human activity (e.g., Pauly et al. 1998; Roberts 2007), raising the first reports of signs for this (e.g., Hempel 1977) to a kind of global certainty.

Especially for the Baltic Sea, one of the few larger marine systems studied with reasonable temporal and spatial resolution (e.g., Kautsky and Snoeijs 2004) human impact has been shown to alter structure as well as functioning of the offshore coastal ecosystems (Österblom et al. 2007; Korpinen et al. 2011; Andersen et al. 2015). Main reasons for this are seen in an increased human population in the catchment area, raising from about 14.4 million around 1700 to present-day ~85 million (Zillén and Conley 2010) and in parallel increased intensity of direct (e.g., transportation, pollution, eutrophication) as well as indirect (e.g., temperature regime and saltwater inflow) anthropogenic pressures (Laamanen et al. 2017). Consequences from these alterations of ecosystem structure and function are numerous, most prominent probably the two regime shifts identified by Möllmann et al. (2008), which took place in the late 1980s and mid 1990s, respectively.

However, having a rather good temporal and spatial resolution of data, if compared to marine ecosystems in general, human pressure and impact differs largely between the regions of the Baltic Sea. As clearly shown by the analysis published by HELCOM (2010a), pressure and impact is highest for the southern Baltic, Gulf of Riga and Gulf of Finland, whereas Bothnian Sea and Bothnian Bay are less impacted. Consequently, studying the effects of human impacts in areas with high pressure was in demand and a comprehensive overview about biological, hydrological, and climatic changes during the past decades, focusing on the southern Baltic Sea, was published by Feistel et al. (2008).

Extending this extensive baseline data for the past years (Chaps. 9–18) and filling some gaps with respect to, e.g., bioturbation (e.g., Chap. 15) created a sound background for the development of scenarios to be evaluated for their ecosystem service distribution patterns. This evaluation was the first time marine ecology aspects became analyzed comprehensively in the context of ecosystem service provision, reflecting the full spectrum of feedback mechanisms between alterations of ecosystem structure and function due to human activities and consequences for societal welfare.