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1. Introduction: towards holistic knowledge of marine environmental changes

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INTRODUCTION

We human beings are increasingly affecting the one thing that sustains us on Earth: the ocean (Intergovernmental Panel on Climate Change, 2019; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). Marine systems provide us with food, materials, energy, and other resources; the ocean enables transportation, regulates our climate, and allows us to enjoy water – for example, providing space for recreational and spiritual practices. Through climate change, non-sustainable resource extraction, emissions, pollution, physical infrastructure, and other habitat degradation, we exert increasing pressure with possibly irreversible implications for us humans (Halpern et al., 2015; Stenseth et al., 2020). The ocean has a limited capacity to adapt to these stressors, and thus the productivity and health of the ocean are severely threatened (Ganachaud et al., 2022; Stenseth et al., 2020; Visbeck, 2018). To support the efforts to reverse the cycle of decline in ocean health, the United Nations (UN) General Assembly announced the UN Decade of Ocean Science for Sustainable Development (2021–2030) in 2017. The Ocean Science Decade provides an opportunity to direct sustained attention to interdisciplinary research on the ocean.

The underlying causes of critical environmental changes in marine areas are diverse and depend on the geographical and temporal context: some problems are older and of long standing, some more recent, some territorially global and some more specific to a particular region. In the era of the Anthropocene (Crutzen, 2002), human activities everywhere, including those on land, impact the state of the sea. These range from shipping, agriculture, fishing, tourism, and energy production to governance structures and regulative practices. While some human activities stem from recent innovations, others have a long

history and are deeply rooted in culture and tradition. Accordingly, many marine environmental changes can be understood in terms of *wicked problems* because of their unique, uncertain, complex, multifaceted, and interdependent character (Paasche & Bonsdorff, 2018). A wicked problem is an urgent problem with numerous causes and effects (Churchman, 1967; Head, 2008; Rittel & Webber, 1973). It involves many stakeholders and value systems and is inherently difficult to solve. Each wicked problem has its specific ecological, cultural, and social dimensions. It is embedded in the wider historical, cultural, economic and policy context, and as such, there is no linear cause and effect relationship to be addressed by siloed disciplinary solutions.

Marine wicked problems are part of unstable, fluid worlds (Hastrup & Hastrup, 2017), which are marked by unstable boundaries, shifting resource bases, and global technologies. They form an inseparable entity with other unstable worlds. Grasping the fluidity of marine wicked problems necessitates not only technological fixes but also fundamental social and cultural changes that cannot be achieved without new ways of thinking and shared understanding created in collaboration with relevant constituencies (see Funtowicz & Ravetz, 1993; Turnhout et al., 2020). This, in turn, requires a wide range of research responses, from the study of oceanic geophysics to the scrutiny of human–nonhuman marine relations and beyond. Interdisciplinary collaboration facilitates multiple viewpoints for increased awareness of all facets of the problem, thereby expanding the potential for innovative solutions. Such interdisciplinarity generally aims at mediating the cleavage between the groups emphasizing technology-led transformation or nature-based solutions and those espousing market-, state- or citizen-led transformation (Turnhout et al., 2020). The option for transformation lies in harnessing synergies across different knowledge systems for a more complete understanding of the problems.

This volume addresses marine environmental changes from an interdisciplinary perspective. The aim is to encourage the recognition of, and dialogue among, different kinds of knowledge systems relevant to the research of marine environmental changes. We intend to seriously engage with different types of knowledge, including not only knowledge produced by researchers representing various scientific disciplines but also knowledge produced together with stakeholders, or outside scholarly practice, such as local knowledge. The book has its own genealogy, stemming from the research of Finnish scholars working at an interdisciplinary research unit called The Sea (https://www.abo.fi/en/the-sea) at Åbo Akademi University, Finland, and the research project Living with the Baltic Sea in a Changing Climate: Environmental Heritage and the Circulation of Knowledge.[2] The methodological objective of the project was to identify the meaningful knowledge and skills needed for living sustainably with the marine environment through analysing and producing such knowledge across academic disciplines and with stakeholders. By extension,

the project aimed to facilitate the circulation of various kinds of environmental knowledge among scientific but also local communities.

'MARINE TURNS': ADDRESSING THE HUMAN–SEA DYNAMICS IN RESEARCH

Within ocean science, how human–sea related problems at this level of complexity should be approached from a methodological point of view has been identified as one of the most pressing research priorities across disciplines (Alexander et al., 2018; Rudd, 2014; Wisz et al., 2020). Management frameworks such as integrated coastal management (ICM) and marine ecosystem-based management (EBM) highlight the need to confirm that ocean management is a societal activity with diverse goals. It is thus largely agreed that the governance of wicked marine problems is best informed by drawing upon a diversity of scientific approaches from natural to social sciences and engaging knowledge systems beyond the scientific (Christie, 2011; Wisz et al., 2020). Yet according to reviews of interdisciplinarity in marine studies (Brodie et al, 2022; Christie, 2011; Phillipson & Symes, 2013), a notable imbalance of disciplines focusing on marine issues prevails, and natural science still plays a major role.

'Blue humanities' (Alaimo, 2019; Gillis, 2012) and 'marine social sciences' (see McKinley et al., 2020) are increasingly recognized as having a crucial role in better understanding the multifaceted and evolving relations between people and the sea. They are not just confined to livelihoods but cover aspects related to health and well-being, memories and experiences, and the sense of place and identity, for instance. The 'oceanic turn' (Winkiel, 2019) has been inspired by the global environmental movement, too; it stresses the life-affirming connection between humans and water, urging Western societies to develop holistic, sustainable relationships with waterways and other ecosystems. As a result, several overlapping conceptual movements such as *aquagraphy* (Lehtimäki et al., 2022), new materialism and posthumanism (e.g., Braidotti, 2013), oceanic studies (Blum, 2010; Steinberg, 2001) and literature by human geographers (Peters & Anderson, 2014) and anthropologists (Driessen, 2004) have evolved.

Regarding marine changes, a historically conscious understanding of how human perception of nature has developed over time is crucial. Thinking about the past involves using imagination to be able to think of a time and place that is different from ours. This is a historian's tool that can be very useful in environmental thinking and analysis even when the goal is not in the past, but in the present, or in the future. While history can give information about the past in a very practical way, thinking historically also means understanding and imagining change – things being done differently than in the present, and this can be used also for the future. Changes in the marine environment are

reflected in human experiences, meanings, and interpretations related to the sea (see Kouri et al., 2020). In humanities, this notion has led, for example, to explore metaphorical, intellectual, and experimental encounters between humans and the element of water while highlighting symbolic representations of water in cultural productions.

Marine social science is coined as an umbrella term covering a wide range of disciplines from sociology and political science to human geography and economics. The field provides multiple lenses to understand the relations between humans and the ocean in terms of both conceptual framings and more practical methods (McKinley et al., 2020). Many social scientists have long advocated greater inclusion of social sciences into marine sciences (see van Putten et al., 2021). In recent decades, the need for increased emphasis of marine social sciences in delivering effective management of marine environmental changes has been highlighted (Bennett, 2019; Gruby et al., 2016; Vadrot et al., 2022). A range of disciplinary approaches from sociology, psychology, and international relations to tourism have examined, for example, the value types and attitudes towards the sea (e.g., Potts et al., 2016), ocean governance and planning (e.g., Flannery et al., 2016; Harris, 2022), stakeholder participation (e.g., Dreyer et al., 2014; Kraan et al., 2014) and the role of the ocean in supporting human well-being (e.g., Kelly, 2018). These approaches provide a broad selection of both practical methods and conceptual framings to make sense of the relationality between humans and the ocean.

On top of recognizing the need for interdisciplinary engagement, research is increasingly acknowledging that scientific rationality needs to be complemented with experience-based knowledge of varying socio-cultural settings, implying that experiential, situational, personal, and sensory forms of local knowledge can offer valuable insight into environmental crisis (e.g., Martello & Jasanoff, 2004; Raymond et al., 2010). For example, *local ecological knowledge* (LEK) has been recognized as a concept highlighting people's experiences and knowledge about their environments in support of inclusive natural resource management and empowering them (see, e.g., Berkes, 1999). How to include such knowledge meaningfully in research is one of the key questions in making sense of and addressing marine wicked problems.

One answer is provided by art and science cooperation (see Strand et al., 2022). At large, art has a lot to offer for science. Art and metaphors have the capacity to add an emotional and physical dimension to communication and express complexity. Thus, arts have the potential to act as a mediator both between scientific disciplines and between science and society. Artistic work can help bridge different disciplinary perspectives, with their distinct vocabularies and methodologies. Further, art and science can work together to express and represent the complexity of wicked problems and improve the communication of knowledge to a wider audience. Many features of marine

changes are difficult to comprehend; they are either too small or too big, too abstract, too invisible, or geographically or temporally distant. Art can help us better see and sense the marine environment and convey connections between humans and non-humans. Art can also play a key role in developing the ocean literacy of citizens. Ocean literacy, defined as an understanding of the ocean's influence on you and your influence on the ocean, is a term coined by a group of American ocean scientists and education professionals in the early 2000s and has grown into an international effort (Dupont & Fauville, 2017; Fauville et al., 2019). Dupont (2017) notes that in order to promote ocean literacy, more fundamental changes in the way science is performed might be required, including deviating from the linear science supply paradigm to produce science that directly targets societal values.

THE CHALLENGE OF INTERDISCIPLINARITY

Disputes about the nature, borders, and rationales of academic disciplines have a long history. Some disciplines have a very narrow scope while others, such as anthropology, cultural studies, or history, are extensive in themselves and have practised holistic approaches from early on. Yet, as already noted, the observations from different fields show that proper understanding of complex problems requires the production of holistic and transparent knowledge by engaging all relevant constituencies across different scientific disciplines and societal levels.

The terms multidisciplinary, interdisciplinary, and transdisciplinary are used in academia to a growing extent and often interchangeably, but they do have differences. The more general term 'multiple disciplinary' is suggested for when the nature of involvement of multiple disciplines is unknown or unspecified (Choi & Pak, 2006). In general, *interdisciplinary research* refers to a form of coordinated and integration-oriented collaboration between researchers from different disciplines in the interest of problem solving (Pohl & Hirsch Hadorn, 2008). *Multidisciplinary research* implies approaching an issue from the perspective of diverse disciplines, in which each discipline works in a self-contained, not integrative, manner with little cross-fertilization among disciplines or synergy in the outcomes (Klein, 1990). *Transdisciplinary research*, in turn, is needed particularly when there is a great deal at stake for those concerned by problems and involved in dealing with them (Osborne, 2015). The transdisciplinary approach thus moves both within and beyond disciplinary boundaries to include stakeholders in the research process.

The extent to which interdisciplinarity leads to integrated approaches varies, from 'simple borrowings and methodological thickening to theoretical enrichment, converging sites, and a general shift … to new "cross-", "counter-", and "antidisciplinary" positions that front the problem of how meaning is

produced, maintained, and deconstructed' (Klein, 1996, p. 153). Different taxonomies and typologies of multi- and interdisciplinarity have been suggested (e.g., Huutoniemi et al., 2010; Klein, 2017; Pohl & Hirsch Hadorn, 2008). Even if most definitions of interdisciplinarity treat integration of disciplines as a 'litmus test', integration is often incomplete in practice, meaning that disciplines remain separate and retain their identity (Lattuca, 2001, p. 109). Some critics therefore question the idea of genuine interdisciplinarity and integration altogether (see Benson, 1998; Mäki & Grüne-Yanoff, 2014). Sometimes interdisciplinarity can also be used – either intentionally or unintentionally – to exclude or restrict certain research questions, approaches, theories, or methods. While interdisciplinarity no doubt provides synergies and novel insights, there is a risk of replacing one orthodoxy with another (Kelly, 2018).

The critique of integration is thus in many respects well justified. Interdisciplinary research is by no means a simple issue; a lot of open questions remain. First, each field of study has its own disciplinary concepts and methods leading to deep understanding – substantial interdisciplinary theory or methodology does not exist. A well-acknowledged challenge of interdisciplinary research and dialogue lies in the differences in disciplinary ontologies and epistemologies stemming from (and leading to) varying knowledge needs and analytical units. Different ontological and epistemological premises easily lead to difficulties in understanding other disciplines' ways of doing research. For example, in humanistic disciplines that aim at (qualitative) hermeneutic understanding, the researcher's own ethical, ideological, or political beliefs are expected to be communicated, with self-reflection and methodological situatedness practised throughout the research process. In some other disciplines, this would be seen as disturbing the objectivity of research. The differences are also reflected in the styles of writing to report the research findings. In the humanities, mechanistic reporting is not considered an academic writing style, whereas in many other fields accurate reporting is required. In this book too, the styles of writing vary from essayist to documentary style, showcasing the different conventions of writing. Consequently, tolerating and, better still, understanding the scientific language of other disciplines are key in interdisciplinary research. Conrad (2002) notes that conceptual precision is a prerequisite for interdisciplinarity. This implies, for example, that researchers need to carefully define the concepts they use so that readers representing other disciplines understand them.

MARINE INTERDISCIPLINARITY IN ACTION

The integration of disciplines can range from peripheral intersection with the subject matter to deep integration of the practices of knowledge production and communication. Our book does not aim to integrate both natural science

and social science findings in a common theoretical frame; rather, we want to demonstrate interdisciplinarity in action. The book thus applies a pluralistic approach, highlighting the integrative practices as well as steps and choices of the research process that are to be taken when looking for the possibilities of interdisciplinary collaboration and multi-actor dialogue. The questions of knowledge co-creation and how to observe, perceive, study, understand, communicate, and manage continuous (marine) changes from the perspective of interdisciplinarity are at the core. Even though the quest for interdisciplinarity has been discussed for decades, less has been written about the practical ways in which this kind of knowledge is produced. Even the most action-oriented and co-productive approaches seldom offer strategies for how to cope with different types of knowledge that help manage diverging visions of sustainability (Turnhout et al., 2020). To facilitate such interaction in knowledge co-production, we invited the authors to a writing retreat in Rymättylä, in the archipelago in south-west Finland, where we discussed the first versions of the chapters in March 2022. This retreat was the first in-person meeting of researchers after the COVID-19 pandemic lockdown was lifted, which added to its special character.

The volume aims at shedding light on the ways in which interdisciplinary knowledge and collaboration can contribute to a greater understanding of the dynamics of marine wicked problems. The outcomes are experiments and examples of interdisciplinary and transdisciplinary research highlighting the needs and/or practices of collaboration, including methodologies of co-creation. When preparing the book, the ways in which the researchers representing different disciplines worked across different types of knowledge and methodologies have been of specific interest. The book aims to demonstrate the importance of discussions related to what the object of study is, how knowledge is created, who defines what knowledge is accurate and how, and how to determine the epistemology underpinning marine science (see Moon et al., 2021).

The book includes examples in which scholars from different disciplines (political science, law, industrial management, marine biology, cultural studies, ethnography, anthropology, study of religion, and history, for example), artists, and other stakeholders collaborate to make sense of diverse ways of knowing, observing, and engaging with both human and non-human stakeholders. Some of the chapters illustrate how researchers can handle tacit knowledge or something that is still unknown. The analytical attention is on knowledge as communication, highlighting the importance of 'knowing with' and 'knowing how', complementary to 'knowing that'. Working with wicked problems requires social and intellectual flexibility, which sometimes means adjusting a scholarly role to that of an organizer, analyst, or interpreter of the knowledge co-created with different stakeholders. In addition to the more

practical findings, the chapters pose good questions produced in multidisciplinary collaborations. Sometimes these questions cannot be answered, at least not in the short term. But good questions are indeed formulations that can be shared across disciplines and professional fields, and if they prove to be relevant, they can be further developed into interdisciplinary research themes.

The book has been written as a dialogue between the editors and authors of different chapters. One result has been the conviction that case studies are a fruitful way to approach (marine) wicked problems, as these unique problems cannot be grasped as delineated or easily definable general (global) phenomena. Instead, they need to be understood as specific problems in a particular spatial, temporal, and cultural context. In this book, this context is the open sea, archipelago, and coastal areas of the northern hemisphere. On the one hand, northern-ness in the book can be understood as a cultural approach that directs the focus to peripheral areas, away from the urban society which is often assumed in social studies. Tedre and Pöllänen (2016) have coined the term 'methodological urbanism' to describe the approach that easily becomes the invisible norm for scholars, who themselves often work and live in urban environments. To study the north can be understood as a way towards a more situated knowledge that is conscious of the place and nature where the study is conducted. On the other hand, as the sea and coastal areas in the north are especially vulnerable to multi-stressors, they can also serve as a prism to study and predict consequences and mitigate future perturbations of the social-ecological system globally (Reusch et al., 2018). The book thus also contributes to the discussion on scalability, the extent to which the research findings or management options can be generalized from one locality to another, and what aspects of case studies can be upscaled.

Part of the reasoning lies in the role of seawater itself. Water – as an object and a subject of research – is peculiar because it does not just stay on the coast but is moving, flowing, and spreading pollution across borders (Kouri et al., 2020). From the cultural point of view, *waterworlds* have the potential for transformation (Hastrup & Hastrup, 2017), carrying ideas as well as practices that can be beneficial or harmful for the environment. The sea serves thus not only as an intersection of individuals and cultures (Jetoo and Kouri, 2021), but also as a space where local and global problems and values meet. In this way, the global is present even when the research is focused on the local level, on the problems of a specific area. The chapters of the book represent the whole spectrum of territorial scales, from planetary and global to local landscapes and microcosmos – and from more conceptual to local and situational case studies.

All chapters emphasize the dynamic and mobile nature of coastal land and water. Interdisciplinary marine research can, at its best, contribute to the governance and management of sea-related environmental changes by

creating solid and holistic yet versatile knowledge on both problems and their solutions rooted in the human–sea nexus. The particular contribution of this book is in making the interdisciplinary research process, its requirements, and its rewards, visible. Therefore, the book appeals to audiences that are engaged with interdisciplinary environmental research and methodologies at large. The case studies are also of interest to practitioners and researchers interested in marine studies and northern regions.

INTRODUCTION TO THE CHAPTERS

The contributions to the book are case studies covering particular environmental issues, such as climate change and its impacts on legal research; aquaculture as a social-ecological question; collaborations with the purpose of understanding and communicating environmental transformations (e.g., between artists and scientists, researchers and policymakers); approaches to environmental knowledge production from sensing and observing to creative writing; and examples of practical technological solutions to avoid marine plastic waste using nature-based solutions, to name but a few. The book leans on methodological pluralism, implying that each chapter applies the concepts and methods that best fit its purpose in its respective context, but in a way that puts particular emphasis on the question of interdisciplinarity.

The book is structured as four parts. The parts illustrate the needs, but also the challenges, of interdisciplinary research in the context of marine wicked problems. Part I examines interdisciplinarity in terms of concepts and theories in the making. What happens when a theory or a conceptual model is transited from one disciplinary field to another? What does such a transition offer and why is it needed? Part II focuses on interdisciplinarity between institutions poised to solve marine wicked problems at various scales and levels of society. In Part III, in turn, the chapters address knowledge co-creation at the level of methodologies used with people beyond academia. Finally, Part IV addresses marine wicked problems from the perspective that pays particular attention to the more-than-human world and water environments as spaces for mutually related communities of human and non-human inhabitants.

Part I: Interdisciplinarity of Concepts and Methods

One challenge of interdisciplinary research is cross-disciplinary borrowing, in which concepts, theories, ideas, and models are plucked from other disciplines. In disciplinary research, the guidelines of the theoretical core of a discipline are followed. These guidelines orient the research to theoretically relevant questions and define the usage of conceptual tools and methods of analysis. To be able to capture the essence of complex problems, open questions have to

be investigated in a problem-oriented manner. In problem-oriented research, uncertainties related to prognosis, complexity, and contingency typically cannot wait until basic questions in a scientific field have been solved (Conrad, 2002). This type of research may benefit from combining tools across disciplinary boundaries, as discussed in Part I of the book.

In the first chapter, Viljam Engström and Michel Rouleau-Dick contribute to the theme by examining the possibility of complementing legal research on climate change with scenario analysis, developed within the social sciences, in the context of the northern seas. The authors scrutinize the limits and possibilities of law in climate change research and note that legal challenges posed by rapidly proceeding climate change are difficult to cover by traditional legal analysis. Scenario analysis helps assess the severity of challenges to international law. Engström and Rouleau-Dick conclude that scenarios can serve to anticipate regulatory challenges and thus provide a tool for acting proactively. Scenario analysis offers a promising way to bridge the current disconnect between international law and climate change research in the social sciences, contributing to interdisciplinary collaboration.

In the second chapter, Chenru Xue notes that positivist approaches – measurements, data analysis, and component testing – to studying marine wicked problems are very effective in helping us understand specific problems, but understanding the relationship between landscape and sea necessitates an interdisciplinary perspective. Accordingly, situating the chapter in the interdisciplinary junction between visual culture and human geography, where the concept of landscape offers the interdisciplinary entry point, the author conducts an interpretive analysis of different types of Arctic (marine) anti-landscape in the context of industrialism and Arctic exploration. Xue's interdisciplinary scrutiny contributes to understanding the contradictory nature of the land–sea relation, a lost Arctic landscape, and its potential for diverse development. Such understanding is essential to the sustainability of the Arctic coastal regions.

Part II: Interdisciplinarity within and between Institutions

The quest for interdisciplinarity in environmental research is justified by the multifaceted and complex nature of environmental problems. There are increasing calls for greater integration and pluralism related to institutions, including public policies, that address the very same problems. Such calls are aimed at avoiding fragmented decision-making by integrating interrelated policies for sustainability (Lafferty & Hovden, 2003) or climate change (Adelle & Russel, 2013), for instance. This is happening at a time when decision-making is facing increasing complexity with, for instance, growing numbers of stakeholders involved in the policy process because of greater emphasis on public

participation. Integration at the level of institutions refers even to the inclusion of stakeholder knowledge in the policymaking processes.

The chapters of Part II demonstrate the interdisciplinary aspect within and between institutions from different angles and bring forward suggestions to overcome the related challenges. The chapter by Nina Tynkkynen, Jaana Kouri, Silja Laine, Otto Latva, Tuomas Räsänen and Kirsi Sonck-Rautio discusses the concept of *environmental heritage* as a term that carries interdisciplinary potential. Environmental heritage offers the possibility to work across the human–nature divide, particularly in the context of heritage policy where the realms of cultural and natural have traditionally been treated differently. Discussing three empirical examples of such heritage construction in the context of marine and coastal environmental changes, the chapter demonstrates how the concept of environmental heritage combines ecological, economic, social, and cultural dimensions in relation to the knowledge of the changing sea. The chapter highlights the interdisciplinary power of the concept that can help bridge cultural heritage and natural heritage policies, which conventionally have drawn from diverging disciplinary backgrounds and sectoral knowledge. The concept can thus be used to support sustainable development, urging us to focus on the future while simultaneously learning from past successes and failures.

Raivo Kalle, Anatole Danto, Renata Sõukand and Andrea Pieroni refer to the concept of *biocultural diversity* as an idea that combines cultural diversity and biodiversity. They provide an overview of how locals on Kihnu island perceive nature conservation restrictions, which are often introduced in a top-down manner and are insensitive to local customs and communities. The authors highlight the importance of acknowledging local communities' own sustainable solutions for preserving local life and the environment, especially in coastal locales that have been dependent on local resources for generations. With their location on the border of land and water, coastal residents have interwoven knowledge of both terrestrial and sea environments. Given that the activities of coastal people affect a much larger area than just their own surroundings, the motto 'think globally, act locally', which has guided ecology and ethnobiology for decades, is especially relevant. How to make sure that local voices are heard in decision-making? Careful ethnographic depictions of local experiences and local ecological knowledge, as showcased by this chapter, are one way.

Finally, in their chapter, Henrik Ringbom, Magnus Hellström, Christian Pansch, Nina Tynkkynen and Anna Törnroos use aquaculture (fish farming) as an example to illustrate and concretize challenges linked to interdisciplinarity. The authors conclude that even in a comparatively straightforward case of decision-making – where information is available, governance is clear and the end objective (i.e., the core elements of sustainable aquaculture) is by and large

agreed on by all involved – there are serious challenges to finding an optimum balance of perspectives. The chapter pinpoints the inherent complexity of environmental decision-making, related not only to different institutional levels or actors but also to their temporal and spatial dynamics. Managing complex environmental problems requires multidisciplinary approaches, but more scientific disciplines necessarily entail more perspectives. How does one arrive at a conclusion when different scientific perspectives point to different solutions?

Part III: Co-creating Environmental Knowledge

Transdisciplinarity is rooted in the wish of scholars from different scientific fields to collaborate not only with each other but also with relevant societal groups to produce knowledge relevant for understanding complex societal problems. In transdisciplinary research, knowledge is co-created together with the participants. Ideally, this is an iterative process that involves reflection among all stakeholders from the beginning of the research until the very end, containing three stages: co-design, co-production, and co-dissemination (Mauser et al., 2013). Mutual learning occurs between practitioners and academics in the attempt to bridge science and society together (Steiner & Posch, 2006).

In Part III of this book, transdisciplinary co-creation takes shape in the intersection of several disciplines as well as contemporary art, arts and science projects, and co-creative meetings with stakeholders. The chapters of Part III showcase also that in co-creative endeavours of environmental knowledge production, the place (the environment) where knowledge is produced becomes particularly important and affects the co-creation. The idea of creativity gets emphasized, too. Creativity can be seen as a transdisciplinary endeavour throughout the process from designing research to methodological choices and the dissemination of research findings. When co-creating knowledge about the marine environment, the emergent and ecological aspects of creativity are at the front.

Jaana Kouri and Savitri Jetoo introduce three different cases of creative writing as a research method in the co-production of knowledge about the marine environment. Through the comparison of these cases, the chapter examines the possibilities of creative writing to document and analyse elements of environmental knowledge. The analytical focus is on understanding the meaning-making process between people and their environments. In this research, the role of the researcher to observe, analyse and interpret is temporarily adopted by the participant, the writer, in the meeting. It is an active means of 'learning while doing' (Kara, 2020; MacDonald, 2012). In particular, the three case studies shed light on how creative writing can serve as a research

method to collect research material about the environment and encourage the writers to observe and write about the environment and changes in it.

Part III continues with Laura Hellsten and Frank Berger, who reflect on two arts and science projects based on co-creation. While Aula, in the following chapter, examines art collaboration as a corollary practice of sensobiography, Hellsten and Berger focus on the lessons learned from co-creation processes in the phase where scientists need to communicate to audiences outside their own research fields. Hellsten and Berger write about the capacity of the artist's work to become attuned to the unspoken and unknown. The public events organized together with the scientists and artists did not just raise or awaken different thoughts, emotions, and holistic experiences within the participants; they also encouraged people to become more involved in political, cultural, and research-based actions in society, as the chapter demonstrates.

In our coinage, co-creation is extended to also include non-human actors, such as the sea itself, which is given both agency and voice. In her chapter, which concludes Part III, Inkeri Aula argues that 'on the recorded accounts, the river environment itself takes part in creating knowledge'. Aula proposes the ethnographic method of sensobiographic walks for tackling people's creative relations with water environments through multisensory, situational narrations. The sensobiographic method can merge on-site bodily experience and longer-term temporal perspectives by inviting people to talk about their sensory experiences while walking on a particular route familiar to them. Aula presents the kind of local knowledge of ecological transformations that sensobiographic interviews can bring forth. In Aula's research experiential and sensory forms of local knowledge offer significant insights into environmental crisis and carry potential for creating local resilience. An intimate relationship with local nature can aid in building resilience against environmental transformations in times of ecological crises.

Part IV: Engaging with the More-than-Human World

The notion of more-than-human sociality as a way of describing worlds made up of both humans and non-humans is of particular interest as we start to experience and imagine the implications of the Anthropocene (Tsing, 2013). In our coinage, marine and aquatic environments and the more-than-human world should be approached as a fundamental part of both the construction of the wicked problem(s) as well as the solution(s). This also applies to water: it is seen not merely as an element but also as the 'other', an active subject to whom one might relate. While water is the 'other', it is also part of the same whole as all of us (Ezzy, 2008; Shaw & Francis, 2008). This approach is inspired by the ontologies of new materialism and posthumanism, the notion of material–discursive relations and the entanglement of the material environment and

human reasoning (e.g., Barad, 2007; Coole & Frost, 2010). It implies that environmental problems can be seen as co-constituted by interaction between 'matter' – a change in the quality of the environment – and 'meaning', i.e., human experience and interpretation of that change, leading to a constantly evolving problem definition (see Tynkkynen, 2008; Haila & Levins, 1992). As brought forward in Part IV of this book, this idea highlights the need for scholars (and stakeholders) engaged in interdisciplinary activities for environmental research to immerse themselves in nature, either in a site, location, or region, or in a novel habitat or substrate. For example, the ecosystem can become a mediator, even a participant, for collaborations, conversations, and observations, thereby facilitating finding the way forward. Arguably, technology can here play a role similar to nature, being thought of not just as a solution but as part of the means to experience and observe the aspects of the wicked problem. Alternatively, it can act as a mediator for multidisciplinary collaborations to induce change by making people feel, understand, and eventually solve the problem at hand, such as marine plastic pollution.

Kirsten Hastrup's chapter opens this section by shedding light on how the hydrologic circle – the most fundamental principle of hydrology and of all life on planet Earth – is increasingly affected by human presence. As an anthropologist, Hastrup demonstrates this by telling a story of Inughuit hunters living at the North Water, a recurrent open water polynya between north-west Greenland and the north-eastern coast of Arctic America. She comes up with the notion of hydro-sociality, which invokes a field of relations that are simultaneously social and hydrological, thus calling serious attention to the infiltration of human life and water. Human life in the Arctic is inextricably connected to the global challenges of the Anthropocene. As the landscape and its affordances change, a new degree of regulation seems called for. But, as Hastrup writes, while protection of wildlife seems a laudable aim, the political imaginary does not necessarily match with the lived reality. Claims made in terms of legal and related languages are always removed from the lived, and changing, actualities.

In the next chapter, Taru Elfving immerses herself in the interdependencies of human life with other species, changing water systems, and the planetary forces that are also present on the island of Seili in the Archipelago Sea in Finland, where Elfving has studied artworks and conducted interviews with artists and scientists. Elfving's field is curatorial research, where the emphasis is 'on transversal approaches to ecology via the different yet entwined registers – environment, social, mental' (Guattari, 2000). This implies that not only environmental changes, but also structures and values of knowledge production that need rethinking in order to address those environmental changes, were in focus. The author argues that in collaboration with science, art practices can amplify the ripple effects from knowledge production to collective action and

cultural change. The chapter illustrates how zooming into divergent temporal rhythms and situated knowledge challenges the universalizing point of view and recognizes the non-scalability of perspectives and practices (Tsing, 2015). This is true also in Seili, where, as Elfving proposes, 'the interdependency of diverse temporal and spatial scales similarly challenges anthropocentric perspectives and illusions of control'.

The chapter by Agniezka Dąbrowska, in turn, investigates the marine plastics problem from an angle where nature is evolving to integrate our man-made plastic materials into marine life as new habitats. She argues for a rethinking of nature and diversification of investigations into the plastisphere both in terms of the nature element and how to tackle the problem in a multidisciplinary way. The proposed new term *plasticology* entails an approach in which plastics are part of nature and thus should be studied from an interdisciplinary perspective that combines natural (e.g., physics, chemistry, biology, and ecotoxicology) and materials sciences with social and humanistic perspectives. Plasticology stresses the importance of the social and human aspects and culture of the usage of the plastics in solving problems related to the plastic problem and marine litter.

The chapter written by Małgorzata Rusińska, Anna Woźna and Michał Rybka brings into the limelight the need to think bravely outside the box when studying wicked marine problems, such as plastic litter. The vast majority of marine plastics originate from land-based sources. Repair and reuse solutions play a key role in the problem of overproduction of plastics, but it is worth analysing possibilities from a wider perspective and considering new technological solutions that can limit the need for mass plastic production. The aim of the chapter is to present one solution by using additive technology to shorten and simplify the logistics chain of plastic components and introduce a solution that could lead to a massive reduction of (marine) plastic waste in the coming years if applied in different branches of the manufacturing industry. The idea relies on implementing so-called additive manufacturing (AM) technology to shorten and simplify the logistics chain of spare parts for household equipment.

This final chapter crystallizes one of the key lessons of the book. Interdisciplinary research is a learning process (Steiner & Posch, 2006), which often results in new ideas and innovations but may also lead to better awareness of already-existing solutions that only wait to be seen, understood and used for a better, less-polluted future. In order to facilitate such learning, different interested parties have to come together and work side by side. In an ecological emergency, which marine life is currently experiencing, multi- and interdisciplinary collaboration is a necessity – and probably the only solution. It is not an end in itself, but a means of supporting individual efforts to protect the ocean. There is no time to wait, but scholars and scientists, engineers, politicians, artists, and civil society actors must unite and start to see individual

efforts as one big collective action. In that way, and only in that way, even single ideas will have a chance to create worldwide impact.

NOTES

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