Wadden Sea Board

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Agenda Item:	**5.7**
Subject:	**Wadden Region Trilateral Research Agenda**
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Submitted by:	**CWSS**

Secretariat's note:

The present document is the first draft of the Trilateral Research Agenda (TRA). It was used as the basis for discussions of the TRA at the 14th International Scientific Wadden Sea Symposium (ISWSS), held in Tønder, Denmark from 8-11 May, 2017. A further draft taking account of the outcome of the discussions at the ISWSS is under preparation.

Proposal: **The meeting is invited to consider the document**

Trilateral Research Agenda

for the Wadden Sea Region and its World Heritage Site

Content

1. General Introduction

From Blåvands Huk in Denmark via the German coast to Den Helder in the Netherlands, the tides and waves of the North Sea have built up a 500 km long unique coastal wetland and a string of barrier islands with dunes. This system, the Wadden Sea region, forms the largest coherent belt of intertidal mud and sand in the world. The wetland has been converted from bogs and pasture into arable land behind dikes over the last 2500 years and a common maritime culture has arisen. More recently, this coast developed into a recreational region with more than ten million guests annually. Coincidentally, the same numbers of shorebirds forage on the tidal flats. Since 2009, the Wadden Sea is listed as a World Heritage Site because of its natural, outstanding universal values.

The Wadden Sea Region comprises the transition zone from the North Sea to the mainland. The coastal provinces and municipalities on the mainland comprise extensive marshland situated less than five meters above sea level, rivers and in some cases also major seaports. About 10% of the Wadden Sea Region belongs to Denmark, 60% to Germany and 30% to the Netherlands.

Since 1978, the Netherlands, Germany and Denmark cooperate actively in the protection of the Wadden Sea as a natural entity and they have agreed to *"achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way"* (Stade-declaration 1982). This trilateral approach should be extended to the entire Wadden Sea Region, with 3.5 million inhabitants on islands and in low-lying coastal marshlands, with a rich cultural heritage but also a continuous risk of severe flooding.

In an era of human-driven global warming and with the prospect of significant sea level rise, the question arises how to maintain this shallow and low-lying coastal region in a sustainable way. The islands are exposed to coastal erosion and marshes are subsiding, partly already below the level of the sea. Tidal flats and salt marshes tend to grow with the sea by means of sedimentation. However, with an acceleration of sea level rise the sedimentation process may lag behind, thereby threatening the World Heritage Site and exposing the mainland to a rough sea without sufficient sedimentary buffers. How can this long-term challenge to the entire Wadden Sea Region be met by proper precaution and adaptive management? In this document the scientific community of the three Wadden Sea countries proposes a coherent trilateral research agenda with the aim to

maintain natural and cultural values and to find a sustainable course for societal and economic development in the entire Wadden Sea Region.

2. Background of the Trilateral Research Agenda

The idea for a Trilateral Research Agenda for the Wadden Sea Region originates from the declarations following the Trilateral Ministers meetings in 2010 and 2014, stating the following:

"Support the establishment of a trilateral research platform directly connected with existing national networks. The platform will elaborate a trilateral agenda for policy-relevant research in consultation with the Board..." (Sylt-declaration 2010).

"Encourage discussions by the scientific community and policy makers on the major policy issues and related knowledge as a basis for further developing a trilateral research agenda and a trilateral research platform" (Tønder-declaration 2014).

These goals have been included in the priorities of the Dutch presidency of the Trilateral Wadden Sea Cooperation in June 2015:

Scientific agenda for the Wadden Sea World Heritage Site: The Wadden Sea has long been a site of much and diverse scientific research. For good management of the World Heritage Site there are plenty of questions that will require common and better coordinated research.

Objective: A coherent scientific agenda, relevant to the World Heritage Site which supports decision-making on current and future issues, captures the interest of young scientists and promotes scientific cooperation between institutions.

In 2015 the Wadden Sea Board has appointed **Prof. Dr. Jouke van Dijk** (the Netherlands), **Dr. Mette Guldberg**, later replaced by **Prof. Dr. Jesper Bartholdy** (Denmark) and **Prof. Dr. Karsten Reise** (Germany) to take the lead in developing this research agenda with coordination support of **Dr. Folkert de Jong** of the Common Wadden Sea Secretariat (CWSS) and **Drs. Klaas Deen** of the Waddenacademie. In the final stage of drafting the research agenda **Dr. Josef Stuefer** NWO (Netherlands Organization for Scientific Research) acted as executive secretary.

As a start, five main fields of interest have been identified: 1. Geosciences, 2. Ecology, 3. Economy and Society, 4. Cultural Heritage, and 5. Climate and Water, based on discussion about the science policy matrix. For each field groups of scientists were asked to produce a short document with major achievements and persisting gaps of knowledge, to identify the main questions relevant for policy and do suggestions for transdisciplinary themes.

Based on input from these groups this trilateral research agenda has been developed along four broad thematic lines and their mutual interactions (chapter 3). Special attention will be given to overarching themes, called challenges (chapter 4) which require transdisciplinary approaches.

3. Thematic lines

CLIMATE & WATER, SEDIMENTS & SUBSURFACE

3.1 Climate & water, sediments & subsurface

Given the prospects of accelerating sea level rise, the main goals of preserving the natural dynamics in the Wadden Sea and protecting the inhabited islands and the mainland against erosion and inundation are not easy to combine. We therefore need to undertake research on how the restoration and protection of coastal ecosystems can be reconciled with the socio-economic functions of the coastal areas, safeguarding the cultural values and preventing salt water intrusions into the freshwater resources. No quick and easy solutions are available to tackle the complex issues of flooding, erosion and salinization. The climate and water-related threats may require permanent sediment nourishments from offshore to inshore areas, sedimentation processes in flooded areas behind dikes and new freshwater reservoirs and wetlands in the marsh. Such measures would entail cascades of adaptations in natural systems, economics, society and life styles in the entire Wadden Sea Region.

Adaptations to climate change and sea level rise require timely public participation in problem analyses and solutions, enhanced understanding of global processes and regional responses, and significant amounts of public funding. The historic interventions in the water and the sediment system of the Wadden Sea Region have provided economic wealth in the past. However, the inherited problem of a subsiding land confronted with a rising sea will aggravate with expected sea level rise. We therefore urge to improve our understanding of the coastal sediment and freshwater balance under elevated temperatures, higher average sea and extreme storm surge levels, higher tidal range and waves. This will be essential for coastal defense strategies and nature protection, economic sectors such as agriculture and fisheries, tourism, harbor facilities and modes of settlement.

Sea level rise is changing hydrodynamic processes with implications for sediment transport, particularly between inshore and offshore zones. Empirical measurements and modeling results indicate that sediment deposition on tidal flats may not keep up with sea level rise. Broad, trilateral efforts are needed to better understand sediment dynamics in the whole Wadden Sea system, to establish net sediment budgets for individual tidal areas and to evaluate the survival of marsh areas under different scenarios of sea level rise. This knowledge is necessary for protecting the universally outstanding natural

values of the Wadden Sea World Heritage Site, the development of sustainable adaptations in coastal defense, and to safeguard navigation channels (shipping to and from coastal ports).

Parts of the Wadden Sea Region include natural gas reservoirs which have been exploited in the past. Extracting gas reserves is beneficial in economic terms, but it also led to increases in the frequency and intensity of regional earthquakes, directly threatening cultural values and the livelihood of many people in the region. There is a need for dedicated subsurface research for counteracting and mitigating the consequences of gas extraction in the region. Furthermore, there is growing public concern on oil drilling, maintaining and renewing coal power plants, dredging shipping lanes for ever larger vessels, and mining sand for sand nourishments in the Wadden Sea Region. The same is true for research on other man-induced and natural causes of land subsidence. Studies into the social and cultural aspects of human-induced earthquakes can inform policy processes directed towards guaranteeing the safety of citizens and their belongings, protecting their livelihoods and rebuilding mutual trust between residents, authorities and private companies. These controversial issues need to be addressed by transdisciplinary research and in a trilateral context.

ECONOMY & SOCIETY, SUSTAINABLE DEVELOPMENT

3.2 Economy & society, sustainable development

The Wadden Sea Region is economically very heterogeneous. Apart from belonging to three different countries the area is characterized by strong locational differences between the islands and the mainland, between remote coastal marshlands and estuarine marshes near large urban centers, between natural shorelines, agro-industrial landscapes and large port facilities with dredged shipping lanes. These locational aspects interact with sectoral dynamics in tourism, agriculture, maritime industries and external trends as well as with employment, education and population development. How can policies help to direct this economic and societal diversity towards sustainable development in the face of global warming, sea level rise and other aspects of globalization?

Given the diverse locational characteristics and the unique natural values of the Wadden Sea World Heritage Site, which sectors provide the best economic opportunities and can best contribute to sustainable development of the coastal region? Which activities can best be stimulated to foster harmonious economic and societal development for residents, guests and business? Answering these questions requires careful

transdisciplinary analyses of the benefits and costs of different economic activities for society, for nature and for the cultural heritage of the Wadden Sea Region and it may also imply the development of a proper trilateral marketing strategy and identity.

There is a need for developing monetary models which permit the evaluation of investments in nature and coastal protection, of sustainable use of natural resources, pending changes towards climate neutrality and measures to initiate and support the energy transition. Such broad socio-economic systems analyses require a solid scientific data base for delivering robust and meaningful outcomes that can inform relevant policy processes. Promoting the well-being of residents and visitors should be an aim to guide local and regional policies. Such models are especially useful to inform the public of available options in the transformation process to regional climate neutrality and a coastal landscape attempting to grow in concert with the rising sea.

The major socio-economic challenge for the Wadden Sea Region will consist in developing balanced policies, measures and incentives to allow both the ecosystem and the social system to develop in a sustainable way throughout the transformation process adapting to accelerating sea level rise and climate change, and in particular, in the face of a strongly changing demographic trends. Not only locational aspects such as access to maritime transportation, extraction of traditional and renewable energy, and the recreational value of the area, but also aspects relating to jobs, human capital, education and housing are important factors to consider in this context. Potential trade-offs between economic sectors and activities, such as (eco) tourism and harbor economy, or large-scale economic activities and the preservation of the typical cultural historic landscape add to the complexity of finding a balance between natural values and sustainable socio-economic development on a longer term. The trilateral Wadden Sea Region could set an example for other coastal flatlands challenged by global change and generate specific expertise.

3.3 Cultural Heritage

CULTURAL HERITAGE
HUMAN-NATURE-
INTERACTIONS

The unique cultural landscape of the Wadden Sea Region is the product of a fundamental transformation from a smooth and highly dynamic sea-to-land transition toward a rigidly divided coastal landscape with an amphibious natural side and a defended drained marshland. Facing a possible sea level rise of some meters, a second transformation from living against

water to living with water in the Wadden Sea Region will be the common challenge for the future. The protection of natural and cultural values will have to be integrated in a sustainable way according to the UNESCO Biosphere Reserve Program. This requires a close collaboration between natural sciences and the humanities such as history, archeology and historical geography. Cultural elements and sites in the Wadden Sea Region have been mapped through an extensive trilateral program, called “Lancewad” [1]. Many scenic and archaeological relics have been preserved, but to be able to interpret these traces, it is important to know how, when and why they originally appeared. Mainly national investigations have been made in the area and unanswered questions relate to regional identity, values, dreams, gender issues and frustrations as well as how these sentiments have been influenced by power structures and discourses.

Historically the Wadden Sea Region has been a laboratory of engineering and water management. As far as the visible elements are concerned, the remaining artefacts of human intervention provide us with indispensable information about the evolution of the cultural landscape and the engineering capabilities that allowed natural hazards and threats to be dealt with. Risks emerging in the wake of climate change and sea level rise can be supported by analyzing former adaptive capacities and forms of resilience, yielding important lessons for the future.

Awareness of the cultural historic dimension of the Wadden Sea Region, not only political and administrative but also among social and natural scientists, professionals, citizen scientists and the regional public, is a prerequisite for the successful conservation and development of the special qualities of the Wadden cultural landscape and to combine these with the protection of biodiversity. The contentious history of the Wadden Sea Region in all its variation has to be presented as a coherent, comprehensive narrative with the existing sense of place and appreciation of the region as home for the people and to cope with the challenges of globalization and climate change. This would strengthen the identity and coherence across boundaries. It would also generate the necessary expertise needed for the transformation of coastal flatlands.

The Lancewad inventory should progressively be expanded to encompass the historical landscape of the Wadden Sea Region as a whole and its constituting natural and cultural values. Constructive inter- and transdisciplinary research in the

[1] Mapping the Landscape an Cultural Heritage in the Wadden Sea Region

trilateral Wadden Sea Region should focus on the interaction between natural characteristics and past, current as well as future settlement in the region, on coastal management informed by a historical perspective, studies on biodiversity from a historical viewpoint, and traditional economic activities such as agriculture, shipping, fisheries, trade, handicraft, early tourism including pathways of socio-economic development.

ECOLOGY & ECOSYSTEM CHANGE, SPATIAL PLANNING

3.4 Ecology & ecosystem change, spatial planning

Several historical threats to the Wadden Sea ecosystem have been successfully mitigated due to a joint effort of the three Wadden Sea countries. Nonetheless, the rate of ecological change has not slowed down, most likely as a consequence of global change. Ecosystem change in the Wadden Sea World Heritage Site, the islands, coastal lowlands and entering rivers is mainly driven by four main factors, namely temperature rise, bio-invasions, sea level rise and regional human impacts. Since three of these factors operate on a large geographical scale, regional studies and future management decisions will have to be linked more closely to processes at a continental if not global scale to meet the ecological challenges in the Wadden Sea Region.

Urgent research questions focus on the effects of climate change and sea level rise on the occurrence and dynamics of species and communities, on habitats, primary production areas and other ecosystem functions. Population level responses to environmental change are poorly studied to date. The same applies to the nature and rates of climate-change-driven biogeochemical processes and their effects on species, communities and ecosystems. Special attention is required for exchange processes between the Wadden Sea, the North Sea, the land and rivers as well as the long-distance migration routes of fish, sea-mammals and birds, calling for close collaborations and coordinated research efforts on a trilateral level and with regions outside the Wadden Sea Region. A major gap of knowledge exists on biodiversity change in land habitats adjacent and connected to the Wadden Sea. The ecological importance of connectivity and exchange processes between the Wadden Sea Region and surrounding environments, such as the North Sea and terrestrial inland habitats, deserves more attention. It is time for adopting a more integral approach to ecological studies in the Wadden Sea Region and to explicitly take into account relevant interactions with adjacent biomes.

New plant and animal species, parasites and pathogens become introduced, establish and gain dominance in dunes, salt marshes

and shallow waters of the Wadden Sea Region. In the wake of the ongoing rise in temperature, species shift their geographical ranges or seasonal population dynamics, thereby invading new territories and altering ecosystem functions and services at an accelerating pace. Biological invasions play a central role in shaping patterns of biodiversity and ecosystem change in the Wadden Sea Region. Nevertheless, we do not understand the consequences of this pervasive process in a wider perspective of food-chains, predator-prey and parasite-host interactions, competitive relationships and potential species loss. This also hinders the deployment of appropriate nature management measures to protect the outstanding universal values of the Wadden Sea system. Basic research efforts should be combined with target-oriented studies to enable flexible, adaptive and timely management and protection measures for a rapidly changing environment.

Coasts provide people with diverse benefits, from fisheries to recreational opportunities and maritime trade. Translating appreciation of these benefits into changes in management and policy is not trivial. Coastal spatial planning is a process that brings together multiple users of coastal areas to make informed and coordinated decisions about how to use coastal resources sustainably. A future framework for coastal spatial planning in the Wadden Sea Region needs to include not only the Wadden Sea but also the North Sea coastal zones, river catchment areas, estuaries, rural marshes on the mainland and on the islands. A novel mapping approach could allow stakeholders and policymakers to refine zones of human use, reduce risks to the ecosystem, and could help integrating natural processes into transformation strategies to cope with sea level rise and climate change.

Transforming the Wadden Sea Region to climate neutrality and adapting the entire coastal zone to accelerating sea level rise with sand nourishments from offshore to inshore and by adjusting the level of the land to the sea, will alter ecological processes on both sides of the dike. Novel research is needed to explore possibilities for sustainable adaptation measures. Nature-based solutions, such as “building with nature” should form the basis for these activities. Responsible innovation strategies must be laid out to interact with the public and gain societal acceptance for adaptation strategies and their potential for economic use in the Wadden Sea Region landscape.

4. Challenges

Proper understanding, effective protection and sustainable development of the Wadden Sea Region requires a transdisciplinary approach. The disciplinary areas described in the previous section should be understood as thematic components or contributing building blocks. They and their manifold interactions on different spatial and temporal scales constitute the Wadden Sea Region as an integral socio-ecological system. In other words, the main challenges for the future can only be understood and successfully tackled by a true interaction between different fields of science, including different disciplines and different types of science (fundamental research, monitoring, applied and citizen sciences), and between science and diverse players in society such as regional and national authorities, private companies, NGO's and citizens.

Preserving its outstanding universal values is the prime component to be taken into account in future management decisions for the Wadden Sea as a world heritage nature area. At the same time the safety of the people in the region and their livelihoods has a high priority. Global climate change is expected to have inevitable impacts on the region via sea level rise and warming, potential intrusion of seawater into arable land and drowning of natural resources and cultural heritage sites. At the same time we enter a phase of energy transition leading towards increased sustainability which will alter regional economic balances, party to the better, partly to the worse, depending on the point of view. Finally, dealing with the demographic change already now seen in the Wadden Sea Region will be a central issue in the efforts of coastal transformation. These transformations both carry risks and bear opportunities. Informed policy decisions are needed to find a balanced way forward.

This section attempts to identify three main challenges for the Wadden Sea Region that need to be dealt with in the decades to come. All of them cross disciplinary borders and hence require multi-, inter- and transdisciplinary approaches.

4.1 Climate change and sea level rise

Global warming with gradual changes in weather patterns, extreme storm events and sea level rise will likely proceed in an unprecedented way over the coming decades and centuries, thereby threatening coastal flatlands, including the Wadden Sea

Region. Climate change forms one of the main challenges with strong repercussions on natural system, socio-economic and cultural structures and processes. Integrated efforts from science and society as a whole are needed to understand and to deal with this issue. Adapting to climate change and sea level rise requires truly transdisciplinary approaches and a close and continuous cooperation between researchers, policy-makers and regional entities in order to develop and implement long-term sustainable solutions.

All four disciplinary lines described in section 2 are needed to understand the background and interacting effects, and to deal with global change. Major impacts are to be expected on ecosystems (e.g. by species invasions, progressive salinization and inundation), regional economies (e.g. maritime industry, fishery and agriculture, tourism), and societies (e.g. flood safety, demography). These impacts, however, are strongly interlinked and form intricate networks of causes and consequences on different organizational, spatial and temporal levels.

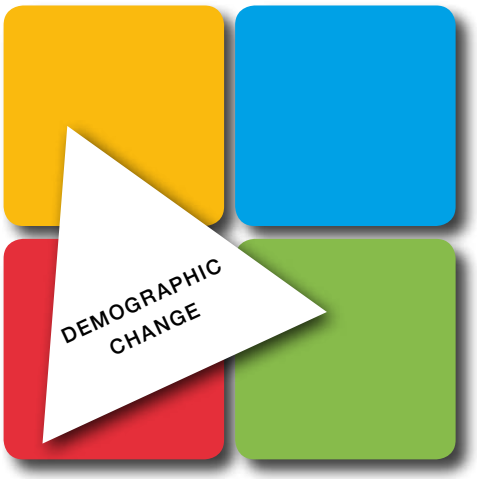
In this respect the Wadden Sea Region can best be seen as a “living lab”, where key functions such as coastal safety, natural values, industry and demography co-exist within the overarching themes of economy, society and environment. Research should help coastal societies to design and implement appropriate and feasible adaptation measures with high urgency in order to mitigate the varied consequences of global change. Historical transformations, i.e. land claim and coastal protection by means of building dikes, is presently causing dilemmas as high-value but unsustainable land-uses (e.g. fixed harbor locations, agroindustry, mining of fossil carbon) are taking place at increasing societal costs. At the same time, adapting to climate change and sea level rise entails new chances and opportunities for the Wadden Sea Region and its universal natural values. Solutions require a targeted and transdisciplinary trilateral research agenda.

4.2 Sustainable coast

An economically sustainable Wadden Sea Region is not possible without a thriving ecology and vice versa. This requires cooperation between residents of the area, scientists, environmental organizations, entrepreneurs and policy makers. All of them benefit from and are jointly responsible for the unique world nature heritage site of the Wadden Sea. Several of the services originally provided by the Wadden Sea Region (food, water quality, coastal protection, recreation) are in transition,

and many economic opportunities for coastal people have been lost, while other types of jobs and chances for building sustainable livelihoods may be developed in future through (eco-)tourism, the impending energy transition and other socio-economic developments.

The major issues for a sustainable coastal development of the Wadden Sea Region will inevitably deal with the search for viable transformation processes creating educational and economic opportunities for residents. Ecology needs to be understood as part of an inclusive economy. A scientific comprehension of natural and socio-economic processes in the Wadden Sea Region will be of paramount importance to support policy and management decisions in an attempt to strike a good balance between people, nature and profit. Sophisticated spatial planning efforts will be needed to help assign different functions to different areas, thereby avoiding overuse of sparse space and minimizing conflicts between separate functions. Natural and social scientists, citizens and policy makers, NGO's and companies will have to work closely together in order to embark on feasible and societally acceptable transformations of the Wadden Sea Region.



4.3 Demographic change

The Wadden Sea Region is an economically peripheral, predominantly rural region with unequally distributed, interspersed urban centers. Various areas in the world with these basic characteristics undergo demographic change, referring to shifts in population structure mainly due to declining birth rates, longer life expectancy and migration. The population is shrinking in the entire Wadden Sea Region and the age-structure of residents becomes gradually biased towards elderly people. At the same time, the relative level of education among residents decreases. Population decline presents severe challenges but offers opportunities as well, such as for natural values, (eco-)tourism, and cultural heritage. Their manifold positive as well as negative implications for nature, economy and livability adds considerably to the complexity within which management and policy-decisions for the future of the Wadden Sea Region have to be taken. The challenge for science is to unravel the underlying mechanism of population change that can be used by policy makers to develop innovative and evidence-based transformation strategies for areas with population decline.

5. Mapping and Monitoring

5.1 TMAP

Monitoring forms an integral part of the Trilateral Research Agenda, as doing research is very much dependent on having coherent, long-term data sets. Based on a decision at the Ministerial Conference in Stade (1997) Denmark, Germany and The Netherlands jointly developed and implemented a common monitoring program, called *"The Trilateral Monitoring and Assessment Program"* (TMAP). The program is one of the cornerstones of the trilateral cooperation and covers the entire Wadden Sea Region including islands and offshore areas, spanning a broad thematic range from physiological processes and population development to changes in landscape and morphology. Over the years the TMAP common monitoring package was further developed to fulfill the needs of various national and international reporting obligations, in particular those from the EU Framework Directives on habitats, birds and water. TMAP aims to be a harmonized monitoring and assessment program for the whole Wadden Sea Region, based on sound scientific evidence. TMAP supports the management of the Wadden Sea as an ecological entity, but the set of indicators monitored has its limitation in scope and geographical detail. To serves the needs of future policy making at all levels, the commitments ensuing from relevant directives and conventions and the World Heritage status and data for scientific research, trilateral monitoring is needed with a larger coherent set of indicators with a broader scope and a greater level of detail.

Monitoring serves the collection of coherent, long-term data sets focusing on critical variables that can provide a better understanding of the functioning and the dynamics of natural and socio-economic systems. Coherence, consistency and continuity are of paramount importance for the quality of data sets obtained from monitoring. For this reason the implementation of monitoring programs should be carefully designed and guaranteed for longer periods of time, e.g. 10-15 years. Shorter time frames as well as disrupted or inconsistent time series inevitably lead to a sharp decline in the relevance and usability of monitoring data and should therefore be avoided.

5.2 Future mapping and monitoring needs

The preparatory workshops for the trilateral Wadden Sea Region agenda have identified several monitoring needs for the near future. These suggestions span a wide thematic and disciplinary range as can be seen from the list below.

- Easy accessible, trilateral Wadden Sea Region geodatabase to be maintained by a group of scientists from all three national geological surveys and coastal authorities.
- Digital Terrain Models for the whole Wadden Sea Region to be carried out with a frequency of a few years and made available for research and monitoring.
- There is a need for a better monitoring program permitting the analyses of socio-economic and demographic trends in the Wadden Sea Region.
- This requires a trilateral set of consistent and coherent indicators at a detailed spatial scale and continuous in time. The Lancewad-inventory should be developed into a monitor.
- A novel mapping approach could allow stakeholders and policymakers to refine zones of human use, reduce risks to the ecosystem, and enhance delivery of multiple benefits.
- It is of great importance to continue and further harmonize long-term field observations within the Wadden Sea Region and to advocate the importance of observations (e.g. satellites) and models covering the entire Wadden Sea Region.

5.3 Innovation in mapping and monitoring

Monitoring needs are likely to increase in future as a result of more and/or broader reporting obligations and as a consequence of our desire to better understand the Wadden Sea Region system by keeping track of relevant changes through time. The expected growth in the number of variables to be monitored, the increasing demand for higher monitoring frequencies and a better geographical data resolution will put pressure on the current monitoring capacities. New ways of monitoring will have to be considered in order to meet the increasing demands for long-term data series.

In various fields, newly developing technology may facilitate significantly monitoring capacities. At the same time,

technological advance may offer the opportunity to monitor new variables in a feasible way. Monitoring and mapping efforts in the trilateral Wadden Sea Region should therefore make better use of techniques derived from e.g. satellite imaging, remote sampling and drones, big-data applications and novel DNA-techniques. Implementing novel techniques into the monitoring program will require initial investments into research and new facilities. On the medium to long term, however, the use of novel approaches could reduce costs per unit of acquired information.

Trilateral citizen science, which already takes place in for example counting coastal birds, could be used more as a pillar for mapping and monitoring exercises in the Wadden Sea Region. Citizens science refers to "the participation of non-scientists in the process of gathering data according to specific scientific protocols and in the process of using and interpreting that data" [2)]. Involving citizens can strongly improve the efficiency and breadth of monitoring activities owing to the "many hands" or "many eyes" that can be used in such approaches. Equally important, citizens science can significantly foster public support and engagement thereby helping to build a robust link between science and society.

6. Outreach, communication and education

To be filled in after Tønder. The development of the Wadden Sea World Heritage Partnership Center can fulfil an important role in this and can among others facilitate to capture the interest of young scientists and promotes scientific cooperation between institutions. The Partnership Center Drafting Group is currently developing ideas for the Wadden Sea Board that can be used in this chapter.

[2)] http://hdl.handle.net/1813/37362

7. Timeline and implementation

The draft research agenda will be presented and discussed at the 14th International Scientific Wadden Sea Region Symposium in Tønder, Denmark (9–11 May 2017). Consequently, the document will be revised and updated with relevant input from the conference. The final draft shall be presented to and discussed by the Wadden Sea Board in autumn 2017. The intention is to have the final document formally adopted and approved during the Trilateral Governmental Conference to be held in May 2018 in Leeuwarden (Netherlands).

A successful implementation of the Trilateral Research Agenda requires a truly joint effort by many stakeholders from the three Wadden Sea countries. Research institutions, national and regional authorities, public as well as private funders and foundations, NGO's, companies and engaged citizens must work together in order to reach the goals described in the agenda.

As stated before, the necessity for a Trilateral Research Agenda for the Wadden Sea Region originates from the declarations from the Trilateral Ministers meetings 2010 and 2014. Funds for implementing different parts of the agenda may come from different sources [3)]. Novel research activities may be funded by research ministries and/or their respective funding agencies, while mapping and monitoring activities are more likely to be funded by regional and national authorities responsible for environmental issues including reporting obligations stemming from national legislation, European treaties and directives. The relative contribution of the three countries to common research programs may roughly follow their respective shares of the Wadden Sea Region.

[3)] NWO executed in the last decade a Wadden Sea Region research program with a duration of five years and a budget of 10 million euro, focusing mainly on marine ecology and sedimentology and improvement of monitoring schemes. An international audit committee evaluated the research program and characterized it as a game changer in Wadden research in the Netherlands. A five year follow up program, including also socio-economic, cultural, historic and demographic research, would need a budget of approximately 15 million euro. Because about thirty percent of the trilateral Wadden Sea Region is the responsibility of the Netherlands, about sixty percent of Germany and about ten percent of Denmark, a comprehensible trilateral research agenda would need 'national' financing of about 15 million euro (Netherlands), 30 million euro (Germany) and 5 million euro (Denmark). Hence, in total approximately 50 million is needed.euro (Germany) and 5 million euro (Denmark). Hence, in total approximately 50 million is needed.