Reflection on the NCK-WA symposium on the interaction between biotic and abiotic factors in the Wadden Sea from a management perspective.

As a manager of the Wadden Sea, Rijkswaterstaat (RWS) is responsible for the accessibility of the islands and harbours, coastal protection and conservation of the natural environment. In particular, RWS has the responsibility for the drafting the Natura 2000 management plan of the Wadden Sea and the implementation of measures in order to achieve the Natura 2000 goals. In addition, RWS is accountable for water quality targets in the framework of the European Water Framework Directive, resulting in monitoring and measures that have the aim to achieve a good ecological and chemical water quality status by 2027. Last but not least, RWS, Staatsbosbeheer (SBB) and Rijksdienst voor Ondernemend Nederland (RVO) are responsible for the implementation of the Program Large Waters (PAGW) that aims to make the large waters more resilient for the future.

To perform these tasks and to assess and implement the measures that are required to accomplish these goals, it is essential to understand the Wadden Sea ecosystem interactions between abiotic and biotic factors and, more specific, the role of ecosystem engineers. The symposium gave a highly interesting overview of the fundamental processes in relation to application for policy and management. There are many factors to take into account when trying to fully comprehend the system. The Wadden Sea is a highly dynamic system, and therefore constantly changing in environmental conditions that set the base for the Wadden Sea food web and habitats. However, since centuries, human influence has increasingly affected this natural area. The closure of different parts of the Wadden Sea (like the Zuiderzee) and the long history of land reclamation has diminished the area by two-thirds of its original size. These constructions together with current human activities like dredging and sand nourishments are still affecting the orientation of channels, banks and flats, water currents and sediment budgets. For example, these interventions changed the sediment dynamics and resulted in an increase of the sediment demand of the Wadden Sea to fill up the deep tidal gullies. In addition to these many human activities affecting the abiotic and biotic conditions, climate change will provide a further impact on the natural system in relation to sea level rise, higher temperatures, changes in storminess and changes in freshwater discharges.

Understanding the interaction between anthropogenic, abiotic and biotic factors is essential for nature conservation and restoration. The need to understand these types of interactions is high as achievement of the policy targets are still out of range. Challenges remain for coastal breeding birds, fish, salt marshes, and ecosystem engineers such as seagrass and mussel beds. The symposium also identified tube-building worms acting as ecosystem engineers such as sand mason worm, ross worm and honeycomb worm as possibly relevant restoration targets. In addition, sediment-reworking organisms such as lugworms strongly impact the abiotic conditions (e.g., burial of other organisms and particles, nutrient and sediment dynamics) and should, therefore, also be considered as ecosystem engineers. Furthermore, the climate is changing, but the impact of the climate on the policy targets are largely unknown.

Several monitoring and research programs that were addressed in the symposium have taught us about interactions between anthropogenic, biotic and abiotic factors with an emphasis on morphological and ecological feedback mechanisms, the function of ecosystem engineers and the importance of models in predicting changes based on natural observations. These programs led to our current understanding of the functioning of the saltmarshes, dunes and intertidal parts of the Wadden Sea, where we gained insights in the interactions between abiotic and biotic conditions.

For the sublittoral parts of the Wadden Sea and fishes, the role of these types of interactions in the functioning of hydromorphological conditions, habitats and species still needs to be explored. In addition, the effects of anthropogenic factors on the functioning of the Wadden Sea sublittoral ecosystem are largely unidentified. There is a pressing need to monitor the sublittoral areas to learn which habitats and species are currently present, under which hydromorphological conditions they thrive and how their diversity and occurrence relate to ongoing historical driven changes and in the cause of the expected global warming. Several current research programs like Waddentools Waddenmozaiek, Swimway and the Kustgenese 2 program are helping to unravel these unknowns. It will take time before we fully understand the sublittoral ecosystem.

In order to accomplish the Natura 2000 goals, there is also a necessity to better understand the system. For example, in the Natura 2000 legislation all sublittoral areas are defined as one habitat. However, in fact, the subtidal consists of several subhabitats with different environmental conditions and typical species. Therefore, there is a need for more specific mapping of the subtidal landscape, in particular in relation to the distribution of habitats and species. Furthermore, some human activities interfere with the dynamics of the ecosystem, but we do not know to which degree and how this affects habitats and species, in particular when such activities are interacting ('cumulative effects'). This information is essential to be able to assess and implement the right measures for nature conservation and restoration. Last but not least, it is prerequisite to need to make the Natura2000 targets more climate resistant. Therefore, it is our task to restore these natural dynamics as much as possible to be able to make the Wadden Sea more robust in a changing world.

In conclusion, a solid monitoring program, better habitat mapping, improved knowledge on the mutual interaction between abiotic and biotic interaction and the effect of human activities are the main issues that we need to address to be able to take the right measures to reach the targets. Relating to climate change, a better understanding of historical driven developments and models that can predict short and long-term changes in the Wadden Sea are needed to understand and anticipate on future development. RWS is therefore pleased to support and initiate several important Wadden Sea research programs. By assembling the right information, research groups and other stakeholders in the Wadden Sea area (including the North Sea coastal zone), we are improving our understanding of the Wadden Sea ecosystem together. The webinar has stressed the importance of open data sources, the use of different models for predicting hypotheses combined with monitoring and the need to increase knowledge on ecological effects of climate change, not only for effects that are already noticeable but especially for effects in the long run that are not measurable in the present. Only by translating the right information to the right policy and management measures, we are not only getting closer in reaching the European conservation targets, but also work on the robustness and resilience on the Wadden Sea ecosystem as a climate buffer. To achieve this a good cooperation between science, governance and nature management is needed.

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