

MEETING DOCUMENT

Wadden Sea Board (WSB 36)

28-29 April 2022
Varde, Denmark



Agenda Item:	4
Subject:	15th ISWSS Report
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Submitted by:	National Park Authority Wadden Sea of Schleswig-Holstein

The 15th International Scientific Wadden Sea Symposium (15th ISWSS): Importance of science for the management of the Wadden Sea World Heritage in the context of climate change, was held online from the 30. November to 02. December 2021. Over 200 participants presented and discussed the latest scientific findings on the status of the Wadden Sea World Heritage. Recommendations for science and management were discussed and formulated for birds, marine mammals, alien species, sublittoral habitats, socioeconomic/ecological sustainable development and fish. This document contains the 15th ISWSS report.

The 15th ISWSS was organised under the lead of the National Park Authority Wadden Sea of Schleswig-Holstein with the support of the Common Wadden Sea Secretariat, financed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Ministry of Energy, Agriculture, the Environment, Nature and Digitalization Schleswig-Holstein.

Proposal: The meeting is invited to note the report.

Importance of
science for the management
of the Wadden Sea
World Heritage in the context
of climate change

**SYMPOSIUM
REPORT**



ISWSS15

The 15th International
Scientific Wadden Sea Symposium
Büsum · Germany · 2021

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Setting of the 15. International Scientific Wadden Sea Symposium

After thorough consideration of the various options and in view of the current Corona pandemic developments, we decided to hold the 15th International Scientific Wadden Sea Symposium (ISWSS) in virtual form from the 30. November to 02. December 2021. The symposium was held online in the Wadden Sea Meeting Platform, which features the future Partnership Centre and offers interactive spaces resembling the Wadden Sea natural environment.

The ISWSS is behind us and we can look back on exciting, instructive and communicative days. Over 200 participants joined the symposium. We were particularly pleased with the lively exchange that took place, which we did not consider self-evident in an online format. Thanks again to all speakers and poster presenters as well as all participants of the symposium.

Special thanks for the re-planning and the effective online implementation of the ISWSS go to the moderators, the rapporteurs, the technical moderators and the technical support - thank you again for your commitment! Also, many thanks to Juliane Reich and Franziska Baum from Inspektour and Christoph Aschenbrenner and Ben from Meetingland for your brilliant support! Furthermore, special thanks to Dr Jagoba Malumbres-Olarte, who accompanied the symposium as a conference illustrator.

The International Scientific Wadden Sea Symposium (ISWSS) traditionally provides a forum for scientists who are active in and around the Wadden Sea to present their research and to discuss how they can become (further) involved in the Trilateral Wadden Sea Cooperation (TWSC). The purpose of the symposium is to report on the state of the Wadden Sea from a scientific point of view and to give recommendations for the future, where needed. The outcomes of the ISWSS provide substantial input for the discussion on the future challenges and work of the Trilateral Wadden Sea Cooperation of Denmark, Germany and the Netherlands, including the preparation of the Trilateral Governmental Conference, which will be held in Wilhelmshaven, Lower Saxony, in December 2022.

The ISWSS 2021 was organised under the lead of the National Park Authority Wadden Sea of Schleswig-Holstein with the support of the Common Wadden Sea Secretariat, financed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Ministry of Energy, Agriculture, the Environment, Nature and Digitalization Schleswig-Holstein.



Results of the ISWSS

Recommendations from Breakout Session

There were six breakout groups related thematically to one of the thematic sessions of the symposium (themes as stated above: birds, marine mammals, alien species, sublittoral habitats, sustainable development - eco and sustainable development - socio).

The objective of the breakout session was to bring together scientists from different disciplines, managers and politicians to discuss the main issues and opportunities in the Wadden Sea in relation to their specific topic and to draft recommendations for the TWSC to improve research, monitoring and assessment as well as management for the preservation of the Outstanding Universal Value, in the light of climate change.

The recommendations had to be in line with the guiding principle, “to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”, and taking into account existing trilateral programmes, strategies and plans. Every breakout group was asked to decide on three recommendations for science and three recommendations for management which were finally presented to all participants of the symposium.

In addition, experts on fish took the opportunity provided by Meetingland to come together, exchanged ideas and - as in the other breakout groups - formulated three recommendations each for science and management for fish.

The recommendations were shared with the corresponding groups of the TWSC and will be part of the discussions regarding future directions of research and monitoring in the Wadden Sea in lieu of the next Trilateral Governmental Conference in 2022.

The specific recommendations, as they were presented in the ISWSS, are included in this report in the following chapter.

Recommendations on Birds

Breakout Group BIRDS

Recommendations

SCIENCE

(1) More studies on birds' habitat choice are needed to identify important sites with different functions (feeding, moulting, resting, moving) within the Wadden Sea and on the entire flyway, specifically also by the use of tracking and remote sensing to unravel critical stages in the annual cycle of migratory birds. Especially the interplay between hydrodynamics, sediment properties, benthos and bird habitats on intertidal flats needs to be studied with respect to climate change and sea level rise.

(2) Monitoring of food resources (fish, benthos ...) for the WS birds is needed – from salt marshes to tidal flats, subtidal creeks and the offshore zone, focusing particularly on hot-spots of bird distribution (as revealed by telemetry).

(3) Life time/long-term studies of individual species/populations are necessary to infer changes/adaptions enabling optimal management of the birds in the WS. This includes demographic and multiple-year movement studies, as well as the focus on the full annual cycle of birds. Special emphasis should be put on birds that have been identified as long-term declining by TMAP. Also, more studies on the cumulative effects of human pressures on feeding and staging birds in the WS and along the flyway are needed.

Breakout Group BIRDS

Recommendations

MANAGEMENT

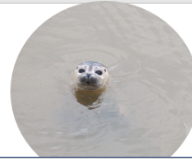
(1) Flyway conservation management on the East Atlantic Flyway (incl. Russia) relies also on a healthy Wadden Sea. Development of sensitivity maps for birds and other biota as well as habitats on both a WS scale and a flyway scale are needed to conserve and manage bird populations in a proper way. This includes the identification of important habitats and their different functions for birds. Connectivity between the Wadden Sea and other wetland systems should be revealed to enable an international management of populations.

(2) Impacts from human activities are well-known as one of the limiting factors to the distribution and the health of many bird populations in the WS, but knowledge about a number of new activities are needed. The monitoring of impacts should include both well-known (contaminants and environmental toxins, fishery, hunting and disturbance) and new human (e.g. wind farms) activities, but also cover all habitats for birds – salt marshes, sandbanks, tidal flats and creeks, and subtidal and offshore areas.

(3) TMAP parameters and outcomes should be reviewed to optimize their use for research and management. Monitoring data show where problems arise for species/populations, and a far more coordinated and cross-bordering management is needed to improve the conditions especially for breeding birds in trouble. New parameters may be needed to include missing information (e.g. outer sands as roosts).

Recommendations on Marine Mammals

MAMMALS Recommendations for [science](#)



1. Since 2012, numbers of **harbour seal pups** have shown an annual increase of 5% while number of adult seals stagnated at 1% increase per year. Monitoring efforts need to be adjusted and new research projects developed to understand the factors causing the mismatch between documented harbour seal pup numbers and adult numbers. These data are needed to predict the **long-term status of the Wadden Sea harbour seal population**.
2. Evidence from telemetry data suggests that individual **harbour porpoises are resident in the Wadden Sea**. Further information on the genetic population structure, distribution and habitat use of harbour porpoises is needed to understand the connectivity between the Wadden Sea and the North Sea habitat as well as their specific resource needs and the role as top predator in the Wadden Sea ecosystem. It is recommended that harbour porpoises in the Wadden Sea should continue to be treated as a separate conservation unit.
3. Climate change is likely to affect the habitat, health, reproduction, and resource use of marine mammals, potentially amplifying the impact that other environmental or anthropogenic effects have on their populations' dynamics. For adequate management actions, monitoring of physiological, behavioural and ecological **adaptations of marine mammals to climate change** and other **anthropogenic disturbance is urgently needed to predict the adaptive capacities and resilience of the species** resulting from the cumulative effect of multiple factors.

MAMMALS Recommendations for [management](#)



1. Ensure the **implementation of existing management protocols and action plans as well as national and international agreements** to reduce the impact of identified anthropogenic and environmental pressures and threats. Due to their functional role as top marine predators in the Wadden Sea ecosystem, **marine mammals are sentinels for the productivity of the ecosystem** as well as for climate change and, thus, mirror the effectiveness of management measures, as their viability depends on a healthy ecosystem and the availability of adequate habitat and food resources.
2. Create and **enforce protected areas for marine mammals in the North Sea EEZs as well as in the Wadden Sea**, free of any anthropogenic disturbance, based on the scientific evidence for the location of key habitats. Consideration of management activities beyond the borders of the Wadden Sea World Heritage site are needed to ensure the integrity of the site.
3. Ensure funding for a **Wadden Sea wide, effective, well-coordinated, long-term monitoring**, consisting of aerial surveys (abundance, distribution), biotelemetry, passive acoustic monitoring (dispersal, behaviour, habitat utilisation) as well as stranding network (health, diet) to assess the population viability of all marine mammal species. Effective and adaptive management decisions need to be based on **scientific evidence provided by a monitoring with high-quality standards that could deliver early warning signs**.

Recommendations on Alien Species

Breakout Group Alien Species

Science

Recommendation 1:

Harmonize trilateral detection and population monitoring of introduced species (including new DNA-based methods), and extend it to more taxa and habitats (e.g. natural habitats on Wadden Sea islands)



Goal:

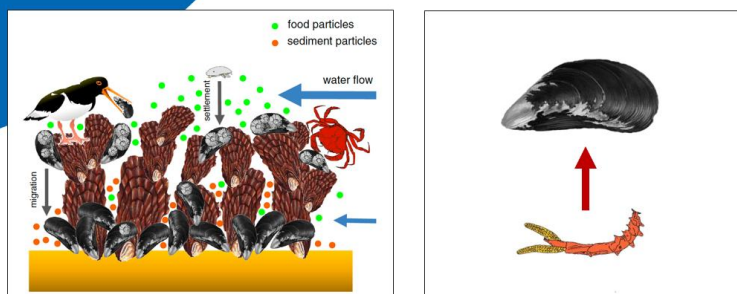
Improving coordination of trilateral detection and population monitoring measures and the joined development of harmonized "modern" methods. Consideration of hitherto neglected taxonomic groups such as parasites and threatened dune habitats.

Breakout Group Alien Species

Science

Recommendation 2:

Intensify research on direct and indirect effects of introduced species including non-native parasites and pathogens in the ecological web



Goal:

Better understanding on the effects (risks and benefits) of introduced species with respect to climate warming and sea level rise.

Breakout Group Alien Species

Science

Recommendation 3:

Initiate a transdisciplinary working group to discuss whether the ecological role and management of introduced species should be reevaluated in the face of climate change



Goal:

Overcoming the dichotomies of native versus alien and of pristine versus novel nature. Interdisciplinary coordination on dealing with introduced species in relation to climate change, preservation of ecosystem functions and potential management strategies.

Breakout Group Alien Species

Management

Recommendation 1:

Tighten preventions of introduced species on regional scales by e.g. reducing artificial substrates and aquaculture activities



Goal:
Reducing artificial substrate suitable for successful establishment of non-native species and avoidance of unintentional introductions with aquaculture organisms.

Breakout Group Alien Species

Management

Recommendation 2:

Accept the established introduced species in the tidal ecosystem as new residents, while on wadden islands controlling of some invaders (e.g. rats, foxes, and the *Rugosa* rose) may be indispensable



Goal:
Different consideration of aquatic and terrestrial areas in the Wadden Sea with regard to introduced species. Avoiding collateral damages in the aquatic environment with attempts of removing introduced species. On wadden islands, safeguarding ground-breeding coastal birds as well as natural dune habitats to maintain characteristic biodiversity.

Breakout Group Alien Species

Management

Recommendation 3:

There is urgent need to implement a trilateral platform to exchange knowledge on introduced species (e.g. detection, distribution, effects) in the Wadden Sea area



Trilateral Wadden Sea World Heritage Partnership Center

Goal:
Improving trilateral knowledge exchange on the occurrence, distribution and dynamics of introduced species. Providing an infrastructure to coordinate monitoring activities and to agree on scientific priorities for research on the effects of introduced species.

Recommendations on Sublittoral Habitats

Feasible Recommendations for science in a trilateral framework

We seek for:

Fundamental system understanding in **applied research** (meeting management goals). **Interdisciplinary** projects on the **mutual Geo-Bio interactions** explore timescales and adaptations of sediments, habitats, species in **connected systems**.

Quantification of the **state and changes** by **comprehensive, interdisciplinary, state-of-the-art and new monitoring / mapping methodology**. We recommend the **combination of synoptic full-coverage observation and continuous monitoring of representative areas**. We need to harmonize, **generalise standards** and state-of-art invasive and non-invasive methods for sediment and ecosystem dynamics.

New **modelling and assessment tools** for **comprehensive analyses and model experiments** across scales and **forcings** (storms to sea level rise projections). Coupling of morphodynamics and ecological models is needed to understand **cumulative effects and mutual developments**.

Recommendations of the Thematic Session on Sublittoral Habitats

Recommendations for policy, management in a trilateral framework

We recommend:

Common methodology and terminology in trilateral integrative policies and reporting. It is necessary to establish **common definitions, indicators, and** descriptors (e.g. MSFD also in Dutch Wadden Sea, synergies between OSPAR and MSFD, definitions of habitats).

Trilateral transdisciplinary communication should be fostered by regular workshops for **joint analyses and assessment** of data, scientific **platforms for joint** field campaigns and monitoring, and interdisciplinary research projects.

To assess and protect ecosystems by observation of reference sites in undisturbed (no take) and disturbed (human impact) areas by using an ecosystem approach. This includes the monitoring of the effect of measures and adaptive approaches.

Recommendations of the Thematic Session on Sublittoral Habitats

Recommendations on Sustainable Development - Eco

Recommendations Sustainability and Ecology

1. Science and Management have a joint responsibility.
2. Develop biodiversity assessment tools (for monitoring and assessment) and improve use of time series.
3. Define biodiversity/sustainability targets on local and regional level.
4. Need to understand the system and recognize complexity of the Wadden Sea. Simple indicators do not work, but the message should be simple. Requiring an adequate communication („complexity is not an excuse“).
5. Shape living labs/project jointly with managers and scientists. The Partnership Hub can be instrumental for all stakeholders involved.
6. Multi-disciplinary approach needed to address biodiversity/sustainability.

Breakout Group Sustainable Development - Eco

Recommendations on Sustainable Development - Socio

Breakout Group Sustainable development – socio

Recommendations for Science

- Strengthen interdisciplinary dialogue and research between natural and social sciences and humanities on values in nature conservation, protected area management and sustainable development
- Strengthen funding opportunities for interdisciplinary and social sciences / humanities led research projects
- Strengthen the development of indicators and trilateral monitoring and recording systems in the areas of archaeology, history, and socio-economic fields, such as tourism, recognizing climate change impacts
- Dare to experiment and bring forth latent opportunities for sustainable development with others, e.g. through leisure and tourism for climate action and sustainable development in the Wadden Sea

Sustainable development – socio

Breakout Group Sustainable development – socio

Recommendations for Management

- Broaden collaboration of the Trilateral Wadden Sea Corporation with civic society and entrepreneurs for Sustainable Development of the Wadden Sea Region
- Acknowledge natural and cultural heritage as mutually reinforcing and recognize that nature conservation has to be informed by multiple societal and natural values.
- Strengthen reference to historical and cultural heritage in management by promoting a more holistic view of the socio-environmental history and possible futures of the Wadden Sea landscape.

Sustainable development – socio

Recommendations on Fish

FISH recommendations to SCIENCE

In addition to
recommendations

- QSR 2021/2016
- Swimway symposium 2019



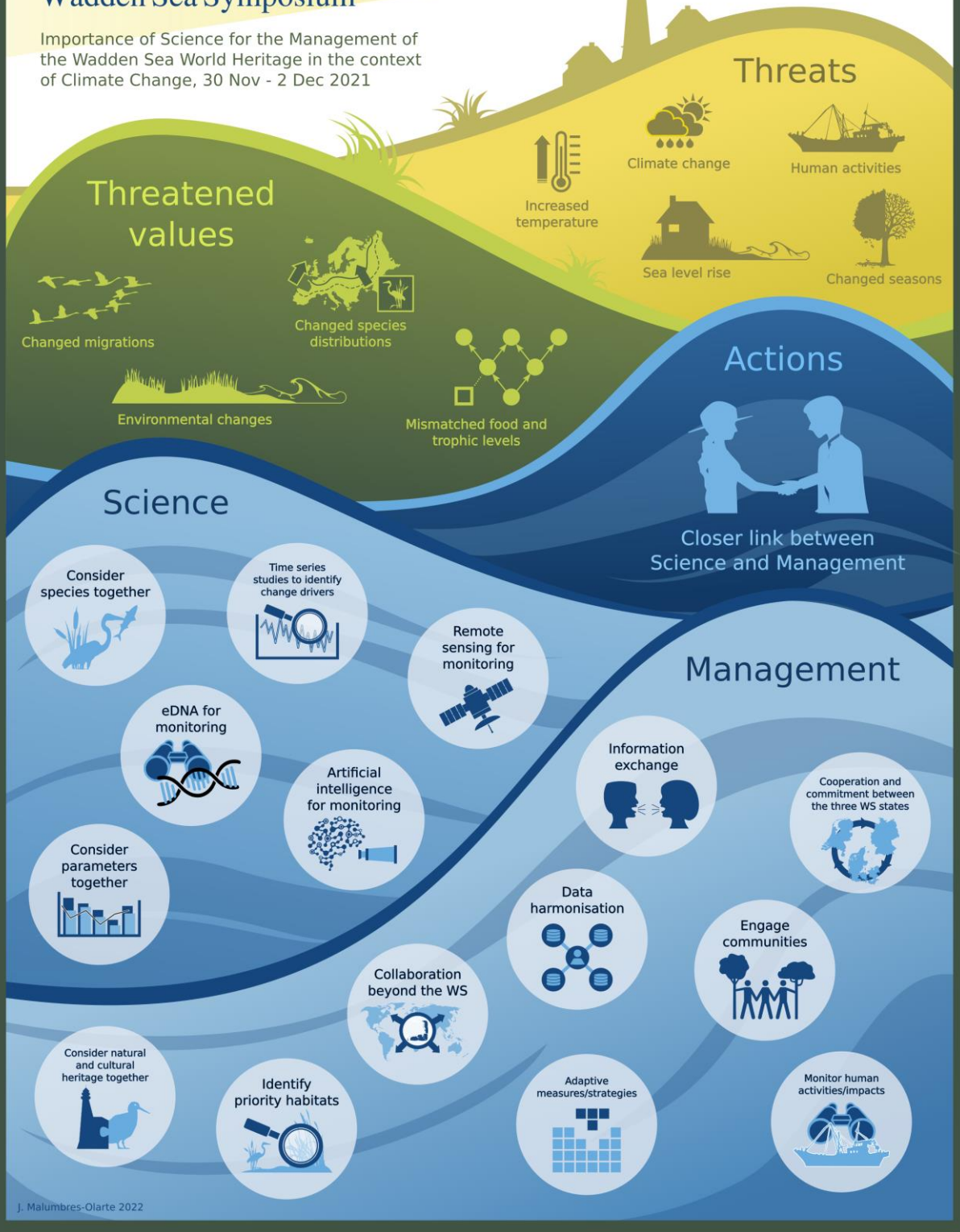
- **Historical reference**
 - observations do not go back further than the 1970's
 - To understand developments on a longer time scale => disclose historic information.
- **The central role of fish in the food web**
 - predator- prey relationships: fish are eaten by birds, sea mammals and fish, predator of zooplankton and benthos
 - Need for integrative trilateral studies involving fish - and other scientists.
- **Spatio-temporal variation ~ climate change (phenology, match-mismatch)**
 - **large species:**
 - extend receiver network of (acoustic) telemetry Western Wadden Sea
 - compatible to other initiatives.
 - migration routes, habitat use, to answer life cycle questions
 - also to mirror level of knowledge on flyway.
 - **small species:**
 - Incorporate yearround sampling in the standard monitoring
 - to evaluate climate effects on phenology of Wadden Sea fish

Recommendations for FISH

15th ISWSS International Scientific Wadden Sea Symposium



Importance of Science for the Management of the Wadden Sea World Heritage in the context of Climate Change, 30 Nov - 2 Dec 2021



J. Malumbres-Olarte 2022

1 This infographic gives a summarized overview of the recommendations developed and presented at the ISWSS.

Conclusions

Climate change and the associated sea level rise are considered among the greatest threats to the Wadden Sea and its Outstanding Universal Value. In fact, the latest research shows that climate change impacts have already affected the Wadden Sea ecosystem. As an example, the study from Montero-Serra et al. (2015)¹ shows how increased temperatures drive species of fish to move northwards to deeper waters, changing communities' composition. Variations in the start and change of seasons also produce a mismatch between the food supply and higher trophic levels, as the study of Van Gils et al. (2016) shows, which causes shrinkage of chicks resulting in smaller juveniles migrating south². Management and protection of the Wadden Sea need to adapt to the challenges posed by climate change while also considering the impact of other anthropogenic pressures in and around the Wadden Sea, such as fisheries, tourism, energy transition and offshore facilities. Different pressures may have cumulative effects that - combined with climate change - can increase the urgency for these challenges to be addressed.

The cooperation and commitment between the three Wadden Sea states in the TWSC provides the basis for adaptive management decisions to be taken at the ecosystem level and is thus of great importance for the protection of the Wadden Sea.

The exchange of information and, where possible, the harmonisation of monitoring data between the three Wadden Sea states must be further intensified. The Wadden Sea is an extremely complex system, thus individual parameters, groups of organisms or thematic fields should not be considered in isolation but in conjunction with each other. Time series are necessary to understand environmental changes over time and to identify the main drivers of these changes. Research projects need to develop strategies to mitigate the impact of pressures. New technologies, such as the use of eDNA and artificial intelligence should be explored as they may help to improve monitoring.

Strengthening the trilateral collaboration in research and monitoring and sharing information on effective management measures will not only benefit the implementation of the Wadden Sea Plan and thus the protection of the Wadden Sea, but it will also contribute to the worldwide recognition the Wadden Sea World Heritage Site receives for its effective management system. Therefore, a closer link between science and management is desirable, as it could further improve our evidence-based conservation management. Sharing information on natural processes in the Wadden Sea, research results, and effective management measures at the local level can be used to further engage local communities and visitors with the protection of the Wadden Sea. And although the Wadden Sea World Heritage is a natural site, its cultural components should be considered in addition to the natural aspects for safeguarding the Wadden Sea.

Finally, the symposium showed that international cooperation beyond the Wadden Sea is of great importance to better understand the interaction between areas, but also to learn from each other's experiences.

¹ Montero-Serra et al. (2015): *Warming shelf seas drive the subtropicalization of European pelagic fish communities*

² Van Gils et al. (2016): *Body shrinkage due to Arctic warming reduces red knot fitness in tropical wintering range*

Publishing in the Topical collection „Biodiversity and Ecology of the Wadden Sea under changing environments“

Peer-reviewed publications of the topics presented at the ISWSS, but also of work being conducted beyond the symposium will be possible in the [“Marine Biodiversity”](#). ISWSS papers will be published under the topical collection „Biodiversity and Ecology of the Wadden Sea under changing environments“ on the journal’s webpage. MARB publication style is ‘Continuous Article Publishing’, meaning that all papers are published online as soon as they are ready and immediately assigned to the issue.

As all papers must be within scope of Marine Biodiversity, all topics need to relate to marine biodiversity research, which most probably will include the contributions by the authors for the themes Birds, Marine Mammals, Alien Species, Sublittoral Habitats, Sustainable development – Eco and Fish. The journal’s [submission guidelines](#) provide the relevant instruction for authors, including the [types of papers](#) which can be considered for publication and the manuscript submission process. Please submit your paper at <https://www.editorialmanager.com/marb/default.aspx> before 31. May 2022.

Annex 1 - Programme

Tuesday, 30.11.2021 (8:30 - 13:30)	
08:15	Opening of the conference platform
08:15 - 18:00	Wadden Sea World Heritage video – cinema (on the rooftop)
08:45 - 09:00	Technical introduction to Meetingland <i>Juliane Reich, inspektour GmbH - Auditorium 3</i>
	WELCOME & SETTING THE SCENE Moderator: <i>Johannes Oelerich</i> , Ministry for Energy, Agriculture, the Environment, Nature and Digitalisation (MELUND) - Auditorium 3 -
09:00 - 09:10	Opening and welcome <i>Johannes Oelerich & Minister Jan Philipp Albrecht</i> , Ministry for Energy, Agriculture, the Environment, Nature and Digitalisation (MELUND)
09:10 - 09:20	Setting the scene <i>Josef Tumbrinck</i> , Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
09:20 - 09:30	Climate change: impact, adaptation and trilateral cooperation. How to adapt? <i>Robert Zijlstra</i> , Directorate-General for Public Works and Water Management & Chair of EG-C
09:30 - 09:40	"Trilateral Research Priorities" - a new approach focussing trilateral research activities on the Guiding Principle and securing the necessary funding <i>Bernd Scherer</i> , Chair of TPC
09:40 - 9:50	Coffee Break

PARALLEL THEMATIC SESSIONS			
	BIRDS	MARINE MAMMALS	ALIEN SPECIES
09:50 - 12:00	Moderator: <i>Stefan Garthe</i> , FTZ, Kiel University Rapporteur: <i>John Frikke</i> , Nationalpark Vadehavet - Auditorium 3 -	Moderator: <i>Anita Gilles</i> , Institute for Terrestrial and Aquatic Wildlife Research (ITAW) Rapporteur: <i>Kristine Meise</i> , Common Wadden Sea Secretariat (CWSS) - Auditorium 2 –	Moderator: <i>Christian Buschbaum</i> , Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt Rapporteur: <i>Winnie Adolph</i> , National Park Authority Wadden Sea Lower-Saxony - Auditorium 1 -
09:50 - 10:10	The Wadden Sea could help migratory bird populations confronted with climate change, but will it actually? <i>Eldar Rakhimberdiev</i> Department of Theoretical and Computational Ecology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam & Department of Vertebrate Zoology, Lomonosov Moscow State University	Anthropogenic pressures on marine mammals of the Wadden Sea <i>Jonas Teilmann</i> Aarhus University	Effects of introduced marine species on biodiversity and ecosystem functions in the Wadden Sea <i>Karsten Reise</i> Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt
10:10 - 10:30	The state of birds in the Wadden Sea in a changing environment <i>Gregor Scheiffarth & Kees Koffijberg</i> NPA Wadden Sea Lower-Saxony & Sovon Dutch Centre for Field Ornithology	Trilateral health monitoring of seals and porpoises – What have we learned? <i>Stephanie Gross</i> Institute for Terrestrial and Aquatic Wildlife Research (ITAW)	QSR 2020-21 Thematic Report on “Alien Species” <i>Heike Büttger</i> BioConsult SH GmbH & Co.
10:30 - 10:50	Towards a healthy Wadden Sea to mitigate effects of Arctic warming on migratory birds <i>Jutta Leyrer</i> Michael Otto Institute, NABU	Harbour porpoise in the Wadden Sea - where do they come from and where do they go? Using current knowledge for successful trilateral monitoring in the World Heritage Site <i>Meike Scheidat</i> Wageningen Marine Research, University of Wageningen	Integration in the Wadden Sea ecosystem - How introduced alien species can affect species interactions in a native ecosystem <i>Annika Cornelius</i> Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt
10:50 - 11:00	Coffee Break		

11:00 - 11:20	Climate driven sediment changes affect abundance of migratory waders <i>Karsten Laursen</i> Aarhus University	At-sea habitat use of juvenile grey seals in a growing population in the Wadden Sea <i>Abbo van Neer</i> Institute for Terrestrial and Aquatic Wildlife Research (ITAW)	The use of molecular tools for monitoring non-indigenous species in coastal waters <i>Carolyn Uhler</i> German Center for Marine Biodiversity Research (DZMB), Senckenberg Research Institute
11:20 - 11:40	Variation in food availability and its consequences for three tern populations <i>Veit Hennig & Sandra Bouwhuis</i> University of Hamburg & Institute of Avian Research Wilhelmshaven	Effect ranges of underwater noise from anchor vibration operations in the Wadden Sea <i>Johannes Baltzer</i> Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover Foundation	Collateral diseases: effects of biological invasions on parasites and pathogens in the Wadden Sea <i>David Thielges</i> NIOZ Royal Netherlands Institute for Sea Research & Utrecht University
11:40 - 12:00	Eurasian Curlew migration along the East Atlantic Flyway: spatial and temporal patterns, and their vulnerability towards offshore wind farms <i>Philipp Schwemmer</i> FTZ, Kiel University	Disappearing harbour seals - How do we explain a changing trend in the Wadden Sea harbour seal population <i>Sophie Brasseur</i> Wageningen Marine Research, University of Wageningen	20 years of monitoring: the role of alien species on intertidal mussel beds in the North Frisian Wadden Sea <i>Jasmin S. Mueller</i> BioConsult SH GmbH & Co. KG
12:00 - 12:10	Coffee Break		
12:10 - 13:30	BREAKOUT SESSION		
	BREAKOUT GROUP BIRDS Moderator: <i>Stefan Garthe</i> Rapporteur: <i>John Frikke</i> - Auditorium 3 -	BREAKOUT GROUP MARINE MAMMALS Moderator: <i>Anita Gilles</i> Rapporteur: <i>Kristine Meise</i> - Auditorium 2 -	BREAKOUT GROUP ALIEN SPECIES Moderator: <i>Christian Buschbaum</i> Rapporteur: <i>Winny Adolph</i> - Auditorium 1 -
End of day 1			

Wednesday, 01.12.2021 (8:30 - 13:30)

08:15	Opening of the conference platform		
08:15 - 18:00	Mulivision Show – cinema (on the rooftop)		
08:15 - 08:30	Technical introduction to Meetingland <i>Juliane Reich, inspektour GmbH (tbd if needed) - Auditorium 3</i>		
08:30 - 08:35	Welcome & Setting the scene for the day <i>Thomas Borchers, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) - Auditorium 3</i>		
08:35 - 08:55	Multimar Wattforum Live Tour <i>Alina Claußen, LKN.SH/NPA Wadden Sea Schleswig-Holstein - Auditorium 3</i>		
PARALLEL THEMATIC SESSIONS			
09:00 - 11:10	<p style="text-align: center;">SUBLITTORAL HABITATS</p> <p>Moderator: <i>Christian Winter</i>, Kiel University Rapporteur: <i>Martha Buitenkamp</i>, Programme towards a rich Wadden Sea</p> <p style="text-align: center;">- Auditorium 3 -</p>	<p style="text-align: center;">SUSTAINABLE DEVELOPMENT – ECO</p> <p>Moderator: <i>Jouke van Dijk</i>, University Groningen Rapporteur: <i>Suzanne Poiesz</i>, Wageningen Marine Research</p> <p style="text-align: center;">- Auditorium 2 -</p>	<p style="text-align: center;">SUSTAINABLE DEVELOPMENT – SOCIO</p> <p>Moderator: <i>Anja Szczesinski</i>, WWF Germany Rapporteur: <i>Catharina Greve</i>, LKN.SH/NPA Wadden Sea Schleswig-Holstein</p> <p style="text-align: center;">- Auditorium 1 -</p>
09:00 - 09:20	<p><i>Nina Fieten</i> Altenburg & Wymenga</p>	<p>Opening Pandora’s Box: Measuring biodiversity change from empirical data</p> <p><i>Helmut Hillebrand</i> Carl von Ossietzky University Oldenburg</p>	<p>Towards Sustainable Development of Cultured World Heritage Nature</p> <p><i>Janne Liburd</i> University of Southern Denmark</p>
09:20 - 09:40	<p>Subtidal habitats in the Wadden Sea: Research Approaches, Findings, Constraints</p> <p><i>Klaus Ricklefs</i> FTZ, Kiel University</p>	<p>Modelling drivers of biodiversity change emphasizes the need for multivariate assessments</p> <p><i>Jan-Claas Dajka</i> Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg</p>	<p>Protecting Natural and Cultural Heritage at the Wadden Sea Coast: A Relational Values Approach</p> <p><i>Cormac Walsh</i> Institute for Ecology, Social-Ecological Systems Institute, Leuphana University Lüneburg</p>

09:40 - 10:00	Striking long-term change in subtidal epibenthos of the northern Wadden Sea <i>Andreas Waser</i> Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt	Potential ecosystem effects of seagrass recovery in the northern Wadden Sea – A food web modelling approach <i>Sabine Horn</i> Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt	Integrating the Humanities in Conservation in the Wadden Sea: Some Lessons from Literature <i>Eveline de Smalen</i> Rachel Carson Center for Environment and Society
10:00 - 10:10	Coffee Break		
10:10 - 10:30	Status of sublittoral habitat mapping and applied hydroacoustic survey methods in the German Wadden Sea of Schleswig-Holstein <i>Klaus Ricklefs</i> FTZ, Kiel University	Salt marshes in the Wadden Sea: Status, trends and effects of climate change <i>Kai Jensen</i> Applied Plant Ecology, Universität Hamburg	New approaches to archaeological research in the Wadden Sea of North Frisia (Germany): Combined geophysical, geoarchaeological and archaeological prospection methods to reconstruct the medieval cultural landscape <i>Bente Sven Majchczack</i> ROOTS Cluster of Excellence, Christian-Albrechts-Universität Kiel
10:30 - 10:50	Large-scale modelling of residual fluxes and accumulation of fine sediments in the East Frisian Wadden Sea <i>Gerald Herrling</i> Coastal Geology and Sedimentology, Institute of Geosciences, Kiel University	Possible impacts and consequences of climate change on the OUVs of the Wadden Sea <i>Katja Philippart</i> Waddenacademie, NIOZ Royal Netherlands Institute for Sea Research	Wadden Sea Tourism Monitor: Helping Destinations to Define Limits of Acceptable Change in Tourism Development <i>Anja Szczesinski</i> WWF Germany
10:50 - 11:10	Wadden Mosaic: Understanding the ecological functioning of the subtidal Wadden Sea <i>Oscar Franken</i> Conservation Ecology Group, GELIFES, University of Groningen	Mutual dependency between coastal morphodynamics and benthic biological functioning: Identifying the main drivers for long term morphological evolution <i>Peter Arlinghaus</i> Helmholtz-Zentrum Geesthacht	Barriers for Sustainable Entrepreneurship in the Wadden Sea World Heritage Area <i>Hellen L.A. Dawo</i> Centre for Sustainable Entrepreneurship, Campus Fryslân, Rijksuniversiteit Groningen
11:10 - 11:20	Coffee Break		

11:20 - 12:35	BREAKOUT SESSION		
	BREAKOUT GROUP SUBLITTORAL HABITATS Moderator: <i>Christian Winter</i> Rapporteur: <i>Martha Buitenkamp</i> - Auditorium 3 -	BREAKOUT GROUP SUSTAINABLE DEVELOPMENT – ECO Moderator: <i>Jouke van Dijk</i> Rapporteur: <i>Suzanne Poiesz</i> - Auditorium 2 -	BREAKOUT GROUP SUSTAINABLE DEVELOPMENT – SOCIO Moderator: <i>Anja Szczesinski</i> Rapporteur: <i>Catharina Greve</i> - Auditorium 1 -
12:35 - 13:30	POSTER SESSION		
	Poster Room 1	Poster Room 2	Poster Room 3
	Foraging ecology of Eurasian spoonbills (<i>Platalea leucorodia</i>) in the German Wadden Sea <i>Leonie Enners</i> FTZ, Kiel University	The Dutch Wadden Sea as an event-driven system: statistical detection of spatio-temporal patterns in the salinity field and variability of the transport time scales <i>Carmine Donatelli</i> NIOZ Royal Netherlands Institute for Sea Research, Texel	Swimways: Linking movement ecology and fish conservation in the Wadden Sea <i>Jena Edwards</i> NIOZ Royal Netherlands Institute for Sea Research, Texel, Wageningen Marine Research, University of Wageningen
	Using Seabirds to monitor pollution: mercury trends and effects in the Wadden See across the last 40 years <i>Frank R. Mattig</i> ICBM Terramare, Carl-von-Ossietzky University Oldenburg	Development of the salt marsh edge due to bio-geomorphic dynamics <i>Charlotte Steinigeweg</i> Technische Universität Braunschweig	Swimway Waddenzee - Tracking fish migration and habitat selection in the Wadden Sea <i>Jena Edwards</i> NIOZ Royal Netherlands Institute for Sea Research, Texel, Wageningen Marine Research, University of Wageningen
	Microplastics in marine mammals of the German North Sea <i>Bianca Unger</i> Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover Foundation	Proposal for a new legal form for the governance of the Dutch Wadden Sea <i>Tineke Lambooy</i> Professor Corporate Law Nyenrode Business University	Swimway NL: a five year research program on the role of the Wadden Sea for fish <i>Ingrid Tulp</i> Wageningen Marine Research, University of Wageningen

	<p>Synergies between ASCOBANS and the Trilateral Wadden Sea Cooperation: Harbour Porpoise</p> <p><i>Jenny Renell</i> Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) Secretariat</p>	<p>Mapping the legal de-objectification of nature. Proposing a taxonomy for rights of nature and co</p> <p><i>Tineke Lambooy</i> Professor Corporate Law Nyenrode Business University</p>	<p>QSR FISH – Trends in Wadden Sea Fish</p> <p><i>Ingrid Tulp</i> Wageningen Marine Research, University of Wageningen</p>
	<p>Sandküste Sankt Peter-Ording - How to Reevaluate and Adapt Wadden Sea Nature with Respect to Climate Change?</p> <p><i>Jannes Fröhlich</i> World Wide Fund For Nature (WWF) Germany</p>	<p>Ecological sediment management in the Ems estuary - Basics for a sustainable ecological management strategy</p> <p><i>Gregor Scheiffarth</i> National Park Authority Wadden Sea Lower-Saxony</p>	<p>Seasonal variation in the value of the Wadden Sea to commercial and non-commercial fish: a pilot study</p> <p><i>Jip Vrooman</i> Wageningen Marine Research, University of Wageningen</p>
	<p>Birth, growth and death of subtidal mussel beds in the Dutch Wadden Sea.</p> <p><i>Suzanne Poiesz</i> Wageningen Marine Research, University of Wageningen</p>	<p>SmallTalk in the Noisy Sea Effects of underwater noises on zooplankton with a focus on predator-prey interactions</p> <p><i>Saskia Kühn</i> FTZ, Kiel University</p>	<p>The Function of Subtidal Reefs in the Wadden Sea: Testing passive acoustics as a tool for monitoring fish habitat</p> <p><i>Maryann S. Watson</i> University of Groningen</p>
	<p>Grass-like algae transform rippled sand bars into bumpy mud flats: An enigmatic and novel appearance in the Wadden Sea</p> <p><i>Karsten Reise</i> Alfred-Wegener-Institute (AWI), Wadden Sea Station Sylt</p>		<p>The function of the Wadden Sea for small pelagic fish</p> <p><i>Margot Maathuis</i> Wageningen Marine Research, University of Wageningen</p>
			<p>Target practice: how current EU legislation supports the realisation of the Trilateral Fish Targets</p> <p><i>Paddy Walker</i> Programme towards a rich Wadden Sea</p>
			<p>Beached dead herring call for more SWIMWAY-oriented research efforts</p> <p><i>Katja Heubel</i> FTZ, Kiel University</p>
<p>End of day 2</p>			

Thursday, 02.12.2021 (8:30 - 12:35)

08:30	Opening of the conference platform
08:55 - 09:00	Welcome & Setting the scene for the day <i>Vera Knoke</i> , Ministry for Energy, Agriculture, the Environment, Nature and Digitalisation (MELUND) - Auditorium 3
09:00 - 11:30	THEME SESSION INTERNATIONAL PERSPECTIVE Moderator: <i>Bernard Baerends</i> , CWSS - Auditorium 3 -
09:00 - 09:15	Interlinking science and practice for the management of World Heritage – Heritage Place Lab <i>Eugene Jo</i> , International Centre for the Study of the Preservation and Restoration of Cultural Property
09:15 - 09:30	Climate adaptation in the Wadden Sea; how deep is your love? <i>Martin Baptist</i> , Wageningen Marine Research, University of Wageningen
09:30 - 09:45	Assessing climate vulnerability in World Heritage sites using the CVI <i>Scott Heron</i> , James Cook University
09:45 - 10:00	Marine World Heritage sites and climate change - how site managers work together <i>Fanny Douvere</i> , UNESCO World Heritage Centre
10:00 - 10:15	Coffee Break
10:15 - 10:30	When Wadden Sea birds are not in the Wadden Sea': trends, distribution, and pressures along the East Atlantic Flyway <i>Marc van Roomen</i> , Sovon Dutch Centre for Field Ornithology
10:30 - 10:45	Benefits of transnational cooperation in the face of climate change <i>Kyong-O Moon</i> , World Heritage Promotion Team of Korean Tidal Flats
10:45 - 11:00	The Yellow Sea working group- an innovative regional platform to support the conservation and management of the intertidal wetlands and associated species in the Yellow Sea <i>Raphael Glémet</i> , Water and Wetlands, Science and Strategy Group, IUCN Asia Regional Office
11:00 - 11:15	Coffee Break

11:15 -12:25	<p align="center">FINAL SESSION PRESENTATION OF RESULTS Moderator: <i>Karin Lochte</i>, Chair of WSB - Auditorium 3 -</p>
11:15 - 12:15	<p align="center">Presentation of the results from breakout session <i>Stefan Garthe, Anita Gilles, Christian Buschbaum, Christian Winter, Jouke van Dijk, Anja Szczesinski</i></p>
12:15 - 12:25	<p align="center">Conclusions and Wrap up <i>Karin Lochte</i></p>
12:25 - 12:35	<p align="center">Outlook Ministerial Conference 2022 and closing of the ISWSS <i>Ilka Wagner</i>, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)</p>
<p align="center">End of the 15. ISWSS</p>	

Annex 2 - Abstracts & Illustrations

Setting the scene

30. November 2021 09:20 - 09:30 Climate change: impact, adaptation and trilateral cooperation. How to adapt?

Robert Zijlstra

Chair Trilateral Expert Group Climate (EG-C), Ministry of Infrastructure and Water, Rijkswaterstaat Noord-Nederland

Climate change will impact the Wadden Sea and surrounding areas, that is certain. But how will the Wadden Sea ecosystem respond? And how rapid will the climate change? Given these uncertainties it is difficult to predict the future of the Wadden Sea. There is a need for more research in order to understand and predict the effects of climate change. And to determine how we should manage the Wadden Sea in a changing climate. The trilateral Wadden Sea cooperation aims for a natural and climate-resilient ecosystem. But how to determine that the ecosystem is resilient? And how to deal with conservation goals if we know things are changing? Already in 2014, the trilateral Climate Change Adaptation Strategy was adopted (Tonder declaration). This strategy - containing 7 objectives and principles – gives guidance on climate adaptation in the Wadden Sea area. Key in the strategy is the principle of working with natural dynamics. But what to do if natural dynamics cannot keep up with the rate of climate change? Should we then intervene, or accept the changes? Quite some challenges remain for the trilateral cooperation on the protection of the Wadden Sea. In this short presentation we want to raise some questions to think about and discuss during the symposium. We will also briefly present the present adaptation strategy and results from recent work of the trilateral expert group Climate on the Climate Vulnerability Index (CVI). A tool to assess and present the (potential) impact of climate change. Suggestions, thoughts and comments on the (future) trilateral work on climate change adaptation are very welcome (via email or in person during the symposium).

30. November 2021 09:30 - 09:40 **"Trilateral Research Priorities" - a new approach focussing trilateral research activities on the Guiding Principle and securing the necessary funding.**

Bernd Scherer

Chairperson Trilateral Programming Committee - Wadden Sea Research (TPC-WSR)

The Trilateral Programming Committee on Wadden Sea Research (TPC-WSR) was installed by the Wadden Sea Board (WSB) and instructed to: "develop and link a joint research program to other national and international initiatives of relevance, taking into account the Trilateral Research Agenda (TRA)." TPC-WSR consists of NL, D and DK experts from science and policies. In July 2021 TPC-WSR has accomplished its first task and presented "Trilateral Research Priorities" to the WSB.

TPC-WSR chose a selection methodology instead of selecting a set of defined research topics. Almost any research project can apply for funding. Prerequisite is however that four criteria are met:

1. Projects must support the Guiding Principle and integrity of the OUV.
2. It must be shown convincingly that they are urgent and relevant for the Trilateral Cooperation for the Protection of the Wadden Sea answering the

needs of responsible and protecting institutions, and where the user/stakeholder is "on board".

3. It must be credibly demonstrated that stakeholders need the required research results and how these should then be put into practice.

4. Quality of the research proposal and quality of the consortium.

These criteria guarantee a strong link to the principles of trilateral cooperation and ensure that stakeholders are on board from the start. This is a remarkable step forward in linking research with societal demands and the interest of the common good.

WSB has signalled support for this approach and funding institutions in NL and D have shown sympathy for these "Priorities".

THEME SESSION BIRDS

Lectures

30. November 2021 09:50 - 10:10 **Keynote: The Wadden Sea could help migratory bird populations confronted with climate change, but will it actually?**

Eldar Rakhimberdiev¹, Julia Karagicheva², Jan van Gils²; Roeland Bom², Jutta Leyrer³, Theunis Piersma^{2,4}

¹Department of Theoretical and Computational Ecology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam & Department of Vertebrate Zoology, Lomonosov Moscow State University;

²NIOZ Royal Netherlands Institute for Sea Research, Texel³Michael Otto Institute, NABU

⁴Conservation Ecology Group, Groningen Institute for Evolutionary Life Sciences, University of Groningen

The many migratory birds that use the Wadden Sea during winter and spring are threatened by sea level rise and climate warming. While sea level rise directly decreases the surface area of the intertidal flats available to feeding birds, the effects of climate warming are more indirect. Although the Wadden Sea is warming up, it is the Arctic region, to where the Wadden Sea birds go for breeding, that experiences the highest rates of temperature increase. Arctic warming advances the peak of food abundance for juvenile birds, pushing adults to start annual reproduction and migration earlier. Earlier migration requires earlier departure from the Wadden sea and thus faster spring fuelling, which is only possible with ample food and no disturbances. Can the Wadden Sea provide enough resources for migratory birds to mitigate the negative effects of Arctic warming? In our talk we present the current state of knowledge, highlighting the unknowns and suggesting cost-effective approaches for future monitoring and conservation of our shared migratory birds.

30. November 2021 10:10 - 10:30 **The state of birds in the Wadden Sea in a changing environment**

Gregor Scheiffarth¹, Kees Koffijberg²

(on behalf of the trilateral Expert Group Migratory Birds)

¹National Park Authority Wadden Sea Lower-Saxony

²Sovon Dutch Centre for Field Ornithology

Breeding and migratory birds in the Wadden Sea have experienced many changes in the past decade, as is shown by recent results of the TMAP bird monitoring program, recently published in the new Quality Status Report. Especially among local breeding bird populations, the majority of species is subject to declines. In several species, this can be linked to poor productivity, caused by e.g. high predation risk (notably along the mainland coast) and flooding, as a result of a combination of increased summer storms and sea level rise. In many migratory birds, a combination of local effects and changing conditions within the entire flyway causes the currently observed dynamics. Strikingly, it is especially iconic Wadden Sea birds as Eurasian Oystercatcher and Pied Avocet which suffer declines during their entire annual cycle and do not show any signs of recovery yet. Still, shellfish feeding birds show a long-term decline, although the rate of decline has decreased. Interestingly, more species decline in the central part of the Wadden Sea than in at its outer part (Denmark and The Netherlands). For breeding birds, several initiatives are on its way to improve breeding conditions. However, still it is unknown if such measures finally work out and if both breeding birds and migratory birds are able to cope with ongoing changes in climatological conditions within their flyways, further economical exploitation of wetlands areas and increased recreation and other pressures.

30. November 2021
10:30 - 10:50

Towards a healthy Wadden Sea to mitigate effects of Arctic warming on migratory birds

Jan A. van Gils¹, Jutta Leyrer²

¹NIOZ Royal Netherlands Institute for Sea Research, Texel

²Michael Otto Institute, NABU

The Wadden Sea forms the stepping stone for millions of birds that annually migrate from their wintering grounds in W Africa and W Europe to their northern breeding grounds. Nevertheless, quite some species in this flyway are in decline, notably Arctic-breeding shorebirds. Evidence is mounting that rapid Arctic warming forms a major challenge for them (warming rates in the Arctic are 2-3 times higher than the global average). Particularly, with the earlier onset of Arctic summers nowadays, migratory shorebirds need to depart earlier from the Wadden Sea in order to time reproduction well in relation to the shifted Arctic food peak. Hence, individuals preparing for migration in the Wadden Sea nowadays need higher food intake rates in order to fatten up faster. This calls for a healthy functioning Wadden Sea intertidal ecosystem that provides enough food and safety. If managed well, the Wadden Sea could become the lifeline for migratory shorebirds facing strong pressures by their rapidly warming breeding grounds. Here we review the role of the Wadden Sea for migratory red knot (*Calidris canutus canutus*) and bar-tailed godwit (*Limosa lapponica taimyrensis*) on their way to their rapidly warming Siberian breeding grounds. We list ways in which we can mitigate, here in the Wadden Sea, dramatic climate-change problems that they experience further up north.

30. November 2021
11:00 - 11:20

Climate driven sediment changes affect abundance of migratory waders

Karsten Laursen¹, Jan Blew², Anders Pape Møller³

¹Aarhus University, Department of Bioscience

²BioConsult SH GmbH & Co.

³Ecologie Systématique Evolution, Université Paris-Sud

Knowledge of factors affecting bird numbers are important for management of populations and habitats. Long-term monitoring of waterbirds in the Wadden Sea revealed that more species have decreased in numbers in the German sector compared to those in Denmark and the Netherlands, and further that the

decreasing trends were associated with species foraging at intertidal flats. Studies of geomorphology in the German sector of the Wadden Sea showed that most tidal basins were influenced by deposition of sediments and the deeps by erosion, processes assumed to be driven by increased sea level rise, wind surges and increasing tidal range. We hypothesise for the German sector that changes in bird numbers connected to intertidal flats were caused by changes in the intertidal sediment budget. We tested these hypotheses by combining monitoring data of waterbirds, with analyses of sediment conditions in the German sector. We focus on a selected group of seven species of waders connected to specific sediment types on intertidal flats for feeding. Most species in the German sector decreased in abundance in the count areas. Abundance of wader species increased significantly together with intertidal flat accretion, erosion of sub-tidal deeps and increase in size of intertidal flats. Positive relationships were found between wader species connected to specific sediment types and changes in their abundance. Species preferring coarse-grained sediment showed larger decreases than those connected to fine-grained sediments. We conclude that sediment changes driven by climate can affect abundance of wader species.

30. November 2021
11:20 - 11:40

Variation in food availability and its consequences for three tern populations

Veit Hennig¹, Sandra Bouwhuis²

¹University of Hamburg

²Institute of Avian Research, Wilhelmshaven

Variation in resource availability is a main driver of life-history variation, both among and within species and with respect to both its average level and its spatial and temporal variability. Here, we report on spatiotemporal variation in fish abundance and its consequences for foraging behaviour, phenology, reproductive performance and the trade-off between reproduction and survival in a long-lived piscivorous seabird, the common tern (*Sterna hirundo*). We compare common terns in the Jade Bay, Dithmarschen and North Frisia and show that they on the one hand adjust their local laying phenology opportunistically according to the availability of suitable prey sizes, while on the other hand adapting their selection for size of prey in relation to the age of the chicks. We also show that the production of successful replacement broods depends on fish availability, and contributes to lifetime reproductive success. Finally, we show that common terns enforce an earlier mortality of offspring when food is short, facilitating an economic adjustment of posthatching parental investment, and that this brood reduction is constrained by sibling competition, but benefits parental survival to the next season. Overall, we therefore point out how common terns show high adaptability to optimize breeding success both across seasons and life.

30. November 2021
11:40 – 12:00

Eurasian Curlew migration along the East Atlantic Flyway: spatial and temporal patterns, and their vulnerability towards offshore wind farms

Philipp Schwemmer¹, Rebecca Pederson¹, Pierrick Bocher², Jerome Fort², Tatiana Sveridova³, Moritz Mercker⁴, Verena Auernhammer⁵, Wolfgang Fiedler⁶, Martin Boschert⁷, Jaanus Elts⁸, Riho Marja⁹, Michal Korniluk¹⁰, Dominik Krupiński¹¹, Stefan Garthe¹

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³A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Science

⁴BIONUM – Consultants in Biological Statistics

⁵Landesbund für Vogelschutz in Bayern e.V.

⁶Max Planck Institute of Animal Behavior

⁷Bioplan Bühl

⁸University of Tartu

⁹'Lendület' Landscape and Conservation Ecology

¹⁰Museum & Institute of Zoology Polish Academy of Sciences

¹¹Towarzystwo Przyrodnicze "Bocian"

The Wadden Sea hosts about 40% of the Eurasian curlew (*Numenius arquata*) population of the East Atlantic flyway. Although its population trend in the Wadden Sea is stable, there are dramatic declines along the whole flyway. Basic knowledge of curlew migration ecology is still lacking. We equipped around 100 individuals with GPS dataloggers across six organizations in four countries (Germany, Poland, France and Estonia) to unravel spatial and temporal migration patterns of curlews from different latitudes.

The Wadden Sea played an essential role for curlews as wintering and staging site. Nearly all individuals tagged in the Wadden Sea migrated to breeding sites in western Russia where they selected bogs, abandoned farmland and active grasslands for breeding. Curlews breeding in bogs showed highest breeding success and likely encountered the most optimal foraging opportunities. Curlews breeding at higher latitudes departed their wintering sites later than curlews in lower latitudes. The average migration time was only 10 days. In individuals tagged over multiple years, the mean departure day from wintering grounds was surprisingly constant (mean variation: 3.68 ± 2.97 days). At the same time, curlews largely ignored prevailing weather conditions, which both indicates a strong genetic trigger for the onset of migration.

The migration in the North Sea region was restricted to the coast whereas many individuals crossing the open Baltic Sea showed overlap with current and planned offshore windfarm sites. Flight heights significantly increased in headwind conditions during departure with some individuals migrating in altitudes of up to 4 km. However, particularly when migrating across the sea, a high proportion of records were below 200 m and therefore overlapped with the operational heights of rotors from offshore wind turbines.

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Posters

01. December 2021 **Foraging ecology of Eurasian spoonbills (*Platalea leucorodia*) in the German Wadden Sea**

Leonie Enners¹, Nils Guse¹, Philipp Schwemmer¹, Anna L.J. Chagas¹, Christian C. Voigt², Stefan Garthe¹

¹Research and Technology Centre (FTZ), Kiel University

²Leibniz Institute for Zoo and Wildlife Research (IZW)

Eurasian spoonbills (*Platalea leucorodia*) were first recorded breeding in the German Wadden Sea in 1995, where since the breeding numbers have been increasing. However, the foraging strategy of spoonbills in this area remains largely unknown. We investigated the habitat selection and diet composition of spoonbills from three colonies based on GPS telemetry and diet analyses (regurgitates, blood samples), respectively. Spatial-temporal GPS logger data (2014–2016) implied that tidal creeks near the mainland coast are used as the main foraging hotspots in the breeding season. Regurgitates suggested that brown shrimps might be less important in the spoonbill diet than previously assumed, while smelts (31.9 %), sticklebacks (22.6 %), and gobies (13.3 %) were the dominant prey source. Stable isotope analyses of spoonbill blood samples confirmed the regurgitates results and enabled to investigate the diet composition on different time scales, indicating seasonal variations in prey availability. Red blood cells (reflecting the diet of up to 3 weeks prior to

sampling) showed that flatfish and sticklebacks were the main prey species in early May, while serum samples of spoonbill chicks (reflecting the diet 1 week before sampling) demonstrated a diverse diet, with flatfish, smelts, gobies, and sticklebacks during end of May. Differences between years, colonies, and seasons indicated an opportunistic foraging strategy, depending on the available prey source. Tracking and diet analyses implied high abundances of small fish near the coast.

01. December 2021 **Using Seabirds to monitor pollution: mercury trends and effects in the Wadden Sea across the last 40 years**

Frank R. Mattig¹, Sandra Bouwhuis², Peter Schupp¹

¹ICBM Terramare, Carl-von-Ossietzky University Oldenburg

²Institute of Avian Research, Wilhelmshaven

As top predators of the aquatic environment, seabirds accumulate persistent chemicals over the food chain. Their eggs have proven to be an excellent source to monitor these chemicals, and to indicate local pollution levels. On the German Wadden Sea coast, seabird eggs have been collected since 1981 to assess environmental pollution with anthropogenic contaminants, such as mercury (Hg). Within the framework of the Trilateral Monitoring and Assessment Program (TMAP), the geographical scale was broadened in 1992 to include the international Wadden Sea. The chosen species, the Common Tern (*Sterna hirundo*) feeding on small pelagic fish and crustaceans and the Oystercatcher (*Haematopus ostralegus*) feeding on mussels and worms, are ideal indicator-species as their diets represent major parts of the Wadden Sea ecosystem. Here, using eggs collected across 40 years and various locations, we show that:

(i) Common Tern eggs generally show higher levels of Hg contamination than those of Oystercatchers.

(ii) the geographical variation in Hg contamination is lower in the western than in the eastern part of the Wadden Sea, probably due to effects of the influx of the rivers Elbe and Weser. Historically, eggs collected at the Elbe and its surrounding areas showed the highest Hg contamination, but a conspicuous decrease occurred over the last 5 years. This may be the result of changed foraging behaviour of the local colony of Common Terns, which previously caught European Smelt in the river, but were forced to switch to herring from the North Sea.

(iii) eggs of both species contained the highest mercury concentrations at the end of the 1980s (maximums of 23.530 ng/g wet weight in a Common Tern egg from the Elbe in 1985 and 1.959 ng/g wet weight in an Oystercatcher eggs from Trischen in 1989). For both species, Hg levels decreased after that, with current average levels across all investigated areas being around 350 ng/g wet weight in Common Terns eggs and 200 ng/g wet weight in Oystercatcher eggs.

Current concentrations of mercury in the Wadden Sea are still high and clearly over the limit of the Ecological Quality Objectives (EcoQOs) defined by OSPAR (Oystercatcher eggs: 100 ng/g; Common Tern eggs: 160 ng/g). A detailed individual-based study of Common Terns at a colony at Wilhelmshaven shows that breeding success is negatively correlated with Hg contamination of females, proving the need for further reductions of Hg in the Wadden Sea.

Illustrated summary



*How will migratory birds
adapt to changing resources?*

3 Theme BIRDS: The birds in this image represent the migration through the Wadden Sea that may be determined by the resources available in the area (the tern with the suitcase and the fish-looking islands) and the genetic trigger in each species (Numenius arquata and the DNA helix) (Dr. Jagoba Malumbres-Olarte, conference illustrator).

THEME SESSION MARINE MAMMALS

Lectures

30. November 2021 09:50 - 10:10 **Keynote: Anthropogenic pressures on marine mammals of the Wadden Sea**

Jonas Teilmann¹, Sophie Brasseur², Anders Galatius¹, Emilie Stepien¹, Anita Gilles³, Lonneke IJsseldijk⁴, Kristina Lehnert³, Dominik Nachtsheim³, Bianca Unger³, Tobias Schaffeld³, Joseph Schnitzler³, Meike Scheidat², Ursula Siebert³

¹Marine Mammal Research, Department of Bioscience, Aarhus University, Roskilde

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Marine mammals inhabiting the Wadden Sea are under the protection of the Trilateral Wadden Sea Agreement and the UNESCO world heritage convention. The habitat use of seals and porpoises may, however, extend outside the Wadden Sea. Therefore, marine mammals of the Wadden Sea are exposed to a variety of human activities both inside and outside the Wadden Sea including shipping, offshore wind farms, oil and gas extraction, recreational, seismic and military activities, fisheries, chemical and pharmaceutical substances and marine litter.

Several research projects conducted by Danish, Dutch, German and other scientists have demonstrated that the anthropogenic activities may have negative effects on marine mammals including disturbance, habitat loss, underwater noise, immune suppression, high number of infectious diseases and traumata, endocrine disruption, lower reproduction success and early death. As the number of activities is increasing, it is important to develop impact thresholds and model the cumulative effects on international level.

The Trilateral Wadden Sea Agreement is a very successful example of how international cooperation can achieve successful protection of many species and landscapes in a defined area. However, in order to protect marine mammals in the Wadden Sea, the international effort in managing anthropogenic activities should consider including the entire home range of the species.

30. November 2021 10:10 - 10:30 **Trilateral health monitoring of seals and porpoises – What have we learned?**

Stephanie Gross¹, Ursula Siebert¹, Line Anker Kyhn², Charlotte Bie Thøstesen³, Aage Kristian Olsen Alstrup⁴, Marcus Fährdrich¹, Anders Galatius², Lonneke IJsseldijk⁵, Trine Hammer Jensen⁴, Tim Kåre Jensen⁶, Jan Lakemeyer¹, Kristina Lehnert¹, Heidi Huus Petersen⁶, Ralf Pund⁷, Simon Rohner¹, Luca Aroha Schick¹, Andrea Gröne⁵

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⁶Department of Health Technology (DTU HEALTH TECH)

⁷Lower Saxony State Office for Consumer Protection and Food Safety (LAVES-Cuxhaven)

Since the first seal die-off in 1988/89, it has been recognized that investigations on the health status of marine mammals are essential to understand the development of harbour seal, grey seal and harbour porpoise populations in the Wadden Sea as part of international agreements such as the Trilateral Wadden Sea Agreement, ASCOBANS and OSPAR.

Health assessment in Germany, the Netherlands and Denmark include investigations of dead marine mammals and the monitoring of live individuals. Necropsies have been conducted since 1990 according to international guidelines collecting biological and health information. Measurements of live animal's weight, length, blubber thickness, antibody titers, blood status and chemistry data have also been conducted.

The health investigations allowed identification of two epizootics caused by phocine distemper virus in 1988/89 and 2002, as well as the first Influenza A outbreak in seals in Europe in 2014. Antibody titers against these viruses are only protective for a limited number of years. Parasit target organs are lung and gastrointestinal system. Bacterial infections including zoonotic agents are frequently found affecting different organs of these marine mammals.

Due to the systematic investigations of live and dead marine mammals over several decades, causes of epizootics and the zoonotic potential of marine mammals are identified and changes in the health and reproductive status, population demographics, genetics and feeding ecology assessed. The trilateral health research of marine mammals in the Wadden Sea area demonstrates the success and need of international cooperation.

30. November 2021
10:30 - 10:50

Harbour porpoise in the Wadden Sea - where do they come from and where do they go? Using current knowledge for successful trilateral monitoring in the World Heritage Site

Meike Scheidat¹, Jonas Teilmann², Johannes Baltzer³, Charlotte Bie Thøstesen⁴, Britta Diederichs⁵, Rune Dietz², Steve C.V. Geelhoed¹, Anita Gilles³, Lonneke L. IJsseldijk⁶, Guido O. Keijl⁷, Jacob Nabe-Nielsen², Andreas Ruser³, Joseph Schnitzler³, Signe Sveegaard², Jip Vrooman¹, Ursula Siebert³

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⁷Naturalis Biodiversity Center, Leiden

The harbour porpoise (*Phocoena phocoena*) is considered part of the "Outstanding Universal Value" characterizing the Wadden Sea World Heritage Site (WS WHS). The Trilateral Wadden Sea Plan aims to preserve the conservation status of the Trilateral Wadden Sea Cooperation Area, encompassing the WS WHS, specified in two conservation targets for the

harbour porpoise: (1) Viable stocks and a natural reproduction capacity; (2) Conservation of habitat quality for its conservation.

To assess monitoring of harbour porpoises we collated and analyzed data from regional and national research projects using telemetry, aerial surveys, strandings and passive acoustic monitoring obtained over the last decades. The results show that porpoises occur in both offshore and intertidal waters of the site showing seasonal movements and changes in local occurrence over time. Some porpoises displayed limited home ranges throughout the year, suggesting a possible residency for part of the animals using the WS WHS. A relationship between porpoise occurrence and tidal phases indicated that porpoises regularly navigate intertidal waters, possibly to access predictable and regular prey sources.

Our review also showed that methods, frequency and spatial coverage of monitoring activities vary among the trilateral countries. We discuss the suitability of the different methods both regarding the challenges of monitoring in the complex Wadden Sea habitat as well as to their ability to target the conservation aims of the WHS. We give a number of recommendations to assess the status of the species to meet the identified conservation aims.

30. November 2021
11:00 - 11:20

At-sea habitat use of juvenile grey seals in a growing population in the Wadden Sea

Abbo van Neer¹, Sophie Brasseur², Jessica Schop², Geert Aarts², Stephanie Gross¹, Dominik Nachtsheim¹, Ursula Siebert¹, Anders Galatius³

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³Marine Mammal Research, Department of Bioscience, Aarhus University, Roskilde

The grey seal is the largest predator in the Wadden Sea and is a good example of a successful management. After the local extinction in the Wadden Sea Area, natural recolonization started in the 1970s after implementing protection and the population has been growing since.

Trilaterally coordinated surveys have been conducted for various years during the moult and pupping season. This provides for the close following of the development of the seal numbers and reproduction. However, to ensure long term protection, a deeper understanding of the seals general habitat requirements is needed, especially that of the juveniles, which will ensure the positive development of the local colonies.

Seals spend most of their lives in water, making it difficult to observe their movements. In this context, telemetry proves an important method for gaining knowledge about behaviour and habitat use, enabling the development of management concepts.

Results from the trilateral monitoring are presented and a summary of the past population development is given. Additionally, movement profiles of wild juvenile grey seals are presented to give a first impression of the habitat use of the animals in their first months of life, showing the importance of such research to evaluate the future habitat use and habitat requirements. With this knowledge, management measures can be developed with the aim of meeting the spatial requirements of the animals in the Wadden Sea as a national park and World Heritage Site.

30. November 2021
11:20 - 11:40

Effect ranges of underwater noise from anchor vibration operations in the Wadden Sea

Johannes Baltzer

Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover Foundation

Anchor vibration operations during the construction of seed mussel collectors were performed in the Wadden Sea. We recorded underwater noise during the construction simultaneously at three positions with increasing distance to the construction site to assess the disturbance potential to marine fauna. The recorded vibration noise was a continuous sound with durations of 2–55 s, with most energy below 1 kHz and peak frequencies around 900 Hz. Background noise level at a distance of approximately 1 km increased around 13 dB at frequencies between 800 and 1000 Hz. We estimated the sound propagation by a non-linear logarithmic regression which allowed us to evaluate the received sound levels reaching an animal in certain distances from the construction site. The estimated sound exposure level (SEL) was 148.2 dB re 1 $\mu\text{Pa}^2\text{s}$ and the median SEL ranged from 120 to 99 dB re 1 $\mu\text{Pa}^2\text{s}$ at distances between 394 and 2288 m, respectively. Behavioural thresholds for indigenous marine mammal and fish species were used to determine effect radii of vibration noise. Our study showed that the detected vibration noise might exert a behavioural reaction on a local scale. Marine mammals could be affected by the construction operations up to a distance of 375 m and fish up to a distance of 766 m. Our study gives an example that a sustainable human use in respect to the complied guidelines, can lead to a harmonious relationship between the needs of society and ecological integrity as conceded by the Trilateral Wadden Sea Plan.

30. November 2021
11:40 – 12:00

Disappearing harbour seals - How do we explain a changing trend in the Wadden Sea harbour seal population

Sophie Brasseur¹, Jessica Schop¹, Geert Aarts¹, Anders Galatius², Jonas Teilmann², Britta Schmidt³, Josef Huesmann⁴, Armin Jeß⁵

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³National Park Authority Wadden Sea Lower-Saxony

⁴Veterinary Task-Force; Lower Saxony State Office for Consumer Protection and Food Safety

⁵Schleswig-Holstein Agency for Coastal Defense, National Park and Marine Conservation (LKN.SH), National Park Authority Wadden Sea Schleswig-Holstein

Over the past 10 years, the growth of the Wadden Sea harbour seal population (estimated at ~40.000 animals), has come to a stop and even seems to be declining in some regions. This, despite an increased production of pups, where currently ~10.000 pups are recorded each year. These are apparently not recruiting in the population and based on the annual counts alone, scientists cannot explain this annual loss of 20% of the population. The sudden change in trend around 2012 is surprising. Since the 1980's, the harbour seal population has shown almost continuous growth, only interrupted by the two PDV epizootics.

Inspection of counts in other areas of the North Sea (ICES) indicate that there is no clear emigration out of the Wadden Sea. Therefore, changes in survival or behaviour are likely to explain this phenomenon. Potentially, recording on one hand behavioural changes (both on land and at sea) and on the other, survival and population structure, might help in understanding the mechanisms behind this seeming dramatic loss.

Currently, the environment of the seals is changing at an unprecedented rate, at least partially influenced by anthropogenic activities. It is of utmost importance to understand where possible, the mechanisms behind the observed changes, if only to mitigate our potential role. Due to the exceptional long term monitoring, and accuracy in recording both pups and adults in the whole population, harbour seals might be the best study animal to understand the effects of environmental changes in the southern North Sea.

Posters

01. December 2021 **Microplastics in marine mammals of the German North Sea**

Carolin Philipp¹, Bianca Unger¹, Elke Fischer², Ursula Siebert¹

¹Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover Foundation

²Center for Earth System Research and Sustainability (CEN), University of Hamburg

Microplastics are known to be ubiquitous. It is thus not surprising that laboratory studies and field experiments demonstrated the ingestion, accumulation, cell migration and the egestion in a variety of different invertebrate species. Marine mammals as top predators are thus known to accumulate contaminants and pollutants through the food web. However, information on the occurrences and effects of microplastics in marine mammals are still scarce in the north-western Atlantic region. This is the first study, dealing with all three species regularly occurring in German waters: harbour porpoises (*Phocoena phocoena*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). It documents the quantity and quality of microplastics found in samples of the gastrointestinal tracts. Intestinal samples, whole stomachs, and faecal samples collected between 2014 and 2019 were analysed after a new established protocol of sample handling, and were compared with samples of the German Baltic Sea. The low share of secondary pollution and the low costs for isolating microplastic particles are significant benefits of this protocol. Results already identified a variety of synthetic polymers (e.g. PE, PET, PP, etc.) by the usage of μ Raman spectroscopy. As a result of a decreased secondary contamination, a higher share of particles compared to fibres, was found. Up to now, the highest share of particles ($n = 90$; 35 fibres and 55 fragments) was found in a sample of a harbour seal. Whereas, the minimum of six fragments and no fibres were identified in an intestinal sample of a grey seal. The presence of microplastics seems to be lower in harbour porpoises, if compared with both seal species. The results of this study allows us to classify the real burden of microplastics in marine mammals of German waters for the first time. Furthermore, the results give needed information for further research in alteration of organ tissues and the accumulation in the organisms of mammalian species.

01. December 2021 **Synergies between ASCOBANS and the Trilateral Wadden Sea Cooperation: Harbour Porpoise**

Jenny Renell¹, Kristine Meise², Sara Kophamel³

¹ Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) Secretariat

² Common Wadden Sea Secretariat

³ Convention on the Conservation of Migratory Species of Wild Animals Secretariat (CMS)

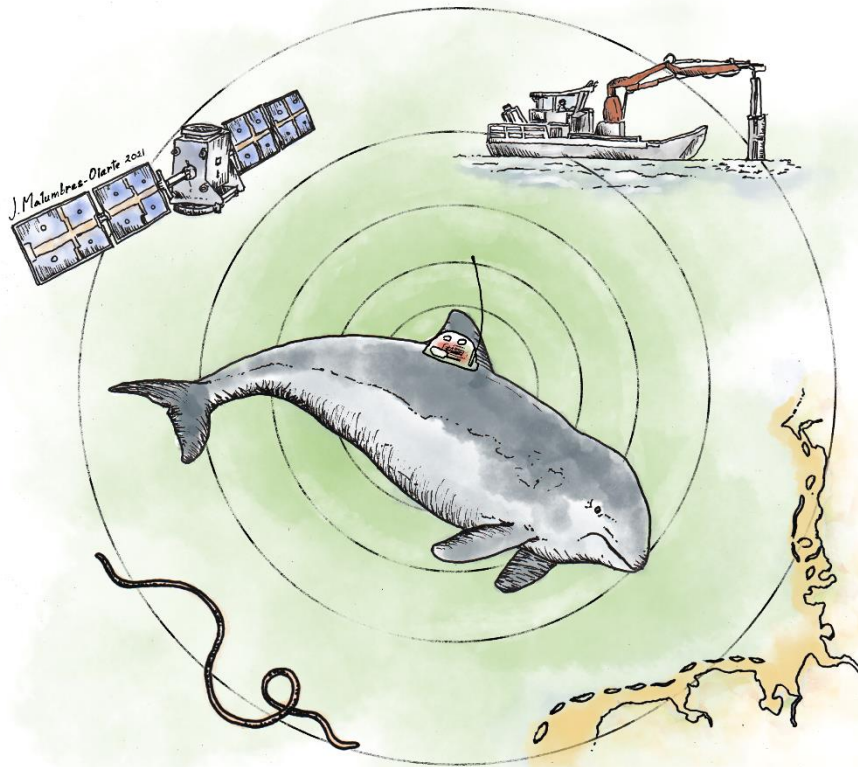
The Advisory Committee (AC) of the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) noted in 2017 that Harbour Porpoises were increasingly being registered in the tidal channels and estuaries of the Wadden Sea and appeared to be an integral part of this ecosystem.

As a result the AC proposed that Parties of the Trilateral Wadden Sea Cooperation (TWSC) consider including the Harbour Porpoise under the mandate of TWSC. Enhanced cooperation between ASCOBANS and TWSC was encouraged, specifically regarding the implementation of the ASCOBANS Conservation Plan for Harbour Porpoises (*Phocoena phocoena L.*) in the North Sea.

In April 2019, the symposium 'Bright Future? Harbour Porpoises in the Wadden Sea' and a subsequent expert workshop were held, to develop expert recommendations on the future handling of the topic in the trilateral framework. Following recommendations from this workshop, it was acknowledged that Harbour Porpoises are part of the Wadden Sea ecosystem and that parts of the Wadden Sea have been shown to be an important habitat for Harbour Porpoises in the North Sea.

This poster explores potential synergies between ASCOBANS and TWSC with regards to work relating to conservation of the Harbour Porpoise.

Illustrated summary



What signals of needs and threats do marine mammals send?

4 This image resumes the research subjects of the seminars presented in the marine mammal session of the Symposium: the species monitoring using telemetry; the (intertidal) habitats used and needed by the different species; the effects of anthropogenic activities (e.g. through noise); and the impact of diseases on the reproduction and population demographics. All these factors must be considered for the management of marine mammals in the Wadden Sea (Dr. Jagoba Malumbres-Olarte, conference illustrator).

THEME SESSION ALIEN SPECIES

Lectures

30. November 2021 09:50 - 10:10 **Keynote: Effects of introduced marine species on biodiversity and ecosystem functions in the Wadden Sea**

Karsten Reise¹, Dagmar Lackschewitz¹, Christian Buschbaum¹, Andreas Waser¹, Mathias Wegner¹, David Thielges²

¹Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

²NIOZ Royal Netherlands Institute for Sea Research, Texel

More than one hundred introduced alien species have established below high tide level in the trilateral Wadden Sea, while none of the residents was expelled in return. As a net result, species and biogenic habitat diversity have increased. This contrasts with the popular generalization that species introductions are a major threat to native biodiversity. We suggest, time is ripe to reconsider our attitude towards the impacts of alien species on the ecological web in the Wadden Sea. We discuss underlying reasons for the disparity with terrestrial

habitats such as on barrier islands. We recommend acknowledging the high integrative capacity of the Wadden Sea ecosystem, appreciating gains in biodiversity and in adaptive abilities for adjusting to climate warming, accepting established immigrants as new residents, and overcoming the outdated dichotomy between pristine and novel nature.

30. November 2021
10:10 - 10:30

QSR 2020-21 Thematic Report on “Alien Species”

Heike Büttger¹, Sina Christoph¹, Christian Buschbaum², Arjan Gittenberger³, Kai Jensen⁴, Saa Kabuta⁵, Dagmar Lackschewitz²

¹BioConsult SH GmbH & Co. KG

²Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

³GiMaRIS

⁴University of Hamburg

⁵Rijkswaterstaat, Ministry of Infrastructure and the Environment

The issue of alien species has gained increasing importance and attention. In accordance with the UNESCO World Heritage Committee request of 2009, the Sylt declaration (2010) and the Tønder Declaration (2014), the Wadden Sea Board initiated the development of a common strategy for dealing with alien species in the Wadden Sea and the TWSC's ad hoc Expert Group Alien Species (EG-AS) developed the trilateral alien species management and action plan (MAPAS) (WG-AS & Gittenberger 2019).

So far, there is no evidence that alien species have caused the extinction of native species in the Wadden Sea, and most alien species become inconspicuous residents. However, some alien species have the potential to alter dominance structures, habitats, and trophic regimes.

The updated thematic chapter documents an increasing number of alien species within the Wadden Sea area as well as an increasing introduction rate. Status and trends of marine alien species introduction in the Dutch, German and Danish Wadden Sea will be presented as well as the knowledge of terrestrial and freshwater alien species introduction in the Wadden Sea Area. But what does this mean for the Wadden Sea? The assessment focuses on the effects of alien species on the Wadden Sea Plan targets and the criteria for the 'Outstanding Un

30. November 2021
10:30 - 10:50

Integration in the Wadden Sea ecosystem - How introduced alien species can affect species interactions in a native ecosystem

Annika, Cornelius, Christian, Buschbaum

Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

The introduction of non-indigenous species may cause strong effects on biodiversity, species interactions and functioning of native soft-bottom coastal ecosystems. Especially introduced bioengineering organisms modify existing benthic habitat structures, and thereby may change habitat-specific species interactions. In the Wadden Sea, epibenthic beds of native blue mussels have been invaded by Pacific oysters *Magalana gigas*, which caused a substantial habitat shift from pure *Mytilus edulis* beds to current mixed reefs of mussels and oysters. These newly developed biotic habitats may affect the occurrence of mussel bed associated key organisms and their ecological functions. In this context, we studied the grazing activity of native periwinkles *Littorina littorea* on settling epibionts and the spatial distribution of *M. edulis* in oyster reefs in the northern Wadden Sea and explored the resulting distribution patterns of barnacle epibionts attached to oyster and mussel shells.

A manipulative field experiment revealed that density of *L. littorea* significantly affects the recruitment success of barnacles *Semibalanus balanoides* on oyster shells. The highest number of barnacles recruited at periwinkle exclusion and this relationship was already known for pure blue mussel beds. Barnacle epigrowth on blue mussel shells, however, changed with the new position of mussels within the oyster matrix and is nowadays lower than in former times. Our results demonstrate that introduced bioengineering organisms may alter native biotic habitats but associated species interactions may remain the same. Additionally, our study shows that native species may profit from new structures by, for example, being less overgrown with detrimental barnacle overgrowth.

30. November 2021
11:00 - 11:20

The use of molecular tools for monitoring non-indigenous species in coastal waters

Carolin Uhlir¹, Mariusz Zabrocki², Sahar Khodami¹, Janna Peters¹, Jasmin Renz¹, Pedro Martinez Arbizu¹

¹German Center for Marine Biodiversity Research (DZMB), Senckenberg Research Institute, Wilhelmshaven

²Federal Maritime and Hydrographic Agency of Germany (BSH), Hamburg

Non-indigenous species (NIS) are species that have recently extended their range of distribution to foreign areas. Usually this process is triggered by human activities, like aquafarming, ballast water of vessels, fouling on ships hulls, etc. While impacts of invasive species on land are rather quickly visible, impacts within the water regime remain invisible at first.

There is a range of molecular tools that can greatly improve early detection and monitoring of (NIS), recognized as a major threat to biodiversity and ecosystem functioning, in coastal ecosystems. Among others, DNA barcoding is used to validate NIS identification based on a morphological characterization, whereas metabarcoding is used to screen whole samples in search for NIS.

In this study we present our results on the detection of NIS in marine coastal waters comparing both barcoding and metabarcoding. For the investigation of benthic communities, scratch and grab samples were taken from hard and soft substrates respectively as well as biofouling samples of recreational crafts according to the HELCOM/OSPAR protocols at harbours and marinas in the North and Baltic Seas. Samples were taken within the framework of the Interreg North Sea region project GEANS (Genetic tools for Ecosystem health Assessment in the North Sea region (<https://northsearegion.eu/geans/>)) in cooperation with the German stakeholder Federal Maritime and Hydrographic Agency of Germany (BSH). In addition, zooplankton communities have been sampled along a transect from Wilhelmshaven to Doggerbank area, as well as in the Helgoland Roads time series location (over 12 months). Metabarcoding was successful in detecting over 30 NIS that will be discussed. We evaluate biodiversity assessments and monitoring by applying molecular methods in comparison to the more traditional methods based on morphology, while opportunities to accelerate monitoring and detection of NIS are discussed.

30. November 2021
11:20 - 11:40

Collateral diseases: effects of biological invasions on parasites and pathogens in the Wadden Sea

David Thieltges

NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, Texel

Biological invasions often result in diverse impacts on native biota in recipient ecosystems and it is now increasingly recognised that they can also affect parasite-host interactions and diseases. In this presentation, I will give a conceptual overview of the different mechanisms of how invaders can affect

diseases in invaded ecosystems. Those include co-introductions of parasites that can spillover to native species causing emerging diseases but also various effects of invaders on native-parasite host interactions. I will illustrate the different mechanisms with results of recent investigations on the invasion impacts of Pacific oysters in the Wadden Sea. The findings presented in this talk will highlight the intricate ecological complexity of invasion impacts and call for a better understanding and monitoring of the ecological role of diseases in the Wadden Sea.

30. November 2021
11:40 – 12:00

20 years of monitoring: the role of alien species on intertidal mussel beds in the North Frisian Wadden Sea

Jasmin S. Mueller, Hanna Schade, Christopher Groß, Heike Büttger
BioConsult SH GmbH & Co. KG

Human activities such as aquaculture and global shipping lead to an increased introduction of alien species in the Wadden Sea in recent decades. Intertidal mussel beds represent hotspots of biodiversity and provide important biogenic hard substrates which facilitate the settlement of numerous native but also alien species. As part of the mussel monitoring program in the Wadden Sea National Park, the associated fauna of intertidal mussel beds in two tidal basins, Lister Deep and Norderhever, has been studied annually since 1999. During 20 years of monitoring (1999-2019), in total 18 alien species were detected. In the two tidal basins, the overall proportion of alien species increased until 2009, representing in some of the investigated mussel beds more than 80% of the total associated fauna abundance. This increase was followed by a rapid decline caused by the ice winter of 2009/10. Since 2017, alien species abundances have returned to sometimes more than half of the overall associated fauna abundances. However, a different spatial development of some alien species is recognized. For example, the prominent alien species Pacific oyster (*Magallana gigas*) has replaced the blue mussel (*Mytilus edulis*) as the dominant habitat builder in the Lister tidal basin since about 2006. In contrast, mussel beds in the Norderhever basin remain blue mussel dominated. Here, we provide an overview of alien species found on intertidal mussel beds over the last 20 years and how the mussel bed community has evolved in terms of species composition and abundance in both tidal basins.

Posters

01. December 2021

Sandküste Sankt Peter-Ording - How to Reevaluate and Adapt Wadden Sea Nature with Respect to Climate Change?

J. Fröhlich¹, J. P. Bonse², S. Gettner², N. Goseberg⁴, G. Herrling⁵, D. Kielinski², O. Lojek⁴, B. Mehrstens⁴, A. Piening¹, J. Rabeler², H.-U. Rösner¹, P. Scheffler², D. Schürenkamp⁴, C. Soares⁵, A. Weber¹, C. Winter⁵

¹World Wide Fund For Nature (WWF) Germany

²Deich- und Hauptsielverband Eiderstedt

³Schutzstation Wattenmeer e.V.

⁴Technische Universität Braunschweig

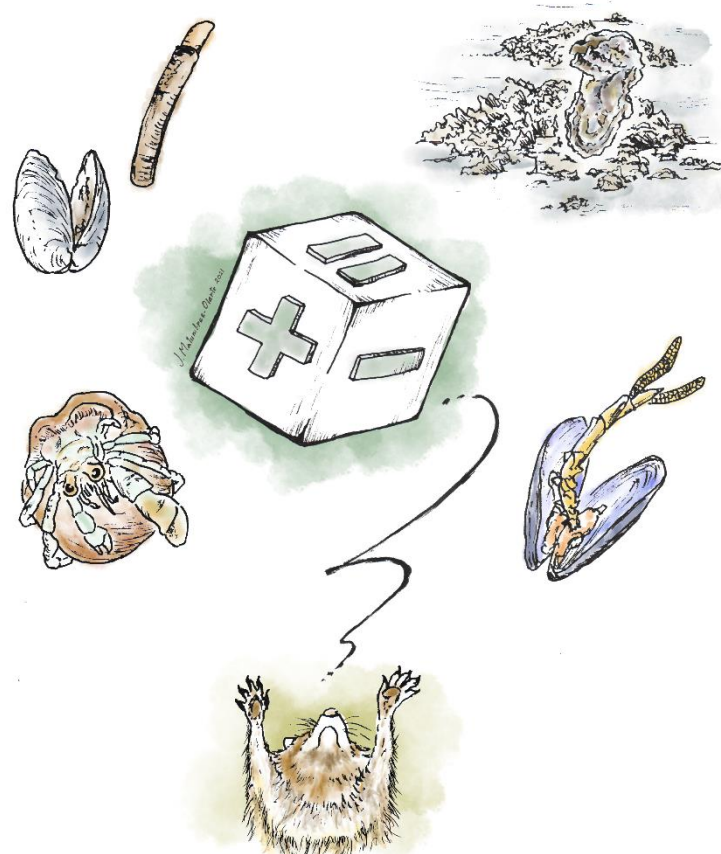
⁵Coastal Geology and Sedimentology, Institute of Geosciences, Kiel University

The coastal landscape of St. Peter-Ording is located at and in the Wadden Sea National Park and UNESCO World Heritage Site. Due to its large variety of natural habitats, St. Peter-Ording is a unique biodiversity hotspot at the mainland of Schleswig-Holstein. However, parts of these coastal habitats are at

risk. The systems are increasingly threatened by habitat loss and climate change: Natural values are already degraded, e.g. due to landscape fragmentation and the introduction of invasive plant species. In the long term, mud flats, salt marshes, beaches and dunes may be lost due to sea level rise and accelerated wave forcing. Therefore, there is a strong need for revaluation of the natural values as well as forward-looking adaptation to climate change, in particular with respect to sea level rise.

The project "Sandküste St. Peter-Ording" reevaluates habitats of the coastal landscape, especially older dune areas and the dune forest, and creates important prerequisites for an adaptation of these habitats to the accelerated sea level rise. As key objectives, the project pursues (1) the revaluation, restoration and ecological interconnection of coastal habitats; (2) the analysis of potential nature-based solutions for stabilization of dunes functioning as natural coastal flood defence; (3) the geomorphological analysis of the foreshore barrier systems; and (4) the strengthening of nature experience and identification of St. Peter-Ording inhabitants and guests with the coastal landscape. The project is funded by the German Federal Agency for Nature Conservation in the Bundesprogramm Biologische Vielfalt as well as by the partners.

Illustrated summary



The many sides of Alien species

5 The image shown here symbolises the current debate about alien (exotic, non-native) species in the Wadden Sea: how alien species should be treated in the Wadden Sea. As discussed in the alien species session during the Symposium, these species may have positive, negative or no effects (shown on the different sides of the die) for local biodiversity and society: the saltwater clam *Ruditapes philippinarum* and razor clam *Ensis leei* (top left); the habitat changing oyster *Magallana gigas*

(top right); the intestinal copepod parasite of bivalves *Mytilicola orientalis*, (illustrated with a native blue mussel, bottom right); the hermit crab *Diogenes pugilator* (bottom left); and the racoon dog (bottom) Sea (Dr. Jagoba Malumbres-Olarte, conference illustrator).

THEME SESSION SUBLITTORAL HABITATS

Lectures

01. December 2021
09:00 - 09:20

Nina Fieten
Altenburg & Wymenga

01. December 2021
09:20 - 09:40

Subtidal habitats in the Wadden Sea: Research Approaches, Findings, Constraints

K. Ricklefs¹, O. Franken², S. Glorius³, F. Mascioli⁴, P. Nielsen⁵, H.-C. Reimers⁶, K., A. Trampe¹

¹Research and Technology Centre (FTZ), Kiel University

²Conservation Ecology Group, Groningen Institute for Evolutionary Life Sciences, University of Groningen

³Wageningen Marine Research, University of Wageningen

⁴Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN), Coastal Research Station, Norderney

⁵Technical University of Denmark, Danish Shellfish Centre, Lyngby

⁶State Office for Agriculture, Environment and Rural Areas Schleswig-Holstein

The Wadden Sea of the southern North Sea can be considered as a quite uniform unit. Although, quite different methods are used in the riparian states for the investigation and monitoring of subtidal, i.e. permanently flooded areas. In the Netherlands, the focus is on the development of benthic communities like those of bivalves, as well as certain snails, and worms. These biological data are collected on the basis of discrete samples and are partly supplemented by sedimentological data. The survey and evaluation of mussel and oyster beds based on the findings of dredge samples is the preferred method for current activities in Denmark. This approach is also used in Germany, but the main emphasis in detecting and describing habitats is on the analysis of area-wide sonar data and supplementary sample information.

The results from all three countries show that the developments of benthic communities are subject to continuous variations and that invasive species like Pacific oysters and American razor clams have a significant impact on subtidal habitats. Furthermore, it turned out that at least in Germany biogenic and geogenic reef structures as well as hard substrates (dead shells and/or gravel) are present in the Wadden Sea and can be considered as hotspots of biodiversity.

Although the monitoring of subtidal habitats has been intensified in recent years, it must be stated that from a trilateral perspective it is still quite sectoral both in terms of scientific and spatial focus. This is partly due to differing interpretations of e.g. legislative guidelines of the European Commission by the riparian states.

01. December 2021
09:40 - 10:00

Striking long-term change in subtidal epibenthos of the northern Wadden Sea

Andreas Waser, Christian Buschbaum, Karsten Reise
Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

In the Wadden Sea, long-term dynamics of macrobenthic communities have been intensively studied on intertidal flats. Much less is known from subtidal bottoms and their habitat structuring organisms. However, first investigations date back to studies on commercial European oyster (*Ostrea edulis*) beds in the late 19th and early 20th century. Since the loss of these native oyster beds due to overexploitation, the subtidal epibenthos has been revisited at intervals from the 1980s onwards up to 2021. We present dredging data from surveys of shallow and deep subtidal bottoms in the List tidal basin in the northern Wadden Sea, using the historic type of a 1-m oyster dredge for comparison. Our study period comprises peak and termination of blue mussel (*Mytilus edulis*) exploitation in the area as well as the invasion of Pacific oysters (*Magallana (Crassostrea) gigas*). We illustrate what has followed the former biogenic formative structures in the subtidal zone, the European oyster beds and reefs of the colonial Ross worm (*Sabellaria spinulosa*) on the scale of a century. Change in the subtidal epibenthos has exceeded by far what has been observed on intertidal flats of the Wadden Sea.

01. December 2021
10:10 - 10:30

Status of sublittoral habitat mapping and applied hydroacoustic survey methods in the German Wadden Sea of Schleswig-Holstein

Anne Trampe, Klaus Ricklefs

Research and Technology Centre (FTZ), Kiel University

Towards a good ecological status international and national directives demand the detection and monitoring of habitats as well as biogenic and geogenic natural structures in the Wadden Sea. Since 2011 most of the sublittoral areas of the tidal flats in Schleswig-Holstein were investigated by the Research and Technology Centre (FTZ) in close collaboration with national park administration. Special attention was paid to the detection of underwater habitat types like biogenic reefs (mussel banks) or sandbanks as well as geogenic reef structures or other types of hardground. All this was combined with an area wide mapping of sediments. For a comprehensive seafloor mapping hydroacoustic methods like side scan sonar or echo sounders are applied. Data are related to physical parameters derived from discrete sampling with sediment grabs or dredges.

In the sublittoral of Schleswig-Holstein fine and medium sandy sediments mainly structured by bedforms of different size and type prevail. Coarse sediments with gravel or even stones indicating the vicinity to geogenic reef structures are mainly found in the north of the study area. Biogenic reefs, which fulfill the requirements of the EU Habitats Directive, are rarely found.

Additionally, the only two to three identified subtidal banks of *Mytilus edulis* are associated with an increasing population of *Magallana gigas*. Patches of dense aggregations of *Lanice conchilega* are detected in fine to medium sand in environments of varying current velocities. Overall, hydroacoustic mapping has proven to be a way to provide reliable information about sediment and habitat distribution. Nonetheless, continuous monitoring is necessary in order to assess the development of sublittoral habitats and to preserve a good ecological status.

01. December 2021
10:30 - 10:50

Large-scale modelling of residual fluxes and accumulation of fine sediments in the East Frisian Wadden Sea

Gerald Herrling, Christian Winter

Coastal Geology and Sedimentology, Institute of Geosciences, Kiel University

Ongoing research aims to evaluate the ability of the Wadden Sea tidal flats to accumulate sediments at a progressive rate in order to keep pace with accelerated sea level rise (Dissanayake et al. 2012; Wang et al. 2012;

Flemming & Bartholomä 1997). The changing forcing of tides, wind and waves may yield in spatial differences of channel-shoal morphodynamics, net sediment transport pathways and related intertidal flat sediment accumulation and grain-size composition (e.g., Herrling & Winter 2014, 2016, 2018; Le Hir et al. 2000). This study focuses on net transport at tidal inlets and in between tidal sub-basins. The significance of tidally- and wind-driven net water exchange among communicating sub-basins and at tidal inlets has been shown with a process-based numerical model (Delft3D) for the East Frisian Wadden Sea. Physical mechanisms responsible for the flood/ebb-asymmetry of time-integrated net water fluxes at tidal inlets and across tidal divides were delineated (Herrling & Winter, 2015). Our actual study extends the former hydrodynamic model by adding the forcing of waves and the transport of graded sediment fractions and morphodynamics. Simulated distributions of mud at tidal basins show satisfactory agreement with spatial observations of cohesive sediment content. Differences in orientation and magnitude of net transport fluxes of water, sand and cohesive sediment are estimated for distinct physical forcings at tidal inlets and across tidal divides. This model approach forms the basis to investigate the effects of extreme events, sea-level rise scenarios or changes in wind and wave forcings on residual sediment fluxes and spatial grain-size distributions. This ongoing research further aims at exploring transdisciplinary issues of net transport basin-exchanges in the Wadden Sea among national and international partners.

01. December 2021
10:50 - 11:10

Wadden Mosaic: Understanding the ecological functioning of the subtidal Wadden Sea

Oscar Franken^{1*}, Sander Holthuijsen², Sterre Witte², Jon Dickson², Katrin Rehlmeier¹, Kasper Meijer¹, Quirin Smeele³, Han Olff¹, Tjisse van der Heide^{1,2}, Laura Govers^{1,2}

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The Wadden Sea is of great ecological importance and supports many species of birds and fish. These species depend on a plethora of benthic invertebrate species living in and on the sediment. While the intertidal mudflats are relatively well studied, the biodiversity and food web structure of the subtidal Wadden Sea is relatively unknown. Yet, information on this subtidal component of the Wadden Sea is essential if we want to understand changes that occur due to climate change, natural and human disturbances. The Wadden Mosaic project aims to shed light on this hidden part of the Wadden Sea. We will map biodiversity and link the benthic communities to habitat characteristics. In addition, we will test the feasibility and effects of possible management actions: i) applying hard substrates, ii) (re-)introducing epibenthic shellfish beds, iii) restoration of subtidal seagrass meadows and iv) and test the effectiveness of excluding human activities from marine protected areas. Here, we will present the first results from a large sampling campaign in which samples were taken throughout the Dutch Wadden Sea with a grid resolution of 1 km, resulting in data from 1394 samples. From each sample we analyzed sediment characteristics; identified, counted and weighted the benthic species; and for the dominant species the stable isotope ratios were analyzed to reconstruct the subtidal food web. Overall, the results from the project will improve our understanding of the ecological functioning of the subtidal Wadden Sea, and predict the effectiveness of management practices aimed at sustaining or increasing biodiversity.

Posters

01. December 2021 **Birth, growth and death of subtidal mussel beds in the Dutch Wadden Sea.**

Karin Troost¹, Jaap van der Meer¹, Marnix van Stralen²

¹Wageningen Marine Research, University of Wageningen

²Buro MarinX

Soft-bottom beds of the blue mussel (*Mytilus edulis*) are of high ecological importance in intertidal and subtidal habitats. They create habitat, shelter and food for other organisms, and play a dominant role in energy flow and nutrient cycling. Intertidal beds are much better studied than subtidal beds. Though it is often assumed that subtidal mussel beds resemble their intertidal counterparts, major differences in factors driving recruitment, growth and survival can be expected. The aim of our study was to estimate survival chances of mussel beds in the subtidal parts of the Dutch Wadden Sea in relation to environmental variables, and to compare the results to those obtained previously for the intertidal. We used data from a long-term annual survey, resulting in a survival analysis of 365 individual subtidal mussel beds. The average life span of subtidal mussel beds, once they have survived their first winter, was estimated at 2.3 years. This is lower than what was found in the intertidal (3.4 years) in a previous study. Survival of subtidal mussel beds in less saline areas is comparable to survival of intertidal mussel beds, whereas survival of subtidal mussel beds in more saline areas is significantly lower. The significant and strong effect of salinity most likely reflects an effect of starfish predation, since starfish (*Asterias rubens*) are virtually absent in the intertidal and their abundance is strongly reduced in the subtidal at lower salinities. The survival of individual beds is furthermore positively correlated with their size. This may be a direct effect of bed size itself, or also an indirect effect of environmental factors affecting the size of newly settled beds.

01. December 2021 **Grass-like algae transform rippled sand bars into bumpy mud flats: An enigmatic and novel appearance in the Wadden Sea**

Karsten Reise¹, Nataliya Rybalka², Rune Michaelis³

¹Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

²Universität Göttingen

³National Park Authority Wadden Sea Lower-Saxony

Proper nature protection needs sound knowledge. In National Parks and World Heritage Sites, this should also include explanations for odd phenomena. We observed the emergence of a novel benthic habitat. It occurs on sand flats from mean low tide level down to a subtidal depth of one meter at gullies. In the northern Wadden Sea, the siphonous alga *Vaucheria cf. velutina* (Xanthophyceae) is primarily invading offshore lugworm flats. Thalli are anchored in sediment by rhizoids down to 50 mm and extend into the water by about the same length. Where forming a coherent green turf, the algae drive out *Arenicola marina*, while facilitating tube-building spionid worms and providing shelter to a nursery of juvenile benthic fauna. Dense growth transformed rippled sand into bumpy mud within two months. We reconstructed that this phenomenon commenced in 2018, and observed an extension to > 200 ha until September 2020. Whether this new habitat will eventually give rise to a novel tidal topography and ecology in the Wadden Sea, remains to be seen. We hypothesize, a new genetic variety of the cosmopolitan *V. velutina* is taking over.

Illustrated summary

*Mapping the status of
sublittoral habitats in the
face of sea level rise*



6 This image shows the mapping of sublittoral habitats by a research vessel using scan sonars and the four current features of/initiatives in these habitats in the Wadden Sea: the invasion of *Ensis leei* and *Magallana gigas* (bottom); the evaluation surveys on native *Mytilus edulis* musselbeds (second from the bottom); the restoration of *Zostera* seagrass (third from the bottom); and the decline of reef-forming *Sabellaria spinulosa* worms. The upwards direction of the sea represents the rise in the sea level (Dr. Jagoba Malumbres-Olarte, conference illustrator).

THEME SESSION SUSTAINABLE DEVELOPMENT - ECO

Lectures

01. December 2021
09:00 - 09:20

Keynote: Opening Pandora's Box: Measuring biodiversity change from empirical data

Helmut Hillebrand^{1,2,3}, Josie Antonucci², Jan-Claas Dajka^{1,2}, Lucie Kuczynski¹

¹Plankton Ecology Lab, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg

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³Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Bremerhaven

The concerns about rapidly changing biodiversity are at the core of many ecological and environmental projects ranging from fundamental research projects to the assessments of ecosystem status. However, quantifying the status and trends of biodiversity is far from trivial, as biodiversity encompasses multiple aspects in which biological life can be differentiated. One way of dealing with this complexity is to keep Pandora's box locked and rely on simple, intuitive proxies. However, these proxies tend to be false friends as they often are statistically unreliable and overlook major aspects of biodiversity change. Here, we use data from Wadden Sea monitoring programs to show how opening the toolbox can enhance our understanding of the dynamics of biodiversity in this unique system. In a series of projects, we created an overarching framework that allows integrating multiple dimensions of biodiversity. From this basis, we show that richness or similar univariate metrics do not suffice to quantify trends, whereas acknowledging species turnover and the imbalance between colonization and extinction allows understanding winners and losers in a changing environment. We link these changes back to environmental drivers and thus provide an avenue for a more holistic view on biodiversity change. Finally, we discuss what these results mean in the context of biodiversity as descriptor in ecosystem status assessments.

01. December 2021
09:20 - 09:40

Modelling drivers of biodiversity change emphasizes the need for multivariate assessments

Jan-Claas Dajka, Josie Antonucci, Helmut Hillebrand

Helmholtz-Institut für Funktionelle Marine Biodiversität (HIFMB) an der Universität Oldenburg

Biodiversity change is often presented as straightforward biodiversity loss that can be addressed with univariate policy targets. However, biodiversity change carries a lot of nuance and the trends at the local scale are far more variable than on the global scale. Additionally, most conservation management is being implemented at this local scale and it has been extremely difficult to single out biodiversity change drivers to form management decisions. We used multivariate modelling of four biodiversity change measures to estimate the long-term impact of environmental variables in four organism groups of the Wadden Sea. Our findings emphasize the complexity – individual drivers can have profoundly different impacts on each measure of biodiversity change. There is not one measure that is better than others in its assessment. Biodiversity change needs to be addressed in multivariate assessments. We advise against univariate assessments as this will distort perceptions of biodiversity change and misguide management actions.

01. December 2021
09:40 - 10:00

Potential ecosystem effects of seagrass recovery in the northern Wadden Sea – A food web modelling approach

Sabine Horn¹, Marta Coll², Harald Asmus¹, Tobias Dolch¹

¹Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

²Institut de Ciències del Mar (ICM-CSIC), Barcelona

In contrast to the global trend, seagrass beds recovered in extension and density in the northern part of the Wadden Sea, but ecosystem effects of seagrass recovery and the impacts to ecosystem services are largely unknown. We used temporal-dynamic food web modeling Ecopath with Ecosim to assess potential ecosystem effects of seagrass recovery in the semi-enclosed Sylt-

Rømø Bight at the German-Danish border. In addition to changes in the system's structure and functioning over time, the model predicted changes in biomass of seagrass-associated species. For seagrass consumers, an increase in biomass was projected due to an increase of food supply. Likewise, the model predicted an increase in biomass of seagrass meadow inhabitants due to decreased predation pressure. Correspondingly, main predators of these inhabitants decreased in biomass according to model results. Proxies representing ecosystem services predicted an increase of touristic attractiveness of the site with increasing seagrass meadows. Indirect mediation effects of seagrass severely influenced the model output and are thus, crucial to forecast potential effects of the recovery of habitat-forming species. Our study illustrates that holistic approaches (e.g food web models) could provide a suitable basis for predicting ecosystem effects of changes in the biomass of habitat-forming species such as seagrasses. Therefore, modelling results would be a valuable tool for conservation and management strategies in future.

01. December 2021
10:10 - 10:30

Salt marshes in the Wadden Sea: Status, trends and effects of climate change

Kai Jensen¹, Peter Müller², Peter Esselink³, Martin Stock⁴, Stefanie Nolte⁵, Kelly Elschot⁶

¹Applied Plant Ecology, Universität Hamburg

²Smithsonian Environmental Research Center

³Puccimar, Ecological Research & Consultancy

⁴Schleswig-Holstein Agency for Coastal Defense, National Park and Marine Conservation (LKN.SH), National Park Authority Wadden Sea Schleswig-Holstein

⁵University of East Anglia, Centre for Environment Fisheries and Aquaculture Science

⁶Wageningen Marine Research, University of Wageningen

Wadden Sea salt marshes (WSSM) are important ecosystems at the interface between land and sea as they deliver critical ecosystem services such as coastal protection and carbon sequestration. However, climate change including rising levels of atmospheric CO₂ concentrations, higher temperatures and accelerated rates of sea-level rise are all expected to affect ecosystem services and the stability of WSSM. Within the framework of the Trilateral Monitoring and Assessment Programme (TMAP), the area and zonation of WSSM have been monitored for more than 25 years. Sedimentation and surface-elevation change (SEC) in WSSM have been measured in different geomorphological settings along the whole Wadden Sea coast. Carbon sequestration rates have been measured in a few WSSM recently. Finally, a whole-ecosystem warming experiment was established in 2018 at Hamburger Hallig salt marsh to investigate effects of increased temperatures on vegetation, soil fauna and carbon cycling in WSSM.

Since the turn of the century, the size of WSSM increased substantially by more than 10% and currently WSSM cover some 400 km². Foreland WSSM show average SEC of 9.6 mm/yr and seem thus to be able to withstand moderately increased rates of sea level rise. In contrast, WSSM at barrier islands, Halligen and in summer polders have much lower SEC. Although large amounts of short-term accumulated organic carbon are lost over time, WSSM reach considerable rates of carbon sequestration. First results from the whole-ecosystem warming experiment at Hamburger Hallig will be presented. The importance of all these findings for a sustainable management of WSSM will be discussed.

01. December 2021
10:30 - 10:50

Possible impacts and consequences of climate change on the OUVs of the Wadden Sea

Katja Philippart^{1,2,3}, Kees Bastmeijer^{1,4}, Piet Hoekstra^{1,3}

¹Waddenacademie

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³Utrecht University

⁴Tilburg University

The inscription of the Wadden Sea as a World Heritage was based on meeting three out of four natural heritage selection criteria, referring to its dynamic landscape (criterion xiii), the undisturbed ecological processes (criterion ix) and the important habitats for species' conservation (criterion x). The Statement of Outstanding Universal Value (OUV) of the Wadden Sea incorporates EU directives (Habitats & Birds Directive, Water Framework Directive, Marine Strategy Framework Directive) and the guiding principle as set by the Trilateral Wadden Sea Cooperation in 1978, which is "to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way" (CWSS, 2010). Here we discuss the potential impacts of climate change on the OUVs, and the consequences this might have for legislation in relation to the guiding principle.

**01. December 2021
10:50 - 11:10**

Mutual dependency between coastal morphodynamics and benthic biological functioning: Identifying the main drivers for long term morphological evolution

Peter Arlinghaus, Wenyan Zhang, Corinna Schrum, Alexa Wrede, Andreas Neumann

Helmholtz-Zentrum Geesthacht

Coastal morphodynamic and hydrodynamic processes impose a first-order control on biogeochemical cycling and distribution of benthic habitats. Although many studies report that benthos significantly interferes with their environment, little is known on how this interference in turn affects sediment transport, biogeochemical cycling and morphodynamics at regional and long-term scales.

In order to bridge this gap we will firstly introduce the major benthic functioning and present a mini review on the state of the art modelling approaches implementing those interactions between benthic biota and coastal morphodynamics. Special emphasis is put on 1) synergetic effects of dominant benthic functional groups on sedimentation and erosion processes, and 2) the macrobenthic response to changing morphological, hydrodynamic and biogeochemical conditions.

In a second part we will present preliminary simulation results on an idealized test scenarios based on Jade Bay (Wadden Sea) using coupled hydrodynamic-biogeochemical-morphodynamic models supported by taxonomic and sedimentological field monitoring data. The emergence and development of channels in tidal embayment systems under combined influence of physical forcing and different benthic activities are investigated with the aim to identify and understand the main drivers triggering and guiding morphological evolution. Based on our results further insights into future development of coastal ecosystem can be gained.

01. December 2021 The Dutch Wadden Sea as an event-driven system: statistical detection of spatio-temporal patterns in the salinity field and variability of the transport time scales

Carmine Donatelli¹, Jeancarlo Fajardo Urbina², Matias Duran-Matute², Ulf Gräwe³, Theo Gerkema¹

¹NIOZ Royal Netherlands Institute for Sea Research, Texel

²Eindhoven University of Technology

³Leibniz-Institute for Baltic Sea Research

The tides and the wind are the two primary agents in water and sediment movements in the Dutch Wadden Sea (DWS). While the former is highly predictable, the latter is episodic in nature; the wind climate varies even strongly from year to year. Here we use a 35-year numerical simulation to study the hydrodynamics of the Dutch Wadden Sea as an event-driven system. We first focus on salinity, which is a crucial factor affecting several biological processes and biodiversity in estuarine systems. Specifically, we investigate temporal and spatial changes in salinity at a basin-wide scale by applying advanced statistical methods to monitor salinity fluctuations systematically and detect potential clusters of events between 1980-2015. Particular attention has been devoted to evaluating the presence of spatial and temporal patterns in the occurrence of events characterized by extreme salinity values since these episodes dramatically increase stress levels on organisms living in intertidal areas. In addition, we analyze the system from a Lagrangian point of view to study the spatio-temporal variability of the transport time scales under different wind conditions. We focus primarily on residence time to examine Lagrangian retention and episodes of strong flushing events between the DWS and its surroundings.

01. December 2021 Development of the salt marsh edge due to bio-geomorphic dynamics

Charlotte Steinigeweg, Boris Schröder

Technische Universität Braunschweig

Salt marshes provide important ecosystem services for coastal protection such as the wave attenuation and shoreline stabilization. However, a global loss of salt marshes was recorded in the last decades, which can be attributed to various anthropogenic and climatic changes. One of the most vulnerable parts of salt marshes is the seaward edge of the pioneer zone, which is particularly exposed by wind and waves. The configuration of those edge structures is formed by extrinsic and intrinsic factors, interacting in bio-geomorphic processes. While wave forcing and sedimentation are the abiotic key determinants for edge lateral advance or retreat, effects of vegetation contribute to inner resistance of the marsh edge.

As a part of the collaboration project "Gute Küste Niedersachsen", we analyse the development of salt marsh edges at the island Spiekeroog, Lower Saxony, Germany. In salt marshes in the south west of the island a sharp seaward edge of the salt marsh pioneer zone is built by *Spartina anglica*. In contrast, salt marsh edges in the south east are dispersed and the bordering tidal flat is populated by *Salicornia europaea*. To understand the underlying bio-geomorphic processes, we determine the geomorphological formation of salt marsh edges and the adjacent tidal flats by using remote sensing techniques and assess the effects of vegetation by periodic vegetation and plant trait monitoring. Additionally, ICBM wave data will help to include hydrodynamic conditions.

01. December 2021 Proposal for a new legal form for the governance of the Dutch Wadden Sea

Christiaan Stokkermans¹, Tineke Lambooy², Jan van de Venis³

¹Judge in the Amsterdam court of appeal, independent academic researcher and former civil law notary

²Professor Corporate Law Nyenrode Business University

³Lawyer at JustLaw and unofficial ombudsperson for future generations in the Netherlands

The Dutch part of the Wadden Sea area is facing various serious threats. Due to climate change, the water will warm up and the sea level will rise, affecting marine life and ultimately causing disappearance of the sand banks and islands over time, i.e. the Wadden Sea will drown. The bottom of the Wadden Sea subsides even faster due to extraction of salt and fossil fuels (gas). Other threats include: water pollution from agriculture, industry, ports, fishing and recreation; noise nuisance; pollution by container ships (e.g. MSC Zoe in 2019 and OOCL Rauma in 2020).

The Dutch Wadden Sea is owned by the Dutch State. It has not been declared National Park. A recent study (produced at the request of the Dutch State) reveals that the governance of the Dutch Wadden Sea is ineffective: ecological commitments pursuant to international treaties and EU legislation are not followed up. The question emerged: how could the governance of the Dutch Wadden Sea be arranged in a more effective way?

A legal doctrinal method was pursued concerning new forms of management. Results include creating a so-called Natureship, akin to the Dutch legal model for waterships ('waterschap'). The main motivation is that the legal mission of the Natureship can be based on the ecological commitments into international treaties. This will provide the administrators of the Natureship with a clear goal for their decision-making.

The presenter will explain how a Natureship can be established and which options he has identified for organising the governance structure.

01. December 2021 Mapping the legal de-objectification of nature. Proposing a taxonomy for rights of nature and co

Tineke Lambooy¹, Alex Putzer²

¹Professor Corporate Law Nyenrode Business University

²PhD student University of Pisa

Purpose: to explore the relationship between humanity and its surroundings. The presenters conducted a study regarding 329 initiatives worldwide that aim to grant rights to nature or to recognize rights of nature. Included are: New Zealand's legislation (three areas), Ecuadorian Constitution recognizing rights of nature, Supreme Court of Bangladesh decision concerning a river, and multiple local authorities' decisions in the USA. In each of these cases, a certain part of nature is not regarded any longer as an object of rights but as a subject of rights ('natural legal de-objectification', hereinafter: NLDO).

Methodologies: (i) the analysis of the cases follows a mostly doctrinal methodology which is centred on the reading and analysis of the primary sources of legal doctrine; (ii) content analysis since the legal texts require a reading that goes beyond their literal meaning, which is necessary for the investigation of the motivation behind NLDO cases; and (iii) inductive approach (all categories, classes, and terms in the findings derive from the legal texts themselves).

Results: findings are grouped on themes, including: Which authorities establish a NLDO? Which natural entities have been legally de-objectified (e.g. marine

ecosystems, land ecosystems, animals)? What governance has been envisioned in NLDO initiatives? What serves as the motivation for NLDO?

Conclusions: when presenting their conclusions, the presenters will connect their findings to the Wadden Sea, discussing whether the NLDO could work for the Wadden Sea as solution for maintaining it in a healthy state, for current and future generations (as aimed for under Sustainable Development).

01. December 2021 Ecological sediment management in the Ems estuary - Basics for a sustainable ecological management strategy

Inga Nordhaus¹, Tina Kunde², Filipe Galiforni-Silva³, Dennis Oberrecht², Christian Winter³, Gregor Scheiffarth¹, Andreas Wurpts²,

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²Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN), Coastal Research Station, Norden

³Coastal Geology and Sedimentology, Institute of Geosciences, Kiel University

Dredging and disposal of sediments for the maintenance of shipping channels and harbours may have contributed to a change in natural sediment dynamics in the outer Ems estuary and may influence the occurrence of mussel and seagrass areas by, e.g. increased turbidity and siltation. Also, in the view of future increase of sea level rise, the sediment demand of the Waddensea is assumed to increase. This urges improved procedures by means of optimized dredged matter disposal with respect to salt marsh sediment supply on the one hand and seagrass and mussel protection on the other. Due to the high natural dynamics of the system, the determination of ecological impacts of sediment management is a challenging task.

The aim of our interdisciplinary project is to gain a better understanding of the sediment dynamics and ecological and morphological effects of human activities. Therefore, a morphodynamic numerical model is developed to describe the sediment dynamics within the outer estuary and adjacent Waddensea areas. The tool describes the predominant sediment transport paths and allows quantitative impact assessments of e.g. dredged matter disposals with respect to natural mussel beds, mussel cultures and seagrass meadows. Feasibility studies are carried out for selected mussel areas, including continuous measurements of sedimentation and erosion rates and determination of biomass and biodiversity in relation to the sediment load and composition. Furthermore, an exemplary evaluation of individual disposal sites with regard to ecological and morphological effects is carried out.

The aim of this approach is to add improved ecological and long-term morphological evaluation criteria to (existing and future) sediment management concepts

01. December 2021 Long-term temporal trends in the composition of Wadden Sea phytoplankton

Josie Antonucci di Carvalho^{1,2}, Jan-Claas Dajka¹, Helmut Hillebrand¹

¹Helmholtz-Institut für Funktionelle Marine Biodiversität (HIFMB)

²Alfred-Wegener-Institute (AWI), Helmholtz-Centre for Polar and Marine Research, Wadden Sea Station Sylt

One of the key challenges in managing eutrophication in coastal marine ecosystems is the harmonized cross-border assessment of phytoplankton. Some general understanding of the consequences of shifting nutrient regimes can be derived from the detailed investigation of phytoplankton community and

its biodiversity. Here, we combined long-term monitoring datasets of German and Dutch coastal stations, and amended these by additional information on biomass. Across the integrated data set, we used multiple biodiversity descriptors to analyse temporal trends in the Wadden Sea phytoplankton. Biodiversity measured as the number of species decreased over the last 20 years in the Dutch stations, while it did not show substantial changes in the German stations over the years. However, the abundance-related biodiversity estimated as the effective number of species (ENS), decreased significantly in the German sites, indicating that the dominance of few species has increased over time. Further, we calculated species turnover based on presence-absence and on relative abundance of species. Along with the significant decrease in species richness in the Dutch stations, we also observed an increase in turnover based on more substantial changes in species identity over time. In the German stations, the high turnover observed was mainly a result of changes in the proportion of abundances. Our study indicates that phytoplankton diversity decreased over the past 20 years in the German-Dutch Wadden Sea, but with different spatial patterns.

01. December 2021 **SmallTalk in the Noisy Sea**
Effects of underwater noises on zooplankton with a focus on predator-prey interactions

Saskia Kühn

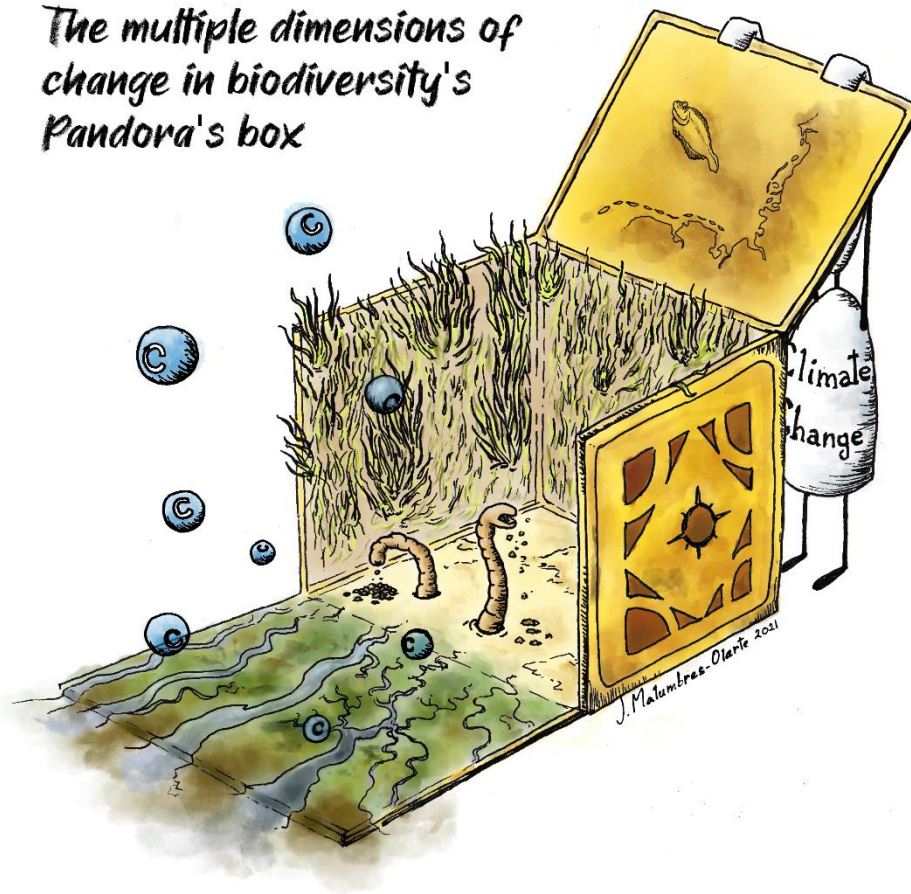
Research and Technology Centre (FTZ), Kiel University

In the marine environment, sound is essential for intra- and interspecific communication, orientation and foraging. Anthropogenic underwater noise generated by ships, during the construction and operation of offshore wind parks or during seismic surveys with airguns, can impair these vital abilities of the individual and consequently can have negative effects on the functioning of entire ecosystems. Zooplankton aggregates in large swarms that feed on phytoplankton and that are an essential food source for higher trophic levels such as fish, marine mammals and invertebrates. Despite the trophic role of zooplankton, there are only a few and contradicting studies on the effects of anthropogenic underwater noise on fitness relevant parameters. The SmallTalk in the Noisy Sea project aims to expand our knowledge on the effects of underwater noise on zooplankton in a predator-prey context. Here we aim to investigate in a laboratory and field setup whether low frequency anthropogenic noise has an impact on zooplankton swarming behaviour, feeding rates and anti-predator behaviour. Here we present first insights on the effects of underwater noises on the feeding behaviour of copepods as well as new approaches to study zooplankton behaviour in the field in order to evaluate predator-prey dynamics in a growing noisy world.

The knowledge gained from the SmallTalk in the Noisy Sea project is essential as it can be implemented in future strategies for a good environmental status of the Wadden Sea.

Illustrated summary

The multiple dimensions of change in biodiversity's Pandora's box



7 The image shows the "Pandora's Box" of the measurement of biodiversity change (in multiple dimensions), which could assist us understand the drivers behind it, necessary for ecosystem status assessments in the face of climate change. These measurements and assessments may show how the recovery of seagrass habitats may be achieved and what effects climate change may have on the carbon sequestered in salt marshes. The worms represent the effects of bioturbation on sediments (not fully understood) and the map of the Wadden Sea on the side of the box is a hint on the effects of climate change on the phenology (migration patterns) of certain species like the plaice (Dr. Jagoba Malumbres-Olarte, conference illustrator).

THEME SESSION SUSTAINABLE DEVELOPMENT - SOCIO

Lectures

01. December 2021
09:00 - 09:20

Keynote: Towards Sustainable Development of Cultured World Heritage Nature

Janne Liburd¹, Bodil Blichfeldt¹, Eva Duedahl²

¹Department of Design and Communication, University of Southern Denmark

²Faculty of Business and Social Sciences, Inland Norway University of Applied Sciences

This paper argues that more nuanced understandings of how people relate to nature are needed, which is aligned with the UN Sustainable Development Goal #11 to make human settlements more inclusive, safe, resilient and sustainable. The aim is to advance conceptualizations to benefit sustainable development and management efforts of cultural and natural heritage by providing more nuanced understandings of what nature and culture "is" in the case of the

Wadden Sea National Park in Denmark, part of which is also a UNESCO Natural World Heritage site. Data collected from 48 research participants by means of a range of innovative, qualitative mobile methods. Findings reveal variations of interpretations and appreciations of nature voiced by the research participants to reveal refined understandings of the subtle nuances of highly intertwined interpretations and enactments of nature and culture. By transcending the simple binary dichotomies of nature/culture and rural/urban, this original research represents a critical contribution towards sustainable development and management of the world's cultural and natural heritage.

01. December 2021
09:20 - 09:40

Protecting Natural and Cultural Heritage at the Wadden Sea Coast: A Relational Values Approach

Cormac Walsh¹, Martin Döring², Linde R. Egberts³

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²University of Hamburg, Institute for Geography

³Vrije University Amsterdam, Heritage Studies

Recent and ongoing debates on the Anthropocene stress the pervasive nature of human-induced environmental change and challenge the existing binary separations of nature and culture. Anthropocene debates furthermore have profound implications for the philosophy and practice of the nature conservation. We agree with Enemark et al (2018) that the Anthropocene must be understood as an urgent call for integration across the nature-society divide, bringing natural and cultural values and perspectives together in research, policy and practice. In this paper we further this agenda, developing a relational perspective on landscape, nature and heritage at the Wadden Sea. In a first step, we examine recent approaches to thinking nature and culture together at the Wadden Sea and reflect on the continued on the diversity of perspectives found along the Wadden Sea coast. In a second step, we explore the implications of a relational perspective on the Wadden Sea drawing on relevant international literature on relational values in nature conservation (e.g. Chan et al 2016). A relational values approach can provide a possible middle way between intrinsic and instrumental value perspectives. We conclude that protected area management at the Wadden Sea needs to 1) consider natural and cultural heritage in an integrated manner, 2) explicitly acknowledge the dynamic contingency of nature-culture relations in the history of the Wadden Sea and 3) recognise Wadden Sea nature as both embedded in global relations and situated in specific place-based contexts.

01. December 2021
09:40 - 10:00

Integrating the Humanities in Conservation in the Wadden Sea: Some Lessons from Literature

Eveline de Smalen

Rachel Carson Center for Environment and Society

The current environmental and climate crisis hinges not just on responses from science and technology, but on those of societies and culture, but research into conservation practices, mitigation and adaptation in the Wadden Sea, as elsewhere, still focuses primarily on the natural sciences. Successful conservation needs to integrate research and discussion on human values and ethics, amongst scientists, management and society at large. Insights from the environmental humanities are crucial in this.

This paper explores one aspect of this field, namely literature. Literature can foster different insights into the values and imaginations that exist in, and affect, the Wadden area. The paper discusses the results of the working group "Teaching the Wadden Sea through Literature," which explores the linked questions of how, firstly, literature can help inhabitants, visitors and others concerned with the Wadden area think about different issues concerning the region, especially in terms of value, responsibility and conviviality; and secondly, how the Wadden Sea as National Park can be introduced into literature classes to enhance an understanding of the significance of coastal conservation to national cultures.

The paper concludes by recommending that the humanities should be incorporated in discussions, teaching modules, research projects and management practices on the Wadden Sea. Conservation science can profit from discussions and collaborations with scholars from literary and cultural studies, history, art history and other related disciplines. Further, it recommends that conservation managers draw on expertise in the humanities in integrating value-based concerns such as conviviality and responsibility into policy, practice and communication.

01. December 2021
10:10 - 10:30

New approaches to archaeological research in the Wadden Sea of North Frisia (Germany): Combined geophysical, geoarchaeological and archaeological prospection methods to reconstruct the medieval cultural landscape

Bente Sven Majchczack^{1,2}, Ruth Blankenfeldt³, Hanna Hadler⁴, Stefanie Kloß⁵, Dennis Wilken², Claus von Carnap-Bornheim³, Ulf Ickerodt⁵, Andreas Vött⁴, Wolfgang Rabbel²

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⁵State Archaeological Office Schleswig-Holstein

The tidal flats of the Wadden Sea of North Frisia (Germany) cover the extended remains of a sunken cultural landscape. The primal marsh landscape was colonized and transformed into a cultural landscape by Frisian settlers in the Middle Ages (7th-12th century CE) through land reclamation, cultivation and dike construction efforts. Vulnerable towards natural hazards, an increased marine influence and major storm surges led to destruction and land-losses that turned large parts of former cultural lands into tidal flats. Notably the notorious flood of 1362 left its mark in collective memory and local identity.

Archaeological research of this cultural heritage began in the 1920's, but until recently largely depended on random finds, quick field surveys and small-scale excavations in erosional areas. The overall knowledge of the lost cultural landscape is therefore patchy and limited to accessible and more dynamic areas of the Wadden Sea; large parts of the submerged landscape were deemed lost for archaeological research.

A new approach combines a multidisciplinary methodology for a more comprehensive understanding of the lost cultural landscape: Geophysical prospection methods in the tidal flats (magnetics, geoelectrics) and shallow waters (marine seismics) provide extensive and detailed insight into settlement remains under sediment cover and enable the tracing of eroded dike courses. Geoarchaeological corings and lab analysis of sediment parameters enable reconstruction of medieval landscapes. Archaeologic surveys are coupled with drone-based aerial photography and targeted excavations. First results demonstrate an unexpected well preservation of settlement and dike remains and demonstrate the great potential for future research.

01. December 2021
10:30 - 10:50

Wadden Sea Tourism Monitor: Helping Destinations to Define Limits of Acceptable Change in Tourism Development

Anja Szczesinski

World Wide Fund For Nature (WWF) Germany

The Wadden Sea along the Danish, German and Dutch North Sea coast is a globally unique ecosystem. Acknowledged as UNESCO World Heritage Site, the entire area is subject to high conservation status aiming for undisturbed natural development and dynamics.

At the same time, the Wadden Sea coast and islands with their recreational values and opportunities for nature experience are highly popular destinations for coastal tourism.

The Strategy for Sustainable Tourism in the Wadden Sea Destination provides a transboundary framework for tourism development that fully considers the Outstanding Universal Value and that contributes to the region's ecological, social and economic prosperity.

With an increase in both the choice of tourism offers and professionalism in marketing, the region's profile as high-quality destination for nature tourism raises. An extended recreational use, however, can impact the natural and cultural resources as well as the quality of the visitor experience. Some "hotspots" already show signs of overtourism, environmental degradation and heritage loss.

To ensure a credible nature protection, wellbeing of local communities and worthwhile visitor experience throughout the Wadden Sea World Heritage Destination, it is thus important to find a balance between the economic, ecological and socio-cultural effects and benefits of tourism development.

Within the framework of the Interreg 5b project PROWAD LINK the "Wadden Sea Tourism Monitor" is being developed in cooperation with local stakeholders as a set of indicators related to the key values of the World Heritage Site to help local communities assess the impact of tourism and prevent negative developments.

01. December 2021
10:50 - 11:10

Barriers for Sustainable Entrepreneurship in the Wadden Sea World Heritage Area

Hellen L.A. Dawo, Thomas B. Long, Gjalt de Jong

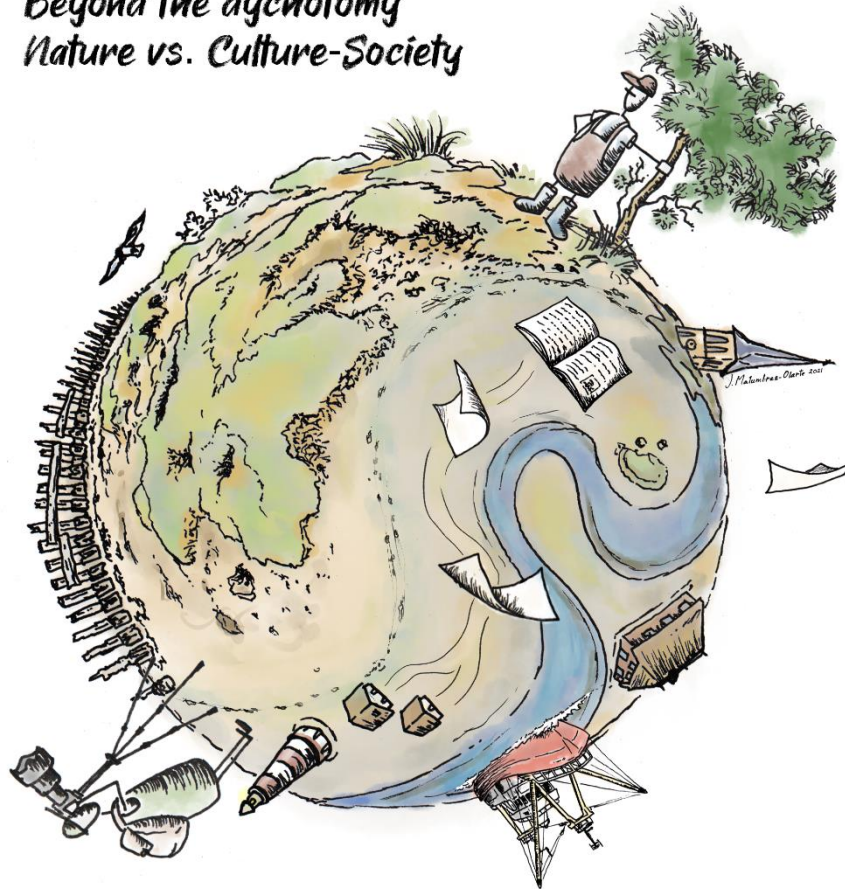
Centre for Sustainable Entrepreneurship, Campus Fryslân, Rijksuniversiteit Groningen

World Heritage sites serve to protect unique natural and cultural heritage. At the same time, they face social, economic, and ecological challenges, as is the case in the Wadden Sea region. Sustainable entrepreneurship provides a promising means to tackle these social, economic, and ecological challenges. However, not all enterprises operating in this semi-remote, sensitive environment implement sustainable entrepreneurship. This study aims to identify what hinders or enables sustainable entrepreneurship in the context of the Wadden Sea region. Working through the PROWAD Link Interreg project, we collected data via semi-structured interviews on the barriers and drivers to the uptake of sustainable entrepreneurship. Our data highlights the complexity of factors faced by both traditional and sustainable enterprises situated in the Wadden Sea region. The results indicate that the barriers for sustainable entrepreneurship are organisational, contextual, and positional in character. Our analysis also shows that place-attachment and social legitimacy (positional factors) discourage sustainable entrepreneurship in some instances. This study builds on literature on sustainable entrepreneurship context, where so far context has been depicted as a positive driver for sustainable entrepreneurship.

The results of this study indicate that context in general, and place-attachment and social legitimacy in particular, could result in inflexibility and reluctance to implement sustainable entrepreneurship. This brings to the fore the role of networks interactions. Semi-remote and sensitive areas such as a the Wadden Sea region site could increase the uptake of sustainable entrepreneurship by building local networks that improve access to information, trends, and best practice examples.

Illustrated summary

Beyond the dichotomy Nature vs. Culture-Society



8 The sphere in this image is based on the classic ying-yang symbol and represents the dichotomy between nature (left) and culture-society (right). This separation is not often (and should not be) clear, like in the case of the tourists that enjoy nature (bottom left). Also, the locals (top right) usually develop a mixture motion of both (by seeing them as part of the same landscape) and a sense of stewardship (hence her/his holding the tree). The book and the flying pages represent the role of literature in understanding and achieving sustainable development. The sunken church tower represents the flooded towns in Frisian marshlands and the interactions between nature and human landscapes (Dr. Jagoba Malumbres-Olarte, conference illustrator).

Posters on FISH

01. December 2021 **Swimways: Linking movement ecology and fish conservation in the Wadden Sea**

Jena Edwards^{1,2}, Allert Bijleveld¹, Tom Buijse², Anieke van Leeuwen¹,

Erwin Winter²

¹NIOZ Royal Netherlands Institute for Sea Research, Texel

²Wageningen Marine Research, University of Wageningen

Since the 1980s, notable declines in the populations of large fish species have been observed in the Wadden Sea, the exact causes of which remain uncertain. However, present knowledge of the factors driving regional fish distribution and habitat use are insufficient for establishing measures for improvement. In recent decades, movement ecology - a field that strives to understand the patterns, drivers, cues, and consequences of animal movements - has been increasingly implemented for conservation and management. As marine management typically relies on area-based approaches, an understanding of the scales and drivers of fish movement is essential for identifying high priority habitats, potential threats, and bottlenecks encountered by wild populations, allowing effective management strategies to be developed. Following this approach, the goal of this study is to provide a baseline from which future research on the movement and habitat use of large fishes can be established in the Wadden Sea. First, we discuss the application of tools and techniques from the field of movement ecology to monitor fish populations and address management concerns. Next, we summarize our current understanding of the use of Wadden Sea habitats by large marine fishes and highlight remaining knowledge gaps that are predicted to impede conservation efforts. Finally, we examine global tracking studies targeting four focal species belonging to distinct ecological guilds within the Wadden Sea. These will be used to illustrate how a movement-based approach can be implemented to determine the causes of population declines and improve the management of local fish communities.

01. December 2021 Target practice: how current EU legislation supports the realisation of the Trilateral Fish Targets

Martha Buitenkamp, Paddy Walker

Programme towards a rich Wadden Sea

In order to address the worrying situation with regards to the apparent declines in fish populations in the Wadden Sea, the three Wadden Sea countries have developed a Trilateral Wadden Sea Swimway Vision, which is described in a Swimway Action Programme, which aims to implement the trilaterally agreed targets for fish. The Swimway Action Programme is built on four pillars: research and monitoring; policy; measures; stakeholder involvement, communication and education. The policy pillar is "... aimed at making an inventory of existing policies and regulations relevant to the Trilateral Fish Targets at the European, trilateral, national and regional level and to analyse their contribution to the realisation of these targets. Following the analysis the need for additional actions could be identified. "

This paper will present a policy review which shows in what way current European legislation and its implementation enable the realisation of the trilateral fish targets. The link between the reviewed policies and the trilateral fish targets, as well as the scope within these policy frameworks to enable the inclusion of the targets, will be discussed. Emphasis will be placed on the inclusion of fish species in future iterations of the national management plans, including research and monitoring within the current EU Directives. The scope to collaborate between the countries to work on a Single Integrated Management Plan, as envisaged in the UNESCO World Heritage Strategy is discussed. An approach is suggested on how to close the plan-do-check-act policy cycle, supported by the SWIMWAY Programme.

01. December 2021 Swimway NL: a five year research program on the role of the Wadden Sea for fish

Ingrid Tulp¹, Anieke van Ieeuwen², Erwin Winter¹, Klemens Eriksson³, Allert Bijleveld², Wouter van der Heij⁴, Anouk Goedknecht⁵, Niels Breve⁶

¹Wageningen Marine Research, University of Wageningen

²NIOZ Royal Netherlands Institute for Sea Research, Texel

³University Groningen

⁴Waddenvereniging

⁵Rijkswaterstaat

⁶Sportvisserij Nederland

Our knowledge on Wadden Sea fish and its drivers is currently insufficient to be able to provide management with sound advice. In order to better understand the cause behind the declining fish populations in the Wadden Sea, we started an ambitious five year programme (2020-2024) with five PhD's and a postdoc. In the project we follow a life cycle approach: by investigating the links between the different life stages in the life cycle we hope to identify which (combination of) drivers are responsible for the observed decline in different fish species. Each PhD concentrates either on a certain group of species or the function of specific habitats previously underrepresented. The subject for the five PhD projects are:

1. The role of salt marshes for fish-Hannah Sharan-Dixon
2. The role of subtidal hard structures for fish-Maryann Watson
3. The role of pelagic fish in the food web-Margot Maathuis
4. The habitat use by large fish (mullet, sea bass, sea trout, tope shark)-Jena Edwards
5. Essential fish habitat (e.g. nursery grounds)-Bass Dye

These topics will be presented on separate posters and/or in presentations. The post-doc will be appointed later in the project and will integrate the information collected by the PhD's into population models that will allow the evaluation of different management scenarios. Potential management measures include: improving passage to and from the Wadden Sea, adjusting fish friendly discharge regimes, fisheries measures and salt marsh management. We are confident this project will boost our knowledge on Wadden Sea fish and will provide a better basis for future management.

01. December 2021 Swimway Waddenzee - Tracking fish migration and habitat selection in the Wadden Sea

Jena Edwards^{1,2}, Allert Bijleveld¹, Tom Buijse², Anieke van Leeuwen¹, Erwin Winter²

¹NIOZ Royal Netherlands Institute for Sea Research, Texel

²Wageningen Marine Research, University of Wageningen

For large, mobile fishes, the Wadden Sea serves as both a seasonal habitat and as a 'swimway' that facilitates transitional movements between marine and freshwater environments. Despite notable population declines observed since the 1980s, our understanding of the movement patterns and habitat use of large fish species in the Wadden Sea remains limited, thereby obscuring our ability to identify the potential causes and consequences of these declines. The growing field of movement ecology presents several approaches with which these factors can be examined to inform the management of large fishes in the Wadden Sea. Biotelemetry devices attached to free-swimming fish allow researchers to monitor both small-scale movements and large-scale migratory patterns remotely, for prolonged periods, and across regions encompassing multiple habitat types. Using these data, high priority areas and potential threats can be identified, in turn, providing insight for the development of effective

conservation and management strategies. The goal of this study is to use a variety of biotelemetry approaches to monitor the movements of large, adult fishes within Wadden Sea and throughout the adjacent coastal and freshwater regions. Specifically, we aim to identify spatial and temporal patterns in fish migration and habitat use by tracking individuals from four focal species belonging to a variety of functional guilds. This research will ultimately allow the identification of potential bottlenecks wherein fish may be vulnerable to increased mortality or factors limiting carrying capacity. These findings will guide future conservation efforts aimed at enhancing fish survival and population stability in the Wadden Sea.

01. December 2021 Seasonal variation in the value of the Wadden Sea to commercial and non-commercial fish: a pilot study

Jip Vrooman, Ingrid Tulp, Marcel de Vries, Ingeborg de Boois
Wageningen Marine Research, University of Wageningen

The fish fauna of our coastal areas and Wadden Sea changed drastically in the past decades. The Demersal Fish Survey, which has been carried out annually for over 50 years by Wageningen Marine Research, shows that the use of the Wadden Sea by fish has changed. This could be due to climate change, but also other potential causes might play a role. In order to better understand why the nursery function has changed we need to know more about the seasonal pattern of the use of the area by fish of different age groups. Do fish still use the Wadden Sea but did they adjust their timing?

In a three year pilot study (2019-2021) a monthly sampling program is carried out. Every month six hauls from the DFS (in an area below Schiermonnikoog) are sampled. The first two sample years demonstrate seasonal differences within and between fish species, where the area seems of importance for different species in different times of the year. After the three years seasonal patterns will be compared to the situation in the 1960's, to investigate whether and how the phenology changed over time.

01. December 2021 Beached dead herring call for more SWIMWAY-oriented research efforts

Katja Heubel, Christian Olesen
Research and Technology Centre (FTZ), Kiel University

Millions of juvenile herring washed ashore within a few days in June 2020. To identify possible explanations, multiple institutions and authorities in Germany joined the effort by focussing on different aspects. We investigated if the event could be explained by differences in condition, stomach fullness, diet composition, external parasites, or morphometric measurements. We dissected fish caught during the event and compared it to measurements on fish caught three weeks later at the same site using identical methods. All individuals were *Clupea harengus* and differences were found for all five parameters between the two batches. Juvenile Atlantic herring arriving in June in the Wadden Sea nursery areas may have different origins. The differences found between the two batches could be caused by stressors during migration or in the spawning area, or just originating from different spawning components or cohorts. Despite Atlantic herring being a well-studied species, there is a lack of knowledge and data accessibility regarding component-specific temporal and spatial variation in relevant traits and proneness to environmental change. To be able to assess whether our measured variables may explain the wave of dead herring in June 2020 and 2021, we need to establish a better knowledge baseline - not only on local single trait parameters but considering various

component-specific SWIMWAYS and how it may be affected by changes in the environment.

We suggest future joint efforts throughout the trilateral Wadden Sea area setting up a trans-disciplinary network to agree on protocols, monitoring, research efforts, and communication for such kill events.

01. December 2021 **The function of the Wadden Sea for small pelagic fish**

Margot Maathuis¹, Bram Couperus¹, Anieke van Leeuwen², Jan Jaap Poos¹, Serdar Sakinan¹, Ingrid Tulp¹

¹Wageningen Marine Research, University of Wageningen

²NIOZ Royal Netherlands Institute for Sea Research, Texel

The Wadden Sea is an important coastal habitat for early life stages of several small pelagic fish (SPF) species. SPF are the major trophic link between zooplankton and predators such as birds and mammals. The biomass of SPF in the Wadden Sea is estimated to be multiple times higher than demersal fish. However, despite their importance SPF have received little research attention. As a result, there are large knowledge gaps on SPF habitat use, feeding ecology, migration behavior, and trophic interactions. This PhD research is part of the Waddentools-Swimway project and aims to gain insight in the drivers of the SPF community composition in the Dutch Wadden Sea. SPF distribution will be studied on two temporal and spatial scales, investigating 1) seasonal variation, by conducting monthly stow net surveys at different locations in the Dutch Wadden Sea and 2) daily and tidal variation, by deploying remote bottom-mounted echo-sounders in the inlet Marsdiep. In addition, both trophic roles of SPF will be studied. As predator, by DNA-metabarcoding of stomach contents and zooplankton sampling, which allows investigating SPF feeding ecology alongside food dynamics. And as prey for common terns, by studying SPF length- and community composition combined with caloric values. This research will provide insight in the role of the Wadden Sea for SPF and the role of SPF in the Wadden Sea food web, ultimately resulting in improved knowledge on the Wadden Sea ecosystem.

01. December 2021 **The Function of Subtidal Reefs in the Wadden Sea: Testing passive acoustics as a tool for monitoring fish habitat**

Maryann S. Watson¹, Ilse Van Opzeeland², Britas Klemens Eriksson¹, Laura Govers^{1,3}

¹University of Groningen

² Alfred-Wegener-Institute (AWI), Bremerhaven

³ NIOZ Royal Netherlands Institute for Sea Research, Texel

Monitoring marine species diversity is critical to managing rapidly changing habitats, such as those in the Wadden Sea. The use of multiple complementary techniques can aid in understanding the different aspects of these ecosystems. Habitats have distinct acoustic patterns, or soundscapes, that are a result of the specific features and biological communities that comprise them. There is growing use of Passive Acoustic Monitoring (PAM) methods to assess marine and coastal habitats. Acoustic analysis can be used to detect the presence and abundance of soniferous species, describe metrics of biological diversity, and can be linked to habitat condition. Therefore, passive acoustics has potential to provide additional metrics for long-term, autonomous, and cost-effective monitoring of marine habitats. However, its utility requires building knowledge of the naturally occurring soundscape components of a habitat, variation over spatial and temporal scales, and validating connections between recorded sounds and species of interest.

There has been very little application of passive acoustic techniques within the Wadden Sea to date and PAM has not been used in habitat monitoring. We aim to test the applicability of PAM in detecting fish communities and different habitat types within the Dutch Wadden Sea, including at habitat restoration experiments, and for different area-based management measures. Increased ability to monitor changes within areas of the Wadden Sea over geographic and temporal scales would provide information to fisheries management to support protection and rebuilding of fish habitat and populations.

01. December 2021 **QSR FISH – Trends in Wadden Sea Fish**

Ingrid Tulp¹, Loes Bolle², Chun Chen¹, Andreas Dänhardt³, Holger Haslob⁴, Niels Jepsen⁵, Annieke van Leeuwen⁶, Suzanne Poiesz¹, Jörg Scholle⁷, Jip Vrooman¹, Ralf Vorberg⁸, Paddy Walker⁹

¹Wageningen Marine Research, University of Wageningen

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⁴Thünen Institute of Sea Fisheries

⁵DTU Aqua

⁶NIOZ Royal Netherlands Institute for Sea Research, Texel

⁷BIOCONSULT Schuchardt & Scholle GbR

⁸Marine Science Service

⁹Tethys: aquatic ecosystem advice

The Quality Status Report describes and evaluates the current ecological status of the Wadden Sea. For the 2021 issue, the status and trends of fish in the international Wadden Sea were analysed based on ten different monitoring programmes that were conducted for at least ten years. In the past decade a total of 124 different species was recorded. In general, trends in marine juvenile species are similar between the Dutch and German Wadden Sea and the strongest changes occurred in the period before 2000. Most marine juveniles have stabilised in the last decade. Overall, the nursery function of the Wadden Sea appears to have declined since the 1980s and has stabilised in the last decade. The abundance of estuarine resident species in the last decade is stable for most species, except for bullrout and hooknose, which showed a decline in both the Dutch and German Wadden Sea. Amongst the diadromous species, in the last decade decreasing species greatly outnumber increasing species. Trends in the Danish rivers have stabilised for all three species analysed (salmon, houting and eel) in the last decade. The endangered fish species included in the trend analyses (mainly diadromous species) show decreasing, stable or uncertain trends in the last decade, with the exception of North Sea houting, which shows an increase in the Dutch Wadden Sea.

SESSION INTERNATIONAL PERSPECTIVE

Lectures

02. December 2021 **Interlinking science and practice for the management of World Heritage – Heritage Place Lab**
10:30 - 10:45h

Eugene Jo, Maya Ishizawa

International Centre for the Study of the Preservation and Restoration of Cultural Property

The World Heritage Leadership Programme has launched a new activity focused on strengthening networks across research and site management in the context of the World Heritage Convention. In order to develop practice-based research agendas for World Heritage properties, the programme invited researchers and site managers to team up in Research-Practice Teams in order to define research agenda for World Heritage properties.

The Heritage Place Lab is targeting to involve World Heritage site managers in the co-production of research agendas, thereby enabling research to influence World Heritage site management and policy-making. It will connect science to practice by generating a platform of knowledge exchange and peer-learning, looking for common grounds between scientific knowledge and local knowledge systems in order to co-create innovative, holistic and inclusive solutions for World Heritage site management.

One of the themes that the Heritage Place Lab is focusing on is the potential of localized indicators to monitor climate change impacts as these could be co-created by researchers and World Heritage site managers while involving Indigenous and traditional knowledge systems at World Heritage places.

02. December 2021
10:45 - 11:00h

Climate adaptation and restoration in the Wadden Sea; how deep is your love?

Martin J. Baptist

Wageningen Marine Research, University of Wageningen

Climate adaptation and ecological restoration projects in the Wadden Sea make active interventions in natural processes, sometimes even for the development of 'new' nature with the intention of increasing the value of nature. These projects are labeled as nature reinforcement projects, for which two opposite motives are identified. The first motive starts from the ecosystem services: "nature facilitates people". The second motive starts from the belief that humankind must help nature: "people facilitate nature". Examples of climate adaptation and restoration projects are presented and discussed. Subsequently, it is foreseen that climate change leads to a 'novel ecosystem'. To adapt to climate change we might need to modify the nature of the Wadden Sea to preserve species and valuable habitats. In this presentation I will make the audience ponder about the current and future possible climate adaptation and restoration measures in the Wadden Sea.

02. December 2021
11:00 - 11:15h

Assessing climate vulnerability of the Wadden Sea World Heritage and its community using the CVI

Scott Heron¹, Jon Day^{1,2}, Julia Busch³, Harald Marencic³, Robert Zijlstra⁴, Barbara Engels⁵, Annkatrin Weber⁶

¹James Cook University

²ARC Centre of Excellence for Coral Reef Studies

³Common Wadden Sea Secretariat

⁴Rijkswaterstaat

⁵German Federal Agency for Nature Conservation

⁶World Wide Fund for Nature (WWF) Germany

Climate change is the fastest growing global threat to World Heritage with many properties already experiencing significant negative impacts. The Climate Vulnerability Index (CVI) process rapidly assesses vulnerability through expert appraisal of the best-available climate science, and is applicable to all types of World Heritage properties (natural, cultural or mixed). For the Wadden Sea, the CVI-assessed vulnerability of the Outstanding Universal Value (OUV) focused on impacts to the key values (attributes) of the property from three identified key

climate stressors: Temperature trend (air and/or water); Extreme temperature events; and Sea level rise. OUV Vulnerability was assessed as High (the highest category) for each of two timeframes considered (ca. 2050 and ca. 2100) using a 'business-as-usual' climate scenario (RCP8.5). Whilst the vulnerability associated with the two temperature-related climate stressors was High in both timeframes, the vulnerability to impacts from sea level rise escalated from Low in ~2050 to High in ~2100. Collectively, and for both timeframes, there is potential for major loss or substantial alteration of the majority of the attributes that convey the OUV. The effect of loss of OUV on the community associated with the Wadden Sea property will be assessed during a workshop scheduled for February 2021, the outcomes of which will also be discussed. Global actions to substantially reduce greenhouse gas emissions are essential to support the OUV and community of the Wadden Sea. Climate adaptation and response measures for both OUV and Community Vulnerability also need to be accompanied by efforts to minimise localised stressors.

02. December 2021
11:15 - 11:30h

Marine World Heritage and climate change - How site managers work together

Fanny Douvere
UNESCO World Heritage Centre

Since the inscription of the first marine site on the UNESCO World Heritage List in 1981, the [marine World Heritage network](#) has grown to encompass 50 globally outstanding sites across 37 nations. Climate change has become the largest threat to the conservation of these sites. Rising temperatures and sea levels, extreme weather and bleaching events compound existing pressures including fisheries, marine pollution and unsustainable coastal development.

The [UNESCO World Heritage Marine programme](#) works to build climate leadership across the marine World Heritage sites and position them as beacons of hope in a changing ocean. Expertise is shared across the network through site-to-site field visits, e-communication, online meetings and tri-annual global managers conferences. For example, in December 2020, scientists and managers from the Wadden Sea and Shark Bay World Heritage sites virtually presented to the network on the [Climate Vulnerability Index and its application at their sites](#); inspiring other sites to do the same.

Managers are also connected with leading scientists to drive critical research clarifying the linkages between marine World Heritage and climate change. Recently, information provided by local site teams was combined with scientific data and literature to produce two novel reports – one assessing [climate change impacts on World Heritage-listed coral reefs](#) and the other assessing [blue carbon assets across all 50 marine sites](#); revealing their outsized role as custodians of globally relevant blue carbon resources. The latter report is a tangible outcome of the active network having emerged from discussions at the 4th World Heritage Marine Managers Conference.

02. Dezember 2021
11:05 - 11:15h

International Cooperations of the TWSC – The Yellow Sea and the Wadden Sea Flyway Initiative

Kristine Meise, Harald Marencic
Common Wadden Sea Secretariat

Since its beginning in 1978, the Trilateral Wadden Sea Cooperation has been collaborating with initiatives and projects around the world. The first Memorandum of Intent was concluded in 1991 with the Wash/North Norfolk Coast

and numerous collaborative projects on monitoring and research, culture and landscape and sustainable tourism have been implemented since then.

In 2000, first contacts started with South-Korea to support the protection of tidal flats in the Yellow Sea. To provide a solid framework for future cooperation, a Memorandum of Understanding between Korea and the Wadden Sea was concluded in 2009. During the same time, Korea has extended the size of protected coastal areas. In July 2021, the “Getbol – Korean Tidal Flats” were inscribed as a World Heritage site.

Building on existing collaborations with West-African states established since 1994, the Wadden Sea Flyway Initiative started in 2012 “to strengthen the cooperation on management and research activities with States Parties on the African Eurasian Flyways”. Bird monitoring and capacity building activities have taken place in close collaboration with international, regional, and local partners. As climate change increasingly threatens the network of sites migratory birds depend on, the newly developed ‘Climate-resilient East Atlantic Flyway Project’ aims for coordinated actions across a vast geographic area, from breeding grounds in the Arctic to essential wintering and breeding areas in Africa.

The Wadden Sea has benefitted from these collaborations through the exchange of knowledge on ecosystem functionality and sustainable management strategies, while contributing to the protection and better management of coastal areas internationally.

02. December 2021
11:30 - 11:45h

When Wadden Sea birds are not in the Wadden Sea': trends, distribution, and pressures along the East Atlantic Flyway

Marc van Roomen

Sovon Dutch Centre for Field Ornithology

As birds using the Wadden Sea are part of flyway populations which rely on a larger network of sites, knowledge from the whole flyway is needed for their effective management. The Wadden Sea Flyway Initiative started an integrated monitoring programme together with Wetlands International and BirdLife International along the East Atlantic Flyway for this reason. Within this programme censuses have been conducted annually in Western Africa from 2013 onwards and total mid-winter counts along the entire flyway, from Norway to South Africa, have taken place with an interval of three years, in 2014, 2017 and 2020. In addition to the assessment of trends in bird abundance, also the assessment of pressures occurring at the different sites along the flyway is part of this monitoring. Thanks to this programme we can document flyway trends for 81 populations of 67 species of which a majority is also occurring in the Wadden Sea. Environmental data including scores of the presence of pressures have been collated from 115 coastal sites in both Africa and Europe. The majority of flyway trends are stable or increasing and in this aspect the East Atlantic Flyway contrasts in a positive way with some other waterbird flyways in the world. Nevertheless, many arctic-breeding and long distance waders are decreasing in number.

02. December 2021
11:45 - 12:00h

Benefits of transnational cooperation in the face of climate change

Kyong-O, Moon

World Heritage Promotion Team of Korean Tidal Flats

Getbol, Korean Tidal Flats is successfully inscribed on World Heritage List this July. The property represents one of the most important and meaningful habitats for the conservation of biodiversity and especially, it has international importance as a major stopover site for globally endangered migratory waterbirds in the East Asian-Australasian Flyway.

The Memorandum of Understanding between Republic of Korea and the Wadden Sea was signed on March 2009. During the promotion process, many scientists in the Wadden Sea shared their experiences and scientific knowledge and helped fill out the World Heritage nomination of the Getbol. The Getbol's World Heritage Inscription will be an important milestone to make a further progress of mutual cooperation.

Mutual cooperation and learning can help establish constructive policies for climate change. A paper is recently published in the international journal named "Science of the Total Environment" and this paper figures out that the whole tidal flat areas in ROK store about 13 million tons of carbon and annually absorb 260,000 tons of carbon dioxide. This experience could help analyze the carbon storage capacity of the Wadden Sea and its role as a blue carbon. Another example is related to offshore wind power. The Wadden Sea has the world's best offshore wind power technology and the largest complex are built or scheduled. Korea is also planning to build a large-scaled (8.2 GW) offshore wind farm outside the Shinan Getbol area. The long experience and technology of the Wadden Sea can greatly contribute to create the complex in a sustainable way that does not have any harmful effect to the coastal ecosystem of Getbol.

02. December 2021
12:00 - 12:15h

The Yellow Sea working group- an innovative regional platform to support the conservation and management of the intertidal wetlands and associated species in the Yellow Sea

Mr. Raphaël Glémet

Water and Wetlands, Science and Strategy Group, IUCN Asia Regional Office

The Yellow Sea ecosystem of intertidal wetlands, associated habitats and the biodiversity that depends on them, encompassed by China, the Democratic People's Republic of Korea (DPRK) and the Republic of Korea (RoK), is among the ecological wonders of the world. It represents one of the largest area of intertidal flats on the planet. It provides an important number of vital ecosystem services including fisheries, tourism, disaster risk reduction, blue carbon storage and climate change resilience, which profoundly underpin socio-economic development. Furthermore, this ecosystem provides a major contribution to the global natural heritage as well as that of the three Yellow Sea nations. It is the most important staging area for migratory waterbirds in the East Asian-Australasian Flyway (EAAF) with millions of waterbirds using these wetlands.

These Yellow Sea intertidal and associated coastal wetlands are critically threatened by a wide range of pressures, resulting in their degradation and destruction, especially through unprecedented rates of conversion; around 66% of intertidal wetlands in the Yellow Sea have been lost in the past 50 years.

The need for the establishment of a regional cooperation mechanism was discussed and identified as part of several national and regional workshops organised by IUCN and partners and participants from the three countries agreed to participate in a joint Yellow Sea Working Group (YSWG). This working group, gathering government representatives and NGOs from the three Yellow Sea countries, is the first of its kind and ensures a coordination at regional level, to harmonise and catalyse national and joint actions on the conservation and management of the intertidal wetlands and associated species in the Yellow Sea.

Illustrated summary



***Connect, Collaborate and Coordinate Actions
to Adapt to a Changing World***

9 The two birds (*Calidris canutus* and *Mergus squamatus*) represent, at the same time, two migratory flyways (East Atlantic and Australasian, respectively) and the research and management groups that work in different parts of the world. These groups (the birds) may collaborate with each other (sharing knowledge, experience, assessment tools and actions) to develop better sustainable development strategies, and to better protect and manage coastal habitats and the related heritage. These actions may include the restoration of coastal habitats (represented in the illustration by reefs formed by *Sabellaria spinulosa* worms), as a strategy to adapt to climate change (represented by the orange dawn) and the rise of the sea level (represented by the rising hand) (Dr. Jagoba Malumbres-Olarte, conference illustrator).



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