swimway
wadden sea

Image A. Dänhardt

SWIMWAYs: Understanding connectivity within the life cycles of coastal fish

Conference report

24 – 26 September 2019, Hamburg, Germany

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The Wadden Sea World Heritage Site since 2009

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Content

Background

In 2014, the SWIMWAY vision was formulated as a framework for implementing quality objectives, known as the 'Trilateral Fish Targets' for fish species present in the Wadden Sea at some time during their life cycle. The SWIMWAY vision seeks to integrate research and monitoring, policy measures, stakeholder involvement and communication and education, as a strategy for making progress towards and achieving these objectives. In 2018, the ministers of the three Wadden Sea countries (Germany, Netherlands and Denmark) declared their support for the SWIMWAY vision and instructed the Wadden Sea Board (WSB) to take action to achieve the Trilateral Fish Targets by further developing this integrated approach and contributing towards its implementation. Working in close cooperation with the Common Wadden Sea Secretariat (CWSS), the trilateral Ad hoc Working Group SWIMWAY (WG SWIMWAY) made up of scientists, government officials, consultants and NGOs, formulated an action plan for the year 2019, which was adopted and financially supported by the WSB. Among activities programmed for 2019 was the organization of an international conference on drivers of fish populations utilizing coastal marine environments during their ontogeny, including identification of potential bottlenecks throughout the life cycle and, the evaluation of current management measures. This conference aimed to connect knowledge and expertise by facilitating exchange among diverse experts and stakeholders, and by identifying potential areas of collaboration. It was hoped that the conference would contribute the organization and expansion of knowledge about the area, as well as ensuring the long-term engagement of relevant stakeholders.

The conference, entitled "Swimways: Understanding connectivity within the life cycles of coastal fish", was held between 24 and 26 September in the "House of the Patriotic Society" in Hamburg, Germany. The conference was organised by the CWSS and a programme committee consisting of Adi Kellermann Andreas Dänhardt (D), Paddy Walker (NL), Morten Søby Frederiksen (DK) and Julia A. Busch (CWSS). More than 90 scientists, managers, policy makers, NGOs and other stakeholders concerned with fish in coastal areas participated in the event. The programme comprised four thematic sessions, a total of 24 expert talks, an opening keynote address, four session keynote addresses, poster presentations, and a workshop on education.

The four thematic sessions were:

i) Integrating monitoring for understanding fish life cycles (chaired by Katja Philippart and Britta Diederichs)

ii) Creating a knowledge community for future collaborations (chaired by Paddy Walker and Morten Søby Frederiksen)

iii) Organizing trilateral stakeholder engagement in the SWIMWAY process (chaired by Martha Buitenkamp and Henrik Pind Jørgensen)

iv) Initiating a trilateral project – where to start and how to proceed (chaired by Adi Kellermann and Andreas Dänhardt).

The lively, informed and very productive discussions among conference participants at each of these four sessions yielded a wealth of insights, conclusions and new context.

The proceedings of the conference will be published in a special issue of the Elsevier Journal “Estuarine, Coastal and Shelf Science”. Manuscripts can be submitted via the journal’s submission portal.

We thank Facts4Emotion and Saalhaus GmbH for their professional support preparing and hosting the conference, and Fischerhaus Hamburg for a delicious conference dinner.

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Welcome and opening

Tuesday, 24 September 2019, 12:00–13:00

The conference was opened by the chair of the trilateral Ad hoc SWIMWAY group**, Adi Kellermann**, and local organiser **Andreas Dänhardt**.

An opening address was given by the director of the National Park and World Heritage Site Hamburg Wadden Sea and WSB member **Klaus Janke**, who welcomed all conference participants to Hamburg. Dr. Janke reminded the audience that in 2019 the UNESCO World Heritage Site Wadden Sea is celebrating its 10th anniversary with a series of events – the SWIMWAY conference being one of them. Even though the three countries can look back at 40 years of successful collaboration and achievements, future challenges need to be tackled jointly. With regard to fish, knowledge of patterns and processes crucial for closing life cycles, successful reproduction and stabilizing populations is still very fragmentary. However, this does not imply that evidence-based fish conservation needs to wait for research results or that we cannot start immediately to improve the situation for fish in the Wadden Sea and beyond. Thorough, focused and hypothesis-driven research to improve the knowledge base, while making best use of the already available knowledge at any given point in time, must continue alongside activities to preserve our natural heritage of the Wadden Sea for future generations.

The conference keynote speech was given by **Karin Lochte**, chair of the WSB and member of the Managing Board German Marine Research Alliance. In her talk “Of fish and frameworks”, Professor Lochte focused on the connection between the “well-prepared ground” (existing frameworks and programmes such as the Wadden Sea Plan, the Trilateral Monitoring and Assessment Programme and the Trilateral Research Agenda, which is still under development) and the SWIMWAY programme. She noted that all these initiatives are being implemented in the context of the UN Decade of Ocean Science for sustainable development 2021–2030. , which “… encourages the science community, the policy-makers, the private sector and the civil society to think beyond business as usual and aspire for real change”. She argued that understanding the SWIMWAY programme as a contribution to the UN decade will facilitate progress towards the overall aim of reversing decline in ocean health, a goal that includes improving the state of fish populations. The WSB supports the efforts of the SWIMWAY working group to develop projects and lay the foundations for the establishment of a permanent fish expert group. Professor Lochte encouraged everyone to make best use of existing resources, while continuing to develop new projects and forge new partnerships. Taking

action and creating new knowledge should go hand in hand; in both cases relevant stakeholders and the general public should be involved at the earliest possible stage: The conference should not be viewed as an isolated event, but rather, as the start of a process leading to the initiation of new activities and partnerships working towards the SWIMWAY vision. This ambitious task can only be achieved through concerted action, at least on a trilateral level, but preferably also by exchanging knowledge, experience with other research communities.

Thematic Session 1: Monitoring and data

Tuesday, 24 September 2019, 13:00–16:15, chaired by Julia A. Busch

The keynote talk for Thematic Session 1, entitled "Concepts and cues for monitoring of fish migration", was given by **Katja Philippart** (Wadden Academy, Royal Netherlands Institute for Sea Research & Utrecht University). Since the Wadden Sea is essentially a delta area, most passages for migratory fishes were blocked e.g. by dams, weirs and other physical obstacles, but recently, some of these blockages were reopened. Effects of measures intended to be fish-friendly must be monitored to evaluate if they act positively (are more measures better for the fish? Is the sum of effects higher than the sum of its parts?) or negatively (saturation of effects with number of measures or unintended adverse effects of measures on fish) on population size. For monitoring impacts of fish-friendly measures, indicators are needed, but multiple stressors cause noise in the data. The design of fish-friendly measures requires species-specific data on cues (e.g. to help navigation), abilities to act on and react to cues, and on endurance. Spatial information on environmental factors will help identify vertical and horizontal links and enable mapping of "cuescapes" for migratory routes. These may provide a means to align all the relevant cues and help the fish to find their way along their natural migration routes. Now is the time to start implementing this knowledge.

In her talk on the Quality Status Report fish 2017, **Ingrid Tulp** of Wageningen Marine Research presented the results of standardized trend analyses of fish data obtained from surveys designed for other purposes (fish is not part of the TMAP). Despite some difficulties in harmonizing data, some overall patterns emerged. Plaice numbers in the Wadden Sea are declining. Despite an all-time high of the adult stock, numbers of marine juvenile species have been declining since the late 80s. Among estuarine resident species, there are winners and losers, and the nursery function has declined everywhere. The QSR includes a list of recommendations for research that has been adopted in the SWIMWAY vision, as well as suggesting measures to make the trilateral fish targets testable.

Wouter van der Heij of Waddenvereniging called for a flyway approach to marine conservation and management. He argued that the Flyway initiative could serve as a model for implementing the SWIMWAY strategy, which in turn, should serve as an umbrella for initiatives oriented towards achievement of the trilateral fish targets. It is already in the revised fish targets (bottleneck

concept, see Tulp et al. 2017), which have yet to be adopted. Government authorities are located far away and the issue of fish in the Wadden Sea is still largely invisible to them, so a top priority is to make SWIMWAY much more visible. The Dutch SWIMWAY project "Waddentools (2019-2024)" will yield valuable data and provide a platform for achieving this, but its research is limited to the Wadden Sea. There is a need for associated research to address connectivity among life stages in species whose life cycles extend beyond the Wadden Sea.

From a food web perspective, **Wouter Courtens** of the Belgian Research Institute of Nature and Forest presented "Insights in forage fish dynamics in space and time based on a seabird's diet". Feeding observations in several Sandwich tern colonies and extensive microstructure analyses of fish otoliths found in pellets revealed spatial and seasonal variation in diet of these seabirds. Sandwich terns function as a 'sampler' of pelagic schooling fish (their preferred diet) and variations in their diet can be used to elucidate fish dynamics over spatio-temporal scales beyond the scope of ship-based monitoring.

Bo Poulsen of Aalborg University adopted a historical perspective on changes to the marine ecosystems far beyond the scope of contemporary monitoring programmes. His presentation "Resurrecting the dead and forgotten: examples of past marine ecosystem components in the Wadden Sea and beyond" provided an overview of methods rarely used by ecologists, including trade records and documentation of people's eating habits. Records of "conspicuous consumption" of expensive (and therefore fashionable) food items can provide insights into historical trends. For example, time series of oyster shipments show that oyster consumption skyrocketed after the Napoleonic wars and that, between 1860 and 1880, large numbers of oyster were caught in the Wadden Sea. Amsterdam got wealthy through eel fishery and 42 historical recipes mention eel as an ingredient. In the Wadden Sea, records indicate the existence of a commercial eel fishery in the Wadden Sea until 1850, but not after this date. This may indicate that overfishing of this presently critically endangered species was already occurring. Historical data are very valuable as references of former situations and conditions, but hard to collect. The stricter the regulations were, the more documentation is available and, therefore, the better is the information base.

Jeroen Huisman of Van Hall Larenstein University of Applied Sciences presented "Roptazijl: A fish pass with many tales", describing lessons learned from studying fish movements through a fish pass at a pumping station in Friesland. Fish can pass the pumping station by swimming through two 60 × 30 cm openings into a 55 m long fish pass, leading into a small basin. The most numerous species in the fish pass are three-spined sticklebacks and glass

eels. There is considerable intra-annual variation in total numbers, with the former being most abundant between February and June, and the latter between March and June. Glass eel abundance also showed within-day variation, peaking during the incoming tide, while sticklebacks were evenly distributed across the tidal cycle. So far, it is not clear whether more fish passes like Roptazijl should be built. The fish pass may provide access to habitats behind the dike, but the pass can also become an ecological trap, because it is only a one-way passage with no way for the fish to migrate back out of the polder towards the sea. In this respect, a positive development is the recent installation of fish-friendly pumps that are intended to facilitate seaward migration.

In the last talk of the first session, **Veit Hennig** of the University of Hamburg presented results on the "Dynamics of the young-of-the-year communities in the Schleswig-Holstein Wadden Sea and the Elbe estuary and their importance for predators". Field researchers investigating the feeding ecology and breeding success of Common and Arctic terns found that these species are largely unselective feeders in terms of species and size composition of their prey. Their diet composition can thus be used to monitor the population dynamics of their prey fish. Common and Arctic terns in marine areas feed mainly on herring and sprat, while smelt is the main prey of colonies closer to the estuaries. Between 2010 and 2018, tern breeding colonies in different areas encountered very variable conditions for raising their young, which was reflected in a corresponding variability of breeding success. For example, smelt populations in estuaries crashed in the years following 2014 due to the effects of dredging. In 2018, long-lasting easterly winds reversed the residual current in the southern North Sea, which transport young-of-the-year herring into the Wadden Sea. In general terms, weather extremes such as storm (2013) or heat (2018) can cause total breeding failures, while in years with favourable feeding conditions (such as 2019), predation can be a major threat. The core questions addressed in the SWIMWAY programme (North Sea–Wadden Sea exchange, feeding hot spots, hiding places from bad weather) are also key for understanding seabird ecology.

Conclusions of the integrated discussion of session 1

- Connectivity (in the widest sense) is crucial as an overarching principle
- It should always be examined if a measure to improve the situation for fish would result in an ecological trap or a valuable habitat
- Seabird breeding and feeding ecology should be considered as a proxy/indicator for mapping spatial bottlenecks within the life cycle of fish
- Bottom-up (originating from research and conservation) and top-down (originating from authorities and governments) management approaches should be carefully balanced
- Impacts of extreme events (e.g. weather) should always be considered
- Make the most of available data, keep asking questions to the available data
- Look beyond the Wadden Sea to address connectivity and to learn from experiences and applications made elsewhere
- Multidisciplinarity: keep the option of employing other than monitoring/sampling data to explain patterns and processes
- Always distinguish between nice to know and need to know, prioritize accordingly
- Involve stakeholders as early as meaningfully possible

Workshop on education, communication and ocean literacy

Tuesday, 24 September 2019, 16:45–18:45, chaired by Anja Szczesinski

The workshop chaired by **Anja Szczesinski** of WWF Germany & International Wadden Sea School (IWSS) tackled questions related to the need for public education on fish and SWIMWAY, including the identity of target groups and multipliers, the content of educational and communication programmes, and the means of information provision.

The "Eel Migration Game", developed by IWSS network partners, provided a playful introduction to the topic of "fish education". More information and educational resources can be found at www.iwss.org.

Rainer Borcherding of Schutzstation Wattenmeer presented the identification key and citizen science platform BeachExplorer (www.beachexplorer.org), where findings from North Sea beaches can be reported and, after quality check by experts, are presented.

The following group discussion focused on the following questions:

i) Why are communication and education important aspects of SWIMWAY?
ii) Which target groups should be addressed and who are effective multipliers?
iii) What should be communicated about fish, migration & SWIMWAY?
iv) How can the information be conveyed?
v) Which means and tools are suitable?

Participants in the discussion came up with a range of ideas, which will be transmitted to the IWSS network of multipliers, as inputs and inspiration for the further development of educational materials and activities. i & ii) Sharing information through communication and education is important as you can only protect what you know. Public support for protection of natural resources such as the Wadden Sea is necessary since achieving this aim will require political change. Improving basic knowledge of ecological processes in children, policy makers, and others is crucially important for wise decision-making. Involving scientists, educationalists and the public will facilitate multiplication of this knowledge (see www.iwss.org/sites/default/files/WHS_Education_Strategy.pdf for examples). iii) Education and communication programmes should promote

love of nature and appreciation of the beauty of fish. Basic concepts that are important to understand include trophic levels, ecosystem functioning and connectivity, as well as the importance of healthy fisheries for the public and the idea that “good ecology makes good economy”. The complexity of the topic should be tackled in a way that is appropriate for the target-groups, for example by telling interesting stories about life cycles (e.g. of eel and herring) and providing fun facts about fish. iv & v) Bringing people into direct contact with nature is the most effective way of communicating the importance of nature conservation. Communication should be positive and transmit emotions. A personal, emotional connection to the sea can open a window onto the topic of fish. Information on fish and threats to fish can be included to a greater extent into existing activities such as mudflat walking and events such as “mud days”. Storytelling is a powerful way of conveying information. Activities that offer a playful approach to the topic of fish can encourage people to think and talk to each other about fish. Competitions, such as “finding Nemo” (or finding the most ugly/strange/etc. fish) can be an appealing way of getting young people interested. If getting involved with fish were promoted by influencers on social media, this could start a trend among young people (in a similar way that adopting a plastic free lifestyle and climate protection have also become trends). Giving members of the public the opportunity to participate in habitat restoration can help raise awareness for fish ecology. People who are already interested in fish (politicians, fishermen, VIPs, etc.) could be further educated to become experts, storytellers and ambassadors. Virtual reality can provide experiences of encounters with fish where real life encounters are not possible. Social media can be used to inform and educate about fish.

Poster session

Tuesday, 24 September 2019, 18:45–21:00

The first day of conference concluded with a buffet reception, where twelve posters were presented by their authors. This informal event provided the opportunity for poster authors to discuss their works with the guests, and for all those attending to get up to date with the latest research, to make new contacts, and renew acquaintances. Poster abstracts can be found in Appendix B.

Thematic Session 2: Fish habitats

Wednesday, 25 September 2019, 09:00–12:00, chaired by Andreas Dänhardt

In her keynote talk for Thematic Session 2, **Josianne Gatt Støttrup** of DTU Aqua discussed the links between environmental and fisheries management in marine fish habitats. Starting with the question "What would you do with 5 million Euros to improve fish habitat for the Wadden Sea?", Dr. Støttrup elaborated on quality and quantity of fish habitats, noting that the latter is much harder to measure than the former. Population size is significantly correlated with habitat size (e.g. nursery area in plaice or reproductive volume for Baltic cod), while population size is essential to enable the fish to make best use of environmental conditions. Size and distribution maps of fish habitats can be constructed from spatial information from different sources at various scales and these can be combined with superimposed maps of fishing pressure. This provides the basis for linking habitat management to species management. Fish habitat maps are used in environmental and fisheries management in the United States (see https://www.habitat.noaa.gov/protection/efh), but this procedure has yet to be adopted in Europe. To make this possible, reliable and adaptive fish habitat maps need to be produced, including coastal areas and incorporating information on population structures and connectivity. Changes in species distribution are fundamentally changing natural and altered systems, and almost everything is changing at the same time. Thus, it is important that maps and information can be adapted to show these changes. Projected effects of climate change may be overwhelming, but this should not keep us from acting locally now, since the local effects on fish are obvious.

Klemens Eriksson (University of Groningen) presented the study on "Ecological consequences of a mesopredator release and habitat loss". The population of three-spined sticklebacks has increased 1000-fold as a result of reduced predation, for example by perch, which is overfished. Three-spined sticklebacks are now the most abundant mesopredators in coastal waters of the Baltic Sea. A full food web survey along the Swedish east coast revealed the connections between food web dynamics and species–habitat relationships. Sticklebacks heavily prey upon the grazers that usually keep filamentous algae under control. These algae now dominate coastal systems. Thus, overfishing of perch and other predators has led to fundamental habitat changes. Professor

Eriksson concluded that adopting an ecosystem approach is essential in order to understand change and decide on appropriate management measures.

Ingrid Tulp (Wageningen Marine Research) and presented a study entitled "Growth of four resident fish species in the Wadden Sea", which examined the links between decreasing trends in fish biomass and de-eutrophication. Using otolith archives of the resident species twaite shad (zooplanktivore), eelpout (benthivore), bullrout (piscivore) and thicklip grey mullet (grazer), the researchers found no indication that fish grow faster during periods of eutrophication; in fact for both sexes of most species the reverse was true. Everything is changing at the same time, which makes interpretation very difficult; the effects of confounding (and often collinear) factors such as temperature, season length and, especially, density dependence still need to be investigated. The carrying capacity and recruitment in the Wadden Sea should be a further focus of future research.

Glenn Wilson of the University of Southern Denmark in Odense reported on the use of otolith and body shape characteristics to provide insights into the recruitment dynamics of sand gobies along a restored Fyn coastline. During their short life span, gobies grow rapidly during a brief onshore interval (3–5 months). During this period, there is minimal change to external body structure, and metamorphosis appears to be a protracted process. Developmental complexity is particularly obvious in the otoliths, with substantial lateral variation among individuals. In the pelagic phase after their onshore period, the gobies are particularly vulnerable to changes to the habitat quality of the coastal water column.

In their talk "Preference, avoidance or coincidence? How nekton utilizes intertidal salt marsh creeks in the German Wadden Sea" **Julia Friese** and co-authors of the Institute of Marine Ecosystem and Fisheries Sciences (University of Hamburg) presented the results and conclusions of a recent research project on habitat utilization patterns of salt marsh creeks by fish (INTERFACE). The fish community is dominated by small fishes (larvae, juveniles and small-sized species), some of which utilize the marsh regularly. The species assemblage is subject to seasonal change, but there is a specific community that is characteristic of this habitat type. Altogether, the combination of shelter from predators, low flow velocities, clear water, ample food supply and high temperatures provides favourable conditions for growth and survival of for fish and crustaceans utilizing the marsh creeks.

Elliott Brown of DTU Aqua and co-authors investigated juvenile flatfish of Inner Danish waters, [by means of] association and growth as habitat suitability models. The researchers sampled and measured physical parameters of juveniles of the target species in a variety of near-shore habitats

and used abundance and growth as response variables to model habitat suitability. Together with the physical habitat parameters, the abundance and growth of the target species was visualized by means of interpolative maps. Habitat suitability could be successfully described in terms of the physical environment. Subsequent steps to improve descriptions of habitat suitability include an increase in temporal resolution and scale and the inclusion of mortality and the degree of connectivity between life-history stages as an additional response variable in the model.

The last presentation of Session 2 was given by **Katja Heubel** of the Research and Technology Center West coast (University of Kiel) and titled "Variation of reproductive decisions in fish along a natural gradient". After outlining the concept of environmental context dependence of reproductive life cycles and reproductive decisions, Dr. Heubel described her in-depth study into the behavioural ecology of sand gobies. Her main conclusion that reproductive decisions are affected by environmental context was supported by diverse observations: Nesting resources are limited by salinity; mating is affected by temperature, season, and social context; males are sensitive to temperature and reproductive value; females are sensitive to female competition; selective filial cannibalism is a male reproductive strategy; low salinity populations have different gonadal investment; and, finally, sex ratio affects clutch size, rate, success and mate choice. This somewhat intimidating variation, plasticity and context dependence in sand goby reproductive behaviour raises the question if effective and efficient management is possible at all.

Conclusions of the integrated discussion of session 2

- Don't be paralyzed by climate change, but act locally
- Areas too deep for rubber boots and too shallow for vessels need to be monitored
- Make use of fishermen's knowledge for interpreting monitoring data
- Promote habitat mapping and research into functional species-habitat relationships
- Combine field/lab experiments & models to test hypotheses coming from monitoring
- Consider (context-dependent) fish behavior
- Understand the biology is key for effective management
- Use existing/old data to test new hypotheses, apply new methods, synthesize and take a more integrative and holistic approach
- Exploit otoliths (microchemistry, microstructure, growth, genomics)
- Map essential fish habitats to provide a tool for spatial management
- Application of genomic tools for stock structure, population size/ bottlenecks, predator–prey relationships
- Translate habitat knowledge into management
- Research but also more emphasis on monitoring trophic interactions
- Identify hot spots for management intervention
- Promote adaptive management and use adaptive maps under changing conditions

Interactive breakout sessions

Wednesday, 25 September 2019, 13:00–15:00

Interactive breakout sessions were held on 1. Integrating monitoring for understanding fish life cycles, 2. Creating a knowledge community for future collaboration, 3. Organizing stakeholder engagement in the SWIMWAY process, 4. Initiating a trilateral research project – where to start and how to proceed. The chairs of the breakout session presented the results and conclusions to the audience.

1. Integrating monitoring for understanding fish life cycles

(chaired by *Katja Philippart* and *Britta Diederichs*, rapporteur: *Mikkel Jensen*)

PART A. What monitoring is required for evaluation of the targets of the SWIMWAY vision (as copied from the QSR2019 Fish chapter)?

Overall target: There should be no human-induced bottlenecks in the Wadden Sea affecting fish populations or their ecosystem functions.

Targets (all in reference to the overall target) are to maintain or improve:

Robust and viable populations of estuarine resident fish species. With respect to the definition, it should be clear what is meant with “robust” (able to withstand disturbances, e.g. by supplying enough space for recovery), “viable” and “estuarine resident fish species” (NB: possible changes in species composition should be taken into account). With respect to monitoring the progress in reaching this goal, the following variables were identified: i) Long-term time series (to detect long-term change), ii) Abundance monitoring (both numbers and biomass), iii) Population structure (e.g. age structure), iv) Growth, v) Demographic measurements (birth rates, mortality (fisheries & natural) and migration), vi) Habitats.

The nursery function of the Wadden Sea and estuaries. With respect to monitoring the progress in reaching this goal, the following variables were identified: i) Factors that provide nursery functions (e.g. food, lack of predators, temperature), ii) Abundance of young fish (e.g. age, numbers, biomass), iii) Habitat structure, iv) Size & morphology of the nursery areas (NB: also in the future), v) Stock – recruitment relationships, vi) Abundances in time (e.g. seasonality, phenology) and space, vii) Connectivity of areas within in the life cycle, viii) Growth, ix) Demographic measurements (birth

rates, mortality (fisheries & natural) and migration), xii) Between and within adaptability to environmental changes.

The quality and quantity of typical Wadden Sea habitats. With respect to the definition, it should be clear what a "typical habitat" is (NB: Most probably species and phase specific). With respect to monitoring the progress in reaching this goal, the following variables were identified: i) Habitats should be grouped & clustered according to their specific function (spawning, feeding, etc.), ii) Four-dimensional (horizontal, vertical & time), iii) Impact of anthropogenic activities should also be mapped, iv) Habitats should be identified as are natural or artificial (e.g. reconstructed), v) Connectivity between habitats should be identified/mapped (e. g. by means of stable isotopes, tracking, capture/recapture, etc.), vi) Factsheets for fish species, including their preferred habitats during different phase of their life cycles, vii) Detailed mapping of the area, not only indicating average values but also variability (e.g. the dynamics of an estuary might be more important than the estuarine gradient itself).

Passageways for fish migrating between the Wadden Sea and inland waters. With respect to monitoring the progress in reaching this goal, the following variables were identified: i) Migratory behaviour of fish (NB: not only within in fish passage ways, but also within their full lifecycle area), ii) Spatio-temporal resolution of monitoring should match with that of the migratory behaviour, iii) Comparison of observed vs. expected fish species passing and nearby the passage, iv) The design, operation & maintenance of fish passageways, v) Correlations between fish migrating via fish passageways and (large-scale) ecological phenomena.

Conservation of endangered fish species. With respect to monitoring the progress in reaching this goal, the following variables were identified: i) Because endangered species are rare, monitoring their abundance and distribution requires an additional monitoring system, ii) Non-destructive methods (e.g. eDNA), iii) Identification of historical drivers for becoming endangered, iv) Monitoring and present threats and developments in bottlenecks.

PART B. What is the time frame for establishing the monitoring required for evaluation of the targets of the SWIMWAY vision?

Efforts to improve monitoring should be aligned with political opportunities in order to gain maximum interaction. As a starting point, a calendar was compiled with main meetings and time frames of programmes and projects

and actions that could be taken when with respect to fish monitoring were identified.

2019: i) Sept: SWIMWAY Conference #1 (Hamburg), ii) Oct: TG_MA workshop on trilateral monitoring (in general), iii) Nov: Proposal and installation (if agreed by WSB) of Fish Expert Group, iv) Dec 3: Symposium on brackish waters (Leeuwarden).

ACTION: In addition to these activities, it is advised that a TMAP Parameter Group on Fish should be set up to help improve TMAP with respect to the SWIMWAY targets. Like the other TMAP parameter groups, this group should be led by three coordinators, one each from the three different countries. In contrast to the other groups, considerable work will be required to raise the capacity of this group to the level required for TMAP, and additional funding will probably be required to support this process (e.g. so that people can meet more often than once a year and be ready in time for SWC#2 in 2022).

2020: i) Publication of Special Issue of Fish (Estuarine & Coastal Shelf Science), ii) Additional (limited) budget expected for the trilateral SWIMWAY project, iii) German call for Applied Sciences (where trilateral SWIMWAY project might probably apply for funding), iv) May 16: World Fish Migration Day

2021: i) SWIMWAY Conference #2, ii) Trilateral Scientific Symposium, iii) Start of the UN Decade of the Ocean, iv) Start of the UN Decade of Restoration.

ACTION: In addition to these activities, it is advised that the newly established TMAP Parameter Group on Fish should present its proposal on improving TMAP with respect to the SWIMWAY targets during the 2nd SWIMWAY Conference. Based on the inputs from participants of this conference, a further prioritised and revised version should then be submitted as part of the "TMAP 2.0".

2022: i) Presentation of TMAP 2.0, ii) Trilateral Ministers Conference (including decision on TMAP 2.0), iii) Opening of Fish Migration River.

2023: i) Start of TMAP 2.0

2024: i) End of trilateral SWIMWAY project, ii) End of Dutch Swimway project, iii) International conference of Dutch SWIMWAY project

2025: i) Trilateral Scientific Symposium (including first results of TMAP 2.0)

2026: i) Trilateral Ministers Conference

ACTION: It is advised that this calendar should be available on the SWIMWAY website, possibly including other meetings such as those organised by large projects and in other relevant fields (such as Marine Spatial Planning).

PART C. How could the advice on the monitoring required for evaluation of the targets of the SWIMWAY vision be structured and organized?

In accordance with the concept of "Theory of Change", the monitoring program should start by identifying the indicators for the goals to be reached with respect to fish in the Wadden Sea area, being i) Indicators to evaluate the trilateral SWIMWAY targets, ii) Indicators providing the framework for a minimum package of measurements that Denmark, Germany and the Netherlands are obliged to carry out under national or European legislation or treaties (e.g. WFD, MSFD), iii) Indicators that are part of (often legally-forced) effect studies that are set up to examine the impacts of human activities that are potentially harmful (e.g. fisheries, dredging) or beneficial (e.g. restoration programs) for natural values (e.g. fish passages and restoration habitats).

Once the goals and indicators for the full pathway of change (e.g. indicators for all steps on the way from human activities to long-term goals) are identified, the list of required data should be checked against available data and possible gaps in data and knowledge (e.g. dose-effect relationships) made explicit. Gaps in knowledge should be filled by additional research, gaps in data by additional monitoring activities. Monitoring should be part of an adaptive program, where results are regularly used to evaluate the progress in reaching the goals.

In addition to the above advice, it was stressed that i) The continuation of existing fish monitoring programs should be promoted, ii) Understanding of monitoring by civil servants should be enhanced, iii) Fish monitoring should be interconnected with monitoring of other parameters in TMAP (and beyond), iv) Open up relations with general public, for support of the work and the results, but also for help in getting the data ("citizen science"), v) Help scientists to come up with pragmatic suggestions for the use of monitoring in management of the trilateral Wadden Sea area, vi) Make sure that everybody knows who is responsible for what, and explore who could take up additional roles (e.g. NGOs in bridging gaps between science and society).

2. Creating a knowledge community for future collaboration

(chaired by *Paddy Walker* and *Morten Søby Frederiksen*, rapporteur: *Lena Holtmanns*)

Eleven participants from policy, science and management backgrounds participated in this breakout session, which addressed the key question of how to collaborate and exchange knowledge. The discussion focused mainly on what we understand by knowledge, means of communicating knowledge, and the identification of actors whose involvement in knowledge exchange is important for the creation of a knowledge community. The following aspects were discussed:

1. Demand-driven knowledge
    - theoretical (talk) <-> practical (go and look) → education
    - pumping stations: modernization → use practical experience of other places
    - local communities work together: make information exchange part of the process
2. Documentation of what data / information are there
    - go across the border: Netherlands, Germany, Denmark
    - managers, politicians etc. usually have no time to read scientific literature, making high quality of summaries/conclusions crucial for communication with theses stakeholders
3. Make time for exchange of information
    - "scientific language": scientific publications often cannot be understood by managers – invest in 'translations' for non-scientists
4. Make scientific language understandable
    - can a portal help?! → questions from non-scientists and answer tailored to purpose by scientists (bulletin board)
    - bibliography for publications
5. Opportunities offered by Integrated Management Plans
    - cooperation between managers
    - geographic orientation (databases)
    - politicians → local view (local = fishermen, scientists, managers, locals)
    - 'persuade' policy / ministry to work trilaterally
6. Creating a knowledge network
    - creating a network, link people with others → everybody has a "Hinterland"

- carry out a network analysis:
  1. Form a core of people
  2. Link them to people they know
  3. Identify key players and influencers in the knowledge community
- in the Netherlands there are already meetings with scientists, managers and translators / communicators with regard to SWIMWAY
- in Denmark: when managers need advice, they ask scientists (independent sources, e.g. Universities)

7. Make use of existing networks

- Marine Science Coordination Centre → representatives for everybody
- Identify the role of the Wadden Sea Board in the knowledge community, e.g. the Network group for sustainable tourism (Wadden Sea Board) which has an expert group (core) < - > network group and is broader than scientists

8. How do different 'disciplines' affect each other (e.g. fisheries and tourism)

- Look globally as well as trilaterally to learn from successes in other areas
  - make use of historical information, no "reinventing the wheel"
  - Google scholar is not the only possible source
- need for bibliography (→ Horizon 2020 (funding))
  → but, better and more specific than Google scholar

Four main issues were identified:

- We are looking at different spatial scale of exchange of knowledge, i.e. local vs. trilateral
- Knowledge is often required 'on demand' and the time to organize and structure the knowledge, or carry out research is not always available. Information and expertise might be available elsewhere. This needs to be facilitated
- We should look for a common 'language' - both in a literal sense (German, Danish & Dutch) as well as in communication that is tailored to the audience (fit for purpose)
- Confidentiality of knowledge can be a bottleneck to exchange, as not all knowledge is freely available

Potential collaborations are:

- Driven by focus and question: for example, solutions for a particular type of sluice or development of a Wadden Sea fish atlas.
- Dependent on identification of the connectors (key persons or key functions)

Future actions:

Create a SWIMWAY online forum: start with a searchable bibliography – initially per estuary – and upgrade to portal in time.

- Identify the SWIMWAY core of people, carry out network analysis and identify connectors (nodes) who will be influential in future activities.
- Use EU funding for cooperative projects

3. Organising stakeholder engagement in the SWIMWAY process

(chaired by *Martha Buitenkamp* and *Henrik Pind Jørgensen*, rapporteur: *Helene Gutte*)

The purpose of the breakout session was to get an overview of how stakeholder management in the three countries is organized and to come up with recommendations. The SWIMWAY Vision encompasses four pillars: research and monitoring, policy, measures and education/communication. Participants were asked to list the organisations currently involved in implementation of each pillar. The list is far from complete; not all organisations involved were known to members of the breakout group. Results are presented in Table 1 and discussed below.

Research and Monitoring. In Denmark, monitoring is executed and coordinated by the NOVANA programme on behalf of the government. Fish are generally not considered in the current version of the programme, but this topic is expected to be included in the next update. Bycatch of non-commercial species is registered on board by fishing vessels.

Four universities have been contracted to develop science-based management and to undertake strategic and ad-hoc research, including in the Wadden Sea. This process is well structured and well organized. Citizen-science research projects are being developing, with members of the public involved in taking e-DNA “pictures” of species present at specific times at specific locations, reporting the occurrence of alien species, as well as general monitoring of coastal fish and other species.

Table 1: List of organizations per country involved with SWIMWAY for four pillars of the SWIMWAY Action Programme.

Activity	Denmark	Germany	Netherlands	Trilateral
Research & monitoring	Ministry of Environment, DTU Aqua, DCE Aarhus University Should be involved: Amateur/recreational fishermen; citizen Science; professional fishermen	LAVES, Thünen Institute, NLWKN, AWI, Senckenberg am Meer, HZG, Universities of Hamburg, Oldenburg and Kiel (FTZ Büsum), National Park administrations and competent ministries of federal states	Fishermen, producer organisation, Ministry of Defense (NATO), RWS (government), Sportvisserij (sport anglers), RUG, WMR, NIOZ, Vissers van de Kust, Ministry Food, Nature, Agriculture, Citizen Science	Trilateral Task Group Management, Ad-hoc Working Group SWIMWAY, Common Wadden Sea Secretariat
Policy	Ministry of Food and Environment Hearing Process including stakeholders	National Park administrations and competent ministries of federal states German Fisheries Association	Municipalities Provinces (3) Ministry of Agriculture and Nature, nature organisations, water authorities, NGOs (conservation, fishery, agriculture)	Ministerial Declarations (trilateral), Wadden Sea Board (WSB)
Measures	Government Agencies Municipalities Restoration Projects, Farmers, Different Level of Fishermen, NGOs Marine Stewardship Council (MSC)	NLWKN Sielachten Port Authorities National Park Authorities, LLUR	Fishing Management Plans, harbours, water management plans, community of practice inform and consult each other. Two-way communication	
Education & communi-cation	CWSS National Ministries Municipalities, NGOs	Nature Information Centres Fishermen and Ferry Companies, NGOs	UNESCO World Heritage, IVN, Ecomare, IWSS, Conservation NGOS Waarneming.nl	Common Wadden Sea Secretariat, International Wadden Sea School, Network Group Education

In the Netherlands, there are a number of research activities, but they compete for funding and so effective cooperation is hard to achieve. Fish are largely missing from the Dutch government's basic Wadden Sea monitoring programme. The Demersal Fish Survey (DFS) comprises one of the longest time series of demersal fish data in the world; it has a good spatial resolution, but no seasonal resolution. At present, there are no citizen science or volunteer data collection initiatives underway.

In Germany, three federal states are responsible for their own part of the Wadden Sea. The Thünen Institute is responsible for the Demersal Young Fish Survey (DYFS), LAVES organises fish monitoring in transitional waters to meet the demands of the EU Water Framework Directive. So far, there is no institutional framework for knowledge exchange among the different organizations involved, although some knowledge exchange takes place at the level of projects.

At the trilateral level, some of the groups operating in each country participate in the trilateral cooperation; however, NGOs are poorly represented in trilateral projects. It was noted that there was scope for increased involvement of NGO's, volunteers, producer organizations, citizens and fishermen in trilateral cooperation. This would provide increased access to data, knowledge and funding and promote public involvement.

Policy. Policy issues are mainly dealt with by governmental bodies. Ways of influencing policies were not discussed during the breakout session, but this is a topic that deserves more attention. Not all parties were well represented in the trilateral Wadden sea forum. Shipping authorities and fishermen were missing, for example.

Measures. Many (regional and local) organisations are connected at the project level, but it is unclear if they feel as part of a larger SWIMWAY Wadden Sea approach.

Communication. In Denmark the Wadden Sea National Park, municipalities and to some extent the Nature Agency, supported by the IWSS and CWSS, are the principal organizations involved in communication and education activities. There are two major permanent information centres in in Denmark, the Vester Vedsted Centre and The Fisheries and Maritime Museum in Esbjerg. Although information centres are expensive, in Germany a lot of work is done via exhibitions and information centers. In the Netherlands, there is mainly project-related communication.

As fish in their natural environment are not very visible or "huggable", it is more difficult (compared to birds or mammals, for example) to make use of them in communication messaging, for example by telling stories about

individual animals to communicate the wider picture. In this respect, aquariums with shallow-water basins could play a vital role in bringing this semi-cryptic species group to public attention.

The Trilateral Communication Strategy of the Common Wadden Sea Secretariat comprises separate strategies for Communication and Education, but SWIMWAY is not explicitly mentioned in either of them. Session participants advocated a Trilateral Common SWIMWAY Communication Strategy or at least incorporation of SWIMWAY into the existing Trilateral Communication Strategy, as a framework for developing other, specific communication strategies.

4. Initiating a trilateral research project – where to start and how to proceed (chaired by *Adi Kellermann* and *Andreas Dänhardt*, rapporteur: *Rebecca Christiaanse*)

A SWIMWAY project has recently been launched in the Netherlands (2019–2024, NIOZ, WMR and University Groningen, supported by the Wadden Fund), incorporating many excellent approaches to improve knowledge of Wadden Sea fishes, habitats and other features relevant to SWIMWAY. A German/Danish project should seek to be complimentary and try to make use of the data and insights produced by the Dutch SWIMWAY project. Since fieldwork of the Dutch project is limited to the Wadden Sea, one option, discussed by participants, would be for a German/Danish project to complement the Dutch research by investigating exchanges with the rivers and the wider North Sea, and features of the “cuescape”.

One idea for a follow-up project would be to produce an interactive map of bottlenecks to inform decisions on how to reduce adverse effects of anthropogenic bottlenecks. Such a tool could help management agencies to identify mitigation measures, for example, by highlighting the need for more fish-friendly solutions for passages across sluices, or for measures to reduce other sources of anthropogenic fish mortality. As well as being a direct cause mortality, bottlenecks may also affect survival rates of fish indirectly. These could include processes that create poor growth conditions in particular areas, anthropogenic aggregations of marine organisms that attract predators, or physical (horizontal and vertical) obstacles to migration on various spatial scales (e.g. between habitat patches and between hatching/spawning grounds, or between nurseries and feeding areas). In addition to anthropogenic bottlenecks, there are also natural or administrative bottlenecks, the latter mostly in the heads/minds of individuals (including researchers). Efforts to achieve the trilateral fish targets by pursuing the SWIMWAY approach, should

take all three types of bottlenecks (natural, anthropogenic and administrational) into account.

Is the science–management relationship driven primarily by a top-down 'pull' from management side (i.e. managers asking for better science) or by a bottom-up push from science (i.e. scientists demanding better management)? During the discussion, it became clear there is a need from the management side for decision support tools to provide a scientific basis for informed decision-making.

There is a need for focused field studies and projects that adopt new approaches, methods, and evaluation criteria to analyse existing data. These should take account of aspects/stressors not previously considered, such as sand extraction, nutrient inflows, etc.. In addition, there is a need for data mining and new perspectives on historical data, for example in the light of shifting baselines due to climate change.

A valuable data source may be the TMAP. The current review and revision of the TMAP provide an opportunity to harmonize research programmes to provide complementary inputs for an improved reinforced fish monitoring and research programme. The resulting data should be collected in a Wadden Sea fish database to be made available for various purposes.

More ideas on project topics were formulated during the conference summary. They are listed below.

Thematic Session 3: Life cycles (Swimways), connectivity and bottlenecks

Wednesday, 25 September 2019, 15:00–18:15, chaired by Adi Kellermann

In the keynote talk for theme session 3, **Axel Temming** of the Institute of Marine and Fisheries Sciences of Hamburg University and co-authors reported on more three decades of research on one of the keystone species of the Wadden Sea, the brown shrimp. Their talk, "Migrating to essential habitats through mortality bottle necks: the complex interactions of shrimp live stages, predators and the fishery", provided insights into the biology, ecology and exploitation of the species. Insights on these topics are urgently needed e.g. for management, but largely missing for most fish species. During the well-known life cycle of the brown shrimp, several, and in most cases interacting bottlenecks were of biological origin. Growth potential, mortality and the variability in these traits are high, and the tides are used for migrating/drifting into favourable areas. Winter recruitment is essential for life cycle and, since winter predation by gadoids has decreased, it also benefits the fishery. The presence of large populations of marine mammals keeps the stocks of predators of brown shrimp stable at a low level, so that the fishery is now the most important source of adult brown shrimp mortality. Thus, the main bottleneck today is possibly the winter fishery, especially when the fleet exploits aggregations, which can have profound effects on entire year classes. Even after decades of research, the complexity and interactive and non-linear nature of shrimp life cycle still leaves researches confused – but on a higher level.

Henk van der Veer of NIOZ presented results on the "Life cycle of some North Sea flatfish species: The role and importance of the Wadden Sea (past, present, future)". Data from the last four decades showed that the survival from egg to larval phase is less than 0.1% p. a. and that there is a positive relationship between size of the nursery area and population size. Mortality rates of flatfish in the Wadden Sea are, not lower than in the adjacent coastal zone and growth of flatfish in the coastal zone is just as fast as in the Wadden Sea. The good news is, that despite climate change, the Wadden Sea is still suitable for some species and some age groups, and that conditions are even improving for sole. The bad news is, that the Wadden Sea has become less important in the life cycle of flatfish, that dab and most III-,,II- and I-group

plaice have disappeared from the Wadden Sea, and flounder numbers have also decreased.

Olivier LePape (Agrocampus Ouest, University of Rennes) presented research from the western channel on "Estimating life-cycle connectivity of an exploited marine fish: implications for management". Combining different methods, the researchers found low connectivity at larval and juvenile stages, using IBMs and nursery maps, respectively; while tagging, genetics, and otolith analyses revealed that connectivity between stocks occurs at the adult stage. Integrating the stage-specific findings in a life cycle model revealed that interpretation depends on assumptions on stock structure (i.e. whether there are one or more local stocks).

Karen van de Wolfshaar of Wageningen Marine Research and co-authors presented their study "Sole growth and survival under climate change conditions using a Dynamic Energy Budget model, parametrized for North Sea sole under four IPCC scenarios until 2040 for six nurseries". The model output suggested that under these scenarios sole end up bigger, but survival goes down under IPCC scenarios assuming earlier spawning. The importance of the nursery habitats decreases, because emigration is size-dependent, and it is early spawning that matters for life cycle closure. Given the lack of seasonal resolution, current monitoring programmes are unsuitable for tracking these kinds of hypothetical developments.

Laura Wichmann and co-authors from the University of Hamburg presented preliminary results of the study "Distribution and growth of European glass eel stocked in the eastern German Baltic Sea". Atlantic eel suffered a massive recruitment decline in the 1990s and has decreased by 99% since 1970. It is classified as Critically Endangered by the Red List and 'outside safe biological limits' by ICES. Stocking usually takes place in freshwater where there are many obstacles to migration and high parasite loads are common. The study asked whether the alternative practice of stocking on the coast would be more successful. Since artificial reproduction is still not possible, recruits for stocking have to be taken from other natural systems (Biscay), where eels are also endangered. Between 2014 and 2016, 1 million glass eels were marked with Alizarin, with a mere 400 recaptured with different gear. One result was that marked eels were larger than unmarked conspecifics.

In his second contribution to the conference, **Jeroen Huisman** of Van Hall Larenstein University of Applied Sciences and co-author presented their study "Measures to improve fish migration at pumping stations, sluices and tide gates". There are about 500 pumping stations in tidal locations in Lower Saxony, 380 in Schleswig-Holstein and ca. 60 in the Netherlands. Measures to

support fish migration are installed at most Dutch locations (in some cases funded by the Wadden Fund), in ca. 10 locations in Lower Saxony and 5 in Schleswig-Holstein. The speakers presented some examples of fish bypasses, and concluded that the best opportunity for installing structures to facilitate fish migration in a dam or sluice is during the initial construction. Changing things afterwards is difficult to impossible. Most dams and sluices are 40–50 years old and will soon have to be renewed. In order to make sure that they are rebuilt in a fish-friendly fashion, a review is urgently needed of the current setup and planned reconstructions, so that appropriate modifications can be proposed.

Also in their second presentation, **Elliott Brown** of DTU Aqua and co-authors presented their study "Otolith chemistry: Discriminating between hybridising con-familials and contiguous, coastal juvenile fish habitats". Plaice, sole and flounder in Skagerrak and Kattegat were used as model organisms. The study found significant differences in trace element composition of co-habiting juvenile plaice and flounder otoliths and showed that these were causes by differences in either physiology or small-scale habitat use. Otolith chemistry could be an effective tool for tracing juvenile habitat contributions to adult fisheries of plaice and sole, and it remains an effective tool for differentiating between juvenile habitats where they exist continuously along open coasts. Moreover, the analysis of otolith microchemistry might provide the link between habitat suitability models and fisheries modelling.

In the final talk of session 3, **Patrick Polte** of Thünen-Institute of Baltic Sea Fisheries and co-authors presented their study "Contribution of coastal nursery areas to the Western Baltic herring (*Clupea harengus*) population". To identify chemical signals of coastal juvenile habitats and to quantify their contribution to the adult population, otolith elemental fingerprints were measured. Specific chemical otolith signatures could be assigned to certain juvenile areas, and inshore nurseries for WB-herring could be defined by otolith chemistry. The contribution of juvenile areas varied between years (e.g. Greifswald Bay and Warnow River Estuary contributed most in 2016). The effects of regional stressors on coastal nursery areas are rapidly transmitted to the population level.

Conclusions of the integrated discussion of session 3

- Windows of opportunity should be identified and used to initiate research and measures
- Close the knowledge gap about the role of shallow waters in fish life cycles
- Accept that climate change will affect fish in the Wadden Sea
- Use biomarkers (e. g. otolith chemistry) to trace back “Swimways”
- Consider drift, behavior and adaptation
- Put emphasis on technical solutions to mitigate bottlenecks
- Connectivity: incorporate scientific knowledge into management advice
- Combine research of different species to track “Swimways”
- Know your baseline
- Consider moving baselines
- Make use of historical fishery data to investigate “Swimways”

Thematic Session 4: Policy

Thursday, 26 September 2019, 09:00–12:00, chaired by Paddy Walker

In the keynote talk for Thematic Session 4, **Mike Elliott** of the University of Hull and co-authors presented their study "A systems analysis approach for integrated management to protect estuarine and coastal fish communities: accommodating natural and human features". Systems analysis can provide insights problems and their impacts on ecosystem structure and function. It can be used to support management by analysing the likely effects of proposed solutions (good governance, stakeholder involvement) and identifying potential bottlenecks, showstoppers and train-wrecks. System analysis can generate a recipe for integrated marine management, applying the DAPSI(W)R(M) (Drivers, Activities, Pressures, State change, Impacts on human welfare, responses and measures) approach. We now have good examples worldwide of good and bad practice. It is essential to undertake a thorough risk and opportunity assessment and to manage these risks, and ensure good water conditions, ecological well-being, and environmental conditions that are fit for maintaining connectivity. Estuarine and catchment management measures have to be implemented together, and initial cost-effectiveness and cost-benefit analyses need to be carried out. Poorly defined long-term vision, objectives and definition of success can be a problem — but even if there was a good long-term vision, would anyone do anything if it was not met? Goals and targets must be SMART (specific, measurable, achievable, realistic and timely). If they are not SMART, there is no point in pursuing them.

In their policy analysis of the SWIMWAY Wadden Sea Fish Targets, **Beno Koolstra** of Koolstra Advies and co-author analysed relevant legislation and management frameworks and found that the status of fish populations is not used as a criterion for environmental quality assessment or taken account of in the definition of Good Environmental Status. Knowledge of fish ecosystem requirements is limited: more complete knowledge of Wadden Sea fish communities and more precise definitions of restoration targets are needed, as well as a review of threatened species and causes of population declines. Major threats are known, but their impacts are not. The most important causal relations are still unknown, which means there is incomplete knowledge of how the fish targets can be achieved, and this in turn makes it difficult to formulate an effective policy to achieve the stated goals. Current policy can be an effective instrument in realising the Fish Targets, but we have to find out what the policy and legislation must regulate. This calls for research

specifically aimed at identifying the bottlenecks that hinder achievement of the Fish Targets.

Hans-Ulrich Rösner and **Eva Lages** of WWF Wadden Sea Office presented an overview of "Bottlenecks for fish in the Wadden Sea region". Many fish species formerly common to the Wadden Sea region have disappeared, even though the Wadden Sea is strictly protected. Why have the fish gone and where are the bottlenecks? There are natural bottlenecks that cannot and should not be managed, and anthropogenic bottlenecks that need to be managed, provided they are relevant to fish population dynamics. Anthropogenic bottlenecks that are relevant include underwater noise, dredging, dumping, fisheries, migration barriers and habitat loss. Of these, the latter three are probably the most important for fish populations. Thus, fish protection should focus on regional drivers that can be managed: removing barriers blocking migration, restoring habitats, and taking measures to make shrimp fishery sustainable.

Jutta Leyrer and co-author from Naturschutzbund Germany (NABU) discussed "The importance of long-term monitoring programmes for implementing nature conservation policy". Monitoring is a prerequisite in order to know what is going on, but just identifying problems is not enough. In the case of the Dutch cockle fisheries, the obvious decline in populations of cockle-eating birds was not enough for the responsible court dealing with the charge of conservation NGOs. Scientific research on foraging ecology was required to provide definite proof of the impacts of fisheries bird populations in order for the court to order the closure of the fishery.

In other example, dredging the Elbe shipping channel was shown to be connected to documented steep declines in smelt abundance and numbers of breeding pairs of common terns breeding at Neufelder Koog in the lower Elbe estuary. The court decided that dredging should be allowed to continue, subject to continuing monitoring of environmental impacts. However, researchers are still struggling to determine procedures for measuring the effects of the dredging on the Wadden Sea mudflats. These two examples suggest that monitoring should go hand in hand with research to establish scientific, legally valid proofs of environmental impacts.

Paddy Walker of Tethys Advice and co-authors presented "Swimway [to the] the Marine Strategy Framework Directive [using] tope shark as case study". It became evident that although there are signs of recovery in the population of tope shark, available data are insufficient to meet the requirement for descriptors, criteria and indicators of the MSFD, and 'Good Environmental Status cannot currently be confirmed due to lack of knowledge. For elasmobranchs, Good Environmental Status corresponds to a situation where

the species concerned has the ability and opportunity to complete its lifecycle and is thus able to sustain itself in the face of the stressors it encounters.

Finally, **Gesche Krause** of Alfred Wegner Institute and co-authors presented "Insights from the INTERNAS project on linking management and governance recommendations from global environmental assessments to national realities". Focusing on the gap between international measures and application in the national context, the INTERNAS project used thematic stakeholder workshops to take up key terms and concepts in digitized ontologies. Using this approach, a range of appropriate implementation strategies of international assessments for the German political context were identified. Recommendations summarized in the document "Protection and sustainable use of the German North Sea and Baltic Sea – measures for an ecological enhancement" address key issues such as the reduction of species and habitat loss, implementation of an ecosystem-based approach to marine resource use in German waters, and measures required to achieve sustainable management and use of marine space, alignment of fisheries with sustainability goals. These results demonstrate the potential of machine-assisted knowledge transfer for promoting action towards achieving the UN Sustainable Development Goals.

The integrated discussion of session 4 was centred on the question of how to make the trilateral fish targets SMART and yielded the following conclusions

- The new targets suggested in the current QSR are not officially adopted by the WSB. This is confusing and could be remedied by having the revised targets (Tulp et al. 2017, QSR 2017) adopted. In a second step, they should be made more specific.
- During discussion of the targets the QSR authors came to no conclusion due to fundamental knowledge gaps
- There is more to success than SMART targets, but SMART targets are prerequisite for measuring success
- SMARTer targets would not automatically be more successful. If targets are too smart they become too specific, which may not help in implementing them.
- It must be clear how the targets are used, and for whom they need to be made SMART
- If the targets are intended to guide monitoring and research, they have to be SMART

- Instead of asking what is actually hindering passageways, look at the societal side and ask why we are not successful, why do the problems prevail? We need to know interests why passage ways are not open, identify socio-economic drivers, barriers and opportunities which potentially affect targets (positive and negative) and identify scope for action/intervention
- Take birds as role model, e.g. by aiming at a fish habitat directive as legal instrument
- At present too many policies and decisions are based on emotional responses and not on facts and evidence. To keep emotions out of decision making, generic overarching goals are needed which everybody can agree upon
- Targets need to be SMART enough to be implemented in legislation, but more knowledge is needed to make targets truly SMART
- One very important target would be a population size needed for long-term viability
- A four level approach appears feasible: 1) formulate generic, overarching goals everybody can agree on, 2) specify these into more specific SMART targets, 3) develop a technical implementation plan, and 4) take immediate action to protect fish while specifying the targets.

Conference summary

Thursday, 26 September 2019, 12:00–12:30

Josianne Støttrup and **Mike Elliott** summarized the main conclusions of the conference and moderated the following discussion, in which all conference participants took part. Key takeaways from the wide-range of topics addressed at the conference were summarized as a set of bullet points:

The Wadden 'C' Take-home Message
The present and future of SWIMWAY

- Complete cooperation
- Critical conditions
- Critical components
- Critical connections
- Carrying capacity
- Cumulative consequences
- Climate change
- Constant change
- Combining competencies
- Checking competence
- Community communication
- Connectivity, connectivity, connectivity!!!

Two major issues became particularly evident during the conference. **One** is that science–policy integration is lacking, due in part to problems of language and terminology. Scientists could facilitate and influence dialogue with policy makers by going back to storytelling to improve communication and get their messages across. This should be relatively easy as politicians and the general public are (or should be) aware of their importance of fish and fisheries-related topics. Despite this, we need to have more focus on "fish", to get the support required for their protection and to make them part of management targets. This may still be difficult, because fish are not always explicitly considered by EU environmental Directives. For example, they are

included in the Water Framework Directive for the Transitional Waters but not for Coastal Waters; while they may be identified as a 'conservation interest feature' under the Habitats and Species Directive (e.g. eels, lampreys, salmon, and shads).

The **second** problem is agreeing on goals for improved scientific knowledge and use of science in management. In this respect, it is essential to improve our mechanistic understanding of processes such as trophic interactions. A good starting point could be re-examine existing monitoring data from different perspectives, using it to ask new questions and test new hypotheses ('*collect once, use many times*'). This review of available data would also make knowledge gaps more visible. Support tools for evidence-based decision-making are readily available, such as multi-layer GIS systems and Decision Support Systems. In addition, there is a plethora of monitoring schemes and indicators for natural resource management. The central question is how to make best use of available tools, and there were many good suggestions made during the conference.

The central tenet of coastal/estuarine science and management is 'connectivity' – among areas, countries, scientists, populations, habitats, species, disciplines, agencies, legal instruments, etc. This includes the important goal of linking responses to global climate change to the local perspective. This has to be done now, because change is evident everywhere and everything is changing at the same time. For this purpose, monitoring, modelling, experiment and fieldwork need to be combined. In this endeavour, there is already good ongoing collaboration between Germany and the Netherlands, but Denmark should try to become more active and involved. As connectivity has been identified as the most important concept in the entire system, other adjoining countries (e.g. Belgium, France, UK) should also not be ignored.

An important issue that requires more attention in the future is bioeconomics. Given the importance accorded to economics (including 'blue growth') and human welfare in environment decision making, bioeconomics needs to be brought in earlier to increase societal acceptance of the science needed for management initiatives in coastal and transitional waters. Making natural science and bioeconomic issues equally visible from the start would likely enhance public acceptance of fish protection measures.

The Major Points

A wealth of insights and recommendations at the meeting can be distilled into **six key recommendations** to facilitate progress by SWIMWAY towards the goal of implementing the trilateral fish targets.

1) In order to understand and manage Wadden Sea systems, we always need to be clear about where we are going (the aims and objectives of our work) and what we are trying to detect or demonstrate. Scientists and managers usually want to act immediately, but we should make sure we spend sufficient time thinking before acting (and remember *the 80/20 rule*: 80% of the effects come from 20% of the causes; e.g. 80% of information and understanding comes from the first 20% of the time spent thinking about a problem).

2) We have to realize that some of our species and environments are fragile systems, whereas others, such as estuaries, are robust. For each system, we need knowledge of it resistance (i.e. capacity to withstand pressure) and resilience (i.e. ability to recover from perturbations) in response to different pressures. Thus, critical pressures and the resulting spatial and temporal effects (footprints) need to be identified and understood. We need to accept that certain pressures emanate from within the management system (such as polluting discharges) whereas others come from outside (such as temperature and sea-level rises). The former can be addressed by local management whereas the latter require global management. In particular, we have to accept two major challenges confronting scientist and scientific endeavours: *moving baselines* and *unbounded boundaries*. Populations and communities are affected by local human activities, but superimposed on these effects are others caused by global changes (in temperature, acidity etc.). Similarly, the populations in an area may be affected not only by local human activities but also by human activities at other places where they spend part of their life cycle. For example, eel populations in NW European estuaries are affected by pressures arising both from human activities in those estuaries and in the catchments and/or at sea.

3) Science needs to be of high quality and fit for purpose, to ensure its results are reliable and its outputs are respected. Our research, like all scientific work, should start by setting out the 'big ideas' we are interested in, and then present our specific objectives, formulated as hypotheses that can be rigorously tested. The objectives for our science and management endeavours should be SMART (specific, measureable, achievable, realistic and time-bounded), otherwise it is not possible to gauge when they have been achieved. Similarly, meaningful quantitative indicators are essential for measuring progress towards defined goals.

4) There is the need to use the best available science and management techniques, including both new and classical techniques; making use, for example, of ecological information on species and their natural history, traits analysis, biomarkers, eDNA, AI-machine learning, community ecology and populations dynamics. Field and laboratory experiments are needed to supplement surveys and test hypotheses. Models should be used rigorously to infer reference conditions and future change, as models are only as good as the system understanding that underpins them. Modelling procedures can range from empirical modelling to explain observed patterns to deterministic or stochastic scenario testing.

5) We need to make use of the best available knowledge and avoid the DRIP (data-rich, information-poor) pitfall. We need to integrate the natural and social sciences in order to consider the links between physico-chemical conditions, habitat, ecology and society and identify natural or socio-economic bottlenecks that may be operating in a wider context than fish life cycles. For example, in addition to ecological bottlenecks, there may be others whose origins lie in physics, in response and management, or in people (what or who is it that is stopping something from occurring?). Thus, it makes sense to link natural sciences (including the aims and knowledge bases of ecohydrology and ecoengineering), social sciences and economics in order to understand the entire network in which bottlenecks may occur. In addition, various stakeholders from different networks may play a role as resources and/or influencers.

6) An appreciation of the interface between science, policy and management is required in order to identify which knowledge and which science are needed and determine how to make them usable for management purposes in an efficient and (cost-)effective way. Thinking “outside the box” will help to identify frameworks relevant for research and monitoring goals, such as the UN Decade of Oceans and Ecosystem Restoration 2021–2030. For example, there is a need to enhance the role of education, e.g. by bringing school pupils into the debate (in the next SWIMWAY conference?) and ensuring that natural science students are familiar with social sciences and vice versa. We should not only talk with the like-minded, but rather reach out to others.

The way ahead and the need for future science and management

- The meeting participants were asked what they would do with 5 million Euros to improve the situation for fish. These are the suggestions:
- Create habitat maps as first layer to put others on top. A SMART target could be *to produce ten maps for ten species in the next ten years*

- Then add fish distribution, sea level rise, temperature and climate change scenarios
- Map the seabed: an aim of UN Decade of the Ocean (2021–30) is to map the ocean. D, DK and NL will have to discuss how to do this, and we need to say we want to include the Wadden Sea
- Similarly, 2021–30 see the UN Decade of Ecological Restoration – many habitats and populations need restoring as a concerted plan of action
- Create maps to identify and mitigate bottlenecks along fish life cycles: Bottlenecks: what, when, how?
- Create species fact sheets for fish to summarize which information (e. g. on recruitment, mortality, life cycle sensitivity, cuescapes, etc.) is already there and what is missing to build meaningful models and scenarios
- Fact-sheets could be linked to habitat and bottleneck maps, for which the online fish atlas of Heiko Brunken might be a suitable platform to use and further develop
- Consider the historical perspective to derive future target scenarios where conservation and development should be heading. Historical information will be crucial to address the shifting/moving baselines phenomenon
- Education should be emphasized within the SWIMWAY activities. A target could be that Wadden Sea issues would be included in school curricula within the next ten years. (However, WWF has been trying just that for the last 10 years without success.)
- Organize lobbies to press the EU to enact a Fish Directive? (Although this might run contrary to 'the ecosystem approach'!)

Three concrete project ideas were suggested:

1) Bottleneck maps. For this, data on habitats (including sea floor), fish distribution, stressors, physico-chemical parameters and climate change scenarios are needed
2) Species interactions (another year of the stomach?): focus on flagship species
3) Research and define historical references on fish in the Wadden Sea to identify and consider shifting/moving baselines in setting targets and goals

Reference to the SWIMWAY action programme

The SWIMWAY action programme was formulated and adopted as a means of achieving the trilateral fish targets (see www.waddensea-worldheritage.org/node/738). The core activities of the SWIMWAY programme are: Supporting and initiating **research and monitoring**, analysing relevant **policies**, identifying feasible **measures** that can be taken to improve the situation of fish in the Wadden Sea, engaging relevant **stakeholders** at the earliest possible stage, and promoting fish through **communication and education**.

The SWIMWAY conference contributed towards progress in all of these closely related fields.

Research and monitoring

Several talks at the conference addressed *flagship species* with a prominent role in the Wadden Sea's fish assemblage, including flatfish such as plaice, dab and sole, the pelagic schooling species sprat, herring and smelt, as well as sharks and rays (which, although much less abundant, are also flagship species).

Several studies presented new knowledge on natural *predator–prey relationships*, e.g. between terns and fish. Others identified and discussed anthropogenic sources of mortality at different stages of the life cycle, including dams and sluices, and fisheries-related *mortality*. A special case was the hypothesis outlined in one of the studies that meteorological anomalies (strong and persistent easterly winds) during the breeding season 2018 cut off food supply for seabirds.

Several talks and sessions discussed how *fish physiology* determines the limits of adaption to climate change. The paramount role temperature plays for fish physiology was reiterated in several presentations and the concept of cues was introduced as means of understanding how fish perceive and utilize their environment. Responses to cues and habitats are the main drivers of spatial and temporal distribution of fish. Where this distribution overlaps with anthropogenic stressors, it can potentially give rise bottlenecks in the life cycles of fish.

Habitat mapping was identified as a crucially important approach to support management of fish populations in the Wadden Sea. Habitat maps, it was shown, could serve as a baseline on top of which other layers can be stacked

(e.g. on distribution of fishing vessels, dredging and dumping sites, physical obstacles to swimways and any other spatial plans). One of the most important outcomes of the conference was the recommendation to adopt the concept of essential fish habitat, which is already widely applied in the United States (see www.fisheries.noaa.gov/topic/habitat-conservation). However, with the notable exception of saltmarsh creeks, knowledge about species–habitat relationships in the Wadden Sea is still very fragmentary. Incorporating habitat ecology as a focus of research and management will facilitated by cooperation with researchers working in other coastal systems (e.g. ICES WGVHES, https://www.ices.dk/community/groups/Pages/WGVHES.aspx).

There were few presentations that did not address *life cycle connectivity,* either directly or indirectly. Several studies provided specific examples — such as brown shrimp, flatfish in the Wadden Sea and English Channel, and diadromous fishes (passing or getting stuck at sluices) — of how, despite considerable progress made in recent years, there are still fundamental knowledge gaps that hamper the identification and application of effective conservation measures.

One such knowledge gap concerns the identification of suitable *indicators* for monitoring change reliably enough to be used as the basis for formulating management measures. Many indicators have been proposed, including numerical abundance and biomass, age and size structure, growth and condition, demography (birth rates, natural mortality, fisheries mortality, and migration) and habitats. For these variables to function as meaningful indicators, they have to be thoroughly calibrated against change in the environment. Using existing monitoring and research data may be the right way to go and provide a means of identifying knowledge gaps that need to be filled through focused, hypothesis-driven research.

Policy

The policy session provided a rich overview of the field and many informative examples of how SWIMWAY issues are dealt with elsewhere. By placing the complex issues involved in implementing the trilateral fish targets into the international context, such an overview is an essential aid to identifying political bottlenecks and feasible options for addressing them. The presentation of an inventory of existing policies and regulations at European, trilateral, national and regional levels provided valuable insights on how to proceed. In this respect, insights gained from the INTERNAS project (www.awi.de/en/science/special-groups/eskp-english-version/internas.html) might prove particularly helpful.

Measures

Presentations to the conference made it clear that much can already be done now using current knowledge to make progress towards the trilateral fish targets. However, it is also evident that much basic knowledge is still missing, hampering focused and effective protection of fish life cycles. Fish conservation measures are being implemented here and there, but we do not have sufficient knowledge to undertake a comprehensive assessment of their success or failure. The conference participants agreed that setting up a web-based service as a platform for identifying, collecting and visualizing bottlenecks in fish life cycles will be an essential step towards re-establishing and/or safeguarding the connectivity of fish life cycles. As an example of the kind of research that is needed, desktop study from the late 1990s investigated how fish migration across sluices can be facilitated along the Lower Saxon Wadden Sea coast (Brunken 1999, in German, drive.google.com/file/d/1INn-zM5G_j4tVH23_-vqKRJot-hZKkFZ/view?usp=drive_web).What is needed now is a Wadden Sea-wide inventory of physical bottlenecks such as sluices, dams and weirs, including a timeline for their renovation, in order to identify opportunities to make these structures fish-friendly. However, conference participants noted that bottlenecks in fish life cycles include not only physical barriers, but also other causes of mortality such as fisheries bycatch, and suboptimal conditions for growth and survival. Conference participants stressed the importance of identifying all anthropogenic bottlenecks as a starting point for developing and implementing appropriate measures to improve and preserve connectivity. Mapping habitats was identified as a another essential step towards understanding spatial and temporal patterns of fish distribution, and a prerequisite for making bottlenecks visible and devising measures to mitigate them.

Stakeholders, communication and education

The concept of bottlenecks is not only a useful concept for identifying ecological obstacles within fish life cycles. It can also help elucidate the political, administrative, economic and other societal circumstances that make it difficult or impossible for fish to close their life cycles. Identifying and involving stakeholders the earliest possible stage will facilitate implementation of measures to achieve the trilateral fish targets. The conference was attended by participants from a range of institutional backgrounds, including academics, representatives of government agencies, and conservation NGOs, fishermen and consultants. This demonstrated the potential value of conferences as a means of informing a wide range of stakeholders about science and conservation initiatives and promoting their participation. However, it was notable that no politicians were present at the conference and a striking conclusion of the education and communication session was that

politicians are apparently not aware of the SWIMWAY programme. Changing this situation is one of the many challenges facing the programme in the coming years. Notwithstanding the absence of this important stakeholder group, the high-level presentations and lively discussions made a valuable contribution towards raising awareness amongst stakeholders (those present and also, hopefully, others subsequently informed about the conference by attendees), and towards engaging them in the work of the programme and inspiring them to take action. The conference also contributed towards fostering international partnerships, dialogue and cooperation. In this respect, proposals for joint research projects and the establishment of a permanent Fish Expert Group were particularly welcome. Several presenters, including the conference keynote speaker, argued that the SWIMWAY conference should not be an isolated event, but rather a start of a series of conferences on the topic. Provided that there are financial and human resources available, future conferences and other similar events will have an important role to play in enhancing communication and facilitating collaboration among different stakeholder groups, including scientists.

Next steps and utilization of conference outcomes

Next steps

- Keep the SWIMWAY capable of acting by installing a permanent fish expert group with carefully selected members and well-defined terms of reference
- Stakeholder analysis: Whom to integrate, why and when?
- Cooperative research projects
- Taking immediate action on the basis of available knowledge
- Linking SWIMWAY to other programs and knowledge communities
- Increase visibility and public outreach to generate support for the SWIMWAY aims

The **next steps** to improve the situation for Wadden Sea fish should be evidence based and carefully balanced between **taking immediate action** making best use of available knowledge and, in parallel, seeking to **fill knowledge gaps** by initiating focused, **hypothesis-driven research**. For conservation initiatives to be successful conservation, the most important tasks are to analyse the results of monitoring in order to provide legally valid, scientific proof of environmental impacts, and to translate knowledge into management.

During the conference, the next steps towards fulfilling the SWIMWAY Vision and Action Programme (implementing the trilateral fish targets) became much clearer. At the same time, the tremendous amount of work required and the need to for joint efforts to achieve this aim also became obvious. One of the most important insights gained from the discussions at the conference was a workable way to make progress towards implementing the trilateral fish targets. It was widely agreed that the trilateral fish targets adopted by the ministers in 2010 are not SMART (specific, measurable, achievable, realistic and timely) in their present form. There is more to success than SMART targets, but if the targets are intended to guide monitoring and research, they have to be SMART. At present too many policies and decisions are based on emotional responses and not on facts and evidence. To keep emotions out of decision-making, generic overarching goals are also needed, in addition to testable targets, in order to define goals that everyone can agree on.

Conference participants agreed that the most feasible approach to achieving the fish targets is to first state the big ideas, then specify their meaning in the form of rigorously testable objectives and hypotheses. A three-level approach was suggested to SMARTen the targets: 1. The trilateral fish targets adopted by the conference of ministers in 2010 should be maintained. Generic as they are, everybody can agree that they should be implemented. 2. Provide concise definitions on what is meant by the generic targets (see the summary of breakout session 1 for specific suggestions and recommendations for how to proceed in this respect), at a level of detail sufficient for the formulation of testable hypotheses. 3. Use these concise definitions to formulate research questions and hypotheses, as the backbone for dedicated, hypothesis-driven, cooperative and interdisciplinary research. This level of SMARTness is a prerequisite for addressing key issues in calls for proposals or other means of allocating research funds to where they are most needed. Monitoring and research should integrate of all relevant stakeholder groups as early as possible in the process and the outcome should be widely communicated and used in education (targeting schools, universities, politicians, etc.). Given the dynamic nature of the ecosystem with its moving baselines, a ongoing, iterative revision of all three steps is essential to ensure management is sufficiently adaptive. Figure 1 below summarizes this process and the following section described the 'next steps' against this background.

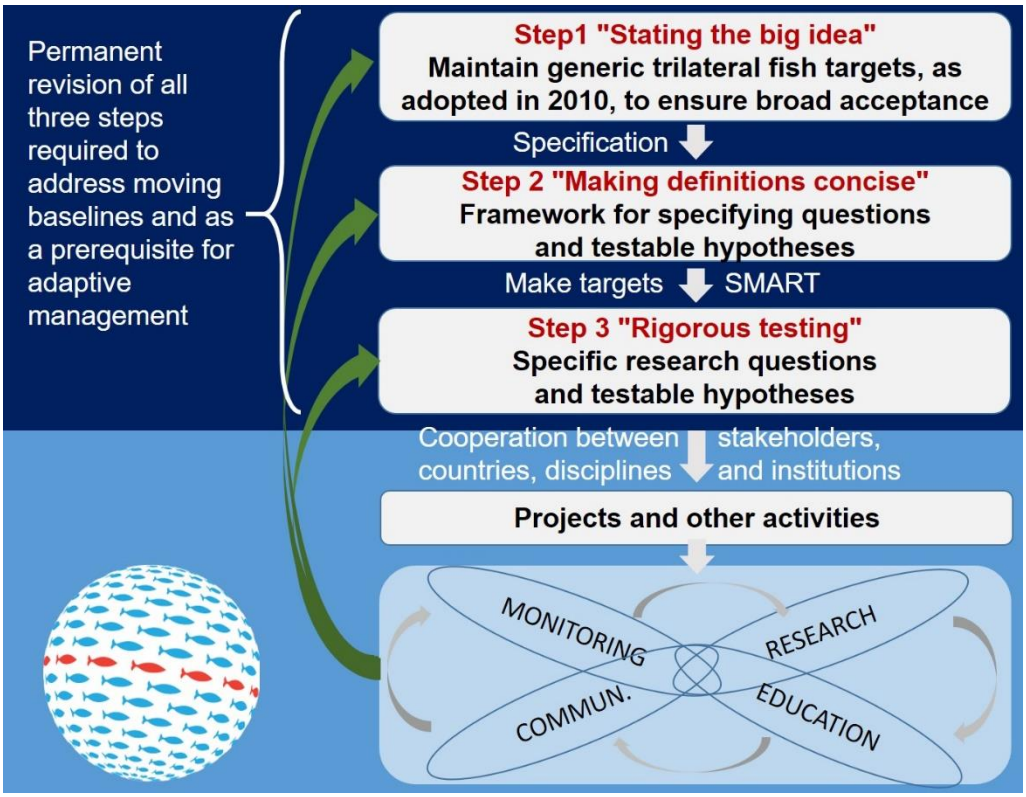

Figure 1: Sequence and interdependence of steps to implement the trilateral fish targets.

The most important next step, which will have a profound effect on all subsequent steps, is the installation of a **permanent Fish Expert Group** to oversee the process in the long term. Given that SWIMWAY is already established as a kind of brand, the new group should keep this name. The terms of reference as well the composition of this group can be deduced from the list of future tasks. Installing a permanent SWIMWAY Wadden Sea group would in itself represents a key step forward towards implementation of two other important recommendations from the conference: to involve all relevant stakeholders at the earliest possible stage and adopt connectivity as an overarching principle (in the sense of scientific interdisciplinarity, but also with respect to different stakeholders, collaboration with other groups such as ICES working groups, and adoption of a holistic life cycle and ecosystem approach to implementing the fish targets).

The discussions during the conference clearly showed that earliest possible **integration of** all relevant **stakeholder** groups is a key to the successful creation of 'effective' knowledge that can be taken up by managers and in legislation. Thus, a thorough stakeholder analysis should always be an integral part of designing research projects and represents an important next step for future SWIMWAY work.

Closely related to the previous two steps and the most important deliverable for 2019 is the initiation of **cooperative projects**. Several research topics were identified during the conference:

1. Mapping: It is essential to obtain detailed information on the spatial and temporal extent of overlap of fish life cycles, anthropogenic threats and impacts. Thus, the first project should be to create **multi-dimensional bottleneck maps**. Size and distribution maps of fish habitats can be constructed from spatial information on various scales and sources, including fishermen's knowledge. Habitats should be grouped and clustered according to their specific function (e.g. for spawning or feeding), and connectivity between habitats should be identified/mapped to capture the entire habitat mosaic relevant for the focal species and life stages. With fish habitat maps as the first layer, maps of other features relevant to closing the fish life cycle can be superimposed. These can be classified as natural (physical environment, predators) and anthropogenic (climate change, underwater noise, dredging, dumping, fisheries, migration barriers and habitat loss). From the resulting "stack of layers", bottlenecks within fish life cycles can be identified as a first step towards finding ways to mitigate them. Natural bottlenecks cannot and should not be managed; anthropogenic bottlenecks need to be managed, provided they are relevant to fish population dynamics. Of these, fisheries,

migration barriers and habitat loss are probably the most important. These stressors are regional or even local in extent and can be managed, e.g. by removing barriers blocking migration, by restoring habitats and by making the fishery sustainable (e.g. through reducing bycatch by technical means). More intangible types of bottlenecks can also be addressed, e.g. those arising from management, legislation and economic interests. We need to ask what or who is it that is causing a bottleneck, and what factors are responsible for its persistence? Identifying bottlenecks is the first step towards determining the causal processes involved, whose interests are served by the processes leading to anthropogenic bottlenecks, and the socio-economic drivers that potentially affect them (both positively and negatively) — as well as identifying opportunities for getting rid of them.

Applying the framework of essential or critical habitat successfully used elsewhere (www.habitat.noaa.gov/protection/efh), this approach will establish an important link from habitat to species to management. It will facilitate translating habitat knowledge into management actions, identifying hot spots for management intervention, and promoting adaptive management required under changing conditions.

Since such a project will need to have a focus on species. Species fact sheets for fish should summarize both existing information (e.g. on recruitment, mortality, life cycle sensitivity, cuescapes, etc.) and knowledge gaps. These will provide inputs for building meaningful models and scenarios as an additional deliverable. Fact sheets should be interactive, adaptive and linked to academic (research institutions and projects), applied (EIA, authorities) and citizen science (e.g. Beach Explorer).

2. Species interactions: Another suggested research project would focus on species interactions and, in particular, trophic relationships of flagship species. Fish should be viewed both as predators/consumers (year of the stomach) and prey (for mammals and seabirds). The core questions addressed in the SWIMWAY programme (North Sea–Wadden Sea exchange, feeding hot spots, hiding places from bad weather) are also the key to understanding seabird ecology.

3. Historical references: The historical perspective is valuable for the definition of targets for where conservation and development should be heading. Historical information, e.g. on former occurrence and abundance of species and habitats, will play a crucial role in addressing the shifting/moving baselines phenomenon. Historical reconstructions will require and can potentially serve as models for interdisciplinary research, bringing together historians, biologists, and managers. However, lack of previous experience of this kind of collaboration and incomplete mutual understanding of methods

and concepts applied by other disciplines represent barriers to the design and implementation of this kind of interdisciplinary endeavour. .

Parallel to initiating cooperation and preparing project proposals, **immediate action should be taken on the basis of available knowledge.**

Presentations to the conference highlighted that there are windows of opportunity for making the numerous dams, sluices and other obstacles along the Wadden Sea coast more fish-friendly. The best opportunity for measures to make these structures permeable to fish again can be included is when they are scheduled for reconstruction or renovation; whereas installing fish passages in dams and sluices while they are operational is very difficult. Thus, an important, potentially urgent next step is to produce an **inventory of dams and sluices,** including information on plans to rebuild them, timelines, and possible measures that could be taken to make them fish-friendly. For the latter, a **best practice guide for making dams and sluices fish-friendly** should be compiled by competent experts.

Another proposal presented to the conference, as a way of mitigating the DRIP (data-rich, information-poor) pitfall affecting some fish monitoring programs, is to **harmonize and reanalyse existing monitoring data**. This could yield new insights and interpretations, which might also be facilitated by making systematic use of fishermen's knowledge. The review and reanalysis of existing monitoring data, but from different perspectives, asking new questions and testing new hypotheses ('*collect once, use many times*'), might also be a good starting point for improving the mechanistic understanding of processes. This is a prerequisite for agreeing on goals for the greater understanding of science and the better use of science in management.

All of the activities described above require or will benefit from closely linking SWIMWAY to other programs and knowledge communities. With regard to the projects described above, considerable effort should be allocated to establishing strong links with at least the following programs and frameworks.

As encouraged by the conference keynote speaker Prof. Lochte, the main objectives of two upcoming United Nations 'decades' (2021–30), i.e. the Decade of Ocean Science for Sustainable Development and the Decade on Ecosystem Restoration, should be scrutinized for their potential for synergy with the SWIMWAY concept. The trilateral countries would be responsible for communicating with the relevant UN bodies and discussing ways that the SWIMWAY program in the Wadden Sea could contribute the two UN decades. It seems clear that SWIMWAY has the potential to contribute towards the

UN's overall aim of reversing the global decline in ocean health, including by improving the state of fish populations.

The newly formed **German Marine Research Alliance (Deutsche Allianz für Meeresforschung, DAM**) seeks to support sustainable use of the sea through research, infrastructure and knowledge transfer. Producing knowledge ready for application and transferring it to where it is needed is at the core of the DAM philosophy and everyone seeking support from this institution is required to demonstrate that their research meets this criterion. Specific mission statements are currently under development, among them one on the protection and sustainable use of marine areas. They will be published early 2020.

In the Wadden Sea, the SWIMWAY initiative is one of three framework programs incorporating research to improve conservation. The conceptual framework for SWIMWAY was adopted from the **Flyway initiative**, which is several years ahead in its development and implementation. Thus, the activities of Flyway may serve as a role model for implementing the SWIMWAY strategy, which in turn, should serve as an umbrella for the trilateral fish targets.

Finally, the **trilateral research agenda,** when finalized, should be SMARTly linked to the other framework programs, in order take advantage of the potential for synergies and, as far as possible, avoid duplication of effort.

Finally, measures to **increase public visibility and** engaging in **outreach work to generate support for the SWIMWAY aims** are essential means towards the goal of raising awareness of fish conservation. A top priority should be to make SWIMWAY much more visible to the public, to authorities and politicians, for example (in the intermediate to long term) by presenting research results in the form of interesting and exciting stories unfettered by scientist jargon. Activities that offer a playful approach to the topic of fish can also bring people to think and talk to each other about fish. A step that can and should be taken immediately is to merge Dutch and trilateral SWIMWAY activities, both to avoid confusion and to make efficient use of our combined resources.

Appendix

a. Programme & Book of Abstracts

Welcome

We are excited to welcome you to the first SWIMWAY conference on understanding connectivity within the life cycles of coastal fish, which takes place at Haus der Patriotischen Gesellschaft in Hamburg, Germany.

During the conference, participants enthusiastic about fish in the Wadden Sea and other coasts will gather to present and discuss drivers of fish populations utilizing coastal marine environments during their ontogeny, identifying potential bottlenecks throughout the life cycle and, eventually, evaluating current management measures.

Organised by the Trilateral Wadden Sea Cooperation´s SWIMWAY Group in cooperation with the Common Wadden Sea Secretariat, the event welcomes scientists, managers, policy makers, NGOs and other stakeholders concerned with fish in coastal areas to contribute. Exchanging and connecting knowledge and expertise between diverse experts and stakeholders will form a pivotal part of the meeting. A workshop and interactive breakout sessions will allow identifying fields of collaboration, expanding and organising knowledge and ensuring long-term engagement of relevant stakeholders.

This SWIMWAY conference is one of a series of events to celebrate the 10th anniversary of the Wadden Sea World Heritage Inscription in the year 2009.

Happy Birthday UNESCO Wadden Sea!

#happywaddensea

Funding

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Information

SWIMWAY conference Planning Committee

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Paddy Walker, Tethys: Aquatic Ecosystem Advice, NL
Morten Frederiksen, Environmental Protection Agency, DK
Adi Kellermann, SWIMWAY group coordinator, D
Julia A. Busch, Common Wadden Sea Secretariat, trilateral

Venues

Conference venue
Haus der Patriotischen Gesellschaft (SAALHAUS GmbH)
Trostbrücke 4-6
20457 Hamburg

Dinner venue
Fischerhaus
St. Pauli Fischmarkt 14
20359 Hamburg
Dinner payments can still be made at the conference registration desk

Guided tour: Hamburg – twelve centuries, slightly shortened

The guided tour will start on Thursday, 26 September 2019, at 1400 local time at Hamburg townhall (main entrance, 5-minute walk from the conference venue) and will end three hours later at the concert hall Elbphilharmonie.

Registration and Help Desk

The conference desk is the central information point for the SWIMWAY conference. Do not hesitate to contact our staff and local organisers in case you need kind words, information or any other assistance. To get in contact with the organisers, please write to info@kellermann-consultants.de

Social Media

Please follow us on Twitter and tag us
@WaddenseaUNESCO
#SWIMWAY2019
#happywaddensea

During the conference, our student supporters will be equipped with blackboard and chalk. Note your wish for SWIMWAY or 10th anniversary birthday greetings to the Wadden Sea World Heritage, take a picture and post it on twitter, Facebook, Instagram by referring to @WaddenseaUNESCO, #SWIMWAY2019, #happywaddensea

Oral presentations

Please register at the registration desk and upload your electronic presentation file (ppt, pptx or pdf) in the morning, latest during the coffee break before your session. Our staff at the registration desk will be happy to assist you.

Poster presentations

Please setup your poster as soon as possible. A note on the poster wall will indicate the space reserved for your poster. Please remove your poster before 1300 on 26 September. Our staff at the registration desk will be happy to assist you.

Session wrap-up

Each of the thematic sessions will be wrapped up afterwards, but not the conventional way. The little experiment we have in mind to capture the main findings, conclusions and lessons learned from each session requires the collaboration of our guests. Details will be given at the conference.

Breakout sessions

There will be four parallel interactive breakout sessions on Wednesday covering the SWIMWAY themes, which you can sign up for when you register at the conference. In small groups, focussed discussions will be organised on

1) Integrating monitoring for understanding fish life-cycles
2) Creating a knowledge community for future collaboration
3) Organising trilateral stakeholder engagement in the SWIMWAY process
4) Initiating a Trilateral project – where to start and how to proceed

All who are interested and like to get involved in these topics are cordially invited to sign up at the registration desk and participate.

Special issue in Estuarine, Coastal and Shelf Science

The Elsevier Journal "Estuarine, Coastal and Shelf Science" has been one of the major outlets for research in coastal ecosystems for many years. We are very pleased to announce that contributions made to the SWIMWAY conference in Hamburg will be published as full papers in a Special Issue of ECSS. All presenters of the SWIMWAY conference are invited to submit their contribution as full paper in a special issue of Estuarine, Coastal and Shelf Science. The submission portal is now ready for submissions:

www.evise.com/evise/faces/pages/oversight/Oversight.jspx?_adf.ctrl-state=g07s3null_175

As an author, please indicate "VSI: Life cycle connectivity" as article type. Editor in Chief will be Prof. Mike Elliott, guest editors will be Dr Josianne Støttrup, Dr. Andreas Dänhardt, Dr. Jeroen Huisman and Prof. Britas Klemens Eriksson, managing guest editor will be Dr. Paddy Walker. For further assistance visit the Elsevier Support Center or contact the guest editors.

Guided City Tour: Hamburg – twelve centuries – slightly shortened

The guided tour will start on Thursday, 26 September 2019, at 1400 local time at Hamburg townhall (main entrance) and will end three hours later at the concert hall Elbphilharmonie. Hamburg is looking back on 1200 years of history – starting as a fortified Saxon trading post and evolving into a leading member of the Hanseatic League in the Middle Ages the city today is one of the world's major ports and a bustling economic and cultural centre.

On this guided tour we will see, where it all began and how Hamburg became what it is today. Why fire played such an important role in the city's evolution. And why Hamburg's Old Town is relatively young indeed. We are starting at the marvellous Town Hall near the Alster lake, passing the forgotten harbour of Hamburg, a cathedral that is no church, old warehouses and their imperial successors – the Speicherstadt –, moving on to the ultra-modern HafenCity and we're ending on the Plaza of the celebrated Elbe Philharmonic Hall or Elbphilharmonie.

This walk with a professional guide will take ca. two and a half hours with a visit of the public areas of the Hamburg Town Hall and the Elbphilharmonie. We are hoping for a sunny autumn day, but please do check the weather forecast in advance and dress accordingly as most of the tour will take place outside.

Minimum number of participants is 8, maximum is 30. The guided tour will cost 20 Euro per person, to be paid cash to the guide. Please register before 15 September 2019. Spontaneous participation may be possible if there are places left. Please ask at the registration desk.

Programme

24 September 2019

Time	*Presenter*	*Event/ Title*
1100	Arrival & registration	
1200-1215	**Adi Kellermann** (SWIMWAY-coordinator), **Andreas Dänhardt** (conference organizer)	Welcome & opening
1215-1230	**Klaus Janke** (Director National Park Hamburg Wadden Sea)	Welcome address
1230-1300	**Karin Lochte** (Trilateral Wadden Sea Board and German Marine Research Alliance)	Conference keynote: Of fish and frameworks
Theme session 1: Monitoring and data		
1300-1345	**Katja Philippart** (NIOZ, Royal Netherlands Institute for Sea Research, The Netherlands)	Session keynote: Concepts and clues for monitoring fish migration
1345-1400	**Ingrid Tulp, Loes Bolle, Andreas Dänhardt, Pepijn de Vries, Holger Haslob, Niels Jepsen, Jörg Scholle, Henk van der Veer** (Authors fish chapter Quality Status Report)	Long-term developments in Wadden Sea fish: the results from the latest Quality Status Report
1400-1415	**Jeroen Huisman** (Van Hall Larenstein University of Applied Sciences, The Netherlands)	Results and lessons of 17 years of monitoring at the tidal fish pass Roptazijl (The Netherlands)
1415-1445	Coffee break	
1445-1500	**Wouter Courtens, Robin Daelemans, Hilbran Verstraete, Nicolas Vanermen, Marc Van de Walle & Eric W.M. Stienen** (Research Institute Nature and Forest, Belgium)	100.000 otoliths later: insights in forage fish dynamics in space and time based on a seabirds' diet
1500-1515	**Bo Poulsen** (Aalborg University, Denmark)	Resurrecting the dead and forgotten. Examples of past marine ecosystem components in the Waddensea and beyond
1515-1530	**Wouter van der Heij** (Waddenvereniging, The Netherlands)	SWIMWAY, a flyway approach to marine conservation and management
1530-1545	**Veit Hennig** (University of Hamburg, Germany)	Dynamics of the young-of-the-year Fish communities in the Schleswig-Holstein Wadden Sea and the Elbe Estuary and their importance for predators
1545-1615	Keynote, chair & rapporteur	Wrap-up and conclusions TS 1
1615-1645	Coffee break	
1645-1845	**Anja Szczesinski** (World Wide Fund for Nature, Germany)	Workshop on education, communication and ocean literacy
1845-1900		1-minute poster presentations
1900-2100		Poster session

25 September 2019

Time	*Presenter*	*Event/ Title*
Theme session 2: Fish habitats		
0900-0945	**Josianne G. Støttrup, Elliot J. Brown & Alexandros Kokkalis** (DTU Aqua, Denmark)	Session keynote: Marine fish habitats – the link between environmental and fisheries management
0945-1000	**Eriksson, BK., Yanos, C., Donadi, S., Hansen, J., Sundblad, G., Bergström, U., Eklöf, J.S.** (University of Groningen, The Netherlands, Stockhom Univeristy and Swedish University of Agricultural Sciences, Sweden)	Ecological consequences of a mesopredator release and habitat loss
1000-1015	**Loes J. Bolle, Ruben Hoek, Ineke Pennock Suzanne Poiesz, Henk W. van der Veer , Johannes IJ. Witte, & Ingrid Tulp** (Wageningen Marine Research & NIOZ, The Netherlands)	Growth of four resident fish species in the Wadden Sea in two periods contrasting in eutrophication level and temperature
1015-1030	**Glenn Wilson** (University of Southern Denmark, Odense, Denmark)	Otolith and body-shape characteristics provide insights into the recruitment dynamics of sand gobies (*Pomatoschistus minutus*) along a restored Fyn coastline
1030-1100	Coffee break	
1100-1115	**Julia D. S. Friese, Axel Temming, and Andreas Dänhardt** (University of Hamburg, Institute of Marine Ecosystem and Fishery Science, Germany)	Preference, avoidance or coincidence? How nekton utilizes intertidal salt-marsh creeks in the German Wadden Sea
1115-1130	**Elliot J. Brown, Alexandros Kokkalis, Josianne G. Støttrup** (DTU Aqua, Denmark)	Habitat association models and habitat growth models for juvenile fish of the inner Danish waters
1130-1145	**Katja Heubel** (University of Kiel, Research and Technology Centre, Germany)	Variation of reproductive decisions in gobies along a natural gradient
1145-1200	Keynote, chair & rapporteur	Wrap-up and conclusions TS 2
1200-1300	Lunch	
1300-1430	**Breakout sessions (parallel)**	1. Integrating monitoring for understanding fish life-cycles, 2. Creating a knowledge community for future collaboration, 3. Organising trilateral stakeholder engagement in the Swimway process, 4. Initiating a Trilateral project – where to start and how to proceed
1430-1500	Chairs & rapporteurs	Reporting on breakout sessions

25 September 2019 continued

Theme session 3: Life cycles (Swimways), connectivity and bottlenecks		
1500-1545	**Axel Temming** (University of Hamburg, Institute of Marine Ecosystem and Fishery Science, Germany)	Session keynorte: Migrating to essential habitats through mortality bottlenecks. The complex interactions of shrimp live stages, predators and the fishery
1545-1600	**Henk W. van der Veer, Loes Bolle, Ingrid Tulp, Suzanne S.H. Poiesz** (NIOZ, Royal Netherlands Institute for Sea Research & Wageningen Marine Research, The Netherlands)	The role and importance of the Wadden Sea in the life cycle of some North Sea flatfish species
1600-1615	**Olivier Le Pape, Marine Randon, Jean Baptiste Lecomte, Etienne Rivot, Elodie Réveillac** (Agrocampus Ouest, Department of Ecology, France)	Estimating life cycle connectivity of an exploited marine fish: implications for management impacts
1615-1645	Coffee break	
1645-1700	**Karen van de Wolfshaar, Leo Barbut, Genevieve Lacroix** (Wageningen Marine Research, The Netherlands)	The fate of juvenile sole growth and survival in coastal nurseries under climate conditions
1700-1715	**Laura Wichmann, Björn Kullmann, Jens Frankowski, Ralf Thiel** (Institute of Fisheries, State Research Center for Agriculture and Fisheries & University of Hamburg, Center of Natural History, Germany)	Distribution & growth of European glass eels stocked in the eastern German Baltic Sea
1715-1730	**Jeroen B. J. Huisman, J. & Oliver-D. Finch** (Van Hall Larenstein University of Applied Sciences, The Netherlands & NLWKN, Germany)	Measures to improve fish migration at pumping stations, sluices and tide gates in the Netherlands and Germany
1730-1745	**Elliot J. Brown, Patrick Reis Santos, Bronwyn M. Gillanders, Josianne G. Støttrup** (DTU Aqua, Denmark, University of Adelaide & University of Sydney, Australia)	Using otolith chemistry to discriminate between hybridising confamilials and contiguous, coastal juvenile fish habitats
1745-1800	**Dorothee Moll, Klaus Peter Jochum, Paul Kotterba, Lena von Nordheim, Tomas Gröhsler, Patrick Polte** (Thünen Institute of Baltic Sea Fisheries, Max-Planck-Institute for Chemistry, University of Rostock, University of Hamburg, Germany)	Contribution of an inshore nursery area to the Atlantic herring (*Clupea harengus*) population in the Western Baltic Sea
1800-1815	Keynote, chair & rapporteur	Wrap-up and conclusions TS 3
1930-	**Conference Dinner at Fischerhaus, St. Pauli Fischmarkt 14, 20359 Hamburg**	

26 September 2019

Thursday, September 26th		
Time	***Presenter***	***Event/ Title***
Theme session 4: Marine Policy		
0900-0945	**Mike Elliott** (University of Hull, Institute of Estuarine & Coastal Studies, United Kingdom)	Session keynote: A systems analysis approach for integrated management to protect estuarine and coastal fish communities: accommodating natural and human features
0945-1000	**Zwanette Jager and Beno Koolstra** (Ziltwater Advies & Koolstra Advies, The Netherlands)	A policy analysis of the Swimway Wadden Sea fish targets
1000-1015	**Hans-Ulrich Rösner & Eva Lages** (World Wide Fund for Nature, Germany)	Bottlenecks for fish in the Wadden Sea Region
1015-1030	**Jutta Leyrer & Kim Detloff** (Naturschutzbund Deutschland (NABU), Germany)	The importance of long-term monitoring programmes for implementing nature conservation policy
1030-1100	Coffee break	
1100-1115	**Paddy Walker, Alina Hillinger & Bree Taylor** (Van Hall Larenstein – University of Applied Sciences; Dutch Elasmobranch Society, The Netherlands)	Swimway and the Marine Strategy Framework Directive: the tope shark as case study
1115-1145	**G. Krause, A.-K. Happe, C. Wolf, K. Raab, J. Hauck, J. Scheve, P.L. Buttigieg, K. Jax** (Alfred-Wegener-Institut Helmholtz Zentrum für Polar-und Meeresforschung, SeaKult – Sustainable Futures in the Marine Realm Consulting, Helmholtz-Zentrum für Umweltforschun, CoKnow Consulting, Germany)	Linking Management and Governance Recommendations from Global Environmental Assessments to National Realities: Insights from the INTERNAS project
1145-1200	Keynote, chair & rapporteur	Wrap-up and conclusions TS 4
1200-1230		Summary and closing of the conference
1400-1700	Christian Meyer-Pedersen	Guided Tour through historical Hamburg: Hamburg – twelve centuries – slightly shortened: A guided tour from Town Hall to Elbe Philharmonic Hall

Book of Abstracts

Conference Keynote
24 September 2019, 12:30 – 13:00

Of fish and frameworks: Crafting the evidence base for implementing the Leeuwarden Declaration and the Trilateral Research Agenda and contributing to the United Nations Decade of Ocean Science for Sustainable Development

Karin Lochte, *Chair of the Trilateral Wadden Sea Board and managing board of the German Marine Research Alliance (DAM), D*

The Trilateral Wadden Sea Cooperation between the Netherlands, Denmark and Germany considers research on fish as an important issue and, therefore, this theme is anchored in the framework of The Leeuwarden Declaration and is a major part of the Trilateral Monitoring and Assessment Programme. The theme is also part of our Trilateral Research Agenda, which needs to be further elaborated in the coming year. The conference can develop ideas and provide input to this Research Agenda. We are in a time when many environmental themes in the marine environment receive increased public attention. Coordinated national research-initiatives in Denmark, Germany and the Netherlands in this context would contribute to UNESCO 2021 to 2030 Ocean Research Decade for Sustainable Development. This chance must be used! Sustainable fish stocks are globally important to safeguard this important protein source for future generations. The research in the Wadden Sea is only a small part of a large picture; it must be embedded in a much wider thematic and international context. When it comes to biological interaction, we need to consider linkages between benthos and plankton, between rivers, coastal areas and offshore sea, between regions along the swim way of fish species and must look at the impacts of climate change. The state of fish stocks in the Wadden Sea is perhaps better known compared to other regions, however, the QSR also indicates problems and much more work needs to be done to improve understanding of fish dynamics, human impacts and conservation measures. These and other topics will be discussed in this conference, but we should not view this conference as a singular, isolated event. Rather, we should take the chance to make it an initiation for future collaboration. Implementing the SWIMWAY vision and developing it further is an ambitious task that can only be achieved through concerted action at least on a trilateral level, but preferably also by exchanging knowledge, experience and dedication with other research communities. Scientists and research institutions from the three Wadden Sea states and further afield are invited to join forces to improve conservation of the Wadden Sea World Heritage. National funding and EU funding should be combined to support joint proposals. The German Presidency (2018-2021) of the Trilateral Wadden Sea Cooperation supports the development of an international and effective research agenda.

Theme Session 1: Monitoring and data

24 September 2019, 13:00 – 16:15

Information and data from long-term monitoring programmes are fundamental for both the structuring of research programmes, as well as for evaluating management measures. The Trilateral Monitoring and Assessment Programme (TMAP) pursues the goal to provide scientific evidence to support decisions on management and policy development for the Wadden Sea. It also provides an evaluation of the progress towards the trilaterally set targets of the Wadden Sea Plan and facilitates the discussion on future priorities. This work is described in the Quality Status Report and plays an important role in the Swimway approach in order to establish research priorities with respect to the Trilateral Fish Targets. This session will both explore how the current monitoring programmes contribute to our understanding of dynamics of Wadden Sea fish stocks in relation to patterns in population variability, and how research can supplement monitoring data to identify ways for effective conservation and management.

Session Keynote: Monitoring and data

24 September 2019, 13:00 – 13:45

Concepts and clues for monitoring fish migration

Katja Philippart, *Royal Netherlands Institute for Sea Research (NIOZ), NL*

The strong decline in Wadden Sea fish since the 1980s has called for action to strengthen local fish stocks. Proposed measures include the reduction of fishery activities, the restoration of natural dynamics in habitats and the improvement of the connectivity between marine and freshwater areas for migratory fish. Identification of the effectiveness of such measures requires long-term field observations of local fish stocks and the most relevant environmental conditions. Such monitoring is essential for finding the best practices of present measures, for potentially allowing modifications in original measures to optimize the investments made, and for more adequate future investments. With respect to passages for migratory fish, for example, such a program should include measurements of the efficiency of the attraction flow guiding the fish towards the passage, the success of entering the passage, the efficiency of the fish migrating through the passage and the fate of the fish hereafter. Because the behavioral response of a fish with respect to environmental conditions not only depends on the fish species, but also on characteristics such as life phase, condition and history, such variables should be monitored as well. To be able to interpret site-specific data on fish and their environment within a wider context, local monitoring should follow similar protocols (including data sharing) as already being applied for other programs. In this presentation, we explore prerequisites for an overarching nested monitoring program to address local, regional and trilateral impacts of measures to strengthen the stocks of migratory fish in the Wadden Sea.

24 September 2019, 13:45 – 14:00

Long-term developments in Wadden Sea fish: the results from the latest Quality Status Report

Tulp I[1], Bolle LJ[1], Dänhardt A[2], de Vries P[1], Haslob H[3], Jepsen N[4], Scholle J[5], van der Veer H[6]

[1] Wageningen Marine Research, NL
[2] c/o Institute of Marine Ecosystem and Fishery Science, University of Hamburg, D
[3] Thünen Institute of Sea Fisheries, D
[4] DTU AQUA, National Institute of Aquatic Resources, DK
[5] BIOCONSULT Schuchardt & Scholle GbR, DE
[6] Royal Netherlands Institute for Sea Research, NL

Many fish species rely on the Wadden Sea for at least one of their life stages. A suite of marine fish (flatfish, other groundfish and pelagic fish species) reach the Wadden Sea as post-larvae and spend their juvenile phase there, benefitting from the high food availability and shelter from predators characteristic of the Wadden Sea (marine juveniles). Other species inhabit the region en route to either marine or fresh water spawning sites (diadromous species), during certain times of the year (marine seasonal migrants) or only occasionally (marine adventitious species). Apart from the temporary visitors, the Wadden Sea is also inhabited by resident species that spend (almost) their entire life in the Wadden Sea. For the latest Quality Status report data from several fish monitoring programmes across the international Wadden Sea was used to examine the status and trends of fish. Programmes vary in onset and duration, with the earliest starting in 1960. In general, marine juvenile species increased until the 1980s and declined since and this pattern was similar in all areas and surveys, with the exception of the Weser and East Frisia. Trends in estuarine species were more variable across areas and surveys. In this contribution, we present the results from the QSR, indicate the caveats in the monitoring and touch upon potential causes.

24 September 2019, 14:00 – 14:15

Results and lessons of 17 years of monitoring at the tidal fish pass Roptazijl (The Netherlands)

Huisman JBH

Van Hall Larenstein Applied Sciences University / Wageningen University and Research Centre, NL

Sluices, weirs and pumping stations form a migratory obstacle for diadromous fish in estuaries and deltas around the world resulting in decreased recruitment success and biodiversity of fish fauna in estuarine-riverine systems. In the Dutch Wadden Sea intertidal fish passes have been built to facilitate diadromous migration. The fish pass of Roptazijl was built in 2002 and is one of the first fish passes in the Wadden Sea. The fish pass functions for part of the tidal cycle. To attract diadromous fish, the fish pass pumps fresh water over the dyke to a small basin on the Wadden Sea-side. The contents of the basin, including fish, is siphoned towards the polder every two hours. Passage of fish has been monitored using a fyke net, every spring, since 2002. In addition, the presence of diadromous fish on the Wadden Sea-side and seasonal abundance was monitored in 2014, 2015 and 2016 using cross nets. Fish pass functioning was logged by the water authority. Results show that the

fish pass is often out of order impairing fish migration. Fyke net monitoring shows that predominantly sticklebacks and glass eels use the fish pass. Cross net monitoring on the Wadden Sea-side shows that arrival of stickleback and glass eels at the fish pass has a relation to the tidal cycle. As such, the research at Roptazijl, shows that in the design and building of tidal fish passes, possible temporal window of opportunities for migratory diadromous fish, can be an important design criterion.

24 September 2019, 14:45 – 15:00

100.000 otoliths later: insights in forage fish dynamics in space and time based on a seabirds' diet

Courtens W, Daelemans R, Verstraete H, Vanermen N, van de Walle M & Stienen EWM

Research Institute Nature and Forest, BE

Monitoring population dynamics and availability of pelagic fish often is costly and time consuming. We propose an alternative way to gain insight in the forage fish communities of coastal areas. Seabirds are positioned in the upper echelons of the food chain: their diet might reflect the relative abundance, availability and shifts in forage species. Sandwich Terns are one of those marine top predators, very specialistic and preying almost exclusively on forage fish of two groups: sandeels and clupeids. The variation in the availability and length-classes of prey species can be linked with chick body condition and breeding success of this sensitive seabird. Therefore, we studied the diet of incubating adult Sandwich Terns by collecting faeces samples and analyzing the prey remains.
In the Dutch Delta area, small-scale variation in adult Sandwich Tern diet was studied in detail trough intensive fieldwork over the last 6 years. Consecutive faeces samples (each containing the prey remains of 3-4 days) were collected in the breeding season (May-July) which allowed us to gain insight in the forage fish dynamics during this period. Obvious short-term changes both in relative prey abundance and age-class composition that were consistent between years and closely related to the ecology of the fish species concerned, were apparent.
Large-scale variation was investigated by yearly sampling of 25 colonies in Europe over the last 3 years, providing information on spatial and temporal differences in forage fish species and length-class distributions. Five colonies in the Wadden Sea were studied: Griend, Ameland, Baltrum, Minsener Oog and Norderoog. These were mainly driven by the younger stages of sandeel, Herring and Sprat but with some notable differences on a small spatial scale. This study allowed us to gain insight in the spatial and temporal variation in prey species and illustrates that diet analysis of a marine top predator such as Sandwich Tern can be used as an indicator for the dynamics of small pelagic fish communities in coastal waters that are otherwise seldom monitored.

24 September 2019, 15:00 – 15:15

Resurrecting the dead and forgotten. Examples of past marine ecosystem components in the Wadden Sea and beyond

Poulsen B

Aalborg University, DK

This paper introduces to the field of marine environmental history and marine historical ecology. In the past couple of decades historians and scientists have increasingly come together to investigate oceans past, in particular combining methods and data derived from otherwise very different disciplines such as history and marine science. The paper will present findings from studies of eel, oyster and herring in the North Sea and the Baltic Sea, where the Wadden Sea has been a central location for both trade, migration of fish and fishermen and shellfish, and - in the case of herring as an important nursery. The Wadden Sea past therefore is central for understanding both the natural and cultural heritage of the area; as they are in fact intertwined.

24 September 2019, 15:15 – 15:30

SWIMWAY, a flyway approach to marine conservation and management

van der Heij W

Waddenvereniging, NL

The Wadden Sea is an important hub in the east-Atlantic flyway for 10-12 million migratory birds each year. Connecting the arctic and Africa. This life history story concerning feeding, nesting and resting has formed the backbone of nature management in UNESCO World Heritage Site Wadden Sea.
Meanwhile below the surface, the Wadden Sea fulfils similar life-history functions for marine life in particularly fish. The proven flyway approach for conservation and management of migratory birds also offers useful tools for sharpening and structuring fish management in the Wadden Sea.
A Swimway approach has the potential to form an integral part of marine conservation and spatial planning. As well as, evaluating the effectiveness of existing nature management actions and policies. By creating an overview of fish-habitat interaction, habitat functioning and insight in migratory patterns the efficiency and effectiveness of marine nature management can be improved.
For example, by temporary or permanent measures protecting and strengthening the spawning and nursery function of the Wadden Sea for fish.
Evaluating habitat restoration activities for marine life and potentially predict the cumulative effects of human interactions on fish species
Using these new insights provides tools for policy-makers and could potentially influence the way we use the precautionary principle in the Nature Conservation Act.

24 September 2019, 15:30 – 15:45

Dynamics of the young-of-the-year fish communities in the Schleswig-Holstein Wadden Sea and the Elbe estuary and their importance for predators

Hennig V

University of Hamburg, D

In general, the Wadden Sea applies to be a very important nursery ground for young fish communities of the North Sea and the estuaries of the associated rivers. Assemblages of young fish are trigger and pacemakers for complex food webs. Concrete examples over a longer period are rare, even for concrete species. The communities of the young-of-the-year differ in the North Frisian Wadden Sea, the northern part of the Schleswig-Holstein area, in contrast to the southern part of the Dithmarschen Wadden Sea. The North Frisian young fish guilds are characterised by an exchange with fish of the North Sea in contrast to the Wadden Sea of Dithmarschen, dominated by species of the estuary of the river Elbe. Since 2010, young fish in the North Frisian part has been surveyed by the University of Hamburg, the southern part in the mouth of the estuary Elbe since 2014. Breeding success of coastal birds is highly dependent of the dynamic changes of Herring (*Clupea harengus*), Sprat (*Sprattus sprattus*) and Smelt (*Osmerus eperlanus*). Young fish monitoring data in the Wadden Sea part of Elbe estuary are correlating highly with yields of the commercial fishery on the river Elbe. Since 2014, stocks of spawning Smelt, the most abundant anadromous species of the river Elbe were collapsing abruptly. Numbers of breeding and migrating fish eating bird species indicate the same pattern like the smelt since the beginning 1990s.

24 September 2019, 16:45 – 18:45

Workshop on education, communication and ocean literacy

Facilitated by **Szczesinski A**

WWF Germany/International Wadden Sea School, D

The wandering eye of a baby flatfish, the permanent hunger of the sea scorpion and the cucumber-smell of smelts - the Wadden Sea´s underwater world is a fascinating ecosystem and aquariums range among the most popular attractions in visitor centres. The ecology of fish and their demand on specific habitats are communicated in various ways in both indoor and outdoor educational offers. However, compared to the knowledge on and experience offers for birds and mudflats, there is certainly more potential of awareness raising for fish through education and communication than currently implemented in Wadden Sea education.
The workshop will give insight into existing “fish activities” and resources on ocean literacy. It will provide a platform to exchange experience and ideas related to science communication and education and together we will explore possibilities for an increased integration of fish matters in Wadden Sea communication and education.

Theme Session 2: Fish habitats

25 September 2019, 09:00 – 12:00

Certain habitat types fulfil important functions in the life cycle of coastal fish. In the course of their development, fish often rely on different habitats, most of which are typical constituents of the habitat mosaic in coastal marine areas. Some may even be essential for fish to close their life cycle. The development of regional maps on essential fish habitats can provide an overview on their distribution and the evaluation of cumulative impacts for use directly in marine spatial planning. One habitat function typical for coastal marine areas is the nursery function. Coastal nurseries can affect demographic rates (births, deaths, immigration, and emigration) of fish at potentially vulnerable stages within the life cycle of a species, e.g. by supporting or inhibiting migration, growth and survival. This session will focus on how demographic rates of fish are linked to habitat conditions in coastal marine areas (species-habitat-relationships) and on the diversity and spatial heterogeneity of natural habitats important or essential for fish to complete their life cycles. This knowledge will help to disentangle the role of habitat use vs. other factors in driving fish population dynamics and to anticipate how habitat changes and impacts from diverse human activities can be taken it into consideration in management decisions.

Session Keynote: Fish habitats

25 September 2019, 09:00 – 09:45

Marine fish habitats – the link between environmental and fisheries management

Josianne Gatt Støttrup, Brown EJ & Kokkalis A

DTU AQUA, National Institute of Aquatic Resources, DK

Marine fish habitats are central to ecosystem functioning due to the dependence of fish on specific habitats during different life-stages. Commercial and recreational fisheries target marine fish habitats depending on their use by important target species, for example habitats where fish congregate to spawn or feed in specific seasons or during seasonal migrations. These habitats are also impacted by other human activities, especially in coastal areas where human activities overlap and compete. As such, there are strong needs to focus on increasing our understanding of their species-specific importance and how pressures from human activities affect these habitats. A main objective for research on marine fish habitats should be to explore the links between habitat characteristics and demographic rates and how these may impact population growth or production at local or regional scales. For science to inform management, methods need to be developed to adequately map, monitor and assess the quality and availability of these habitats. Furthermore, effective management of species requires both the knowledge of distribution as well as connectivity among populations.

25 September 2019, 09:45 – 10:00

Ecological consequences of a mesopredator release and habitat loss

Eriksson BK*[1], Yanos C[1], Donadi S[2], Hansen J[3], Sundblad G[2], Bergström U[2], Eklöf JS[4]

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[4] Swedish University of Agricultural Sciences (SLU), S

Human induced losses of top-predators restructures coastal foodwebs, degrades biodiversity and impairs ecosystem services across the globe; leading to widespread economic and cultural loss. Today, it is becoming increasingly clear that restoring the biodiversity of such degraded ecosystems, often requires addressing a multitude of interacting human impacts.
Here we present results demonstrating that a three-spine stickleback invasion have had cascading effects on the coastal ecosystem in the western Baltic Sea. The effects include changing ecological dynamics, food-web structure and water quality measures. Today the changed ecological dynamics have generated feedback loops that seem to lock parts of the coast in an alternative unwanted stable state. We now have indications that the cause of the predator loss leading to the unwanted regime shift is a combination of offshore overfishing, climate change, and the destruction of coastal habitats that are important nursery grounds for larger fish. The results demonstrate that we need an ecosystem approach that include both food-web dynamics and habitat-fish interactions to predict and manage the consequences of changing fish communities.

25 September 2019, 10:00 – 10:15

Growth of four resident fish species in the Wadden Sea in two periods contrasting in eutrophication level and temperature

Bolle LJ[1], Hoek R[1], Pennock I[1], Poiesz S[2], van der Veer HW[2], Witte JIJ[2] & Tulp I[1]

[1] Wageningen Marine Research, NL
[2] NIOZ Royal Netherlands Institute of Sea Research, NL

Fish growth is strongly influenced by environmental factors such as salinity, oxygen concentration and temperature. Because fish are ectotherms, temperature affects growth rate directly through a physiological response. Indirectly, temperature controls growth rates through its effect on food availability. Food availability is also affected by a suit of other factors, possibly including nutrient levels at the bottom of the food chain. The evidence for an effect of nutrients cascading onto the next levels, secondary production and beyond, is, however, often not clear in empirical data.
These dynamics play a major role in the Wadden Sea, regarded as a nursery area for several fish species. Nutrient levels in the international Wadden Sea increased in the 1960-1970s and reached maximum values around the late 1970s. Since the mid-1980s, nutrient levels have declined sharply, through nutrient reduction methods. The trend in nutrient loading is reflected in the trend in total fish biomass as recorded by different surveys. In particular, the

trend was followed most closely by those fish species that only spend the first part of their life in the Wadden Sea (marine juveniles). Thus, in the public debate and among fishermen, the decline in nutrient loading and fish productivity are often presumed to be causally linked.
However, whether nutrient dynamics can be directly linked to dynamics in the higher trophic levels remains unresolved. Since the marine juvenile fish species spend only the first year(s) of their lives in or near the Wadden Sea, we focussed on species that spend their entire life inside the Wadden Sea and coastal area to study whether the period of high eutrophication levels were indeed beneficial for fish growth.
Based on a large archive of otoliths from the Wadden Sea, containing samples from two periods that contrast in eutrophication levels and mean temperature, we compared growth during a period of high eutrophication and relatively low temperatures (1970-1990) to a period with reduced eutrophication and higher temperatures (2005-2019). The species selected were: twaite shad (*Alosa fallax*), bull-rout (*Myoxocephalus scorpius*), thick-lipped grey mullet (*Chelon labrosus*) and eelpout (*Zoarces viviparus*). All these species spend the larger part of their juvenile and adult life within the Wadden Sea and their growth patterns are therefore likely to reflect the local growing conditions.
Our preliminary results show that all four species grow faster in the recent period compared to the historic one, mainly due to growth differences in the first and/or second year of life. As the observed increase in growth rates coincided with a decrease nutrient loading, our results clearly indicate that the decline in eutrophication in the Wadden Sea since the 1980s did not have a major detrimental effect on fish growth. Other factors, which enhance growth rates, are clearly more important. Increased growth rates may be caused by temperature rise, either directly or through a prolonged growing season. They may also be caused by the alleviation of density dependent processes due to an overall decrease in fish population sizes in the Wadden Sea.

25 September 2019, 10:15 – 10:30

Otolith and body-shape characteristics provide insights into the recruitment dynamics of sand gobies (*Pomatoschistus minutus*) along a restored Fyn coastline

Wilson G

Department of Biology, University of Southern Denmark

Habitat restoration is common in the conservation of coastlines and their biota, although requires a parallel understanding of how particular habitats contribute to processes such as recruitment that are essential for population recovery. Sand gobies are an abundant demersal fish along the Baltic coast, and ideal for examining how coastal fishes might respond to shoreline restoration. While the species' life-history is broadly understood, we have a very limited sense of its recruitment dynamics and other processes during early life-history
Otoliths can provide information on the timing and rate of early development processes, while shifts in body shape may signal the timing of parallel development events. Here I describe change in otolith characteristics, early growth, and body shape in sand gobies ≥ 6,8 mm SL from central Denmark. Sagittae shifted from an oval to circular or cubic shape at around 9,6 mm SL, coincident with completion of juvenile fin development. Otolith size varied

substantially within individuals: over 25 % of fish had otoliths differing by 5 to 45 % in length. Sagitta growth with body length suggested transitions before 7 mm and around 24 mm SL. Early somatic growth was rapid, decreasing from an average 5,3 %.d^{-1} in body length and 26 %.d^{-1} in body weight at 10 to 15 days in age. Change in external morphology followed linear trajectories with body length without obvious inflections. These patterns suggest a species driven by rapid establishment within coastal environments over the recruitment season, with some loss of 'developmental control' as a trade-off.

25 September 2019, 11:00 – 11:15

Friese JDS[1*], Temming A[1] & Dänhardt A[2]

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One of the key processes structuring animal occurrence is how they utilize specific habitats during their ontogeny. Worldwide, salt marshes have proven important or even essential for a wide variety of marine nekton, but although salt marshes are also characteristic for the Wadden Sea, their role for nekton is surprisingly unexplored here. Building on extensive field sampling, we i) present an overview over the species utilizing German Wadden Sea salt marshes, ii) evaluate habitat properties, iii) address habitat utilization and affinity by nekton, and, iv) discuss functional aspects in a life-cycle context. Species composition between salt-marsh creeks and the adjacent subtidal differed significantly, indicating a salt-marsh-specific nekton community. Its members were usually small (98% < 4.5 cm), consisting of larvae, juveniles and adults of small species. Despite extremely variable temperatures and inundation, habitat affinity was high, with ten dominant species occurring regularly. Compared to the subtidal, flow velocity, turbidity and grain size were lower, while temperature varied stronger in the marsh creeks. In both areas, oxygen concentrations were sufficient, and ecological redundancy was low. Despite the limited availability for aquatic organism, intertidal salt marsh creeks appear to provide favourable habitat for small nekton due to reduced swimming effort, increased prey visibility and density, and increased growth potential during seasonally higher temperatures. Aquatic and avian piscivores were absent, indicating low predation. Knowledge on how nekton utilizes specific habitats within their life cycles will allow identifying potential bottlenecks and, with it, effective and efficient conservation options in the Wadden Sea and beyond.

25 September 2019, 11:15 – 11:30

Habitat association models and habitat growth models for juvenile fish of the inner Danish waters

Brown EJ, Kokkalis A & Støttrup JG

DTU AQUA, National Institute of Aquatic Resources, DK

In order to quantify the indirect effects of human activities on important fisheries species, the natural drivers of their spatial distribution must first be understood. There exist many different methods that describe these drivers based on diverse habitat suitability metrics. One fundamental decision to be made in quantifying habitat suitability is the measure used to represent it. Here, we compare two measures, density and growth, as proxies for habitat suitability applied to data collected during a survey of juvenile habitats from the inner Danish waters. Habitat suitability is modelled as a function of the physical environment using generalised linear (mixed) models, which are validated using repeated random sub-sampling before being employed to create predicted maps of habitat suitability and their inherent uncertainty. The resultant density and growth models are discussed and contrasted.

25 September 2019, 11:30 – 11:45

Variation of reproductive decisions in gobies along a natural gradient

Heubel K

University of Kiel, Research and Technology Centre West Coast, D

Many studies on reproductive decisions thus far have been carried out while ignoring the interplay between individual behaviour, population ecological context, and the environment. Here I address the question how mating decisions and subsequent paternal care interact with its natural context in a small annual marine fish with exclusive paternal care, the common goby (*Pomatoschistus microps*) breeding in the North Sea, estuaries, and the Baltic Sea along a steep salinity gradient and seasonally changing temperatures in shallow water. As common gobies rely on clams (*Mya arenaria*) as nesting resource, there are both direct links between fish, temperature, and salinity (morphological, behavioural, life history, and demographic) as also indirect links in relation to clams (abundance, size, fragility, competition). Hence, different male paternal care strategies and life history decisions apply. The results elucidate plasticity of reproductive traits and decisions in populations with changing environmental and demographic contexts and highlight the importance of taking potential environmental and community-related interactions into account. Insights in temporal and spatial dynamics of reproductive decisions interacting with the natural context and its potential population level evolutionary consequences shall be discussed.

Theme Session 3: Life cycles (Swimways), connectivity and bottlenecks

25 September 2019, 15:00 – 18:00

Fish as mobile organisms connect habitats and ecosystems. From the fish perspective, connectivity may be the "Achilles heel" in the life cycle. Species inhabiting coastal marine areas only during part of their life depend on a functioning link with the regions where they spend other parts of their life. Depending on species and developmental stage, these links are provided e.g. through drift with tides or residual currents, or through active migration. Regardless of the transport mechanism, fish may be faced with multiple, sometimes anthropogenic, bottlenecks during their life cycle. This session takes a life-cycle perspective by asking where species and life stages come from, where they go and what kind of environment, including anthropogenic threats, they experience. It focusses on how stage-specific areas and within stage habitats are connected to each other and the role spatial connectivity plays for recruitment variability. For example, diadromous species migrate between rivers and the open sea via coastal marine areas, making them vulnerable to physical bottlenecks on their swimway. At much smaller spatial and temporal scales, different habitat patches make up a habitat mosaic interconnected by movements between them. Knowledge on connectivity on different temporal and spatial scales is key to identify bottlenecks along the swimways of fish and to implement targeted and effective protection measures.

Session Keynote: Life cycles (Swimways), connectivity and bottlenecks

25 September 2019, 15:00 – 15:45

Migrating to essential habitats through mortality bottlenecks. The complex interactions of brown shrimp live stages, predators and the fishery

Axel Temming

University of Hamburg, Institute for Marine Ecosystem and Fishery Science (IMF)

Brown shrimp is both one of the few key species and target of the largest fisheries along the trilateral Wadden Sea coast. Thus, the population dynamics of this species has been studied for decades, which has yielded a comprehensive understanding of its life cycle and associated bottlenecks. The shrimp release their larvae in winter and spring in deeper offshore waters (10-30m), where the main spawning places are spatially distinct and sufficiently predictable for the fishing fleets to exploit these aggregations. The best protection against this type of predation is stormy weather. Larvae reach their shallow coastal nurseries most likely via selective flood tide transport. Upon arrival in the Wadden Sea, they encounter their key predators, juvenile cod and whiting. In some years, probably depending on the larval drift, fast-growing whiting is abundant enough near the coast to massively deplete stocks of juvenile shrimp, much to the detriment of the fishery. While preying upon the shrimp, juvenile whiting themselves risk ending up as bycatch in the shrimp fishery and/or of being eaten by marine mammals. At

the same time, brown shrimp themselves are efficient and usually very abundant predators of juvenile plaice, which likewise drift into their coastal nurseries, where they share the fate of the juvenile whiting. Shrimp grow rapidly in the shallow regions of the Wadden Sea and after a few months use selective ebb tide transport to reach their spawning grounds in deeper waters. Recently, overfished cod and whiting stocks have faced strong predation by large populations of marine mammals supporting increasing shrimp stocks. At the same time, a thriving shrimp fishery and successful mammal conservation stabilized this state at the expense of cod, whiting, plaice and probably other fish species. The talk takes a food web perspective to give an overview over the last two and a half decades of research on the life cycle of brown shrimp, to identify real or potential bottlenecks and to discuss management options.

25 September 2019, 15:45 – 16:00

The role and importance of the Wadden Sea in the life cycle of some North Sea flatfish species

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North Sea flatfish species are characterized by a common life cycle with a pelagic egg and larval stage, followed by settlement and a demersal juvenile stage of a few years (0-, I-, and II-group fish), and finally the reproductive adult stage. For several species, the various life stages are separated in space and time, with settlement concentrating in shallow coastal areas, i.e. the juvenile nursery grounds.
The Wadden Sea is one of the important shallow coastal nursery areas for a number of flatfish species, especially plaice, flounder and sole. Spawning grounds are located offshore at the North Sea and developing eggs and larvae are thought to be transported mainly passively to the coastal zone. Settlement seems to be actively induced by prevailing food conditions not only in the Wadden Sea but also in the coastal zone.
The relative importance of the Wadden Sea as compared to the coastal zone is determined by prevailing hydrodynamic conditions at the time of larval drift. Currents and wind patterns determine which proportion of the larvae is able to reach the Wadden Sea. Relationships between the number of settling larvae and nursery size suggests some kind of carrying capacity, however the absence of density-dependent growth in the settling period indicates that larval supply to the nursery grounds is the limiting factor.
Habitat use differs among species with sole concentrating in the subtidal and plaice and flounder using both the subtidal and intertidal. Juvenile growth performances indicate that the quality of the Wadden Sea nursery is better for epibenthic feeders (plaice and flounder) that for benthic feeders (sole).
Over the last decades, habitat use of the Wadden Sea nursery by flatfish juveniles has decreased, especially for dab and plaice. Several causes for this pattern have been suggested (eutrophication. climate change, fisheries, habitat change). For plaice, the reduced use of the Wadden Sea as juvenile nursery has not affected overall recruitment, suggesting that other areas have taken over part of the Wadden Sea nursery function.

25 September 2019, 16:00 – 16:15

Estimating life-cycle connectivity of an exploited marine fish: implications for management impacts

Le Pape O[1], Randona M, Lecomtea JB, Rivota E & Réveillaca E

[1] *Agrocampus Ouest, University Rennes, F*

The common sole is a commercially valuable coastal nursery-dependent flatfish. In the Eastern English Channel, fishery managers currently consider sole to consist of a single, spatially homogeneous stock. To explore finer-scale connectivity, we estimated (i) the level of connectivity at different life-history stages, and (ii) how mixing among potential local subpopulations may impact both population dynamics and consequences of anthropogenic disturbances. An individual-based model coupled to a hydrodynamic model simulated larval drift from spawning areas. Low levels of connectivity were seen at the larval stage, with spawning areas directly feeding adjacent coastal nursery grounds. A combination of in situ analysis and habitat mapping with a meta-analysis was used to estimate juvenile connectivity. Very moderate movements resulted in coastal segregation among patches of juvenile fish, resulting in the strong dependence of young of the year upon local nursery habitats, and low juvenile connectivity. Mark-recapture surveys of mature sole suggest moderate mobility. In addition, spatial differences in a pool of markers including abundance in cohorts, growth, otolith shape, otolith microchemistry, and genetics are suggestive of sub-population segregation at adult stage inside the eastern Channel. The different aforementioned pieces of knowledge and data at different life stages were incorporated in a spatial Bayesian integrated life-cycle model that could estimate how connectivity among subpopulations affects stock dynamics. An assessment considering a metapopulation with loosely connected subpopulations revealed both contrasting status of fishing exploitation and contrasting consequences of anthropogenic disturbances on coastal habitats among those sub-populations.

25 September 2019, 16:45 – 17:00

The fate of juvenile sole growth and survival in coastal nurseries under climate conditions

van de Wolfshaar K, Barbut L & Lacroix G

Wageningen Marine Research, NL

This study shows the effect of climate change on the growth and survival of juvenile fish in different nursery areas in the North Sea. The climate conditions are based on the IPCC scenario for 2040. Two climate scenarios are used, one with only abiotic changes and one with also a climate driven timing of spawning. Comparisons are done between a base scenario, with current conditions, and the two climate scenarios, for multiple years and multiple nursery areas.
Under climate conditions the early arrival of fish larvae in their nurseries results in larger young of the year at the end of summer, but the initially slow growth, despite warmer winter and spring temperatures, causes higher mortality for early arrivals. The combination of arrival densities and arrival day determines which nursery has the highest absolute numbers surviving. Overall, under climate change conditions juveniles have increased growth rates leading to larger size at the end of the first growth season, reduced survival and mixed affects to total biomass.

25 September 2019, 17:00 – 17:15

Distribution & growth of European glass eels stocked in the eastern German Baltic Sea

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The recruitment of the catadromous European eel (*Anguilla anguilla*) stock has been collapsed and stagnates at historically low levels since the early 2000s despite various stock-supporting efforts. In 2007, the EU member states were requested to elaborate eel management plans to ensure a minimum escapement biomass of at least 40 % compared to the pristine level. Most eel management plans only consider stocking measures in inland waters. To determine if stocking is also a management option in coastal waters, a stocking experiment with glass eels has been conducted in two different areas of the eastern German Baltic Sea. In both areas, over 1 Million glass eels have been stocked between 2014 and 2016. To allow discrimination of stocked from natural recruits after recapture, all stocked eels were chemically marked with alizarin red S.
In 2017 and 2018, a total number of 1127 eels were captured inside and outside of both stocking areas. 21 % (n = 235) of all investigated individuals were marked. It was found in 2017, that 71 % of all marked eels have been recaptured within approximately <12 km of the stocking site, while one year later the number of marked individuals within the stocking areas decreased to 44 %.
Furthermore, initial analyses revealed, that marked eels showed a significantly higher mean total length at the age 3+ compared to naturally recruited conspecifics in both stocking locations. This might indicate a life-history dependent growth pattern as previously observed in the American eel.

25 September 2019, 17:15 – 17:30

Measures to improve fish migration at pumping stations, sluices and tide gates in the Netherlands and Germany

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Most small tributaries of the Wadden Sea coast of The Netherlands and Germany are blocked by intertidal pumping stations, tide gates or sluices making fish migration near impossible and resulting in the loss or a significant population decline of diadromous fish species. However, in the Netherlands several projects have been done aimed at improving diadromous fish migration and almost all small tributaries have implemented fish migration measures. Fish passes have been built at tidal sluices and pumping stations and in some cases these pumping stations have been equipped with fish friendly pumps. In contrast, in northern Germany so far only a few locations have been equipped with fish pass solutions and there are no fish friendly pumps. Especially in Germany many pumping stations and sluices are in need of systematic overhauls due to reasons of coastal defence and in addition all

Wadden Sea countries are developing projects to cope with rising sea levels that could impact fish migration. As such, there is a great need for knowledge how to incorporate fish migration in upcoming projects. We will provide an overview of existing fish passes at tidal locations and planned measures to improve connectivity between inland waters and the Wadden Sea. Secondly, we will address the often very basic questions that arise when water authorities are designing fish migration measures and provide a framework for the design and building of such structures.

25 September 2019, 17:30 – 17:45

Using otolith chemistry to discriminate between hybridising con-familials and contiguous, coastal juvenile fish habitats

Brown EJ[1], Reis-Santos P[2], Gillanders BM[2], Støttrup JG[1]

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Life-history connectivity is an important component of fish population dynamics, which when well described can inform spatial management by identifying important habitats, fisheries management by providing earlier indices of future recruitment and fundamental understanding of population dynamics. While genetic tools can be used to document degrees of population connectivity and to trace spawning population contributions to juvenile habitats, the potential mixing of different population's juveniles in their preferred habitats renders genetic differentiation ineffective for tracing juvenile habitat contributions to adult populations. To close the loop, other tagging tools must be used, one such tool is the natural tag of trace element incorporation into fish otoliths which is imprinted from the environment through-out a fishes life. This tool has been successfully used for identifying different estuarine habitats' contributions to marine adult stocks, but its efficacy in open coastal settings is poorly documented. This study uses juveniles of European plaice and common sole from the inner Danish waters to demonstrate high-rates of successful reallocation to coastal, contiguous juvenile habitat areas. Additionally, otolith chemistry effectively differentiates between juveniles from hybridising populations of European plaice and flounder even where they occupy the same habitat. These findings lay a foundation for the application of otolith chemistry to supplement genetic investigations of life-history and population connectivity – even in open coastal settings.

25 September 2019, 17:45 – 18:00

Contribution of an inshore nursery area to the Atlantic herring (*Clupea harengus*) population in the Western Baltic Sea

Dorothee Moll[1], Klaus Peter Jochum[2], Paul Kotterba[3], Lena von Nordheim[1,4], Tomas Gröhsler[1], Patrick Polte[1]

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Although the understanding of fish migration patterns and population structure is crucial for a successful fishery management, there is still a lack of knowledge on spatial habitat connectivity of economically important fish species, such as herring. Atlantic herring (*Clupea harengus*) in the Western Baltic Sea rely on inshore coastal spawning grounds, attaching their benthic eggs predominately to submerged aquatic vegetation. Hence, herring early life stages are vulnerable to multiple stressors, acting on a local scale of important spawning grounds. Since recruitment of Western Baltic herring population decreased during the last two decades, estimations on the contribution of single herring spawning areas to the overall Western Baltic herring population are vital to evaluate their potential function as nurseries.
We used elemental fingerprinting in 0-group herring otoliths from four different spawning areas along the Western Baltic coastline to identify habitat-specific chemical signatures and combined these natal fingerprints with otolith core signatures from adult herring to investigate the contribution of single spawning habitats to the overall population. Analysis revealed that the contribution of one main spawning area to the adult population was high but varied between the years. Moreover, analysis on herring homing behavior showed that Atlantic herring in the Western Baltic Sea return to their natal spawning areas with some straying individuals from other areas. With respect to the high anthropogenic impact on coastal inshore waters, these findings highlight the essential function of local spawning habitats to the persistence of herring populations and support the need for sustainable, coastal zone management strategies.

Theme Session 4: Marine Policy

26 September 2019, 09:00 – 12:00

Understanding factors affecting life-cycle connectivity is not only a physical or biological issue. In order to ensure that there are enough opportunities for fish populations to develop in the natural environment it is important that there is coherence in management measures and harmonization of policy objectives. Science has an important role in underpinning these aspects. This session will focus on the science that is necessary for successful implementation of European and national policy directives with regards to fish. Attention will also be paid to analyses of current national and international policies and regulations and how these are potentially relevant to achieving the Trilateral Fish Targets. How current management measures improve fish populations will be explored.

Session Keynote: Session Keynote: Marine Policy

26 September 2019, 09:00 – 09:45

A systems analysis approach for integrated management to protect estuarine and coastal fish communities: accommodating natural and human features

Michael Elliott

Institute of Estuarine & Coastal Studies, University of Hull

Marine and estuarine management requires an excellent understanding of the interacting, interrelated and interdependent sub-systems comprising ecological, societal and management complexity. Hence, system mapping should encompass the pathways of information (skills/capabilities), energy (including time), money and materials required to achieve a successful overall and agreed vision. It relies on knowing what aspects can be managed and why and how, and conversely what aspects are outside the control of the manager. The proposed Systems Analysis focusses on understanding and protecting estuarine and coastal fish communities and populations and especially the connectivity between the estuaries and their catchments and adjoining marine areas. The analysis links 13 component sub-systems in a cycle. The Underpinning Framework Sub-system (1) follows the DAPSI(W)R(M) concept (whereby Drivers require Activities which create Pressures; these in turn effect State Changes and Impacts (on human Welfare) which require Responses (using management Measures)). This then leads to the Issue Sub-system (2) which is vision-related and includes causes and consequences of pressures to be managed showing the repercussions of natural and anthropogenic changes. The Ecological Sub-system (3) links the fishes, their prey and the environment and then links to the Socio-ecological Sub-system (4) showing ecosystem services and societal goods and benefits. The Resources and Delivery Sub-system (5) considers who does what and how do they do it whereas the Provenance Sub-system (6) underpins the fit-for-purpose science and a defendable evidence base. The Governance Sub-system (7), incorporates policies and politics plus the Legislative Sub-system (7A) and the Administrative Sub-system (7B), using horizontal and vertical integration of

the management organogram respectively to accomplish the vision. The Communication (7C) and Stakeholder Sub-systems (7D) require informed dissemination across the stakeholder typology (of formal and informal actors). Finally, the Achievement Sub-system (8) (including scale) and the Feedback Sub-system (9) uses monitoring to indicate the success of marine management.

26 September 2019, 09:45 – 10:00

A policy analysis of the Swimway Wadden Sea fish targets

Jager Z[1] & Koolstra B[2]

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In recent decades, the populations of many fish species have declined in the Wadden Sea due to largely unknown reasons. As fish are an important part of the Wadden Sea ecosystem, the three Wadden Sea countries presented in 2018 a Trilateral Swimway Wadden Sea Vision, aiming to reach trilateral fish targets Wadden Sea. These targets haven been specified in the Swimway Action Programme (2019) and aim at: maintaining or improving viable fish populations, the nursery function of the Wadden Sea and its estuaries, the typical Wadden Sea habitats, the passage ways for migrating fish and the conservation of endangered fish species. The realisation of these targets depends heavily on effective policies and legislation. The policy objectives for fish in the Wadden Sea are formulated at different levels, ranging from European and Trilateral levels, and by implementation of those to national and possibly regional levels. The aim of our study is to analyse the relevant existing legislation and policies at the European level (e.g. Habitats Directive, the Water Framework Directive, the Marine Strategy Framework Directive, the Common Fisheries Policy) and the associated implementation in the national laws in the Netherlands (e.g. Nature Protection Act, Water Act, National Ecological Framework), taking into account the uniformity, coherence. The contribution of the existing policy to the realisation of the Trilateral Fish Targets will be analysed and evaluated. Existing gaps will be identified. The results of the Dutch situation will be presented at the conference. If feasible, German and Danish experts will also present their results, using the same format for policy analyses.

26 September 2019, 10:00 – 10:15

Bottlenecks for fish in the Wadden Sea Region

Rösner H-U & Lages E

WWF Germany, D

There is a considerable number of fish species occurring in former times in the Wadden Sea and the adjacent waters, which are very rare today or even have disappeared already. This may in most cases be explainable by different „bottlenecks“ for the population occurring in the Wadden Sea Region is experiencing, or was experiencing. We present and discuss a number of such cases, including options for protection and/or restoration.

26 September 2019, 10:15 – 10:30

The importance of long-term monitoring programmes for implementing nature conservation policy

Leyrer J[1] & Detloff K[2]

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Results from long-term monitoring programmes are important for developing and evaluating conservation management measures. They are also fundamental when assessing the potential impact of intended interventions particularly in protected areas. Various international laws and EU directives provide the framework to guide the evaluation of monitoring data in relation to decision making when it comes to management measures and environmental impact assessment. This presentation will explore weak points in the evaluation and interpretation of monitoring data, their application and the coherence between different statutory frameworks using the example of ecosystem interrelations in the Elbe estuary. We will also elaborate on the importance of insights from long-term monitoring programmes for the work of nature conservation authorities and NGOs and their challenge to connect scientific insights and environmental policies.

26 September 2019, 11:00 – 11:15

Swimway and the Marine Strategy Framework Directive: the tope shark as case study

Walker P[1,2], Hillinger A[1] & Taylor B[1]

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[2]*Dutch Elasmobranch Society, Amsterdam, NL*

In the Swimway approach, five different ecological groups have been defined for the fish community in and around the Wadden Sea. The species utilise the area during (part of) their life-cycle and for each of these groups, flagship species have been determined. For the adventitious species the migratory tope shark (*Galeorhinus galeus*) was identified. As this species has a transboundary distribution and carries out long-distance migrations, it is relevant to attempt to define and assess what the 'good environmental status' (GES) of the species is in relation to the Marine Strategy Framework Directive (MSFD). This paper will address an assessment of the relevance of using MSFD for elasmobranchs and the applicability of the current operational indicator approach. The use of surveillance indicators, allowing for pressure-state relationships to be understood will be discussed. A new target approach and definition for GES will be described, which correlates well with the Swimway approach. New ´priority indicators ´, for which data collection is feasible have been selected. This analysis will be illustrated with available field- and model-data. Through increased data collection efforts, interpretations of results and trends can be made, based on which management adaptions can be made to move towards both GES and reaching the Swimway targets.

26 September 2019, 11:15 – 11:45

Linking Management and Governance Recommendations from Global Environmental Assessments to National Realities: Insights from the INTERNAS project

Krause G[1,2], Happe A-K[1], Wolf C[3], Raab K[3], Hauck J[3,4], Scheve J[1], Buttigieg PL[1] & Jax K[3]

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[3] Helmholtz-Zentrum für Umweltforschung, D
[4] CoKnow Consulting, D

Important environmental topics like climate change and biodiversity loss are globally discussed through a range of intergovernmental platforms like the IPCC (Intergovernmental Panel on Climate Change) and the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services). These international panels develop guidance and measures of implementation for national governments in order to address the environmental degradation and to achieve the international goals and commitments for a sustainable development. Despite that these assessments play an important role internationally, their results find only partially application in the national political context. One reason may be the limited applicability of the measures in the national context, vis á vis the missing acknowledgement by the Intergovernmental Platforms of the needs of national policy makers.
This observable gap in knowledge transfer is at the core of the project INTERNAS (Knowledge transfer of international environmental assessments). To address these gaps, thematic stakeholder workshops and focus groups with a variety of stakeholders from politics, science and civil society are conducted. During these events, key terms and concepts are taken up and digitized in ontologies that are made available by Environmental Ontology ENVO. By this combined approach, a range of different and fitting implementation strategies of international assessments for the German political context can be identified. The presentation showcases some central recommendations on “Protection and sustainable use of the German North Sea and Baltic Sea – measures for an ecological enhancement”.

Posters
24 September 2019, 19:00 – 21:00

The Quality Status Report (QSR) 2017

Bostelmann A., Busch J.A., Klöpper S

Common Wadden Sea Secretariat, D

Since 1999, the Trilateral Wadden Sea Cooperation (TWSC) between Denmark, Germany and the Netherlands has periodically produced Wadden Sea Quality Status Reports (QSR) describing and evaluating the current ecological status of the Wadden Sea. The QSRs identify changes in this status and their possible causes, classify issues of concern and indicate possible measures of amelioration, including evaluation of the likely effectiveness of these measures. They also indicate gaps in our knowledge. The QSRs are based upon the Trilateral Monitoring and Assessment Programme (TMAP). The programme and the reports were key elements in achieving the inscription of major parts of the cooperation area on the list of UNESCO World Heritage Sites. In 2017, the last QSR has been published qsr.waddensea-worldheritage.org.

Biodiversity warehouse atlas software enables user-friendly distribution maps for the whole Trilateral Wadden Sea area

Brunken H & Vatterott H-R

University of Applied Sciences Bremen, D

The third and recently published edition of the online “Fish Atlas of Germany and Austria” (biodiversity.hs-bremen.de/fische/#!/home) also shows the distribution of marine fish species. The atlas consists of species descriptions consisting of distribution maps, fact sheets, photo galleries and literature references. For the first time, fish distribution maps for the entire trilateral Wadden Sea area also were included. The data from the Trilateral Wadden Sea Area mainly originate from a first ad-hoc literature search and do not claim to be complete. However, the first online distribution maps show that the atlas offers a user-friendly web-based system for the coordination, evaluation and communication of distribution data. We see potential users in the scientific field as well as in official nature and species conservation and environmental education. Citizen Science data can also be integrated via simple interfaces. All data are freely accessible and are available for non-commercial applications. The technical coordination of the fish database is carried out by the German Ichthyological Society (Gesellschaft für Ichthyologie e.V.). The development of the underlying software (Biodiversity Warehouse) takes place at the University of Bremen in a joint working group of biology and computer science. The technical implementation takes place as a distributed system with PostGIS as spatial database system, OSM as source of the basic maps, GeoServer for the publication of map overlays, java and node.js for the implementation of backend services and Javascript APIs such as Angular, Leaflet, D3. js for the implementation of the frontend.

Stepping up efforts to implement trilateral Wadden Sea fish targets: The Trilateral SWIMWAY Action Programme -

Busch J.A.

Common Wadden Sea Secretariat, D

This action programme is written by a trilateral coordination team. It describes actions suitable to improve knowledge on relevant processes, optimize population monitoring, adjust policies and develop, realise and evaluate measures towards reaching the Trilateral Fish Targets. Therefore, activities such as coordinating, facilitating collaboration, fundraising and project development are part of this action programme. Collaboration with existing activities and programmes that address the Fish Targets is a prerequisite for success. Communication and education are also key elements of the SWIMWAY Programme, helping to increase public awareness to facilitate holistic, ecosystem- and evidence-based fish conservation in the Wadden Sea.

Impossible balance? Time series integrity, spatio-temporal connectivity and representativeness of fish monitoring data in the Wadden Sea

Dänhardt A

c/o SWIMWAY Wadden Sea group, D

There is no such thing as the perfect monitoring programme, rendering the strict focus on the relevant questions mandatory. Where monitoring objectives cannot be met with a single method, several methods need to be combined. Where new (combinations of) methods are about to replace traditional approaches, benefits of old and new monitoring methods need to be carefully evaluated against each other, and integrity of time series needs to be maintained e.g. by means of thorough calibration. Joint and harmonized analyses and interpretation of fish data from as many sources as possible will yield a more robust foundation for evidence-based management. Adequate spatial resolution is usually inversely related to adequate temporal (seasonal) resolution, specific gear target only specific components of the fish community, and monitoring results are usually analysed and evaluated separately from instead of together with results from other monitoring fisheries. The resulting mismatch between available knowledge and the scale of anthropogenic activity on fish hampers the assessment and avoidance/mitigation of man-made environmental impacts on fish. Building upon 13 years of fish monitoring and research in the Wadden Sea on various spatial and temporal scales, the poster compares monitoring objectives with current monitoring standards in the Wadden Sea, summarizes lessons learned, and proposes a combination of existing and newly established fish monitoring methods to meet the multiple demands brought about by implementing EU-Directives, National law and other legal obligations, all more or less aimed at identifying and turning off anthropogenic bottlenecks along the life cycles of fish and other organisms.

The Demersal Young Fish Survey in German Wadden Sea areas (1974 – 2018)

Haslob H

Thünen Institute of Sea Fisheries, D

The Thünen Institute of Sea Fisheries performs the Demersal Young Fish Survey in German Wadden Sea areas since the 1970s. This survey, which is part of an internationally coordinated survey campaign, is mainly dedicated to estimate a relative abundance index of the youngest age groups of plaice and sole. The gear in use is a 3m beam trawl, which is deployed from chartered commercial vessels covering different depth strata. Today, the survey is conducted during the third quarter, mainly in September. The investigation area includes five different areas along the German coastline. Since 2012, the station grid is complemented by the German research vessel "Clupea" which covers stations seaward to the island chain. The data obtained by the German DYFS from 1974 to 2018 comprises a valuable time series, not only for plaice and sole, but also for other important fish and invertebrate species (e.g. *Crangon crangon*) in the Wadden Sea area.

Ems fish monitoring

Marampouti C, van der Heij W, Eriksson BDKH, Jager Z, Vegter J & Walker PA

The Waddenvereniging has designed a project to carry out sampling of fish in the Ems estuary between March and November 2019. The aim of the project is to increase our knowledge and understanding of the seasonality in the fish community in the estuary and to perform comparative sampling strategies with a view to finding a cost-effective alternative method to sample the fish community. There are also concerns about the health of the Ems estuary and fish can be seen as an indicator for ecosystem health. Currently there is a sampling programme using a stow net in May and September which has been designed to meet the requirements for the Water Framework Directive (WFD). This programme covers three sampling points (Spijk, Oterdum and Terborg) which are placed at locations from the estuary mouth and cover different salinities. For this project, the current WFD programme is being carried out an extra five times by the same consortium in the months March, April, June, October and November at the Oterdum location. This will provide some insight into the seasonal variation in fish species and their abundance. Concurrent with the WFD sampling there is a comparative sampling programme carried out using a stake net in order to further identify seasonal patterns in the fish assemblage and to compare the two fish sampling methods. This work will help to underpin the Swimway approach by gaining insights into seasonality in the Ems fish community and will provide a basis for comparative work in the estuaries of Germany and Denmark. The poster will show the project set-up and preliminary results.

Growth rate and hatch date distribution of European Smelt larvae in the Elbe estuary estimated by otolith microstructure analysis

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The anadromous smelt *Osmerus eperlanus* (Linnaeus, 1758) is considered as a key species in the Elbe estuary. Here, the smelt plays an important role in the food web due to its high abundance. Over the last five years, a decrease of the smelt stock was observed in the Elbe estuary. Especially with regard to the ninth fairway adjustment of the Elbe River, studies are highly necessary to detect possible causes for the recent decline of the smelt stock as a basis to develop conservation measures. As indicators for reproductive conditions, in this study actual growth rates and hatch date distributions of smelt larvae were estimated in 2018 and compared with values obtained in 1993 by Sepúlveda (1994), when a decrease of the smelt stock was not observed. Smelt larvae were caught at six different sampling sites in their main nursery area in the Elbe estuary between the 24th of April and the 29th of June 2018. Microstructures of overall 231 sagitta otoliths were analysed for all sampling sites and dates. Surprisingly, in 2018 smelt larvae showed a better growth than 25 years ago. Moreover, at the southern bank a higher growth rate of smelt larvae was estimated compared to the northern bank. The main hatching period of smelt larvae took place in April 2018. 85% of all analysed larvae hatched between the 6th and 21st of April 2018. In 1993, most smelt larvae hatched during a nearly identical period from the 7th to the 22th of April.

Representative species for biodiversity assessments: How to select species objectively?

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The Marine Strategy Framework Directive (MSFD) seeks a good environmental status for the European Seas. Therefore, the different ecosystem and biodiversity components need to be assessed on a regular basis. Although progress has been made during the last years, there are still a lot of gaps to fill, particularly at the sub-regional and regional level, where cooperation of Member States is required for harmonized assessments. The assessment of fish under the MSFD descriptor “Biodiversity” for the Greater North Sea (GNS), for instance, is currently highly incomplete. There has not even been an agreement on which species to select for the biodiversity assessment according to the defined species groups (coastal, demersal shelf, pelagic shelf and deep-sea fish). This would be a first, very important step towards the goal of harmonized assessments.
In this study, we focus on the coastal species from the GNS and test three different objective approaches to select a set of species as basis for MSFD biodiversity assessments. Species are selected a) according to their occurrence in the GNS, b) if listed as threatened in OSPAR or IUCN red lists and c) if all life-stages are restricted to the coastal environment. The selections of the three approaches are compared with regard to their representativeness of diverse ecological guilds, and a final suggestion is made on the preferred selection process.

Fish weirs to fill the Gaps that Nature 2000 and WFD left us with Fishermen, Conservationists and Scientists

Preparing the toolbox for monitoring trends in fish stocks and identifying Swimway functions in a Dutch Wadden Sea tidal basin

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Fisherfolk, nature conservationists and scientists aim to improve fish-data collection in the eastern Dutch Wadden Sea. Considerations are that trends should be monitored at fixed sites in different tidal basins. Until now, ecosystem monitoring and Nature 2000 management and the Water Framework Directive might focus to highly on demersal fish and benthic fauna. Pelagic species might represent a large part of fish biomass in the food web in tidal basins and estuaries, offering useful indicators. In 2018, PRW commissioned VvdK for an experimental fish weir monitoring in cooperation with NIOZ. This artisanal device was adapted for the purpose. The pilot showed good samples of juvenile herring, 0- and 1-year-old Flounder and Plaice and an occasional Tope. Based on the promising results, LifeIP Deltanature with SBB as project leader took over and financed a three year extension of the project by NIOZ and the fishermen. With the proposed 'Basismonitoring Waddenzee' as long-term follow up. A parallel, even important, ambition is to give people an opportunity to experience the natural world below the surface themselves.
Both goals suit the fishermen of VvdK who specialize in conducting monitoring projects since 2016. They aim for a better understanding of the dynamics of fish stocks by public, NGOs and authorities. Hopefully, the combined effort will help identifying and restoring 'Swimway-functions' in this part of the Wadden Sea.

Trilateral Swimway perspective: management goals in sight

Walker P[1,2]

[1]Programme towards a Rich Wadden Sea, Leeuwarden, NL
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Targets for a healthy and robust fish community in the Wadden Sea have been proposed and adopted as part of the revised Wadden Sea Plan in 2010. At the ministerial conferences in 2014 and 2018, it was agreed to work on the further implementation of these so-called Trilateral Fish Targets through the Swimway approach. Managers and policy makers are eager to address these targets as soon as possible in order to improve fish communities, but are limited in their knowledge of these communities due to lack of research and monitoring. Fortunately, the Swimway approach describes the extensive and collaborative research programmes needed to understand the dynamics of the fish populations, but this will take time. Also, as the targets are formulated at a high level of abstraction the links with management are not immediately obvious. Taking the Trilateral Fish Targets as a starting point, and in order to facilitate the discussion on developing new monitoring programmes and management measures, a suite of preliminary indicators has been developed which can be used to initiate a dialogue between managers and scientists. This poster will illustrate the policy and management background for fish, propose

indicators and how these might be used in this dialogue. In this way, no time is lost and the future results from research can link in to dedicated monitoring programmes.

Evaluation of the bioaccumulation potential of Alizarin red S in fish muscle tissue using the European eel as an example

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University of Hamburg, D

Alizarin red S (ARS) is an often-used chemical marker substance for fish otoliths and therefore an important tool for fish stock monitoring and large-scale management programs. Also for the endangered European eel (*Anguilla anguilla*), ARS marking proved to be the most promising option in terms of time, cost and toxicity. In addition, the marking of pre-grown eels from aquaculture is a necessary procedure to avoid age overestimation caused by farming related stress rings.
However, there are still open questions regarding the effects and accumulation potential of ARS in fish muscle tissue. This lack of knowledge led to a statement by the German Federal Institute for Risk Assessment in which the use of ARS was classified as not harmless. As a result, the current use of ARS for marking eel was banned throughout Germany as long as there was no scientific evidence of a possible accumulation of ARS in edible eel muscle tissue. In the present study a method for a liquid chromatography–mass spectrometry (LC-MS/MS) protocol for ARS detection in fish muscle tissue with a detection limit of 8.9 µg kg-1 was developed. The examination of 250 eels, which differed in body size (7 – 57 cm) and time after marking (0 days up to 3 years), showed that the highest ARS concentration of over $6x10^3$ µg kg-1 fish muscle was found immediately after marking. One year later the ARS concentration already was below the detection limit.

b. Participants

Surname	First name	Affiliation
Abel	Christian	National Park Administration Lower Saxon Wadden Sea
Akkerman	Siem	Provincie Fryslân
Baerends	Bernard	Common Wadden Sea Secretariat
Bauer	Maren	Ministerium für Energiewende, Landwirtschaft, Umwelt, Natur und Digitalisierung
Beier	Ulrika	Wageningen Marine Research
Borcherding	Rainer	Schutzstation Wattenmeer
Born	Gesine	Photographer
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Gutte	Helene	University of Hamburg, Institute for marine Ecosystem and Fishery Science
Hartmann	Uwe	LLUR Schleswig-Holstein
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Le Pape	Olivier	Agrocampus Ouest
Leyrer	Jutta	Michael-Otto-Institut im NABU
Lochte	Karin	Wadden Sea Board & German Alliance of Marine Research
Luna	Soledad	Common Wadden Sea Secretariat
Marampouti	Christina	University of Groningen
Matthiesen	Lisa	University of Hamburg
Mikkelsen	Caroline	Danish Environmental Protection Agency
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Nielsen	Peter Juhl	The University of Southern Denmark
Patberg	Wouter	Wetterskip Fryslan
Philippart	Katja	Wadden Academie
Pind G. Jørgensen	Henrik	Danish Environmental Protection Agency
Poiesz	Suzanne	Royal NIOZ
Polte	Patrick	Thünen Institute of Baltic Sea Fisheries
Poulsen	Bo	Aalborg University
Probst	Nikolaus	Thünen-Institute for Sea Fisheries
Roelsma	Jan	Wetterskip Fryslan
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van Bernem	Carlo	retired, formerly HZG

van Bernem	Janna-Lynn	University of Hamburg
van de Wolfshaar	Karen	Wageningen Marine Research
van der Graaf	Sonja	Programma naar een Rijke Waddenzee PRW
van der Heij	Wouter	Waddenvereniging
van der Snoek	Marelle	Waddenvereniging
van der Veer	Henk W.	Royal NIOZ
van Dijk	Jouke	Wadden Academie
Vegter	Jaap	Vissers van de Kust
Walker	Paddy	Tethys Advice
Wichmann	Laura	University of Hamburg & Research Center of Agriculture and Fisheries M-V
Wilson	Glenn	University of Southern Denmark

c. Selection of Photos

Participants of the SWIMWAY conference 2019, heads all up.

SWIMWAY coordinator Adi Kellermann welcomes the guests.

Klaus Janke, director of the National Park Administration Hamburg Wadden Sea, welcomes the conference participants to Hamburg.

Karin Lochte sets the stage for the SWIMWAY conference.

Katja Philippart fascinates her colleagues with her session keynote talk …

… and takes questions afterwards.

Presenters and organisers (left to right): Klaus Janke, Katja Philippart, Josianne Støttrup, Adi Kellermann, Paddy Walker, Andreas Dänhardt, Karin Lochte, Mike Elliott, Morten Søby Frederiksen and Julia Busch.

Klemens Eriksson receives instructions for the eel game during the education session.

Mike Elliott approves how Anja Szczesinski facilitates the education session.

Josianne Støttrup and Suzanne Poiesz are not quite sure what's going on.

Travelling along an eels' formidable swimway: the eel game.

Three fifths of the SWIMWAY organising team in a spontaneous breakout session.

Habitat maps are the basis.

Applied trilaterality: Julia Busch (black, center) with the Dutch, Danish and German student supporters of the SWIMWAY conference. From left to right: Helene Gutte, Mikkel Jensen, Peter Juhl Nielsen, Lena Holtmanns and Rebecca Christiaanse. Thanks for a great job!

Jouke van Dijk, Bernard Baerends and Katja Philippart.

Julia Friese and Klemens Eriksson, most likely talking about fishes in saltmarshes.

Paddy Walker and Bo Poulsen.

Josianne Støttrup making a good case for habitat maps.

Henk van der Veer presents the essence of his seminal long-term research on flatfish in the Wadden Sea.

Olivier LePape shows how integrating multiple methods really answers the questions on life-cycle connectivity of sole in the English Channel.

Britta Diederichs (left) and Eva Lages agree that scientific conferences are only as good as their coffee breaks.

Henk van der Veer and Mike Elliott under the SWIMWAY banner.

Julia Busch, Bernard Baerends and Hans-Ulrich Rösner at different stages of amusement.

Mike Elliott enjoys giving his keynote presentation as much as the audience did.

Jutta Leyrer provides context between long-term monitoring programmes and nature conservation policy.

Lead-author of the current QSR fish chapter Ingrid Tulp reports on pains and pleasures of compiling, analyzing and interpreting long-term fish monitoring data.

Jeroen Huisman calls upon paying close attention to windows of opportunity to make sluices fish-friendly.

Participants of the post-conference guided tour from townhall to concert hall also passed the conference venue and learned several interesting things about it (Photo: Siem Akkerman).

The new pride of Hamburg: Concert hall "Elbphilharmonie" (Photo: Siem Akkerman).