Trilateral Wadden Sea Swimway Vision
Action Programme

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The Wadden Sea World Heritage Site since 2009

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Authors

Trilateral SWIMWAY Group:

- *Martha Buitenkamp* (Coordinator), Programma naar een Rijke Waddenzee (NL)
- *Christian Abel,* Nationalparkverwaltung Niedersächsisches Wattenmeer (DE)
- *Loes Bolle*, Wageningen Marine Research (NL)
- *Kerry Brink*, World Fish Migration Foundation (NL)
- *Andreas Dänhardt* (DE)
- *Morten* Søby *Frederiksen*, Environmental Protection Agency (DK)
- *Gerard Janssen,* Rijkswaterstaat (NL)
- *Henrik G. Pind Jørgensen,* Environmental Protection Agency (DK)
- *Adolf Kellermann,* Kellermann-Consultants (DE)
- *Anne Sell*, Thünen-Institut (DE)
- *Ingrid Tulp,* Wageningen Marine Research (NL)
- *Paddy Walker*, Programma naar een Rijke Waddenzee (NL)
- *Wouter van der Heij*, Waddenvereniging (NL)
- *Ralf Vorberg*, Marine Science Service (DE)
- *Sascha Klöpper & Julia A. Busch* (Secretary), Common Wadden Sea Secretariat

Editors

Julia A. Busch, Common Wadden Sea Secretariat

Cover Photo:

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Content

Summary

Fish are an integral part of the Wadden Sea ecosystem, shuttling energy and matter up and down the food web. Many marine and estuarine fish species depend on the Wadden Sea at some point in their life cycle. The majority of these species spend only part of their lives in the Wadden Sea, as juveniles to feed and grow, or as adults to spawn or search for food, or en route between marine and freshwater habitats. 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 authors of the QSR (2009) proposed fish targets for the Wadden Sea, which were adopted as part of the revised Wadden Sea Plan in 2010 - the so-called Trilateral Fish Targets. These Fish Targets are:

1. Viable stocks of populations and a natural reproduction of typical Wadden Sea fish species;
2. Occurrence and abundance of fish species according to the natural dynamics in (a)biotic conditions;
3. Favourable living conditions for endangered fish species;
4. Maintenance of the diversity of natural habitats to provide substratum for spawning and nursery functions for juvenile fish;
5. Maintaining and restoring the possibilities for the passage of migrating fish between the Wadden Sea and inland waters.

At the ministerial conference in 2014 Denmark, Germany and the Netherlands agreed to "Acknowledge the importance of fish for the Wadden Sea ecosystem and therefore instruct the WSB to work on the further implementation of the Trilateral Fish Targets of the Wadden Sea Plan" (Tønder Declaration 2014, no. 28). The three countries agreed to implement the Trilateral Fish Targets through a Wadden Sea SWIMWAY Vision (including an Action Programme 2018-2024). This Vision will be part of the declaration at the ministerial conference in 2018 in Leeuwarden, in the shape of a condensed 2-page version (Annex 1). The elaboration of this SWIMWAY Vision is presented in this action programme. Implementing the Trilateral Fish Targets is the main goal of the Vision and the aim is to provide an overarching SWIMWAY approach – an umbrella – for a wide variety of initiatives related to achieving the targets. The Vision is based on four pillars: research and monitoring; policy; measures; stakeholder involvement; communication and education.

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.

The Wadden Sea Board will be responsible for the coordination of this action programme. The three countries will work together and provide expertise, capacity and resources for the implementation.

1. Introduction

1.1. General introduction

The Wadden Sea is one of the world's largest coherent intertidal wetlands. It is legally protected as the Dutch Wadden Sea Conservation Area, the German Wadden Sea National Parks of Lower Saxony, Hamburg and Schleswig-Holstein, and most of the Danish Wadden Sea maritime conservation area. The Wadden Sea is one of the last remaining large-scale, intertidal ecosystems where natural processes continue to function largely undisturbed. In 2009, the UNESCO included the Dutch and the German Wadden Sea in the World Heritage List (UNESCO, 2009), and the Danish Wadden Sea followed in 2014.

With 162 known species (Berg et al. 1996) the fish community of the Wadden Sea, including the North Sea and inflowing rivers, is exceptionally diverse. The populations of many fish species in the Wadden Sea have declined in recent decades and causes of these declines are only partly known or understood. Formerly typical elements of the Wadden Sea fish fauna such as sharks, rays and cod are largely absent, and the nursery function provided for juvenile plaice and sole, both characteristic for the Wadden Sea, has apparently declined. Processes and developments well outside the Wadden Sea can have an impact on the fish fauna in the Wadden Sea. For example, obstructions in rivers may block the SWIMWAY of juvenile diadromous fish into their coastal nurseries, and rising water temperatures may affect fish population dynamics in various ways, e.g. by influencing the length of time that juveniles spend in the Wadden Sea (Teal et al., 2015). The natural dynamics characteristic for the Wadden Sea come as changes in habitat- and food availability and thermal regimes fishes need to adapt to. This adaptability might be impaired by reducing the natural dynamics.

Basic understanding of essential processes and functional pathways is still missing in many cases, hampering effective and efficient fish conservation (Walker, 2015, Tulp et al. 2017). Danish, Dutch and German fish experts developed conservation objectives for fish - the so-called Trilateral Fish Targets, which were adopted at the 11th Trilateral Governmental Conference (TGC) as part of the revised Wadden Sea Plan 2010. At the 12th TGC in Tønder in 2014, Denmark, Germany and the Netherlands agreed to further implement these targets. The governmental declaration from that meeting states that parties: "Acknowledge the importance of fish for the Wadden Sea ecosystem and therefore instruct the Wadden Sea Board (WSB) to work on the further implementation of the Trilateral Fish Targets of the Wadden Sea Plan".

1.2. Trilateral Fish Targets

As fish are an important part of the Wadden Sea ecosystem, Danish, Dutch and German fish experts have developed conservation objectives for fish - the so-called Trilateral Fish Targets, which were adopted as part of the revised Wadden Sea Plan in 2010. These Fish Targets are:

1. Viable stocks of populations and a natural reproduction of typical Wadden Sea fish species;
2. Occurrence and abundance of fish species according to the natural dynamics in (a)biotic conditions;
3. Favourable living conditions for endangered fish species;
4. Maintenance of the diversity of natural habitats to provide substratum for spawning and nursery functions for juvenile fish;
5. Maintaining and restoring the possibilities for the passage of migrating fish between the Wadden Sea and inland waters.

This Action programme involves steps to operationalize the Fish Targets of the Wadden Sea Plan 2010 by deriving concrete courses of action to guide the implementation of programmes dedicated to approaching the approved targets.

These objectives are broadly formulated and need further specification in order to make progress towards making them measurable. The authors of the Wadden Sea Quality Status Report (QSR) fish chapter concluded that defining more specific objectives for fish – needed in order to operationalize the Fish Targets of the Wadden Sea Plan and to quantify their implementation- is not possible at this stage, because of the lack of basic understanding on the functioning of the Wadden Sea system for fish. In order to identify bottlenecks along the SWIMWAY of typical species utilizing the Wadden Sea during their life cycle, profound knowledge on key processes driving fish population dynamics is required. Scientific evidence is an important basis for effectively managing human activities to achieve the best possible conservation of fish in the Wadden Sea.

1.3. Action Programme

Implementing the Trilateral Fish Targets is the main goal of the SWIMWAY Vision, and the aim is to provide an overarching SWIMWAY approach – an umbrella - for all kind of activities contributing to the SWIMWAY Vision. This action programme is written by a trilateral coordination and writer's team, and describes the actions needed to improve knowledge on relevant processes, optimize population monitoring, adjust policies and develop and 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.

Stakeholder involvement, 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. Existing good practical solutions for migrating fish exist but are not widely enough known and exchanged between stakeholders at the basis (for example water authorities).

The action programme is based on the following pillars.

Research and monitoring

Present knowledge of the factors driving fish population dynamics in the Wadden Sea is largely insufficient to establish measures for improvement. Funds, time and capacity are needed for generating this knowledge. A SWIMWAY research approach will be developed as part of the action programme, which contains applied research essential for deriving management recommendations in addressing the trilaterally defined targets. Therefore, an overview of gaps will be made to determine actions for filling these gaps. Connections will be made with other initiatives, such as the Trilateral Research Agenda (currently under development,) and the Trilateral Task Group Climate. The programme should be complementary to national research agendas.

Policy

Current national and international policies and regulations which are potentially relevant to achieving the Trilateral Fish Targets will be described and analysed with regard to their contribution to the realisation of the Fish Targets. Following the analysis next steps can be identified.

Measures

At various locations conservation measures have already been carried out to improve living conditions for, and to mitigate threats to, fish. An integrative and comprehensive overview of such measures, together with a review of their contribution to the realisation of the Fish Targets, will help to evaluate the do's and don'ts and identify the "lessons learned". Combining this with the analysis of the bottlenecks will help gain insight into where measures might be developed in a participatory process with stakeholders.

Stakeholder involvement, communication and education

It is important to build an integrated framework of raising awareness, motivating relevant actors, inspiring decision makers and promoting actions. The aim is to raise public awareness and develop strong partnerships with stakeholders, which need to be involved in any kind of action. A trilateral education and communication programme will be developed for stakeholder involvement and political support.

2. Research and monitoring

2.1. General approach

The SWIMWAY approach refers to much more than only migration of fish swimming from river to sea or from offshore to the coast and vice versa. It also relates to movements of all life stages nested in different spatial scales: Across several 100s of kilometres larvae drift or, later in their development, move actively from their spawning grounds and aggregate in their coastal nurseries, where they switch between available habitat patches according to biotic (predators, feeding, intra- and interspecific competition) and abiotic (availability of physical habitat, tides, currents, temperature distribution etc.) conditions. Adult fish of species closing their entire life cycle in the Wadden Sea or going there to spawn may have different habitat requirements but are still vulnerable to interruption of their life cycle, be it through limited spawning substrate, poor growth environments, food shortage or direct sources of mortality such as predation or certain human activities (Figure 1).

In this research plan it is advocated that the only way to arrive at sensible measures aimed at improving the situation for fish is to view the function of the Wadden Sea within the whole life cycle of a fish species. To understand population dynamics, investing in quantifying the rates that drive population developments, such as births, deaths, immigration and emigration (demographic or vital rates) is needed.

Given the backlog of knowledge development in fish ecology of the Wadden Sea as compared to, for example, birds or benthos over the past decades, this means that there is a need for investment in basic knowledge in order to identify factors that are currently limiting for Wadden Sea fish populations. These factors may vary between species and areas.

2.2. Wadden Sea Plan Fish Targets and QSR 2017

The trilateral revised Wadden Sea Plan (WSP; CWSS, 2010) includes Fish Targets (see section 1.2). In the QSR 2017 fish-chapter it was concluded that these targets are not formulated in a testable way and not all easy to comprehend, allowing multiple interpretations (Tulp et al. 2017). Therefore, to facilitate objective evaluation in the future, the QSR-writers proposed to restructure and reformulate the targets as follows (Table 1):

Maintain or improve

- Robust and viable populations of estuarine resident fish species (WSP targets 1 & 2);
- The nursery function of the Wadden Sea and estuaries (WSP targets 1 & 2);
- The quality and quantity of typical Wadden Sea habitats (WSP target 4);
- Passage ways for fish migrating between the Wadden Sea and inland waters (WSP target 5);
- Conservation of endangered fish species (WSP target 3)

The QSR is based upon the Trilateral Monitoring and Assessment Programme (TMAP), which 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. The SWIMWAY initiative therefore relies on a tight connection to the fish chapter of the QSR, in order to establish research priorities with respect to the Trilateral Fish Targets of the Wadden Sea Plan.

The action programme sets the stage with a selection of fish species typically found in the Wadden Sea at some point along the SWIMWAY during their life cycle. These are grouped into focal species ("flagship species") exhibiting a certain lifestyle and representing others with a similar lifestyle ("fleet species"). Research needs have been identified based on reviews of current monitoring and research activities in the Wadden Sea (summarized in Tulp et al. 2017). Open research questions are specified in subsequent sections, relating to the Trilateral Fish Targets and the adjusted targets as formulated in the QSR 2017, and focussing in particular on species-habitat relationships, predator-prey relationships, fisheries, connectivity and ecophysiology along the SWIMWAY of focal species. Within each of these subjects, climate change is potentially important and will be referred to under each research topic.

This research agenda will provide important information that helps to develop meaningful and robust indicators to assess progress towards the Trilateral Fish Targets. Hereafter the research topics that are needed to arrive at such indicators and how each of them relates to the formulated Fish Targets are discussed.

The matrix connecting research fields with the Wadden Sea Plan Fish Targets and the reformulated targets in the QSR is presented in Table 1. Paragraphs 2.4 to 2.7 illustrate how the specific field contributes to each target (Table 1).

Table 1. Matrix of Fish Targets of the Wadden Sea Plan (CWSS, 2010) and as suggested in the Quality Status Report (Tulp et al. 2017) and research fields.

Targets		Research field			
		Predator-prey relationship	Eco-physiology	Species-habitat relationship	Connectivity
Wadden Sea Plan targets for fish (2010)					
WSP 1	Viable stocks of populations and natural reproduction of typical Wadden Sea fish species.	x	x	x	x
WSP 2	Occurrence and abundance of fish species according to the natural dynamics in (a)biotic conditions.	x	x	x	x
WSP 3	Favourable living conditions for endangered fish species.	x	x	x	x
WSP 4	Maintenance of the diversity of natural habitats to provide substratum for spawning and nursery functions for juvenile fish.			x	
WSP 5	Maintaining and restoring the possibilities for the passage of migrating fish between the Wadden Sea and inland waters.				x
Revised QSR targets for fish (2017)					
QSR 1	Maintain or improve robust and viable populations of estuarine resident fish species.	x	x	x	
QSR 2	Maintain or improve the nursery function of the Wadden Sea and estuaries.	x	x	x	x
QSR 3	Maintain or improve the quality and quantity of typical Wadden Sea habitats.			x	
QSR 4	Maintenance or improve passage ways for fish migrating between the Wadden Sea and inland waters.				x
QSR 5	Maintaining or improve conservation of endangered fish species.	x	x	x	x

2.3. Flagship & fleet species

Based on occurrence patterns, feeding and reproduction behaviour Elliott et al. (2007) defined functional guilds to increase the understanding of the use of estuaries by fishes. The grouping of species for the SWIMWAY programme was inspired by this approach. The following species may represent flagship and fleet for the Wadden Sea (Table 2).

Table 2. Possible flagship and fleet for the Wadden Sea.

Life style	Flagship	Fleet
Pelagic marine juvenile	Herring	Sprat, anchovy, horse mackerel, seabass
Demersal marine juvenile	Plaice	Sole, dab
Wadden Sea residents	Eelpout	Gobies, sandeel, sea snail, rock gunnel, mullets
Diadromous species	Smelt	Twaite shad, salmon, sea trout, houting, eel
Marine adventitious	Tope	Thornback ray, dogfish

2.4. Fish and other species: predator-prey relationships and other sources of mortality

Natural mortality through predation and human-induced mortality through a.o. fisheries are simultaneously affecting Wadden Sea fish communities. For an effective management towards viable populations, it is necessary to evaluate natural disturbances and sources of mortality against the effects of fisheries or other human activities.

Many issues regarding trophic interactions of fishes in the Wadden Sea remain unresolved but need to be known to make progress towards the Trilateral Fish Targets. The ecological mechanisms underlying the trade-off between rich food supply and threat through predators and diseases, is largely unknown. In addition to natural mortality, removal of fish by fisheries (including by-catch) is important. At the same time, the relationship between surplus and loss may determine the nursery value of the Wadden Sea and may be a bottleneck along the SWIMWAY of fish. Dänhardt et al. (2018) identified knowledge gaps regarding the interactions between seabirds and pelagic fish. Pelagic monitoring revealed a steep increase of gelatinous zooplankton (both indigenous and introduced species), potentially capable of affecting larval fish and zooplankton, which is the main food of pelagic schooling fish (van Walraven et al. 2013). Attempts to quantify trophic relationships in certain Wadden Sea areas have been made using mass balance models (e.g. Baird et al. 2012). These and other technical approaches allow for a broader view on ecosystem processes by quantifying trophic multispecies interactions.

Trophic relationships may affect spatio-temporal distributions, growth and survival of fish. Yet for many species, detailed and quantitative diet data are still missing. Research on predator-prey relationships and other sources of mortality thus is integral and indispensable to the SWIMWAY approach.

2.5. Fish in their physical environment: ecophysiology

Fish have clear requirements regarding the environment they live in. Temperature, salinity and oxygen are for instance important factors that determine whether the environment is suitable for a certain species or life stage. Physiological tolerances therefore also determine the ability of species to adapt to changing conditions and determine species' resilience or vulnerability against various stressors including climate change.

A large proportion of the Wadden Sea area is relatively shallow with high temperatures and high food production, together favouring fast growth of fishes and other poikilothermic animals. The Wadden Sea fauna is well adapted to high and extreme temperature fluctuations, but long-term warming trends and more frequent temperature extremes may challenge fish and other ectotherms to adapt, e.g. by shifting the period they use a specific area or by moving into deeper water (Dulvy et al. 2008). Known occurrences of species define conditions under which species are likely to be found, but effective conservation management requires models that make projections beyond the range of currently available data (Queirós et al. 2016). Physiological tolerances of species to environmental factors can be estimated experimentally or based on first principles (e.g. Dynamic Energy Budget models). In both these approaches, it is important to consider physiological response of various life stages to translate this information into full life cycle physiology-based models (Peck et al. 2013, Teal et al. 2015).

To understand what drives the use of the Wadden Sea by different fish species the physiological tolerances of species to environmental factors must be known. Experiments e.g. on temperature optima and aerobic scope combined with modelling exercises will help to evaluate the organism's response to changes and patterns of extreme events observed in nature (e.g. severe hypoxic events, short-term extreme warming events).

2.6. Fish in their habitat: species-habitat relationships

Several habitat types fulfil important functions in the life cycle of coastal fish (Seitz et al. 2014). In the course of their development often fish rely on different habitats. Most of these habitats are also typical and rather unique constituents of the Wadden Sea habitat mosaic. To complete their life cycle from egg to adult, all these habitats need to be present in the right scale and location. Identifying and where possible quantitatively assessing species-habitat-relationships are at the core of the research to be carried out in the SWIMWAY approach. To anticipate the impact of habitat changes and to take it into consideration in management decisions, it is necessary to know what degree of diversity and spatial heterogeneity of natural habitats is essential for Wadden Sea species to complete their life cycles.

A sound understanding of processes driving fish distribution over different habitats at different life stages is required for identifying sensitive or essential habitats relevant for closing the life cycles of different species (Figure 1). To successfully reproduce, suitable characteristics of larval and juvenile habitats supporting growth and survival are essential.

It is important to increase our understanding of the most prominent benefit the Wadden Sea holds for fish: 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 (Vasconcelos et al. 2014). These rates likely vary between habitats (for instance some fish may grow faster in eelgrass beds than on bare sand, or fish survive better if they have places to hide, e.g. stones). The link between demographic rates and habitat conditions in fish species found in the Wadden Sea is hardly established. Data on habitat-specific demographic rates for various life-history stages are needed to disentangle the role of habitat use vs. other factors in driving population dynamics (Vasconcelos et al. 2014).

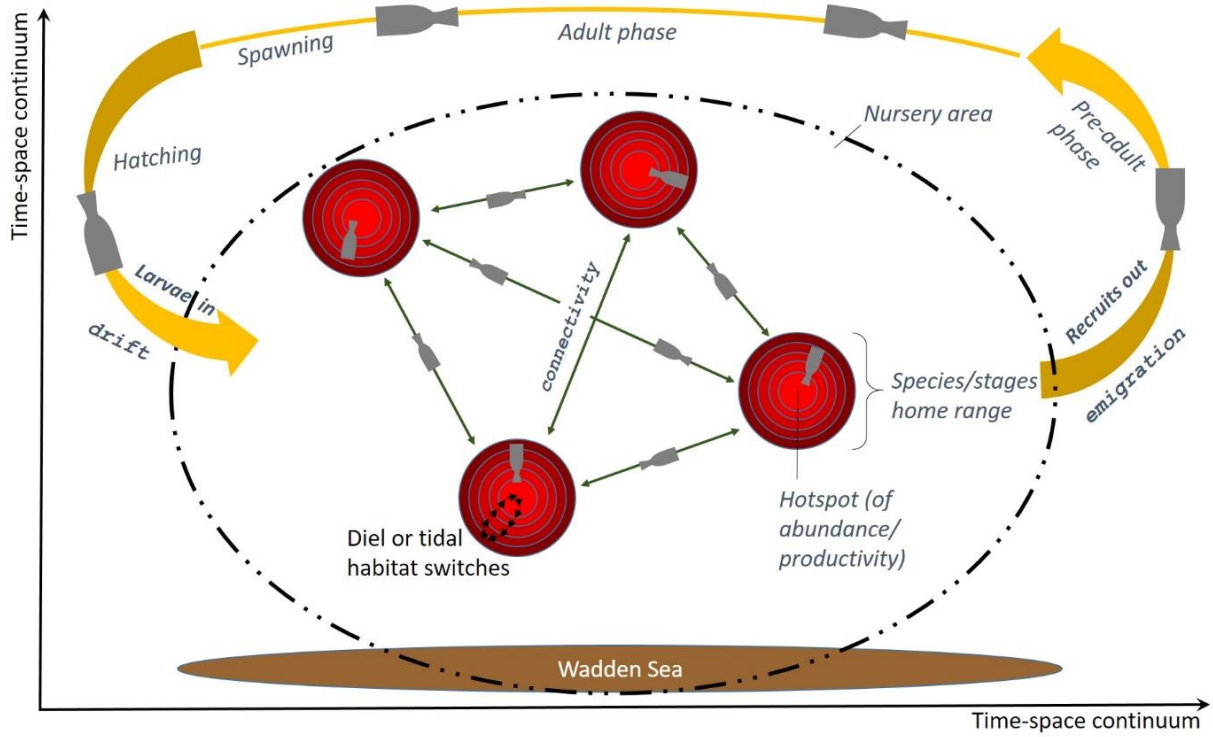


Figure 1: Schematic life cycle of fish, showing potential bottlenecks (grey), large-, intermediate- and small-scale movements along the time-space continuum along the SWIMWAY. Processes occurring in the Wadden Sea are inside the circle. The dashed line emphasizes that it is an open system. (Figure: A. Dänhardt).

2.7. Fish on the way: connectivity

Knowledge of limiting factors in the passage of migrating fish species between freshwater and the Wadden Sea, the North Sea and the Wadden Sea, or - at a smaller scale - between habitats within the Wadden Sea, is necessary to implement effective measures.

Fish are mobile organisms connecting habitats (Nagelkerken et al. 2015) and ecosystems (Lundberg & Moberg 2003), rendering connectivity an essential concept within the SWIMWAY approach. Fish found in the Wadden Sea exhibit a wide variety of lifestyles and can be classified accordingly (Bolle et al. 2009a). Species inhabiting the Wadden Sea during only part of their life (such as marine juveniles and diadromous species) 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. Variation in hydrodynamics driven by meteorology impacts habitats and habitat engineers such as reefs and mussel beds, and greatly affects transport patterns of eggs and larvae. Consequently, it plays an important role in determining recruitment variability and spatial connectivity (Bolle et al. 2009b, Hufnagl et al 2013). Likewise, the life cycle of diadromous species such as salmonids, smelt, twaite shad and river lamprey covers the rivers far upstream and the coastal marine areas (e.g. Aprahamian et al. 2003; Walther & Limburg 2012), making them vulnerable to obstruction and dependent on a wide variety of habitats along their SWIMWAY (Jepsen et al. 2012, Danish Salmon Management Plan 2017). At much smaller spatial and temporal scales, different habitat patches in the Wadden Sea make up a habitat mosaic interconnected by movements between them (Nagelkerken et al. 2015).

Connectivity is the process putting the previous research areas into the life cycle perspective by addressing where species and life stages come from, where they go and what kind of environment, including anthropogenic threats, they experience. Connectivity on different temporal and spatial scales is thus a key process to be investigated within the SWIMWAY approach.

2.8. Indicators

Eventually, knowledge and an enhanced process understanding arising from the SWIMWAY research can be integrated to define meaningful and robust indicators. Indicators are also required by many legal conservation frameworks such as the Marine Framework Strategy (MSFD). When thoroughly calibrated, they have the potential to integrate complex interactions and phenomena into easy-to-grasp measures e.g. of driving forces, pressures, states, impacts and responses of populations or ecosystems (Kristensen 2004). Measures currently used e.g. in the national red lists (e.g. Thiel et al. 2013) include the stock situation, abundance trends and risk factors. Many conservation targets, including those of European Directives, are kept generic and are untestable on the grounds of current knowledge (see Tulp et al. 2017). Consequently, their operationalization, implementation and evaluation demand further research. In recent years, attempts have been made to reconcile the requirements of the European Directives with existing conservation goals in the Wadden Sea. The basis for some potential indicators can be derived from existing fish monitoring programmes, e.g. size ratios, mean trophic level or the occurrence of species with

known habitat requirements. Yet, for a final selection of suitable indicators, a mechanistic understanding of underlying causes and effects is needed to derive recommendations for operational measures.

The research carried out within the SWIMWAY programme will improve cause and effect understanding, enabling researchers to develop more reliable and, thus, meaningful indicators as an applicable product of the research. These would go a step further than the examples given about, for example: population demographic characteristics; or abundance trends of functionally important selected groups/species. These indicators will enable managers not only to observe but also to explain phenomena and to react to them as required. Indicators developed on a sound process understanding will also allow evaluating progress towards reaching conservation goals as set by Natura 2000, the Wadden Sea Plan and other legal frameworks.

2.9. Concluding remarks

The main benefit arising from the SWIMWAY research outlined above will be the identification of population bottlenecks and the translation of this knowledge into effective management and conservation measures. Closing these knowledge gaps will help to improve effective conservation.

3. Policies

3.1. General approach

Policy objectives for fish in the Wadden Sea are formulated at the European, trilateral, national and regional level. The aim of the SWIMWAY action programme is to:

- Make an inventory of existing policies and regulations relevant to the Trilateral Fish Targets at the European, trilateral, national and regional level
- Analyse their contribution to the realisation of the Trilateral Fish Targets
- Following the analysis, the next steps can be identified

3.2. Topics

Inventory of existing policies and legislation

At the European level, there are a number of directives and regulations relevant to the Trilateral Fish Targets. These include o.a. Habitats Directive, the Water Framework Directive, the Marine Strategy Framework Directive, the Common Fisheries Policy, Ballast Water Convention, the Marine Spatial Planning directive and the Alien Species Regulation. Each of the Wadden Sea countries has legislation which can be relevant for the targets. Policies dealing with fisheries in the trilateral Wadden Sea will also be relevant[1].

Evaluate these policies in their contribution to the realisation of the Trilateral Fish Targets

The inventory of existing policies and regulations at European, trilateral and national level concerning fish will be analysed with regard to their contribution to the realisation of the Trilateral Fish Targets, taking into account uniformity, coherence and gaps. Following this analysis the next steps can be identified. In order to support this part of the action programme, a collaborative EU project evaluating European policies could be developed.

[1] A.o. Tønder Declaration on sustainable fisheries (paragraphs 36-40), CWSS report 2013 sustainable fisheries, TGMM working paper on fisheries from the TG-M 13 meeting in August 2015.

4. Measures

4.1. General approach

The processes determining the abundance and distribution of fish species are largely unknown and the challenge for the action programme will be to facilitate the further development of science-based conservation measures.

As a lot of measures are already taken, the first step will be to create a comprehensive overview of fish conservation measures currently being carried out or planned in the Wadden Sea Region and to identify how these may contribute to the trilateral Fish Targets. The information will be gained from public sources such as national management programmes, and, where possible, from interviews with relevant management bodies as well as publications. This information will then be combined with the analysis of the bottlenecks along the migratory routes of the flagship and fleet species for each functional lifestyle to gain insight into where measures might be developed. This analysis could be supported by an international workshop of experts to scope the issues and come up with solutions or mitigation measures.

The SWIMWAY programme will assist in sharing data and information between the three countries, defining best practices and applying research outcomes to develop measures and improve fish conservation. The information will be provided clearly and coherently and discussed with stakeholders. Special emphasis will be given to the exchange of best practice examples between the different water and nature authorities and the stakeholders concerned.

4.2. Possible measures

Possible measures could be allocated to the following categories (with some information from Walker, 2015, and Tulp *et al.* 2017).

Improving connectivity

1. Construction of fish passages (see e.g. plans at the Afsluitdijk in the Netherlands), technical installations for the bidirectional transport of fish past such obstacles, optimization of sluices for fish passage (see for example www.masterplan-ems.info). This issue is not limited to the Wadden Sea coast.
2. Removal or mitigation of obstacles from the migration routes between marine coastal areas and spawning grounds upstream restoration of spawning habitat for houting, salmon and sea trout as has been done in Denmark. Bottlenecks could be either physical obstacles, such as weirs and dams, or sources of mortality, such as catch and bycatch of recreational and commercial fisheries or cooling water extraction but also habitat degradation by dredging or sand nourishment. This could be in the Wadden Sea or surrounding waters, or even further away in the freshwater or marine environment.

Reducing impact of human activities

3. The effects of plastics and activities, such as fisheries and dredging on habitat and food web have not been well-studied in the Wadden Sea to date. Coherent management measures have not been developed.

4. Starting with a trilateral workshop, sources of anthropogenic fish mortality in the Wadden Sea should be identified and documented, e.g. in a fish mortality register. Regular updates and development of this register may help to implement effective and efficient measures to eliminate bottlenecks in the life cycles of fish utilizing the Wadden Sea. For example, fish extraction from the Wadden Sea system with the cooling water of power plants or hydropower generators can be minimized by deterring fish or separating them from the water used for technical purposes and return them to the system as carefully as possible. A position paper on the issue quantifying the problem published by Jager (2010) needs updating.

5. Within the framework of ensuring continued harbour access, an assessment could be made of the effects of the existing regulations concerning removal and dumping of sediments on the life-cycle of fish species.

Wise sand nourishments

6. Sand nourishments take place yearly in different parts along the coast and from time to time at the same location. Recovery time of the local benthic fauna after sand nourishments has been estimated at 1-5 years

Alertness for toxic substances

7. Potential effects of toxic chemicals in river runoff or other sources remains a relevant issue, given the speed at which new chemicals are introduced.

5. Stakeholder engagement, communication and education

5.1. General approach

The actions described in the previous chapters can be more successful if they go along with commitment from all stakeholders. It is therefore that raising awareness, activating practitioners, stimulating knowledge exchange, creating commitment and developing networks, are also important goals of the SWIMWAY approach. More specific aims are:

- **Raise awareness amongst stakeholders:** Collate and communicate the existing knowledge of fish using the Wadden Sea and promote the knowledge about the exchange of fish species beyond the Wadden Sea including inland waters and North Sea and beyond.
- **Engage and activate stakeholders:** Inspire people to share knowledge and experience and connect trilaterally with each other.
- **Foster international partnerships, dialogue and cooperation:** Stimulate communication between countries and sectors about fish in the Wadden Sea.
- **Develop tools to enhance the communication between the different focused stakeholders**
- **Perpetuating and optimizing** the interaction between all stakeholders, including scientists.

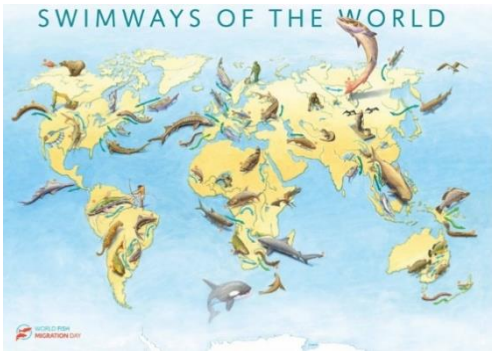
For each of these aims, it is necessary to have a clear impression of stakeholder involvement and communication strategies and activities that need to be planned. These activities will all be closely connected with actions related to research and monitoring, policy and measures and are discussed below.

5.2. Specific activities

Showcases

The approach will be to focus on four successful, national case studies already in progress in the Wadden Sea that fit to the Trilateral Fish Targets, to use as good examples that can help reach our communication objectives. To this end four showcases have been developed:

Global: SWIMWAYs of the World



Trilateral poster/flyer and a Wadden Sea poster. The SWIMWAY Poster visualises the routes migratory fish species travel around the world as well as the measures and key species. This is designed in an eye catching design, which is appealing to a broad range of people, from politicians to children. For World Fish Migration Day 2018, this SWIMWAY poster will be translated into Dutch, German and Danish. This will be used as a good example for the development of a trilateral poster for the SWIMWAY Wadden Sea Project.

Germany: Masterplan Ems 2050

A bundle of measurements focus on the overall improvement of the habitat and water quality of the Ems estuary and its tributaries. Special emphasis is put on an enhancement of the connectivity between the river Ems and the smaller rivers as well as the transmittance of the river Ems itself for fish. The rehabilitation of estuarine habitats especially aims at fish species like the smelt, depending on these habitats. First steps have been taken in 2017.

Denmark: Citizen Science

Use of citizen science in fisheries, with focus on recreational fisheries, the Key fishermen's project.

Netherlands: Collaborative project

From previous work with commercial shrimp fishermen it appears that the coastal area and tidal inlets of the Wadden Sea could be pupping areas for the tope shark (*Galeorhinus galeus*). This species carries out migrations of hundreds of km – spending at least part of its life cycle off the coast of Scotland. In order to identify the role that the Dutch coastal waters play in the life cycle of the tope shark, a collaborative project will be set up with the shrimp fishermen, NGOs and the VHL University of Applied Sciences to tag and release the individuals the fishermen catch.

Stakeholder engagement

Stakeholder engagement is essential for the success of the action programme. The SWIMWAY action programme focusses on professionals having direct or indirect impacts on fish through their work, such as researchers, commercial and recreational fishermen, water authorities, relevant governmental agencies and NGO's. Through the SWIMWAY initiative these stakeholders should become involved in mutual and balanced exchange of knowledge and experience, e.g. by linking each other via existing activities (see Table 2) and organizing new fish-related activities in the future.

Public engagement and education

Communication between stakeholders of ideas, results and experience forms an integral part of the SWIMWAY Programme (current stakeholder projects see Table 3). As such, communication activities are integrated into the research, monitoring and measures efforts proposed:

- A communication strategy and activities in the framework of the existing Communication Programme for the TWSC will be developed, encompassing both public engagement and education. Collaboration with community groups, tourist boards, information centres, visitors centres and other groups that engage directly with the public and schools (via the International Wadden Sea School) will be guided by the communication plan;
- Annual workshops and events directed towards various stakeholder groups;
- Connecting with citizen science, make use of existing exhibition centres such as the MULTIMAR (G), the Danish Wadden Sea Centre (DK) and Afsluitdijk (NL);
- Symposia: Dissemination of knowledge developed during programme;
- Website/ Branding/social media etc./flyer;
- Products such as a SWIMWAY Wadden Sea map, with migratory fish routes, valuable fish habitats, bottlenecks, and measures (categorised) taken in preparation;

Table 3: Current stakeholder projects.

Stakeholder project	Country	Notes	Time frame
World Fish Migration Day	All 3 countries	WFMD2018: Launch SWIMWAY Wadden Sea Poster WFMD2020: Initiate project	May 2018 May 2020
Fish migration river	Netherlands		Feb 2018 -April 2018
World biodiversity Day	All 3 countries		
Wadden Sea Day	All 3 countries		
AMBER	All 3 countries	Coastal barriers	
Dam removal Europe	All 3 countries	Coastal barriers	
SWIMWAY Global	International	Link SWIMWAY WaddenSea to SWIMWAY Global website	
Year of the Salmon (2019)	International	http://www.nasco.int/iys.html	

6. Organisation, planning and funding

6.1. Project structure

The Wadden Sea Board will be responsible for the coordination of the SWIMWAY Vision. The three countries will work together and convey expertise, capacity and resources on a project based approach for the implementation. According to the decision by the Ministerial Conference, the implementation of The SWIMWAY Vision is foreseen to be accomplished within the German Presidency plus two years i.e. in the period 2018-2024.

A trilateral implementation body for the SWIMWAY will develop a draft Terms of Reference (ToR) and workplan 2019 for the implementation of the SWIMWAY Vision.

This ToR will contain a description of tasks, deliverables, accountability and organisational structure. It will encompass a coordination task and capacity for supporting development of project proposals (national and European funding). This ToR and workplan 2019 will be submitted to the TGMM and the WSB for approval.

6.2. Planning and Costs

After the Trilateral Governmental Conference in May 2018 a trilateral start-up meeting will be organised to discuss the ToR and workplan, estimating required capacity and costs. The costs for the SWIMWAY programme have three components:

Ad 1 Coordination and organisational costs (meeting, material, travel costs)

Funding for coordination and organisation is essential to effectuate the SWIMWAY programme and to initiate further funding for activities in the project itself.

Ad 2 National representation

The actions mentioned in this program require capacity of scientists, NGOs, authorities and other professionals from the three Wadden Sea states. Without this effort, the SWIMWAY initiative will not succeed. The three countries are asked to deliver members for the SWIMWAY group and to enable them to contribute adequately to the SWIMWAY programme. The estimate of the required amount of time needs a more detailed elaboration of the activities per year.

Ad 3 Projects

It is envisaged that a number of collaborative projects will be developed to address the objectives of the SWIMWAY programme. The funding of these projects will be sought from external sources, both national and EU.

Even if national funding cannot be used in a trilateral context, it is important that the available financial resources are being coordinated as much as possible. Scientific institutes may be able to develop students' projects and PhD programmes for elaborating the SWIMWAY topics.

The process of submitting proposals and getting funds is usually long and intense. The project leader/members of the trilateral countries should be available to help, making use of national support, e.g. from the National Contact Points.

In 2019 a trilateral Fish summit will be organised. In 2021 there will be a midterm review.

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