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Invasive alien species (IAS) policies and management in the German Wadden Sea

***Hemigrapsus sanguineus*-**
The Japanese shore crab as an example for an invasive alien species in the German Wadden Sea

Client:
Common Wadden Sea Secretariat (CWSS)
Wilhelmshaven/Federal Republic of Germany

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Client:	Common Wadden Sea Secretariat Vichowstrasse 1 D-26382 Wilhelmshaven Federal Republic of Germany Tel. +49 (0)4421 9108 – 13 Fax +49 (0)4421 9108 – 30 dejong@waddensea-secretariat.org www.waddensea-secretariat.org
Title:	Invasive alien species (IAS) policies and management in the German Wadden Sea
Consultant:	BIOCONSULT Schuchardt & Scholle GbR Reeder-Bischoff-Str. 54 28757 Bremen Telefon 0421 · 620 71 08 Telefax 0421 · 620 71 09 Klenkendorf 5 27442 Gnarrenburg Telefon 04764 · 92 10 50 Telefax 04764 · 92 10 52 Internet www.bioconsult.de eMail info@bioconsult.de
Editors:	Dr. Bastian Schuchardt Dr. Duygu S. Sevilgen
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Summary

One of the goals within the framework of the Trilateral Wadden Sea Cooperation (NL, GER, DK), is the development of common strategy that uniformly addresses the management of invasive alien species (IAS). As a basis for this, consultants in Germany and the Netherlands were commissioned to carry out desk top studies on the current situation and relevant developments regarding the national IAS management. In Germany, this study was conducted by the environmental consulting agency BioConsult Schuchardt & Scholle GbR.

Currently the international management of IAS undergoes a dynamic change: since January 1st 2015, a new EU regulation on the prevention and management of the introduction and spread of IAS is in force that introduced the concept of a "Unionlist" of IAS; in addition, the international Ballast Water Management Convention (BWMC) is expected to come into force by 2016.

In the German Wadden Sea more than a dozen international conventions, EU guidelines, regulations and national laws address IAS. Generally, German IAS regulations are in line with international conventions (e.g. BWMC, OPSAR, HELCOM), EU-guidelines and -regulations. IAS topics are mainly addressed by the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN) as well as the nature conservation agencies of the Wadden Sea federal states. The BfN generates and publishes species lists (black/grey/white) which are compliant with the EU strategy on IAS (2003); within this year, it will furthermore publish a management-/measures-handbook focusing on terrestrial neobioata, and compile an invasiveness assessment of aquatic IAS.

The marine IAS management in Germany is addressed by a national group of experts (Fach AG Neobiota, amongst other institutions). In accordance with the new EU regulation, this group e.g. generates a potential German IAS list. The current focus of the Fach AG Neobiota lies in the operationalization of descriptor D2 of the marine strategic framework directive (MSFD) that addresses non-indigenous species introduced by human activities. In line with this, a trend-indicator was recently developed which enables an assessment of newly introduced IAS, their spread and decline, and by this the assessment of the descriptor D2 and the good environmental status of the investigated marine region. The indicator is based on data from monitoring-campaigns, which are commissioned by the BfN as well as by the single Wadden Sea federal states and which are carried out according to established protocols (rapid assessment survey (RAS) and HELCOM). Within these campaigns, the current focus lies on benthic IAS introduced by ballast water and ship's hulls to hot spots such as industrial harbors and marinas. In addition, the development and establishment of neobiota monitoring programs for the (German) Wadden Sea partially takes place in exchange with the neighboring countries (e.g. data exchange with the Netherlands for a comparison and optimization of the trend indicator). However, whether or not national approaches such as the trend indicator will flow into a uniform solution, remains an open question at this time point. This should be one of the remits within the development of a future coherent trilateral IAS strategy. Another field of activity should aim at the development of a common monitoring approach for the terrestrial realm of the Wadden Sea; a sector that is currently much less developed than the aquatic realm.

The ongoing work and discussions on IAS in the German Wadden Sea show, that within the national strategic sequence on IAS management (prevention → early detection/monitoring/rapid assessment

→ acceptance/control/eradication) the focus mainly lies on early detection and monitoring. This seems reasonable, as it can be assumed that after a successful establishment in the marine realm, the eradication of invasive species is very difficult, rarely successful and to date hardly described. An orientation of the trilateral IAS strategy towards prevention and early detection, as well as education, ballast water treatment and long-term monitoring thus seems reasonable as well.

Overall, the present analysis on IAS management shows that the main focus within the management approach should lie on prevention. Furthermore, it is recommended that a substantial step for the development of a trilateral strategy should lie within the weighting of vectors or pathways that will help to point out the most relevant ways of introduction. It is suggested to decide on a common type of monitoring, base it on and/or make use of the already developed trend-indicator and to determine terrestrial and marine monitoring hot spots that should be targeted. With respect to risk assessments, it will be important to set time frames for their realization. As eradication in the marine realm is very difficult, the focus should be given to less laborious and more promising, long-lasting and preventive actions. It is recommended to take distance from general eradication ideas in marine realm as being an equally weighted possibility like e.g. preventive measures or equally weighted like eradication in the terrestrial realm. If eradication in the marine realm is considered, it should be reduced to activities in small/ enclosed places (e.g. marinas) and needs to be designed highly case-specific. For the terrestrial realm, focus should also be given to prevention and, with respect to eradication, coordinated and specific approaches. Raising awareness is important, at the same time, it should be well organized, target-group specific and linked to the results of the suggested vector analyses/prioritization. On a structural level, setting up an organigram with contact institutes/contact persons for each country and the distribution to relevant bodies will help for a more efficient international management approach. To enable long-term overview and control/feedback-mechanisms of the approaches in place, it is recommended to include a regular reviewing and reporting processes in the DSF. In any case, the basis of finding a common strategy should also be a content based, sound risk assessment considering the specific situation of the Wadden Sea - a dynamic area that is currently already characterized by a multitude of neobiota.

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Abbreviations

BfN	Bundesamt für Naturschutz (Federal Agency for Nature Conservation)
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency)
BWMC	Ballast Water Management Convention
DSF	Draft Strategic Framework
GES	Good Environmental Status
H	Hamburg (Federal State, Wadden Sea)
IAS	Invasive Alien Species
MSFD	Marine Strategy Framework Directive
MV	Mecklenburg-Vorpommern (Federal State, Baltic Sea)
NIS	Non-indigenous species
NdS	Niedersachsen/ Lower Saxony (Federal State, Wadden Sea)
RAS	Rapid Assessment Survey
SH	Schleswig-Holstein (Federal State, Wadden Sea)
TG-M	Task Group Management
TWSC	Trilateral Wadden Sea Cooperation
WFD	Water Framework Directive
WIASAP	Wadden Sea Invasive Alien Species Action Plan
WSP	Wadden Sea Plan

1. Background of the study

In June 2009 the Dutch-German Wadden Sea was inscribed in the World Heritage list. Together with this inscription the World Heritage Committee encouraged the Wadden Sea Countries Denmark, Germany and The Netherlands to implement monitoring and management strategies to control IAS (Bouma et al. 2011).

Since 1978, the Netherlands, Germany and Denmark have cooperated to protect the Wadden Sea as an ecological entity. The Guiding Principle of the Trilateral Wadden Sea Cooperation is to *"achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way"*. This formal but legally non-binding cooperation is based on **the Joint Declaration on the Protection of the Wadden Sea** which was first signed in 1982 and updated in 2010. At the 12th Wadden Sea Conference (Sylt, 2010) it was agreed to develop a common strategy for dealing with alien species introductions in the Wadden Sea, also taking account of the request of the UNESCO World Heritage Committee and the Ballast Water Management Convention (BWMC).

In 2011, a comprehensive overview of the situation with regard to invasive alien species was presented in the report "Neobiota in the Wadden Sea" (Bouma et al. 2011). This report has been the basis for **drafting a strategic framework for dealing with alien species** (supplement S1, CWSS 2011), which was submitted to the 12th Trilateral Governmental Wadden Sea Conference in Tønder (Denmark, February 2014). The **Tønder Conference** agreed to further develop the trilateral strategic framework for dealing with alien species in the Wadden Sea and to coordinate the further development of an alien species management and action plan, taking into account inter alia an EU draft proposal on a Regulation on invasive alien species, closely following the implementation of the LIFE+ project (EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU).

In June 2013 a proposal for a trilateral project application on the development of a Wadden Sea Invasive Alien Species Action Plan (WIASAP) had been submitted to the EU LIFE+ program by a consortium of ministries/authorities and research institutes from the Wadden Sea countries. After having been informed in April 2014 that the LIFE application had not been awarded, the Wadden Sea Board instructed the task group management (TG-M) to develop a proposal for a trilateral project that should develop a trilateral alien species management and action plan, using the contents of the LIFE proposal. The TG-M agreed that before setting up a project, a desk study shall be carried out by the Netherlands and Germany reporting on the state of the art and current developments regarding IAS Management, with specific emphasis on the situation in the Wadden Sea, so as to be able to focus the project as much as possible. For Germany, the environmental consulting agency BioConsult Schuchardt & Scholle GbR was commissioned with this project and the report is presented in the following.

1.1 Task

The present desk study aims at providing an overview of the current state and relevant developments with regard to IAS management in the German Wadden Sea. The report comprises two main topics that are relevant in this context:

- Policies on IAS from a global to European, national and German Federal state level (chapter 2),
- Monitoring approaches from a trilateral to national and German Federal State level, as well as activities that are currently in place or under development (chapter 3).

Based on these chapters, the current situation of Wadden Sea Alien Species Monitoring and Management is holistically evaluated in the light of the draft strategic framework and a gap analysis is included (chapter 4). From here, recommendations for amendments of the current strategic framework and for necessary additional actions and measures, both with regard to monitoring and management are formulated (chapter 5).
Throughout the report, the focus lies on the three German Wadden Sea Federal States Niedersachsen (Lower Saxony, NdS), Hamburg (H) and Schleswig-Holstein (SH) and also Bremen (B). However, due to the tight link of the North- and Baltic Sea and relevant non-indigenous species related activities on a national level, the Baltic Sea Federal State Mecklenburg-Vorpommern (MV) will in some chapters also be presented.

The overall focus of the report lies on the present situation, general problems and possible approaches towards a successful trilateral solution and does not include detailed species lists or details on the ecology of neobiota/ invasive alien species. Where relevant, we refer to the respective publications.

1.2 Approach

Sources of information

Most of the information for the present report was collected through a primarily internet based literature review of peer-reviewed articles, reports and conventions/laws/regulations. For the state of the art information on a national and regional (federal state) level within Germany, several experts were contacted and interviewed by phone and/or e-mail. These are either enrolled in federal agencies such as the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN) or the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH), related to regional authorities such as the Wadden Sea National Park Authorities and Environmental State Offices of the single Wadden Sea related federal states, representatives of port operators or marinas (Niedersachsen Ports, Port of Kiel, Hamburg Port Authority, etc.) or engaged in consulting agencies and research institutions (e.g. Bioconsult SH, Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI), Leibniz Institute for Baltic Sea Research Warnemünde (IOW)).

A detailed list of the persons contacted, their affiliations and contact details is appended (Table A1).

Definitions

Throughout the report the term of 'invasive alien species' and related are used as defined by the Convention on Biological Diversity (page 17) and as used before within the Trilateral Strategic Framework (Table 1).

Table 1 - Definitions used within the report, as used in the Trilateral Strategic Framework and as defined by the Convention on Biological Diversity.

Definitions (based on the Convention on Biological Diversity, CBD VI/23)	
Native species	"Native species" refers to a species, subspecies or genetically distinct populations, occurring within its natural range (past and present).
Alien species[1]	"Alien species" refers to a species, subspecies or genetically distinct populations, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.
Invasive alien species	"Invasive alien species" means an alien species whose introduction and/or spread threaten biological diversity (For the purposes of the present guiding principles, the term "invasive alien species" shall be deemed the same as "alien invasive species" in decision V/8 of the Conference of the Parties to the Convention on Biological Diversity)
Problem or nuisance species	A species for which it can be assumed that based on the best available scientific evidence it will have a (significant) negative impact on the conservation goals of a Natura 2000 area.
Introduction	"Introduction" refers to the movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present). This movement can be either within a country or between countries or areas beyond national jurisdiction.
Intentional introduction	"Intentional introduction" refers to the deliberate movement and/or release by humans of an alien species outside its natural range.
Unintentional introduction	"Unintentional introduction" refers to all other introductions which are not intentional.
Establishment	"Establishment" refers to the process of an alien species in a new habitat successfully producing viable offspring with the likelihood of continued survival
Risk analysis	"Risk analysis" refers to: (1) the assessment of the consequences of the introduction and of the likelihood of establishment of an alien species using science-based information (i.e., risk assessment), and (2) to the identification of measures that can be implemented to reduce or manage these risks (i.e., risk management), taking into account socio-economic and cultural considerations.

[1] *Species occurring naturally in neighboring countries of the Wadden Sea and entering independently due to e.g. climate change, do not fall under this definition.*

2. Invasive Alien Species (IAS) Policy: current situation and developments

In a first step, this chapter gives a short introduction to IAS with the main vectors of introduction (relevant for the Wadden Sea), IAS impacts and management approaches. In a second part an overview of regulations that are currently in place will be given.

2.1 Introduction

The dispersal of organisms is a natural process limited by multiple barriers, among which geographical barriers are the most evident. However, for centuries, numerous species have been introduced to new areas by human activity in which they were previously absent (Nehring et al. 2009). These include introduced viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals (IUCN 2000). In many cases, these non-indigenous species (NIS) do not harm the regional ecology and economics. However, NIS can become "invasive" (invasive alien species, IAS) and can have enormous and long-lasting impacts on the region (environment, economy, society) when they suppress and replace the indigenous biota or cause damage to present structures. Alongside habitat change, overexploitation, pollution and climate change, IAS are recognized as one of the five pressures directly driving biodiversity loss (Reid et al. 2005, Shine et al. 2010, Bax et al. 2003). It is estimated that there are already over 12,000 alien species present in Europe, of which around 10–15% are invasive (European Union 2014).

2.1.1 Vectors

Various transport ways (=vectors) facilitate the dispersal of non-indigenous species worldwide, with the main ones differing for the marine and terrestrial realm (Table 2). These human-mediated pathways are the ones primarily influencing the global species movement.

Table 2 - Possible aquatic and terrestrial vectors (transfer mechanisms) for the global dispersal of non-indigenous and invasive alien species, ordered by significance (modified after Gollasch et al. 2013 & fao.org).

vector	
aquatic	**terrestrial**
ballast water (commercial shipping)	horticulture
ships' hull biofouling (commercial and recreational craft)	agricultural crops
canals	seedlings
intentional and unintentional aquaculture introductions	pet trade
release from aquaria/ornamental species trade	escape from research/ botanical gardens
release of bait species	hitchhikers
discharges of wastes following fish processing	travel and tourism
internet and mail order	internet and mail order

This order of vectors reflects a global consideration for various habitats and regions. A Wadden Sea specific order of the most relevant vectors, or a weighting of them does not exist. However, the human-mediated vectors that were mainly linked to non-indigenous species introduction into the North Sea and Wadden Sea Region most often (Buschbaum et al. 2012, Nehring et al. 2009, Gollasch & Nehring 2006, NORSAS 2015) are introduced in the following and shall be elaborated in more detail.

Shipping

Shipping is a major vector for global introductions of marine NIS both via ballast water and sediments, as well as biofouling (Lehtiniemi et al. 2015 and references therein, NORSAS 2015).

To increase their stability and for load-compensation, ships take in enormous amounts of **ballast water**. This is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port of call, wherever more cargo is loaded. At any given moment 10,000 different species are being estimated to be in transit around the globe in the ballast water of ships tanks (Bax et al. 2003). Typically some 30-40% of the ships deadweight tonnage can be carried as ballast water, although ballast capacities on large bulk carriers can make up 60% of deadweight tonnage. The amount of sediment can reach several hundred tons with sediment thickness in the tanks exceeding half a meter. Whereas the ballast water mainly contains pelagic species (plankton, nekton) and larvae of sessile organisms, the sediment hosts many ground-dwelling organisms (encrusting benthos, meiofauna and –flora) (Nehring 2005, Bax et al. 2003). International shipping also represents the main introduction pathway for aquatic alien species in Germany (Nehring 2005).

Biofouling describes the accumulation of organisms on a wetted surface and covers a wide range of organisms. It includes bacteria(l films) (microfouling), soft macrofouling specimen (seaweeds, invertebrates (soft coral, sponges, tunicates)) and calcareous organisms such as barnacles, mollusks and tubeworms (hard macrofouling) (Callow & Callow 2002). Biofouling concerns all submersed structures of commercial ships, recreational crafts and other water sports gear. Particularly on commercial ships' hulls it is of high economic interest as it changes hydrodynamics and reduces the speed of the vessels. Thus prevention (anti-fouling coatings) and reduction (cleaning) of biofouling are of great concern for the ships' owners. During the 1960s the chemicals industry developed efficacious and cost-effective anti-fouling paints using metallic compounds, in particular the organotin compound tributylin (TBT). By the 1970s, most seagoing vessels had TBT painted on their hulls. However this was soon to be proven highly ecotoxic. Since 2003 the application of TBT containing antifouling is forbidden for all ships flying the flag of an EU country and prohibited or restricted strictly also in more countries (The Green Blue 2003). Alternative coatings however are less efficient and despite ongoing development of antifouling coatings, cleaning remains challenging, especially as organisms also settle on structures and in areas which are not necessarily easy to clean or to reach (dents, propellers, etc.). This makes biofouling a major vector for non-native marine species. A German study addressing ship related species introduction into the North Sea showed that non-native species were recorded in 96% of all studied ships' hulls (186 vessels) (Gollasch 2002).

For regulations targeting shipping as a vector: see page 22.

Aquaculture

Since more than 100 years commercial shellfish transfers across the globe to Northern Europe are carried out (Wolff & Reise 2002). Imports of shellfish for aquaculture activities provide a suitable vector for attached macroalgae and their spores, for invertebrates as well as phytoplankton species. Until 2005, fifteen alien species were believed as being imported in association with American or Japanese oysters on the German North Sea coast (Nehring 2005).

Within the Wadden Sea area, aquaculture is an important economic branch. In 1964 the Pacific oyster *Crassostrea gigas* was introduced into the Oosterschelde estuary of the Netherlands (Drinkwaard 1999) and in 1971 to Germany (Wadden Sea/Island of Sylt vicinity) (Reise 1998; Diederich et al. 2005). Around Sylt the commercial farming with *C. gigas* started 1985 (Nehring 2003). After successful reproduction, in 1991 the first oysters were found outside the culture plot. Spat settled on any hard substrate in the intertidal zone but preferentially upon wild banks of the native blue mussel *Mytilus edulis* (Reise 1998). Thus, near Sylt solitary oysters have developed into coherent reefs, often with large quantities of oysters dominating over the native mussels. However there are a few example of the co-existence of oysters and blue mussels in mixed beds and small numbers of areas where blue mussels dominate. Whether or not native blue mussel beds will disappear over time due to the rapid spread of the Pacific oyster cannot be answered clearly (QSR 2009).

For regulations targeting aquaculture as a vector: see page 25.

Overall, for species introductions in the North Sea and the Baltic Sea shipping and species imports for aquaculture are the most important vectors. In comparison, in inland waters most aquatic alien species invasions are attributed to **canal** constructions that facilitate species migrations, to the release of species that have been imported with the **ornamental trade**, **stocking** and ship traffic (Gollasch & Nehring 2006).

Horticulture

Ornamental horticulture has been recognized as the main pathway of plant invasions worldwide (Council of Europe 2008, Reichard & White 2001). It is estimated that 80% of current invasive alien plants in Europe were introduced as ornamental or agricultural plants (Council of Europe 2008 and references therein). One of the most renowned invasive plants in the Wadden Sea that is represented by extensive populations is the cordgrass *Spartina*. For the purpose of reclamation of land, *Spartina anglica* had been intentionally introduced in the Netherlands in 1924 and is present in Germany since 1927 and is now widely spread in the entire Wadden Sea region (BfN 2015b). Another important example is the Japanese rose (*Rosa rugosa*) which was initially introduced as an ornamental plant and is known to be in culture in Germany since 1854. Nowadays, it widely populates the coastal areas and dunes of the German and other European North and Baltic Sea coastal regions (neobiota 2015).

Pet trade/ Escape

The trade and import of pets is an important vector for invasive species when the animals, particularly when they become loose. Thus, e.g. ferrets and feral house cats can cause problems for the inventory of breeding birds, especially on the Wadden Sea Islands (Nationalpark Wattenmeer 2010). Additionally, the use of live bait in fishing can serve as a source of introduction.

Tourism/ Transport

The Wadden Sea area is a frequently visited region, from both the commercial and private sector. Intense commercial ship traffic, national and international ferry lines, traffic between small Islands and visits from land all together increase potential introductions of NIS which, upon introduction to the new area may establish self-contained populations and become invasive.

Natural/Secondary dispersal and Climate change

Several natural pathways additionally facilitate the secondary dispersal of species. Thus, individuals or the seeds of non-native or invasive alien species that are established somewhere can be carried over long distances to other areas by **winds and currents** that connect different water bodies. In this context for instance tropical drift seeds on the Dutch coast were discussed as an indicator of long-range transport by marine currents (Wolff 2005 and references therein).

Furthermore, it has to be considered, that climate change and the involved alterations of physico-chemical parameters can make it much easier for non-indigenous species to establish at a new destination. It has been suggested that most of the important elements of global change are likely to increase the prevalence of biological invaders (Dukes & Mooney 1999). **Climate change** can disrupt ecosystem processes therefore enabling naturally dispersed (*"climate shifters"*) or human-mediated introduced species to become established.

Besides the introduction of non-indigenous species into the Wadden Sea region as described above, it needs to be kept in mind that in addition to single vector introductions, the change of a biological system by a an interplay of human mediated factors, natural components, contingencies and time is an ongoing dynamic process and has ever been in the natural history and development of the Wadden Sea (Reise 2013).

2.1.2 IAS Impacts

The establishment of IAS can have a multitude of impacts. Alongside economic impacts (agricultural sector, aquatic systems, health sector) IAS directly affect ecosystem services (e.g. food provision, ocean nourishment, recreation and tourism) and biodiversity which have recently been presented in greater detail in a pan-European review (Katsanevakis et al. 2014). Accordingly, impacts of IAS on biodiversity can be summarized in three main branches: **impact on species** (e.g. food provision^{+}, predation^{-}), **impact on ecosystem engineering** (e.g. structural engineers (creation/modification of structural elements of habitats$^{+/-}$), light engineers (control of penetration of light$^{+/-}$)) and **impact on ecosystem processes/functioning** (e.g. creation of novel habitat$^{+/-}$, algae blooms^{-}, anoxia^{-}, overgrazing^{-}). For all categories, there are both positive ($^{+}$) and negative ($^{-}$) examples and it has been pointed out that mainly due to lack of information, the positive effects are likely to be underestimated hitherto (Katsanevakis et al. 2014). Typically, effects would summarize as interspecific competition (space, food, nutrients), alteration of the habitat (structural or by altering abiotic factors such as nutrients/hydrodynamics/light), interference with existing food-webs (predator-prey shifts), hybridization and disease transmission caused for example by the introduction of bacterial or viral infections.

Furthermore, climate change can intensify the effects caused by invasive species, including competition with native species for resources and the alteration of native ecosystems (IUCN 2009). The European green crab (*Carcinus maenas*) for example is a well-known invasive predator along the western and eastern coast of the United States where it damages coastal fisheries by consuming juvenile native bivalves. Controlling and managing the green crab populations is very difficult and both biocontrol and physical control methods were not successful so far. In Maine the only circumstance diminishing the crab population were winters with below average temperatures. The trend of warmer winters may thus cause further establishment and expansion of the species (U.S. Environmental Protection Agency 2008). A study on marine fouling communities has shown that ocean warming increases the threat of invasive species in the fouling community as the introduced species were in advantage over native species with respect to temperature tolerance, survival and growth (Sorte et al. 2010). In the Wadden Sea, over a decade ago Nehring (1999) already suggested that there was a climate induced change of primary producers whose original habitats were in warmer waters.

2.1.3 Management approaches

Depending on the habitat addressed and the country looked at, there are a few management approaches that address IAS. Commonly they include prevention, early detection (site-specific & general monitoring, detection on place of origin) as well as management (containment, control, eradication). Within the Trilateral Strategy five elements were defined:

1. prevention (as the first line of defence),
2. early warning/ detection & rapid response (prevent and control introductions by risk assessments, detection- and monitoring-programs)
3. eradication & control
4. raising awareness and
5. structural arrangements and way forward (cooperation between different authorities on a national and international level).

The first three elements address IAS on a practical level both in the marine and terrestrial realm. However, the challenges and the status of IAS management in these two realms can be very different. This issue will be illuminated in more detail in later sections (section 3 & 4). Generally, the management consists of a sequence of approaches and represents an interplay of legislative specifications and actions to meet the management goals as exemplary shown for Canada (Figure 1).

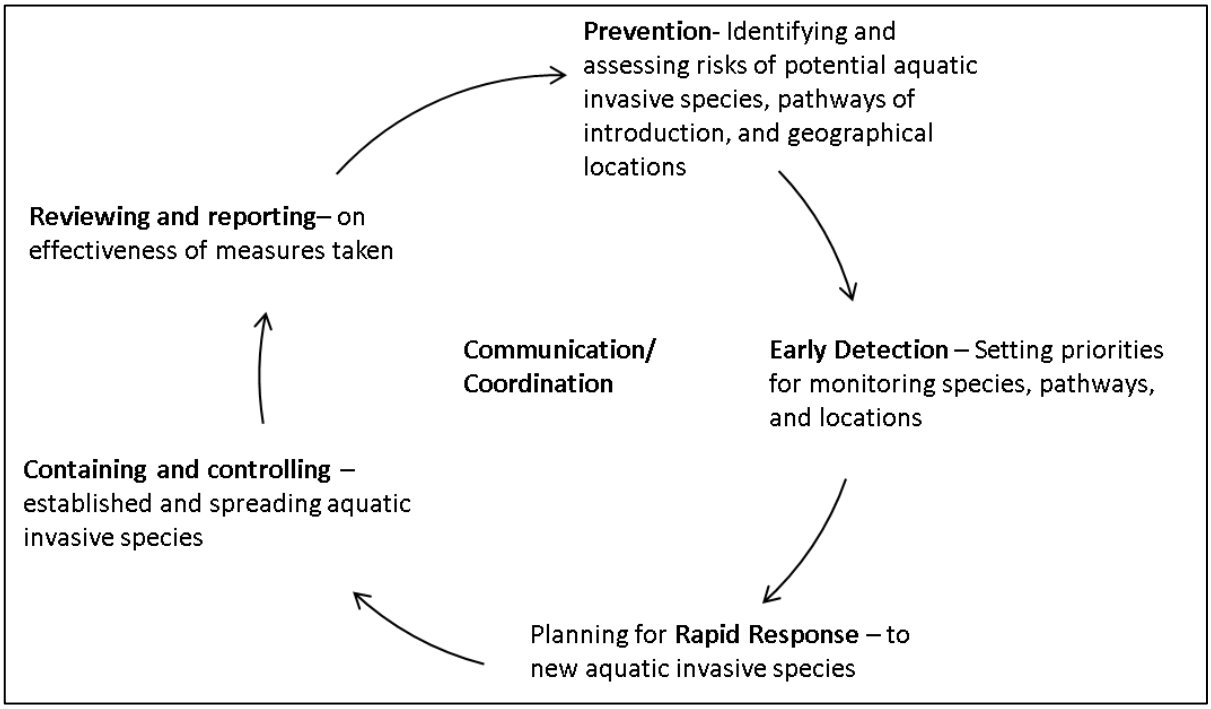

Figure 1 - Approach addressing aquatic invasive species as adopted from the IAS strategy Canada (OAG 2008).

On an international level a multitude of policies concern IAS and globally there is no fixed common strategy on how to address this issue. Within Europe more than a dozen conventions, regulations and laws concern IAS and recently steps are made towards common EU regulations. Just in 2014 a new European Regulation specifically addressing IAS was released (page 25). Whereas there is no overarching approach for the terrestrial realm in practice, the Marine Strategy Framework Directive (MSFD) specifically targets NIS in the marine realm. Thus, in the descriptor D-2 for the determination of good environmental status (GES) it is defined that "*non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems*" (European Union 2008a). Derived from this, it becomes evident that monitoring IAS presence and impact is a prerequisite for (marine) environmental management as well as sustainable development (Lehtiniemi et al. 2015). A well-structured approach for IAS management becomes particularly relevant in designated habitats that are exposed to increased human activity but require a high degree of protection. One of such areas is the Wadden Sea.

2.2 Regulations

In the past, more than 50 international and/or regional conventions, codes of conduct or practice and other instruments have been developed to address (invasive) alien species and are reviewed by Shine et al. (2000). More than a dozen apply to the Wadden Sea Region. Only a minority of these refer to aquatic species. Some of these instruments which are partly binding and partly voluntary provide a good starting point from which national legislation can be and is developed (Bouma et al. 2011). A detailed overview of international and regional agreements and guidelines on IAS is published by the Convention on Biological Diversity (CBD Secretariat 2015). The most relevant (parts of the) conventions and regulations in the context of non-indigenous and invasive alien species that

apply to the trilateral Wadden Sea Region are summarized in Table 3 and outlined in detail in the following.

2.2.1 Global Conventions

Convention on Biological Diversity (CBD)

On 29 December 1993 the Convention on Biological Diversity (CBD) entered into force. This global agreement addresses all aspects of biological diversity based on three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. With article 8 on in-situ conservation, all contracting parties of the convention *"shall as far as possible and appropriate … (h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species"*.

In 2002, the CBD Conference of the Parties adopted a specific Decision and Guiding Principles to help parties implement this requirement. The Decision urges parties, other governments and relevant organizations to prioritize the development of IAS strategies and action plans at a national and regional level and to promote and implement the CBD Guiding Principles. The CBD Guiding Principles set out a "Three-stage hierarchical approach" as the basis for all action on IAS: a) prevention of IAS introductions between and within state is generally far more cost-effective and environmentally desirable than measures taken after IAS introduction and establishment; b) if an IAS has been introduced, early detection and rapid action are crucial to prevent its establishment: the preferred response is often to eradicate the organisms as soon as possible; c) where eradication is not feasible or resources are not available, containment and long-term control measures should be implemented (CBD Guiding Principle 2) (Genovesi & Shine 2003).

Current issues: In October 2014 the conference of the parties (COP) to the CBD addresses IAS and gives *"Guidance on devising and implementing measures to address the risk associated with the introduction of alien species as pets, aquarium and terrarium species, and as live bait and live food"*.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Also known as the Washington convention CITES is an international agreement between governments that entered into force on 01 July 1975. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Recalling previous decisions, the Conference of Parties (CoP) to the convention adopted a resolution on IAS during CoP13 in 2004. This was reviewed in the CoP14/2007 Resolution (Conf. 13.10 (Rev. CoP14)), where it was recommended to consider IAS during development of legislations regarding trade of live animals and plants, to consult with national authorities in case of proposed import/export of IAS, and to strive for synergy between the CITES and the Convention on Biological Diversity (see section 2.2.1). In Europe, CITES is translated in the "Regulation of the protection of species of wild fauna and flora by regulating their trade therein, (EC) No 338/97".

Table 3 - Overview of main official writings which are of concern regarding invasive alien species (IAS) in the trilateral Wadden Sea Region from a global to regional level. For further details see section 2.2.

Writings	Aim (relevant to IAS)	in force since
Global Conventions		
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington Convention)	that international trade of live plant and animals should not threaten their survival	1975
The Convention on Wetlands (RAMSAR CONVENTION)	maintaining the ecological character of wetlands of international importance	1975
Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention)	to conserve terrestrial, aquatic and avian migratory species throughout their range	1979
Convention on Biological Diversity (CBD)	in-situ conservation of biological diversity	1993
United Nations Convention on the Law of the Sea (UNCLOS)	protection and preservation of the marine environment: prevent, reduce, control "pollution"	1994
Convention for the Control and Management of Ships' Ballast Water and Management (BWMC)	treat Ballast water to reduce potential introduction and dispersion of IAS	2015?
European policies/directives/regulations		
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)	control of IAS introduction	1982
Birds Directive	no prejudice of local biota by introductions of birds to habitats where they don't occur naturally	1979
Habitat Directive	no prejudice of natural habitats of wild native fauna and flora by introduction of other species	1992
Water Framework Directive (WFD)	good environmental potential of surface water, no "bio" pollution	2000
Marine Strategy Framework Directive (MSFD)	IAS as descriptor 2 to reach good environmental status	2008
EU regulation concerning use of alien and locally absent species in aquaculture	protect aquatic environment from risk of nan-native/invasive AS through use in aquaculture	2008
Regulation on the prevention and management of the introduction and spread of invasive alien species	prevention, early warning & rapid response, and management of IAS, IAS-List of Union concern	2015

Regional Regulations		
Oslo and Paris Convention (OSPAR Convention)	"pollution" that may harm protection of the marine environment of the North-East Atlantic	1998
Baltic Marine Environment Protection Commission- Helsinki Commision (HELCOM)	prospects a healthy Baltic Sea with good environmental status	2000
Trilateral approaches		
Trilateral Wadden Sea Plan	common policy and management plan for the protection and sustainable management of the Wadden Sea Area- support and intensify efforts to harmonize approaches to the prevention, management and monitoring of aquatic and terrestrial alien species introductions, develop a common strategy for dealing with invasive alien species associated with ballast waters and aquaculture	1997/ 2010
Joint Declaration on the Protection of the Wadden Sea (Sylt Declaration)	achieving, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way, coordinated and consistent management, including the production and implementation of a periodically updated Wadden Sea Plan	2010
Tønder Declaration	further develop the trilateral strategic framework for dealing with alien species in the Wadden Sea and to coordinate the further development of an alien species management and action plan	2014

Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (CMS) was adopted in 1979 and is an intergovernmental treaty that aims to conserve terrestrial, aquatic and avian migratory species throughout their range. Article III 4.c defines that *"Parties that are Range States of a migratory species that is listed in* (the convention's) *Appendix I shall endeavor to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species"*. With Article V.5.e, the contracting parties furthermore agree to provide for *"conservation and, where required and feasible, restoration of the habitats of importance in maintaining a favorable conservation status, and protection of such habitats from disturbances, including strict control of the introduction of, or control of already introduced, exotic species detrimental to the migratory species"*.

Ramsar Convention

The Convention on Wetlands (Ramsar Convention, in force since 21 December 1975) is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their wetlands of international importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories (Ramsar Convention Secretariat 2014). In resolution VII.14 from 1999 on invasive species and wetlands it calls upon the contracting parties to *"12. …wherever possible address the environmental, economic and social impact of invasive species on wetlands within their jurisdictions…"* and *"13. …to take account of the methods of control and solutions for combating invasive species"*. In the 2002 resolution VIII.18 it furthermore *"urges Contracting Parties to address the problems posed by invasive species in wetland ecosystems in a decisive and holistic manner, making use, as appropriate, of the tools and guidance developed by various institutions and processes, including any relevant guidelines or guiding principles adopted under other conventions,.."*, and gives several suggestions on how to approach the topic of invasive species on a national and international level.

Bern Convention

The Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats) is a binding international legal instrument in the field of nature conservation that entered into force on 1 June 1982. By now fifty countries and the European Union have signed up to the Convention and committed to promoting national conservation policies, considering the impact of planning and development on the natural environment, promoting education and information on conservation, and coordinating research. According to Article 11 §2.b of the convention, *"Each Contracting party undertakes to strictly control the introduction of non-native species."*. In 1992 the Standing Committee to the Bern convention established a specialized "Group of experts on Invasive Alien Species". Acting under the same article, this group collected and analyzed different national laws dealing with invasive species and proposed work aimed at the harmonization of national regulations on introduced species. One of the main products of the group was the European Strategy on IAS (page 21), whose implementation is regularly monitored by the group (Council of Europe 2014).

Current issues: In December 2014, a list of decisions and adopted texts was published which amongst others addresses recreational fishing activities in the prevention and management of the introduction and spread of IAS in the territory of the Convention.

United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea (UNCLOS) lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources. It was opened for signature in December 1982, signed by the European Community in December 1984 and entered into force in 16 November 1994 (United Nations, Office of Legal Affairs 2013). In Part XII which addresses the protection and preservation of the marine environment, article 196 on the use of technologies or introduction of alien or new species defines that *"1. States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto."*

IUCN Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species

These guidelines were approved by the IUCN council in 2000. They are firmly based on the precautionary approach, and on what is required to prevent biodiversity loss (native) caused by alien invasive species. They are meant to aim high towards an ideal solution, and it is not expected that all recommended actions would be put into practice in the short term. The goal of these guidelines is to prevent further losses of biological diversity due to the deleterious effects of alien invasive species. The intention is a) to assist managers, policy or decision-makers, at all levels (local, national, regional) to give effect to Article 8(h) of the Convention on Biological Diversity, to b) contribute to the development of strategies, regulations and practical measures by international, regional, national and local bodies and to c) play a role in awareness-raising of all stakeholders involved in the invasives issue (IUCN 2000).

European Strategy on Invasive Alien Species

At their 23rd meeting in December 2003 the standing committee of the Bern convention (page 20) endorsed a European Strategy on Invasive Alien Species which set up a very precise "road map" to deal with the crucial ecological problem of IAS (Genovesi & Shine 2003). The strategy is in full harmony with the guidelines adopted in 2002 by the 6th Conference of the Parties of the Convention on Biological Diversity.

To facilitate common approaches to decision-making on proposed introductions and to avoid unjustifiable trade restrictions, a dynamic and regularly reviewed species listing system for IAS was proposed. It comprises three categories: a black, white and grey list. The black list would include species whose introduction is strictly regulated with priority given to species that are a) already identified as highly invasive in one or more European states, b) proven to be invasive in other regions and c) species that are likely to cause problems to several European states, are not yet present there and have a high potential of introduction. Species classified as low risk following a risk assessment or based on long-standing experience would be assigned to the white list. With the request for caution, introduction of specimens of white list species may be authorized without

restriction or under conditions. The grey, or "holding" list would cover any species not included in the black or white list, potentially species related to black- or white-listed species, species that are date-deficient or should be subject to risk assessment prior to a decision on authorization. Within Germany, corresponding black, grey, and white lists of alien species are published by the BfN on the neobiota website (Neobiota 2015).

Convention for the Control and Management of Ships' Ballast Water and Sediment (BWMC)

The International Maritime Organization (IMO) has formulated the International BWMC which was adapted by consensus at a diplomatic conference at IMO/ London (February 2004). From 2009, but not later than 2016, the Convention requires the establishment of a BWM system on board ships which will replace the uncontrolled ballast water uptake and discharge operations common until then. In the future, ballast water has to be treated on board (first by a filter, secondly chemically) before being discharged into the marine environment, in compliance with the ballast water performance standard in Regulation D-2 of the BWMC (BSH 2015). The Convention will enter into force 12 months after ratification by 30 States, representing 35% of world merchant shipping tonnage. There are no specific national legislations on Ballast Water Management. Germany has ratified the convention by signing the corresponding national law in February 2013.

Current issues: As of June 5th 2015, 44 States representing 32.86% (of the needed 35%) of the world merchant shipping tonnage have ratified the convention (IMO 2015). Amongst these are all three Wadden Sea countries.

In July 2014 OSPAR agreed to endorse a proposal for specific exchange areas for ballast water exchange in the North Sea for intra North Sea traffic. The regulation designates areas in which ballast water exchange cannot take place in the North Sea for intra North Sea traffic in accordance with the BWMC as the required depths is too shallow. It enables ships to still meet D-1 standards as required by the convention. The regulation enters into force when the convention enters into force, and terminates when ships shall meet regulation D-2 of the Convention (ultimately 2016 for all categories of ships).

IMO guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species

These voluntary guidelines were released in July 2011 and are intended to provide useful recommendations and practical guidance on general measures to minimize the transfer of invasive aquatic species and the risks associated with biofouling for all types of ships and are directed to States, shipmasters, operators and owners, shipbuilders, ship cleaning and maintenance operators, port authorities, ship repair, dry-docking and recycling facilities, ship designers, classification societies, anti-fouling paint manufacturers and suppliers and any other interested parties. A State should determine the extent that the Guidelines are applied within that particular State. They suggest

- to implement a biofouling management plan and record book,
- to install and maintain antifouling systems for successful biofouling prevention,
- to undertake in-water inspections, cleaning and maintenance,

- to take biofouling into account during initial ship design and construction,
- the States to exchange relevant experiences and information through the Organization and
- training for ships' masters and crews, in-water cleaning or maintenance facility operators and those surveying or inspecting ships (with respect to biofouling management).

There are no specific national activities for the control and management of ships' biofouling.

IMO guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft

Released in 2012 these guiding information addresses mainly crafts <24m in length. It explains (the problem of) biofouling and invasive aquatic species and gives detailed guidelines for minimization of biofouling, points out niches, and gives suggestions for cleaning (out of- and in-water cleaning) and recording of biofouling activities. The guidelines have been translated into German by the sailing association but there are no specific national legislations on ships' biofouling for recreational crafts.

2.2.2 EU directives and regulations

Within the EU, several directives" and "regulations" are released that automatically address all EU member States. A "directive" is a legislative act that sets out a goal that all EU countries must achieve within a certain timeframe. However, the means on how to achieve the result are not dictated and it is up to the individual countries to decide how to adopt the directive. A "regulation" is a binding legislative act. Upon publication it is self-executing and must be applied in its entirety across the EU.

Natura 2000, Birds Directive (2009/147/EC) and Habitats Directive (92/43/EEC)

Both the Habitats Directive and Birds Directive form the cornerstones of Europe's nature conservation policy. They lay out the basis for the so called Natura 2000 network (i.e. nature protection areas within the EU that are designated to assure the long-term survival of Europe's most valuable and threatened species and habitats) which was founded in 1992 and also covers large parts of the Wadden Sea.

The **Birds Directive** (based on Directive 79/409/EEC of 2 April 1979, updated as 2009/147/EC) provides a framework for the conservation and management of wild birds in Europe with a broad objective regarding non-native birds. Article 11 of the Directive defines that *"Member States shall see that any introduction of species of bird which do not occur naturally in the wild state in the European territory of the Member States does not prejudice the local flora and fauna."* Non-native native species are also addressed in the **Habitats Directive** of 21 May 1992 which states in Article 22.b that Member states shall *"ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider it necessary, prohibit such introduction. The results of the assessment undertaken shall be forwarded to the committee for information"*.

Within Germany the Birds Directive is translated in the **Vogelschutz-Richtlinie** (2009/147/EG). Its implementation is mainly carried out by the Federal Conservation Act (BNatSchG, see 2.4.1), the Federal Species Conservation Regulation (Bundesartenschutzverordnung, BArtSchV) and some regulations of the Hunting Act (Jagdgesetz). By means of the Birds Directive, all "European bird species" are especially protected under §7 of the Federal nature Conservation Act (BNatSchG).

The **Fauna-Flora-Habitat Richtlinie** (92/43/EWG) is the German national pendant of the Habitat Directive.

Water Framework Directive (WFD), 2000/60/EC

The Water Framework Directive (WFD) is the main policy document for the management of inland surface, transitional and coastal waters as well as groundwater in the EU. It was published and came into force on 22 December 2000. For the prioritization of management measures under this Directive water bodies are being classified according to their chemical and ecological status. Ecological status assessments are designed to detect responses to anthropogenic pressures such as eutrophication, acidification, hydromorphological modification and dangerous substances. Also alien species may constitute an important pressure at the level of the communities, habitats and ecosystems (Vandekerkhove & Cardoso 2010).

Marine Strategy Framework Directive (MSFD), 2008/56/EC

The Marine Strategy Framework Directive (MSFD) was adopted in June 2008 and came into force on 15 July 2008. It extends the EU water legislation as defined in the WFD to marine environment. Each Member State was required to transpose the MSFD into national legislation by mid July 2010. The Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. To achieve these objectives the Directive established European marine regions on the basis of geographical and environmental criteria (the Baltic Sea, the North East Atlantic, the Mediterranean and the Black Sea). To help Member States interpret what GES means in practice, the Directive sets eleven qualitative descriptors which describe what the environment will look like when GES has been achieved (European Commission 2015a). Amongst these the second one (MSFD, supplement S2, descriptor D-2) addresses non-indigenous species and states that *"Non-indigenous species do not adversely alter the ecosystem"*. By 2012 member states were asked to make an initial assessment of their marine waters complying with indicative lists of elements including biological features such as *"an inventory of the temporal occurrence, abundance and spatial distribution of non-indigenous, exotic species or, where relevant, genetically distinct forms of native species, which are present in the marine region or subregion."* (MSFD, Annex III Table 1). On a national level the status of non-indigenous species has been reported upon in line with the implementation of the MSFD and the initial assessment, the description of good environmental status and the definition of environmental goals of the North Sea (BMU 2012 a, b & c).

Current issues: According to the general time-plan, the development of a program of measures designed to achieve or maintain GES by 2020 shall be finalized by each member state within this year (2015). Currently, defined measures for the implementation of the MSFD in Germany are published for revision until 30 Sept 2015 (BLMP Secretariat 2011b). The German monitoring frame concepts were forwarded to the EU (Oct/Nov 2014). Subprograms are being developed or are

already in place in Germany. However there is no established final general monitoring program for the descriptor D-2 in place yet but shall be established until 2018 (BLMP Secretariat 2011a). In addition, no measures addressing alien species are planned until now (BLMP Secretariat 2011b).

EU regulation concerning use of alien and locally absent species in aquaculture, (EC) No 708/2008

As of 11 June 2007 this regulation aims to create a framework governing aquacultural practices in order to ensure adequate protection of the aquatic environment from the risks associated with the use of non-native species and locally absent species in aquaculture. It particularly provides a legal framework for the application of a procedure for special permits (European Union 2011). The Regulation aims to create a framework governing aquacultural practices in order to ensure adequate protection of the aquatic environment from the risks associated with the use of non-native species and locally absent species in aquaculture. The Regulation applies to movements of alien species (introductions) or locally absent species (translocations) for their use in aquaculture in the European Union (EU). The Regulation covers all aquatic species including any part that might survive and reproduce. It applies to all types of aquacultural installation. Nevertheless, it lays down special provisions relating to closed aquaculture facilities. Movements of non-native or locally absent species to be kept in closed aquaculture facilities may be exempted from the requirement to obtain a permit on condition that they are transported under conditions that prevent them from spreading in the environment. Member States must draw up a list of closed aquaculture facilities and update it regularly. The Regulation does not apply to translocations of organisms within Member States, except if there is a risk to the environment; to pet-shops, garden centers or aquaria where there is no contact with EU waters and to certain species listed in the regulation's Annex IV, except for certain provisions (Eur-LEX 2011). In 2011 the regulation was amended with respect to closed aquaculture facilities ((EU) No 304/2011).

Regulation on the prevention and management of the introduction and spread of invasive alien species, (EU) No 1143/2014

Published in November 2014 this Regulation has been in force since 01 January 2015. It seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have. The Regulation foresees three types of interventions: prevention, early warning & rapid response, and management. The regulation centers around a list of IAS of Union concern ('The Union List') that will be drawn up and managed with Member States according to paragraph 3 of the regulation (European Commission 2015b). It will contain a sub-set of IAS that is thought to be of major concern amongst the 1,200–1,800 IAS present in Europe. Decisions to list a species as IAS of Union concern will rely on evidence-based risk assessments and scientific evidence. The assessments must be done according to agreed criteria so that the results are valid for the entire EU. A standing committee of experts nominated by the Member States and the Commission will then evaluate each risk assessment and decide if the species should be included in the list of EU concern (European Union 2014). Within Germany, potential Unionlist species are being discussed presently; however nothing is published yet (page 43).

Code of conduct on horticulture and invasive alien plants

Belonging to the Bern Convention, this voluntary Code of Conduct is addressed to governments and the horticultural industry and trade – plant importers, commercial nurseries, municipal nurseries, garden centers, aquaria – and to those who play a role in deciding what species are grown in particular areas such as landscape architects, municipal parks and gardens departments, recreation and leisure departments.

Its aim is to enlist the co-operation of the horticultural trade and industry and associated professionals to adopt good practices in (a) raising awareness on this topic among professionals, (b) preventing the spread of alien invasive species already present in Europe, and (c) preventing the introduction of possible new plant invaders into Europe (Council of Europe 2008).

2.2.3 Regulations within the regional seas

OSPAR Convention

The OSPAR Convention is the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. It combines and up-dates the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution and entered into force on 25 March 1998. Work under the Convention is managed by the OSPAR Commission, made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Union (ospar.org). Alien Species are addressed indirectly in Article 1.d by the defining 'pollution' which "means the introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea."

In May 2008, OSPAR countries have started preparations on a collective approach on the regional aspects of the implementation of the MSFD and have identified the issues for cooperation and coordination by analyzing the requirements in the Directive and to what extent this cooperation and coordination on all steps of the marine strategies should take place (ospar.org). Within OSPAR, biodiversity indicators are developed in the International Correspondence Group Coordination of Biodiversity Assessment and Monitoring (ICG-COBAM) under the umbrella of the ICG-MSFD and reported to the Biodiversity Committee (BDC). NIS and IAS have been the topic within MSFD workshops of OSPAR. The mitigation of NIS/IAS by vector control was mentioned as well as that formulations of contracting parties addressing NIS/IAS were vague and that there were mixing of targets and indicators covering both NIS and IAS (OSPAR 2012a). Within the implementation of the MSFD and reaching GES, OSPAR already had published a MSFD advice manual in 2012 in which it addressed NIS (OSPAR 2012b). It states in chapter 6 NIS (6.6,2.1) that *"It may not be possible to develop targets on the basis of abundance, occurrence and spatial distribution of invasive NIS due to the lack of sufficiently detailed knowledge on their current status. Such targets are also constrained by the difficulty of removing these species once they have become established in any location. Trend-based targets for new introductions of NIS, however, may be possible using a combination of best available information on abundance/distribution and expert judgment. Such targets could however be based on long-term monitoring at high-risk sites, for example, in selected*

marinas or port". This recently became relevant within joint approaches of OSPAR and HELCOM and a suggested trend indicator from Germany (page 39).

Current issues: In Nov 2014 OSPAR published a regional plan to improve adequacy and coherence of the MSFD implementation between 2014 and 2018 in the member states (OSPAR 2014). It addresses the following chapters: common indicators, assessment and determination of GES; environmental targets; monitoring; addressing knowledge gaps; programs of measures and cross-cutting issues. In section II.9., one goal specifies *the "further development and operationalization of Common Indicators and (where possible) Priority Candidate Indicators (and thematic assessments planned), to be used by OSPAR Contracting Parties in the Intermediate Assessment 2017 (Roof Report) for 2018 initial assessment."*

HELCOM

HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission) is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as the Helsinki Convention. It entered into force on 17 January 2000 and by definition applies to Denmark and Germany as trilateral Wadden Sea representatives. The Convention acts as a policy maker for the Baltic Sea Region and is a body for developing, according to the specific needs of the Baltic Sea, recommendations of its own and recommendations supplementary to measures imposed by other international organizations. It was established to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation. It prospects a healthy Baltic Sea environment with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable economic and social activities (HELCOM 2015).

OSPAR/ HELCOM joint activities

In 2013 the OSPAR and HELCOM Task Group on Ballast Water Management Convention Exemptions (HELCOM/OSPAR TG BALLAST) released a Harmonized Procedure for the contracting parties of OSPAR and HELCOM on the granting of exemptions from the BWMC (see section 2.2.1) under regulation A-4.

In July 2014, a revised version of an online decision support tool on alien species introductions via ballast water was released. The tool comprises a database on observations of alien species and physical features in ports, a list of target alien species, a list of all marine and alien species observed in port surveys in the region and an agreed risk assessment model. It will allow administrations and ship owners to quickly identify routes that may qualify for exemptions to the application of ballast water management for ships (Regulation B-3) and those that are unlikely to. Thus it will help protect the environment by identifying routes that could present a high risk for the transfer of alien species (HELCOM/OSPAR 2015).

In Oct 2014 a first joint meeting of HELCOM and OSPAR on Biodiversity Indicators to harmonize reaching GES for the respective ocean areas took place in Gothenburg/Sweden (COREBAM - Joint meeting of HELCOM CORESET II and OSPAR ICG-COBAM). Within this meeting, the topic of NIS was addressed specifically. Particular opportunity for cooperation was identified for one existing trend-indicator that was developed and presented by Germany (supplement S3 page 4 & Annex 7).

One key outcome with respect to this topic was that based on this indicator there is good opportunity for a joint NIS trend indicator. The trend-indicator is described in more detail later in this report (page 39).

2.2.4 National regulations and recommendations

Federal Conservation Act - Bundesnaturschutzgesetz (BNatSchG)

The central body of rules and regulations in Germany is the Federal Nature Conservation Act which implements the European directives into national law. Since 01 March 2010 it defines IAS in §7 and fundamentally regulates this subject area in §40. Under this paragraph, the overall objective is the prevention to counteract threats to ecosystems, habitats and species imposed by non-indigenous or invasive species by appropriate measures (para. 1). Paragraph 2 formulates the installation of monitoring programs for species for which there is existing evidence that they are invasive. If a new IAS is detected, it shall be removed immediately. If not possible at least its spread is to be prevented (para. 3, sentence 1). Concerning IAS that have already spread, a further spread or impact of the spreading shall be reduced (para.3, sentence 2).

The spreading of alien plant species in the wild and of all animals (including within the populated area) is subject to approval (para. 4, sentence 1). The approval for spreading operations is to be refused if a risk for ecosystems, habitats or species cannot be excluded; the study area includes all European Member States (para. 4, sentence 3). No permit is required by the Federal Nature Conservation Act regarding agricultural and forestry cultivation of plant species, native animal species that are subject to the hunting and fishing, biological plant protection in case of a present phytosanitary permission, as well as the spreading of woody plants and seeds outside their occurrence areas up to and including 1 March 2020 (para. 4 sentence 4).

Additional national regulations

Further regulations which pertain to neobiota are represented by the

- Plant Protection Act (Pflanzenschutzgesetz),
- Federal Hunting Act (Bundesjagdgesetz),
- Federal Forestry Act (Bundeswaldgesetz),
- Seed Regulation (Saatgutverordnung),
- Plant Variety Protection Law (Sortenschutzgesetz),
- German Animal Disease Act (Tierseuchengesetz) and the
- Animal Welfare Act (Tierschutzgesetz).

(overview on www.neobiota.de)

Basic principles for the development of a national strategy against invasive alien species

In 2007, the Federal Agency for Nature Conservation (BfN) released this extensive report (Grundlagen für die Entwicklung einer Nationalen Strategie gegen invasive gebietsfremde Arten) which was prepared by the Center for Nature Conservation of the Georg-August-Universität

Göttingen (Zentrum für Naturschutz). It represents the final report of a research and development project between 2003 and 2005 and thoroughly analyses the political, legal, economic and ecological framework conditions.

National strategic plan on aquaculture

Generally IAS in aquaculture is regulated by the respective EU regulation (see page 25). In June 2014 the national strategic plan on aquaculture (Nationaler Strategieplan Aquakultur) was released in response to article 34 of the Regulation on the Common Fisheries Policy ((EU) 1380/2013). It concerns IAS only indirectly.

Marine aquaculture in Germany is (except for one company in MV and one in SH that produce salmon trout on a very small scale) basically not existent. The potential for development within the German North Sea is, due to the status of Wadden Sea, categorized as rather low. Potentials outside the National Park areas however are described as rather well suitable. Yet, possible developments towards these areas cannot be foreseen as there are knowledge deficits with respect to the usability of these potentials and legislative restrictions (Bundesverband Aquakultur 2014).

According to the German Federal Association for Aquaculture and regarding shellfish culture in the North Sea (mussels and oysters), a spatial extension of shellfish production beyond the already approved districts for shellfish culture is not in accordance with the goals of the Wadden Sea National Parks and thus will not be pursued. Shellfish cultures (mussels) in the Baltic Sea are currently of minor importance as they are not well established yet (Bundesverband Aquakultur 2014).

2.2.5 Federal state regulations

Within the federal states additional nature protection laws such as federal state laws on fisheries and aquaculture address NIS/IAS and are outlined federal state specific in the following. Due to the tight North Sea- Baltic Sea link and a common management in Germany, this includes the regulations that are effective in the Baltic-Sea State Mecklenburg-Vorpommern (MV).

Niedersachsen (NdS), Lower Saxony

With respect to shellfish fisheries, the coastal fishing regulations (Küstenfischereiordnung, NKüFischO) of Lower Saxony regulates in §8(5) that shellfish which has been fished for the stocking of a shellfish-culture-area within NdS is only allowed to be spread within NdS. Furthermore shellfish that was fished outside NdS can only be used in NdS upon permission (§8(7)). For specific regions in the Wadden Sea, approval for import can only be granted when shellfish originates from certified European shellfish-breeding-areas (Muschelzuchtgewässer). For other areas of origin shellfish needs to be certified as free of parasites and diseases before approval for import. All laws and regulations concerning mussel fisheries in NdS are also summarized in the management plan for mussels issued by the Lower Saxony Ministry of Food, Agriculture, Consumer Protection and Regional Development (MoA) and the Lower Saxony Ministry of Environment and Climate Protection (MoE).

The release of NIS is regulated in §9 NKüFischO. Thus, release of non-indigenous fish, crustaceans and shellfish needs to be permitted by the fisheries authority. Permission shall not be granted if the release of such species would distort the indigenous fauna or if a threat of its stock cannot be excluded.

Schleswig-Holstein (SH)

After a lawsuit in 2011 the import of blue mussels other than from regions within the SH Wadden Sea is forbidden since 2013 to minimize the introduction of NIS. By the fisheries law of Schleswig Holstein (Landesfischereigesetz, LFischG §39(1)) it is prohibited to use vertebrates as live bait, thus live bait is eliminated as a vector for NIS/IAS. Furthermore, the regulation for freshwater fishing of SH (§10 Binnenfischereiverordnung (BIFO)) regulates the water-body (-inherent) origin of dead bait fish. Thus, if legislation is followed, angling should not be a relevant vector for NIS/IAS (pers. comment Dr. Roland Lemke, MELUR SH).

Hamburg (H)

The fisheries law of Hamburg defines prohibitions for the protection of fish in §9. According to section (2) it is forbidden to fish using live bait; section (3) defines that fish of non-indigenous origin are only allowed to be released in inland waters after permission of the responsible authorities.

Bremen (B)

In §21(6) the fisheries law of Bremen prohibits the use of live bait fish. In an ordinance for the protection of fish stock, it defines with §28(12) that the fisheries authority (Oberste Fischereibehörde) is entitled to lay out regulations concerning aquaculture facilities including the registration of all proposed introductions and translocations of non-indigenous and alien species.

Mecklenburg-Vorpommern (MV)

The fisheries law of MV also prohibits the use of live bait fish (paragraph 12(2)). So far, there are no federal state specific regulations on non-indigenous species in fisheries. Regarding aquaculture the EU regulation concerning use of alien and locally absent species in aquaculture (section 2.2.2) is implemented within MV. There are no further federal state specific regulations for the implementation of the regulation yet (pers. comment Dr. Scharschmidt, LALLF-MV).

3. Monitoring & Management of IAS in the German Wadden Sea: current situation and developments

Within a trilateral context, Germany is involved in the trilateral monitoring assessment program (TMAP). The TMAP common package was implemented based on a decision at the Ministerial Conference in Stade (Germany), 1997. It is the common monitoring program for the Wadden Sea carried out by the Netherlands, Germany and Denmark. It is carried out by the respective national and regional authorities that are in charge of monitoring. Data is evaluated in assessment reports (Quality Status Report, QSR), of which the latest was issued in 2009 and which includes reports on aquatic alien species.

In Germany**, the German Federal Law on Nature Conservation (BNatSchG, page 28) follows a hierarchical approach to IAS handling** with §40: initially this comprises the prevention of invasive species introduction (measures must be taken to counter threats for ecosystems, biotopes and species caused by non-indigenous or invasive alien plants and animals). Where there are indications that species could be invasive species, the relevant species are to be monitored. If this is not sufficient, the competent Federal and Lander authorities shall immediately take suitable measures aimed at eliminating, or preventing the spread of, newly appearing plants and animals of invasive species (although these are not specified). General **information on neobiota and guidelines are made publically available by the Federal Agency for Nature Conservation, BfN (Bundesamt für Naturschutz**). It has set up an informative internet platform (www.neobiota.de) that gives a general introduction and overview into the topic of neobiota and IAS, offers contact to experts, gives portraits of invasive and potentially invasive plants and fish, and gives access to black, grey and white lists of species. Additionally it informs the reader about ongoing projects such as the development of a management handbook which summarizes any measures that have been put into action, evaluates these and aims to then give species specific management recommendations for Germany.

The German Wadden Sea comprises of the Wadden Sea areas of the federal states Schleswig-Holstein (SH), Hamburg (H) and Niedersachsen/Lower Saxony (NdS) and represents the largest area of the entire trilateral Wadden Sea Region. Each Wadden Sea region has its federal state specific "National Park Wadden Sea Authority" (Nationalparkverwaltung Wattenmeer SH, H and NdS). With respect to the link of the Baltic and Wadden Sea and national approaches towards IAS management, the neighboring federal state Mecklenburg-Vorpommern (MV) and its marine and terrestrial activities on IAS will also be considered in the following.

3.1 Marine realm

Generally, nature conservation and monitoring in German coastal waters <12 nm lies within the responsibility of the federal states. In the German Exclusive Economic Zone EEZ (12 to 200 nm from the coastal baseline) the responsibilities lie with the German Federal Government. They are assigned to the Federal Environment Ministry, UBA (Umweltbundesamt), and the Federal Agency

for Nature Conservation, BfN (Bundesamt für Naturschutz). However, the BfN is also enrolled in NIS/IAS programs within the German coastal Wadden Sea Region (see below).

With the law on the convention on the conservation of the marine environment of the Baltic and North-East Atlantic (BGBL. 1994 II, S. 1355), Germany has ratified the reformulated HELCOM and OSPAR convention and thus committed itself to implement the obligations concerning the monitoring, assessment of the quality and status of the marine environment.

In March 2012, the German Federal and Länder (federal states) ministries signed a new Federal/Länder Administrative Agreement on Marine Conservation. **The agreement governs the cooperation between the Federal Government and the coastal federal states, particularly with regard to the implementation of the MSFD and monitoring**. Since then, the official decision making bodies are the Federal/Länder Committee on the North and Baltic Sea, BLANO (Bund/Länder-Ausschuss Nord- und Ostsee), and the Marine Conservation Coordination Board, Kora (Koordinierungsrat Meereschutz), (Figure 2).

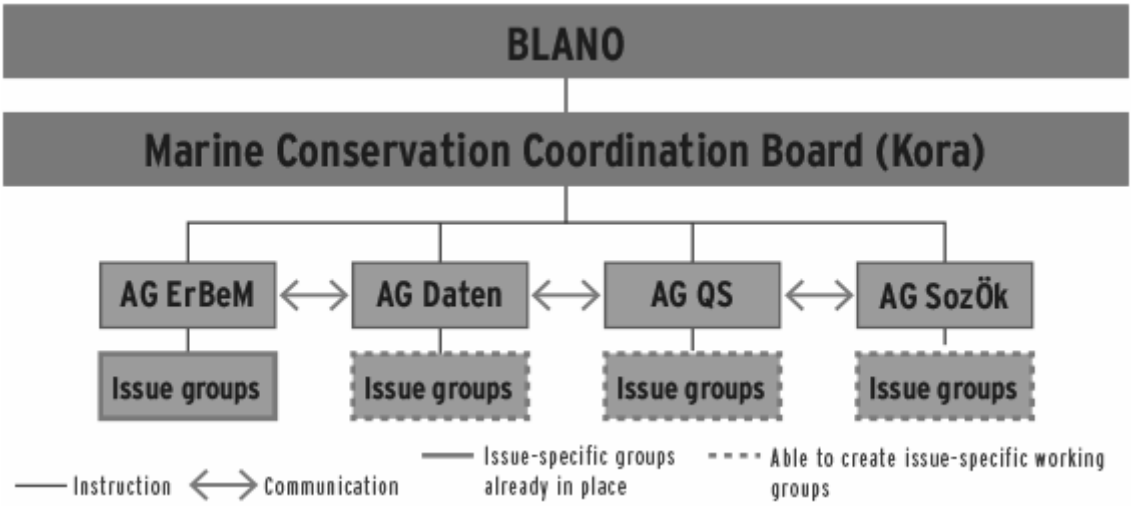

Figure 2 - Marine monitoring in Germany. Organizational chart of the Federal/Länder Committee on the North and Baltic Sea (BLANO) with its subordinated working groups (modified after BfN 2015).

BLANO is the top-level decision making body and assigns the preparation and implementation of its resolutions to Kora. The chair of Kora comprises representatives of the coastal federal states. Kora tasks include elaboration and concretion of policy and conservation requirements defined on a European, national and regional level.

Realization of working projects is done by different self-organized and self-responsible cross-cutting working groups (Arbeitsgruppe, AG). **The AG ErBeM** (Erfassen, Bewerten, Maßnahmen/ surveying, assessment and measures) **is in charge of the marine monitoring** of the Federal Government and Länder. It is responsible for the conceptual and content-related assistance with and final preparation of drafts for measures and monitoring programs (in accordance with article 11 MSFD) as well as the coordination of activities for, and supervision of the implementation of national marine monitoring. Within the AG ErBeM several specific issue groups exist (see Fach AG Neobiota, page 37).

Alongside the EU regulation on Alien Species (page 25), **the main elements driving activities for the marine realm are the MSFD and the IMO BWMC convention and guidelines**. As pointed out above non-indigenous species are addressed in an own descriptor in the MSFD (D-2) and thus receive special attention (as in comparison to e.g. the WFD) in the overall goal to achieve Good Environmental Status (GES) of the EU's marine waters. The following activities, measures or approaches to develop measures are essentially carried out in the frame of implementing the MSFD.

3.1.1 Activities linked to the MSFD

Prior to MSFD-related activities studies were already conducted that served as background information for assessments that followed, and are listed in Table 4.

Table 4 - Activities prior to MSFD related monitoring concerning neobiota in the German marine realm.

Federal State	Responsible Body/ Commissioner	Date	Activities	Frame	Aim/ underlying idea	Authors/ Contractor
	BfG, Bundesanstalt für Gewässerkunde	1999	overview of neozoa (macrozoobenthos) in the German Wadden Sea	CBD, not yet motivated by the MSFD (pers. comment Stefan Nehring)	first comprehensive literature overview	Nehring & Leuchs (1999)
Niedersachsen (NdS), Lower Saxony	NLWKN, Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz	2012	Macrozoobenthos Monitoring in German transitional and coastal waters on hard substrates and associated habitats including neozoa	WFD	develop a holistic approach for future monitoring of hard substrates that captures the entire species spectra	BioConsult Schuchardt & Scholle GbR

Mainly since 2009, marine (NIS/IAS related) monitoring activities are carried out within the single federal states and commissioned by the federal state authorities. Additionally, overarching long term monitorings are in place and ongoing that are commissioned and financed by the Federal Agency for Nature Conservation (BfN) since 2011 (and so far planned until 2018). An overview of these projects is given in Table 5 (A: Federal State related activities; B: Federal related activities) with the related monitoring/sampling sites depicted in Figure 3.

Table 5 - Overview of national monitoring activities on the A) Federal State level and B) commissioned by the Federal Government of Nature Conservation (BfN). Monitoring/sampling sites of all listed projects are shown in Figure 3.

A)

Federal State	Responsible Body/Commissioner	Date	Activities	Protocols used	Aim/underlying idea	Contractor
Niedersachsen (NdS), Lower Saxony	NLWKN, Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz & Nationalparkverwaltung NdS Wattenmeer (Alexander Schröder & Dr. Gregor Scheiffarth)	10&11 2014	Data assessment for the baseline in 14 Stations comprising 4 harbor locations (Container terminal Bremerhaven, Emden, Jade Weser Port Wilhelmshaven, Marine-vorhafen Wilhelmshaven, Innenhafen Wilhelmshaven), 4 jetties/dykes (Minsener Oog, Leitdamm Robenplate, Leitdamm Cuxhaven, Borkum), 1 fairway buoy (Ems), 1 soft bottom (Reede Nord) and 4 oyster reefs (Nordland, Dornumer Nacken, Hoher Weg/Kaiserbalje, östl. Hoher Knechtsand). Samples were analyzed and the report is currently being finalized	HELCOM and rapid assessment survey (RAS)	to generate a species baseline and to carry out a cost-benefit analysis to compare the effectivity of the protocols	University Oldenburg & Senckenberg Museum
Schleswig-Holstein (SH)	LLUR, Landesamt für Landwirtschaft, Umwelt und Ländliche Räume in the frame of the MSFD (Rolf Karez)	2009-2011	Macrozoobenthos monitoring along German coast at 14 locations in the North (8 stations: Emden, Bensersiel, Wilhelmshaven, Cuxhaven, Brunsbüttel, Büsum, Hörnum, Wyk/Föhr, List) and Baltic Sea (6 stations: Flensburg, Kiel, Wismarbucht, Unterwarnow, Strelasund, Oderhaff), focusing on spots easily accessible and most vulnerable to the introduction of NIS (close to aquacultures, in harbors and marinas)	rapid assessment survey (RAS)	to get a general overview of IAS in the German coastal zone based on a systematic approach (up to then there had been no systematic alien-monitoring but alien species were rather detected "by chance" alongside other projects and the knowledge on them was very sparse (pers. comment Dagmar Lackschewitz))	AWI Sylt (Lackschewitz & Busch-baum)

		2014/2015	Examining marinas and harbors in the Baltic Sea for neobiota. Plankton samples were taken twice per year (Flensburger Förde, Kieler Förde and around Neustadt (3 stations each)). Preliminary results revealed that there were differences regarding the community composition of the different sites on a short-term scale (with respect to sampling days). However, the regular monitoring revealed that over the course of one year the community overall was the same. Thus, a plankton monitoring scheme will be aspired sampling only one spot on a weekly basis (Kieler Förde, GEOMAR) and five other spots on a monthly basis along the Baltic Sea coast SH (sampling by LLUR, processing by GEOMAR) (pers. comment Matthias Paulsen, GEOMAR)	rapid assessment survey (RAS)	a) the ongoing collection of information for the base line of IAS and b) a better assessment of future efforts and costs for sampling	GEOMAR Helmholtz Ocean Research Centre Kiel and LLUR
	LKN, Landesamt für Küstenschutz, Nationalpark und Meeresschutz SH	since 1998/1999	Monitoring of wild mussel beds in the eulittoral zone are carried out since 1998. Since 1999 these annual monitorings include the analyses of benthos data, i.e. the associated biota is identified, including neobiota. Data from these monitorings shall be also used for the MSFD, HD, WFD (pers. comment Heike Büttger, Bioconsult SH).	based on TMAP	to monitor the inventory and change of mussel/oyster proportion	Bioconsult SH
		2011-2013	Monitoring on sublittoral blue mussel beds. Species lists of shellfish-associated biota were generated including the relative share of non-indigenous species, and forwarded to the National Park administration in Tönning	based on TMAP	to get insights into shellfish-associated biota including non-indigenous species	Bioconsult SH
		since 2014	annual monitorings of wild mussel beds	based on TMAP		IfAÖ
Hamburg (H)	Institut für Angewandte Umweltbiologie und Monitoring GbR (U. Hellwig & L. Krüger-Hellwig)	since 2000	Annual monitorings in the National Park Wadden Sea Hamburg/Neuwerk take place. These are done along permanent benthic transects in the marine realm and reveal neobiota if present (pers. comment Mr. Körber, national park administration H).			National Park Administration Wadden Sea Hamburg

Mecklenburg-Vorpommern (MV)	LUNG, Landesamt für Umwelt, Naturschutz und Geologie (Mario von Weber)	Sept 2013, Sept 2014	In September 2013 and 2014, 14 harbors were sampled. At each sampling site (harbor/marina) three habitats/structures where addressed: hard substrates, soft substrates/sediments and floats/submersed structures. The HELCOM protocol was applied at three sites in the harbor of Rostock (Sept 2014).Both protocols were successfully applicable and feasible in all harbors. Analyses are ongoing and not published yet but preliminary results reveal 108 taxa of macrozoobenthos with 19 neozoa and 35 Taxa of macroalgae with 4.	rapid assessment survey (RAS) and in accordance with MSFD and HELCOM requirements	to give recommen-dations for an optimized Neobiota monitoring.	BioConsult Schuchardt & Scholle GbR
B)						
Federal						
	BfN, Bundesamt für Naturschutz	since 2011	Macrozoobenthos monitoring along German coast at 14 locations in the North (8 stations) and Baltic Sea (6 stations), focusing on spots easily accessible and most vulnerable to the introduction of NIS (close to aquacultures, in harbors and marinas)	rapid assessment survey (RAS)	to acquire data on Neobiota and to generate lists of IAS	AWI Sylt
		01/2015-12/2018	Macrozoobenthos monitoring along German coast at 14 locations in the North (8 stations) and Baltic Sea (6 stations)	rapid assessment survey (RAS), HELCOM, OSPAR	Trend-analyses for distribution of neobiota in German coastal waters	AWI Sylt

ADDITIONAL ACTIVITIES

With respect to shellfish aquaculture no regular monitoring programs are in place. However, preventive measures are carried out, such as a mandatory monitoring of oyster-associated species that are imported from Ireland (Sherkin Island) prior to the import into the SH Wadden Sea (pers. comment Maarten Ruth, fishing authority LLUR SH). This does not apply for blue mussels as since 2011 import of blue mussel from Ireland and Great Britain is prohibited in SH. In 2013 shellfish fishermen have attempted to generate a baseline of associated fauna with the help of an expert. For this, in 2012 & 2013 several hundred sampling spots were targeted for a SASI (Shellfish Associated Species Inventory). The analyses revealed that ~30 epifauna and -flora species were found that were not described within the shellfish-cultures before (pers. comment Maarten Ruth, fishing authority LLUR SH).

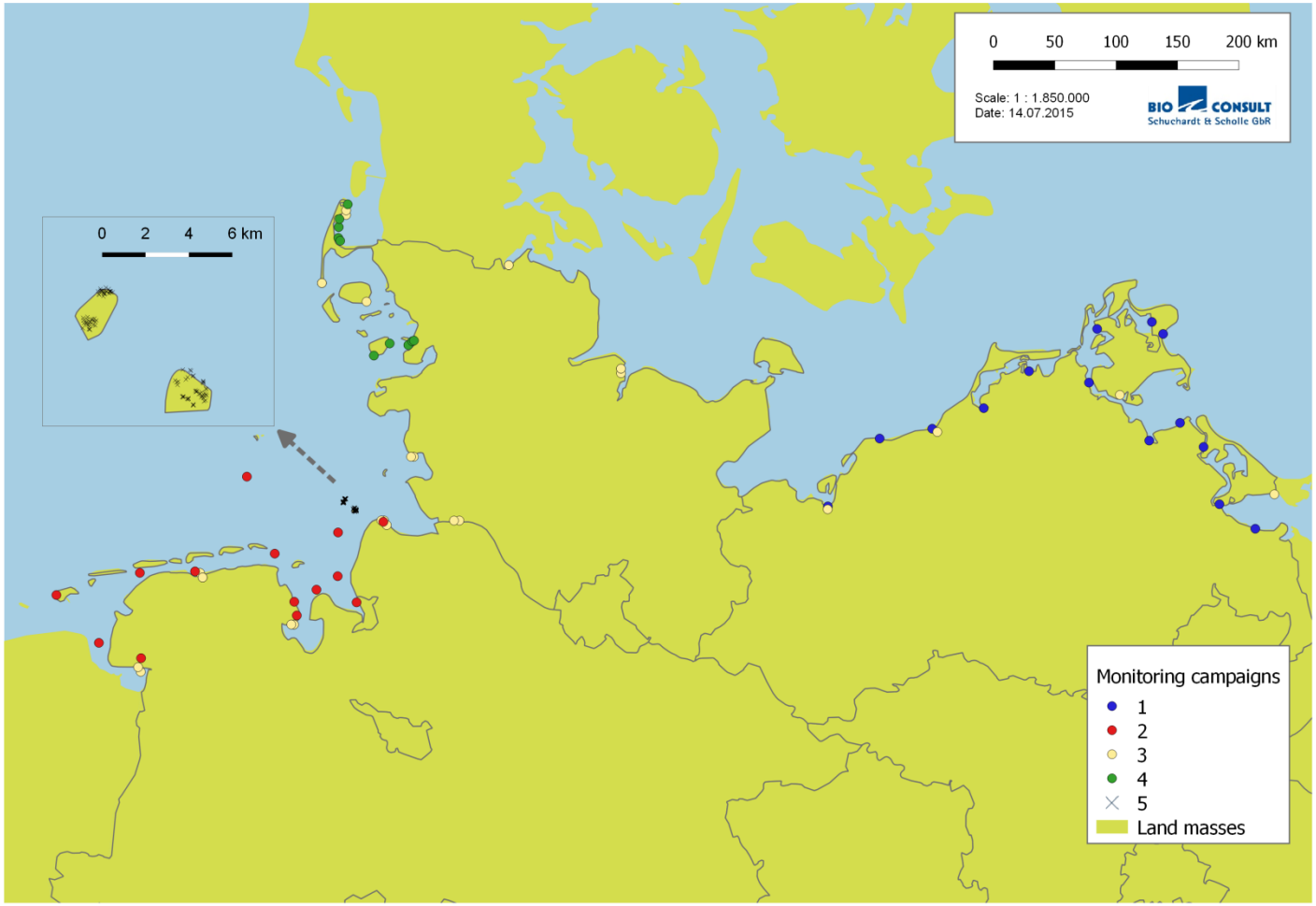

Figure 3 - Monitoring campaigns carried out in Germany along the Wadden Sea and Baltic Sea coastline including Islands. 1: Macrozoobenthos monitoring at 14 sites in Mecklenburg-Vorpommern according to Rapid Assessment (RAS) and HELCOM, 2013/2014; 2: Macrozoobenthos Monitoring at 14 sites in Lower Saxony by the University of Oldenburg and the Senckenberg Museum, 2014; 3: Rapid assessments (9 North Sea sites, 6 Baltic Sea Sites) carried out during 2009-2014 (station data from 2012); 4: Monitoring in wild mussel beds in Schleswig-Holstein, 1999-2013 and 5: sites of annual monitoring in Hamburg (2 marine sites, 1 on the Island of Neuwerk). For details see Table 5.

As depicted in Figure 3, study sites for neobiota monitoring within Germany cover many areas along the Wadden Sea and Baltic Sea coast. At the same time it reveals that different institutions target the same spots (e.g. Rostock, Wilhelmshaven). The different projects are however often complimentary to each other; some of the sampling locations were only sampled in a pilot study. Coordination of the projects takes place in the BLANO group on NIS/ the Fach AG Neobiota (pers. comment Dr. Gregor Scheiffarth). Especially in the light of limited resources an intra-national coordination of assessments this will help to avoid double work in future projects.

In line with the operationalization of the MSFD, **the AG ErBeM had formulated specifications of measures** to prevent the introduction of neobiota from aquaculture (shellfish culture and fish farming) and aquaria (ornamental fish/trade and unintentionally introduced associated species) in Germany. However they were not included in the overall draft which is open for public revision and are thus, currently not issued further (see page 25, BLMP Secretariat 2011b). Thus, concrete measures for the prevention of NIS introduction through aquaculture and aquaria to reach GES are recently not available. **The German monitoring frame concept (as of 5 Nov 2014) which was forwarded to the EU** points out that although subprograms are currently being developed, there is no overarching monitoring program in place yet which addresses the descriptor D-2. However, approaches are made towards a harmonized concept which shall be established until 2018, mainly based on RAS that are being carried out within the single Wadden Sea Federal States (BLMP Secretariat 2011a).

The AG ErBeM includes a specific issue group that addresses topics related to Neobiota (Fach AG Neobiota, chair Mr. Kai Hoppe). The Fach AG Neobiota is a national consortium and consists primarily of representatives of different federal state authorities, consulting agencies and scientific institutions (Table 6). Meetings are scheduled semi-annually. Within the group, data is collected, topics are discussed and approaches are developed for the monitoring and management of IAS. A main outcome of the work of the Fach AG Neobiota was the development of a trend indicator that is currently in place and described in the following.

Table 6 – List of members of the special issue group "Fach AG Neobiota", sorted in alphabetical order.

aquaecology	Institute for Aquatic Ecology (Gewässerökologisches Institut)
AWI	Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (Alfred Wegener Institut Helmholtz Zentrum für Polar- und Meeresforschung)
BfG	German Federal Institute for Hydrology (Bundesanstalt für Gewässerkunde)
BfN	Federal Agency for Nature Conservation (Bundesamt für Naturschutz)
BioConsult	Environmental Consulting Agency (Gutachterbüro)
Bioconsult SH	Ecological Research and Consulting (Ökologische Forschung und Consulting)
bsh	Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie)
geomar	Helmholtz Centre for Ocean Research Kiel (Helmholtz-Zentrum für Ozeanforschung Kiel)
GoConsult	Consulting Agency
hzg	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung)
IOW	Leibniz Institute for Baltic Sea Research Warnemünde (Leibniz-Institut für Ostseeforschung Warnemünde)

LLUR	Federal State Agency for Agriculture, Environment and Rural Areas (Landesamt für Landwirtschaft, Umwelt und Ländliche Räume)
LUNG	Federal State Agency for Environment, Nature Conservation and Geology (Landesamt für Umwelt, Naturschutz und Geologie)
MariLim	Aquatic Research (Gewässeruntersuchungen)
MELUR	Ministry of Energy, Agriculture, the Environment and Rural Areas (Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume)
nlpv wattenmeer	National Parl Administration Waddensea (Nationalparkverwaltung Wattenmeer)
NLWKN	State Agency for Water Economy, Coastal- and Nature Conservation of Lower Saxony (Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz)
Rostock Port	Baltic Sea Harbor for Ferry- and Freight-Traffic as well as Cruise Shipping (Ostseehafen für Fähr- und Güterverkehr sowie Kreuzfahrtschifffahrt)
UBA	Federal Environmental Agency (Umweltbundesamt)
ICBM Uni Oldenburg	Institute for Chemistry and Biology of the Marine Environment Carl von Ossietzky University Oldenburg (Institut für Chemie und Biologie des Meeres, Carl von Ossietzky Universität Oldenburg)
IfAÖ	Institute for applied ecology (Institut für angewandte Ökosystemforschung)
Senckenberg/DZMB	German Center for Marine Biodiversity Research (Deutsches Zentrum für Marine Biodiversitätsforschung)
vti bund	Johann Heinrich von Thünen Institute/ Federal Research Institute for Rural Areas, Forestry and Fisheries (Johann Heinrich von Thünen-Institut/ Bundesforschungs-institut für Landliche Räume, Wald und Fischerei)
Waddensea Secretariat	Common Wadden Sea Secretariat (CWSS)

Trend Indicator for Marine Neobiota

One strong factor for the definition of GES can be seen in the progression (= trend) of IAS within a certain sea region. The basis to the assessment of such a trend must be provided by a founded knowledge on already established IAS in the region of interest. This is given by NIS/IAS list that serves as a baseline and that was generated through the above mentioned RAS programs. The most recent list (Lackschewitz et al. 2015, submitted) of IAS for the German Wadden Sea Region that is based on these assessments is currently under revision and expected to be published within the first half of 2015. It serves as the baseline for a trend indicator that has been established within the Fach AG Neobiota (pers. comment Christian Buschbaum, AWI). This indicator has particularly been established to serve the implementation of the MSFD and to address the descriptor D-2 (non-indigenous species). It was developed at the AWI (Sylt) and introduced to the Fach AG Neobiota. Within the Fach AG it was discussed and agreed upon to be forwarded to the national and international level. Thus it was forwarded to the ErBeM and further on to Kora. In October 2014 the trend-indicator was introduced at an OSPAR/HELCOM harmonization meeting (Gothenburg, Sweden) where it was presented as a positive example for a tool that could be applied on an international level (OSPAR 2012b, pers. comment C. Buschbaum). The trend indicator focusses on three parameters:

- the number of new introductions within a certain time frame into the sea region of interest (species-parameter),
- the development of the inventory of NIS in a certain time frame within this region (inventory-parameter) and
- the way newly introduced NIS disperse within this region (dispersion-parameter).

Based on significant differences between the North Sea and the Baltic Sea, the two Sea Regions are observed separately. Results hitherto show that one to two species are being introduced per year in the North Sea with a sum of nine NIS that appeared within the last six years (2009-2014). In accordance with a five-staged evaluation scheme (very bad, bad, moderate, good, and very good) (pers. comment Christian Buschbaum, AWI; Krause et al. 2011), the GES would e.g. not be reached and the ES would be described as "bad". The trend indicator is operationalized and monitoring guidelines are currently being established.

Additionally, the Fach AG Neobiota plans a national **exchange platform for Neobiota**. The goal is to build up a taxonomic network specifically for Neobiota that gathers the variety on available information and generates a central list which will continuously be updated. A user group of taxonomic experts shall re-identify presumable first-discoveries of potential non-indigenous species and publish these when required. This shall allow for a regular update of the newest introductions and developments with respect to Neobiota for all parties concerned (pers. comment Detlef Henning, Bioconsult; Fach AG Neobiota).

3.1.2 IMO linked activities

Next to the MSFD the main umbrella that covers the topic of NIS/IAS species in the marine realm is set by the IMO BWMC and IMO guidelines addressing ships' hulls biofouling (page 22).

IMO Ballast Water Management Convention (BWMC)

With respect to the **IMO BWMC**, Germany ratified the convention and advances the developments for a near-time implementation of the required standards once the convention is in force. This includes the availability of an adequate number of "D-2-facilities" (facilities which enable to meet the strict IMO D-2 standard as defined in the BWMC, see page 22; not to be mistaken with the descriptor D-2 of the MSFD) that can suffice the number of ships wanting to put the standards into operation (pers. comment Manfred Rolke, BSH). Furthermore, German institutions are involved in testing and optimizing indicative methods that enable rapid aboard analyses of ballast water. Within this context the German Research Vessels Meteor takes along producers of ballast water treatment systems in June 2015 who will conduct on board tests for the development of such analyses (pers. comment Manfred Rolke, BSH). Although there is no register for German-flagged ships that already fulfil the standards as defined by the IMO BWMC, certain ships are already known to meet the requirements (e.g. the German Research vessels 'Meteor' and 'Sonne' meet D-2 standard) (pers. comment Manfred Rolke, BSH).

IMO guidelines on ships' hulls fouling

Besides the translation of the IMO guidelines on ships' hull fouling for private crafts into German language (by the 'Deutscher Seglerverband'/German Sailor Association), to our knowledge there are no activities on a national level with respect to the two IMO guidelines released (page 22).

3.2 Terrestrial realm

The German terrestrial Wadden Sea covers all islands and the coastlines of the three Wadden Sea States. Each federal States governs its own territory in this context. Although the respective authorities are aware of problems regarding IAS (species appear which weren't present before and which may take over natural habitats/ harm local biodiversity/ cause problems for local structures), at present there are no harmonized approaches regarding terrestrial IAS monitoring, management or measures within and between the federal states (pers. comment Bernd Oltmanns, National Park Wadden Sea NdS). Currently there is no overarching organized structure comparable to that of marine monitoring (BLANO/ Fach AG Neobiota) or which commonly addresses terrestrial NIS/IAS in the terrestrial German Wadden Sea Region. Currently, a comprehensive or long-term oriented Federal State approach for terrestrial IAS is not planned. Activities that take place are usually set on a small scale and region specific level and federal state specific activities are presented in the following. Amongst the federal states, informal exchanges on the level of the persons in charge exist but there are no fixed structures for regular interactions (pers. comment Dr. Gregor Scheiffarth, National Park Wadden Sea NdS).

Niedersachsen (NdS), Lower Saxony

Twelve Wadden Sea Islands (East Frisian Islands) are associated with the state of NdS, counting Borkum, *Memmert*, *Brauerplate*, *Kachelotplate*, *Lütje Hörn*, Juist, Norderney, Baltrum, Langeoog, Spiekeroog, Wangerooge, *Minsener Oog* and *Mellum*, (*italics*= uninhabited). Generally there are no defined monitoring plans that address animal Neobiota or IAS in the NdS Wadden Sea region. However, there are permanent plots on islands, where the vegetation is monitored and where new species upon appearance and detection are recorded (pers. comment Dr. Gregor Scheiffarth, National Park Wadden Sea NdS). Locally and island specific, activities are carried out by single municipalities and volunteers and smaller programs are in place. These are not always communicated to the National Park Administration Wadden Sea NdS and thus often remain unknown (pers. comment Bernd Oltmanns, National Park Wadden Sea NdS). The National Park Administration Wadden Sea NdS primarily focusses on the gathering of information for a comprehensive overview of the current situation to be able to develop problem-specific and island-specific solutions (e.g. the distribution of the Japanese knotweed *Fallopia japonica* on Borkum, or the occurrence of the black cherry *Prunus serotina* in the community of Juist) (pers. comment Bernd Oltmanns, National Park Wadden Sea NdS). Tentative approaches are in place, which aim at observing the occurrence and spreading of invasive plant species such as the Japanese rose (*Rosa rugosa*), the black cherry and the New Zealand pigmy weed (*Crassula hemsii*). Currently cooperative studies with researchers of the University of Oldenburg on *Crassula hemsii* are being carried out. These are primarily explorative, assessing quantitative distribution patterns (pers. comment Dr. Gregor Scheiffarth, National Park Wadden Sea NdS).

Similar to monitoring, there are no common measures in NdS addressing the management of plant IAS. Locally activities take place on a small scale by communes and volunteers but often these small scale programs are not communicated to the Wadden Sea National Park Administration. Focus on the federal state side lies more on measures regarding species conservation than on targeting eradication of IAS with the goal to find island- and problem-specific solutions. For example, locally the eradication of the Japanese rose (*Rosa rugosa*) is not realistic anymore;

measures against a distribution of the bird cherry (*Prunus padus*) however are feasible. Thus the focus lies on the latter (pers. comment Bernd Oltmanns).

The Wadden Sea National Park Administration NdS carries out a predator management on the NdS islands which addresses breeding birds. These are primarily endangered by hedgehogs, foxes and ferrets as well as by domestic cats. Although these animals do not represent exotic species, they are non-indigenous on the islands, potentially harmful for breeding birds and thus addressed (pers. comment Dr. Gregor Scheiffarth).

Schleswig-Holstein (SH)

From the side of the National Park Wadden Sea SH, there is currently no organized monitoring of terrestrial IAS for the Wadden Sea area SH and no regular federal state-specific programs approaching terrestrial IAS in SH (pers. comment Mr. Olischläger). A draft concept generally addressing the handling of terrestrial IAS has been formulated by the State Agency for Agriculture, Environment and Rural Areas (Landesamt für Landwirtschaft, Umwelt und ländliche Räume SH, LLUR-SH) in coordination with the Ministry of Energy, Agriculture, the Environment and Rural Areas SH (Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume, MELUR-SH) that gives a theoretical guideline for IAS management in SH. It explains the problem of IAS and gives examples for SH. Furthermore it addresses measures for IAS in SH by means of

- outlining the legal specifications and requirements
- discussing the need for and the different forms of IAS lists (black/grey/white)
- presenting concepts of the EU and on a federal level for Germany
- discussing the success of measures
- making suggestions on IAS handling within SH (pers. comment Mr. Augst, LLUR).

A management of predators (not only alien species) on holms (Halligen) has started recently (pers. comment Klaus Koßmagk-Stephan).

Hamburg (H)

As for the marine realm, (see section 3.1), annual monitoring in the National Park Wadden Sea Hamburg/Neuwerk takes place within the TMAP. In the terrestrial realm these are carried out on permanent vegetation areas (Figure 3) and reveal Neobiota if present (pers. comment Mr. Körber, national park administration H). Within the National Park Wadden Sea H there are currently no programs or measures against terrestrial IAS in place (pers. comment Mr. Körber).

Mecklenburg-Vorpommern (MV)

At present there are no general regular or long-term monitoring programs or other organized activities regarding terrestrial IAS in place. Due to personnel and financial constraints, the state office (LUNG-MV) will wait for the concretization of the legal frame (development of the EU directive and associated modification of the BNatSchG (see section 2.2.4) with corresponding IAS lists) before taking any action such as setting up an organized structure addressing IAS. The underlying approach in the management of IAS is to focus on species which are not yet established rather than focusing on IAS which are already well established and basically not manageable

anymore. In the fall of 2015 meetings are planned with the ministry to make plans on the basis of the new legal framework (pers. comment Bernd Presch, LUNG-MV).

However, regarding coastal breeding grounds of birds there are very specific approaches addressing IAS in such that e.g. raccoon dogs, minks, raccoons, foxes and wild pigs are selectively eliminated. Eliminations are carried out by the working group 'protection of coastal birds' (AG Küstenvogelschutz) belonging to the LLUNG. As these are mainly huntable species, no additional authorization is needed. If however certifications for exemptions are needed, these are applied for and granted by the highest hunting authority (Oberste Jagdbehörde) (pers. comment Christof Herrmann, LLUNG).

3.3 General developments

Within this year, **the Federal Agency for Nature Conservation (BfN) will publish a management and measures handbook with a focus on terrestrial Neobiota as well as an invasive species assessment (Invasivitätsbewertung) of aquatic alien species**. Currently the Federal Ministry for the Environment, Nature conservation and Nuclear Safety (BMUB) and the BfN are discussing different possibilities and suggestions for a German list of species of Union concern. The focus is given to species that are either not yet present or only occurring in small numbers within the EU. The BfN soon will tender a research project in which respective IAS will be assessed under all relevant criteria of the current IAS regulation. However, so far it is not clear if it will be in time for the EU discussion (pers. comment Stefan Nehring).

Furthermore the BfN plans a pilot study that addresses the design and implementation of a database (Fach AG Neobiota).

4. Analysis including gaps

The Draft Strategic Framework (DSF) (supplement S1) aims at finding a common trilateral approach to prevent threats to the Wadden Sea ecosystem and biodiversity through (invasive) alien species. Overall the framework focuses on five key elements, namely (1) prevention, (2) early warning/detection and rapid response, (3) eradication and control, (4) raising awareness, and (5) structural arrangements and way forward.

In the present chapter an analysis will be conducted based on the summary and findings for Germany presented previously and on interviews, mainly carried out with harbor/port authorities. National findings will be discussed in the frame of the DSF. Each of the above listed elements will be displayed individually; within the discussion, first the general situation and challenges related to each element will be summarized and then nation specific links will be built. The corresponding gaps will be highlighted. Finally overarching challenges will be addressed.

The present national examination of IAS management and regulations in the German Wadden Sea Region has led to some key findings:

a) monitoring and management for the marine realm has an organized structure that is supported by both the federal and federal states and that brought up a special task group addressing neobiota (Fach AG Neobiota). So far these do not specifically focus on NIS/IAS but include them in the assessments,

b) the NIS/IAS focus in Germany lies primarily on preventive and early detection activities in the marine realm. These are mainly monitoring programs (RAS) which have now led to the development of a trend indicator within the Fach AG Neobiota which is currently being operationalized. Several programs have been realized and are ongoing, mainly in the frame of the MSFD (and mainly since 2009),

c) in the German Wadden Sea Region, the approach towards NIS/IAS management and related activities differ greatly for the marine and terrestrial realm,

d) although in Germany and related to the MSFD, activities towards a harmonized NIS/IAS monitoring are much further developed in the marine than in the terrestrial realm (e.g. RAS), for both there are no general, long-term, centrally organized, standardized or institutionalized NIS/IAS monitoring programs in place yet, however planned until 2018 for the marine realm,

e) sustainable long-term activities regarding IAS management are, so far, mostly only put into action when there is a legal necessity. Although there are some national activities that go beyond regulations, guidelines in most cases are usually not followed as long as they are not binding (e.g. ships' hull fouling).

In the following, these findings will be included in the consideration of the key elements of the DSF (sections in reference to the trilateral policy and action mentioned in the DSF are underlined) and point out **related problems and gaps** (**in bold fonts**).

4.1 Prevention

Prevention has to take place on various levels. These reach from e.g. targeted vector control to the development of legally binding regulations.

Different vectors lead to the introduction of alien species into the Wadden Sea. These range from ballast water introductions to the use of live bait fish in fisheries as well as from horticulture to private purchases of non-indigenous animal and plant species. These vectors are individually of different importance. **A weighting of vectors with corresponding risk analyses for the Wadden Sea, thus a targeted prioritization of vectors does not exist yet** but is necessary and in due time obligatory by the IAS regulation 1143/2014/EC (page 25). One example for the prioritization in the marine realm is given by the BWMC that addresses the ballast water and has been signed by all three Wadden Sea States. The formulation of this convention was the result of many years of development within the IMO's Marine Environment Protection Committee (MEPC) after an initially increasing international expression of concern about (mass) invasive alien species introduction and problems towards MEPC in the late 1980s. Similar **prioritization of vectors for the terrestrial realm is lacking**. Almost a decade ago it was already pointed out that policy and management should focus on vectors of introduction and prevent immigration of species, which are suspected to impair the goods and services that the European coastal biota could provide (Reise et al. 2006).

Another main factor for an efficient prevention is **a profound legal basis for actions**. Many regulations exist that sufficiently address IAS. However, there are only a few with concrete definitions on how to "approach the problem". The regulation on alien and locally absent species in aquaculture e.g. clearly defines what is allowed and what not; still, there are differences between e.g. the Dutch and German approach. The Dutch policy is risk-based on species level which gives the opportunity to combine economic activities with nature conservation and restoration targets (pers. comment Mr. Smolders). The EU regulation on IAS is to date the most defined general regulation in place and serves as a valuable guideline on how to approach IAS (e.g. by definition of 'Unionlist'). As regulations have to be applied on a national level these (have to) lead to a quick reaction/respond/action. The same applies soon in the case of Ballast Water Management (as soon as in force, it is legally binding). Several harbor authorities and marinas along the Wadden Sea Coast were contacted. This was done to gather information on the general awareness of and dealing with the topic of IAS related to ship traffic. A further aim was to find out if there are any activities or programs taking place in the harbors (raising awareness on IAS and related regulations, preparations in the context of BWMC, ships' hull fouling etc.) as this is a main part within the prevention of NIS/IAS in the marine realm. Outcomes of the interviews are presented in Box1. A list of questions that were asked is appended (Questionnaire A2).

Overall, the communication with harbor authorities has shown that stakeholders are mostly aware of the general problem of IAS (e.g. the presence of non-indigenous or invasive alien species that overgrow ships' hulls, port and harbor structures, etc.). However, **nothing is, or likely nothing**

will be put into practice as long as it is not mandatory by law. This concerns ballast water treatment and ballast water control, as well as the cleaning of biofouling on both commercial and recreational vessels and crafts as well as port and harbor sanitation. This was mainly reasoned by the high costs and efforts needed. Generally, harbor infrastructure companies do not see the responsibility on their side and the responsible authorities will wait with their actions until corresponding laws are in force while, at the same time, preparations are being made to meet future demands.

BOX 1 – FEDERAL STATE SPECIFIC SUMMARY OF INTERVIEWS WITH HARBOR AUTHORITIES ALONG THE GERMAN WADDEN SEA AND BALTIC SEA COAST

Niedersachsen (NdS) - For NdS the harbors of Cuxhaven and Bremerhaven were addressed. The head office Niedersachsen Ports representatively responded as a central information point. Additionally the harbor captain in Wilhelmshaven was interviewed. In the ports of Lower Saxony, the topic of invasive alien species has been a big issue for over a decade. The problem is very clear and present. Although there are no activities promoting the IMO regulations and guidelines from the side of the harbor infrastructure company, generally skippers seem highly aware of ballast water regulation and the problem of biofouling. Awareness of the latter is also present in the private sector (smaller crafts and yachts). However it is not clear if the guidelines are (and rather doubted to be) realized, as long as there is no strict legal basis (pers. comment Mr. Wilhelm, harbor captain Wilhelmshaven; pers. comment Mr. Banik, head office Niedersachsen Ports).

Schleswig-Holstein (SH) -In SH the "Seehafen Kiel", the "Yachtclub Fischereihaven Travemünde" and the" Lübecker Hafengesellschaft" were contacted. Feedback was only received from the Port of Kiel. There, general awareness of both ballast water and biofouling as vectors for NIS is present. Now and again there have been inquiries for cleaning of biofouling in the Seehafen Kiel – however, currently there are no corresponding facilities yet. As long as it is not mandatory by law there are no plans to install any. Also with regard to the BWMC enforcement of laws will be awaited. One motivation for this is also to see if it will be possible to apply for exemptions for certain routes (Querverkehr) e.g. between Germany and Sweden/Lithuania (interview Seehafen Kiel).

Hamburg (H) - The Hamburg Port Authority is highly aware of the topic of IAS but considers itself as an infrastructural service provider, rather than being responsible for the management (pers. comment Mr. Leitz, Hamburg Port Authority). From the side of the administrative body (IB, BSU) no programs/activities are in place and will not/very unlikely be, unless they are mandatory by law (e.g. with respect to ballast water or waste water introductions). Generally, the topic of IAS in context of ship traffic is present and preparations are made to be able to act as soon as law is in force. There is for instance exchange with companies that provide surveillance possibilities for ballast water (SGS Institut Fresenius GmbH). Due to the necessary expenditures of money and time involved not many ships have as yet installed ballast water treatment facilities. Random samplings on ships (~20-40 ships) revealed that either a) there was no awareness of ballast water treatment facilities to meet the standards requested in the future or b) the awareness of ballast water treatment was there but the decision to wait with putting the ballast water treatment into practice was consciously made until the corresponding laws are in force. Even ships that already have installed treatment facilities (e.g. cruise ships) rather wait to put them into operation until it is legally requested (pers. comment Dr. Dagginus, IB, BSU).

So far however, even when changes have been implemented (such as installation of ballast water treatment facilities on board), they are likely, related to the additional efforts, not yet in use. Thus, binding regulations significantly help in approaching the problem. However, this is only the first step. **Regular and/or strict controls are subsequently needed** to see if regulations are being followed and efficient.

In contrast to regulations, guidelines are different as such that they are legally non-binding. These are represented for instance by the IMO Ships' Hulls Fouling guidelines. As the suggested activities are related to enormous efforts and expenses, such guideline(s) in most cases are usually not followed. This seems to mirror a problem: "*if you can you don't, if you have to, you do*" (pers. comment Manfred Rolke, BSH).

With respect to commercial/recreational crafts this vector should be analyzed within a prioritization. An efficient cleaning of hulls of recreational boats entering the Wadden Sea often takes place on a private level (Minchin 2006, interviews harbor authorities). Because small crafts are discussed as a main vector for IAS introduction (Gittenberger et al. 2011) information should be gathered on how many private and commercial crafts in fact enter the Wadden Sea States from international waters. It has been mentioned by harbor authorities and harbor contact persons to keep in mind that the majority of private crafts remain within the Wadden Sea area. However, doubtlessly within the Wadden Sea they can be an important vector for secondary dispersal between harbors. Making efforts to make the IMO guidelines for recreational vessels mandatory should be reconsidered in this light.

There are only very few examples of the detection and subsequent successful risk assessment or eradication of (invasive) alien species in the marine realm. Of these only one comes from within a European eradication program and addresses the eradication (through a 2 yrs. full eradication program) of the ascidian *Didemnum vexillum* in Wales/Britain (Sambrook et al 2014). However, in this case, after an initial success, recolonization occurred. Thus the eradication was not lasting. As of yet there are **no overarching structures or guidelines that give case-specific instructions for eradication in the marine realm**. This is most likely linked to the fact that once an (invasive) **alien species has been detected in the marine realm, it is, even with an immediate response, very difficult to eliminate it sustainably and holistically,** even if a legal basis for these actions, as suggested in the DSF would be developed. Furthermore, the eradication programs and methods applied (chemical treatment, heat treatment, dredging) need to be individually and specifically designed for the addressed species. Nevertheless, there is a small number of programs that were successfully carried out in California/USA and New Zealand (see section 4.2 & 4.3).

Regarding aquaculture, blue mussels import into the Wadden Sea States is strictly regulated. Import and spreading of blue mussels is only allowed from and within the same State. For any other import, permission from the fisheries agency is required (sections 2.2.5). Were the mussels fished in the Wadden Sea region within the area with specific geographic boundaries (North of 52°54'N, South of 56°N and East of a line of 52°54'N/ 4°36'E and 56°N/ 7°30'E), the permission will only be granted when the mussels originate from waters with certified European shellfish cultures (Muschelzuchtgewässer). For shellfish from other regions, permission can only be granted when evidence is provided that the area of origin is free of parasites and diseases (NKüFischO, §8(7)). Oyster import from e.g. Ireland is accompanied by a previous evaluation of the associated

fauna, thus allowing for an assessment of neobiota introduction. This is a good element in the DSF which proposes to stop or not start with the import of seed bivalves or to constrain the import to bivalves originating only from OSPAR regions II & III (North- and Celtic Sea).

In the **terrestrial realm there are no standard control mechanisms or programs in place** that aim at preventing introduction or immigration of alien species to the German Wadden Sea area or mammalian predator species to the Islands. **Building artificial structures** to prevent immigration of mammalian predators or preventing to build artificial structures that help further distribution in a long-lasting manner (cost and other expenses like maintenance in comparison to effects) **seems to be an unrealistic approach**.

4.2 Early Detection and Rapid Response

Within Germany, several subprograms are in place, forming the basis for a future harmonized monitoring approach. This is aimed to be developed and put into action until 2018 (BLMP Secretariat 2011a). To date, several studies that enable an early detection and monitoring of (new) alien species at hot spots of invasion which are in line with the MSFD are in place for the marine realm. There is ongoing exchange within an organized group of experts (Fach AG Neobiota) that focuses on exactly this topic. Both effectiveness and cost efficiency are considered. Some of the studies have been in place since many years and can lay the basis for an aspired long-term monitoring. To optimize the ongoing work focus should be given on

a) timely finding a standardized approach (what do we sample, how do we sample, how often do we sample- as planned until 2018) that unifies the NIS/IAS monitoring on a national basis and allows for extension on an international level and

b) avoiding double work in terms of having different institutions targeting the same sites and deciding "who does what" (at the moment different institutions partly sample the same sites, however efforts for a harmonization are done (BLANO/ Fach AG Neobiota)).

A central network is planned that will collect data on the neobiota found- if this is set up, it will be a valuable source from which information can be passed on for an early-warning and reporting system to the CWSS website which has been suggested to be set up within the strategic frame-work. With regard to early detection of IAS in marine harbors and an immediate response by measures including the cleaning of ships hulls, **this approach, especially for larger harbors seems rather impossible to be put into practice and thus unrealistic** (see section 4.3). With respect to the terrestrial realm, there are **no organized structures in place** as for the marine realm. There is great need for an organized structure such as a group of experts that addresses this topic similarly as done within the Fach AG Neobiota.

4.3 Eradication and control

Within several guidelines, regulations and management cycles that address IAS, eradication is always included as a step within the management scheme. As mentioned in the DSF, apart from

single successful exceptions as in California (sabellid polychaete *Terebrasabella heterouncinata*) and New Zealand (seaweed *Undaria pinnatifida*) (van Pelt et al. 2015), there are **no known or available efficient, ecologically sustainable and long-lasting eradication methods** for the marine realm. Within Europe as of 2005 no eradications of alien invertebrates and marine organisms had been recorded (Genovesi 2005). This is a major issue and highlights a key problem- when it comes to IAS **in the marine realm** (except within ballast water before it is discarded) **an ecologically friendly, locally targeted and sustainable eradication is very difficult**.

Overall, in coastal waters, it seems that no control on aliens is feasible which would not also harm other components of the biota once an invasion process is underway (Reise et al. 2006). Thus, it is important to either **put more effort into finding solutions for eradications that are feasible** (which in most cases is very difficult, especially when considering the different size classes and groups of marine biota and their habitats, and the chemical/physical force needed to holistically eliminate them) but even more **to focus on prevention** (and early detection which e.g. indeed is more or less the only moment when one can eradicate marine organisms in ballast water). The DSF suggests to clean landing stages and pontoons if alien species have been discovered during surveillance and monitoring of marinas and, if species are known to be invasive, immediate cleaning should include ships' hulls. As harbors and marinas are functioning often as a first entry point for NIS/IAS, with early detection there may be a chance in some cases to then eradicate the NIS/IAS by port sanitation and thus prevent a further spreading into other Wadden Sea regions- however this can be very costly and risky and it seems highly difficult to undertake such actions. The more so, on a large scale such as in big harbors and on commercial ships. Even upon an immediate risk assessment (days), the time and money often stand in little relation to the resulting effects. Use of *in situ* chemical substances is highly difficult due to water quality standards that must be maintained within several regulations. A successful holistic "cleansing" of a water body such as a harbor or marina, insuring an elimination of all elements of an invasive species seems rather improbable.

In the terrestrial realm, selective eradication indeed takes place. Locally, plants are removed and animals are eradicated or removed from the islands. Nonetheless, these activities are **not yet centrally organized** and an overall picture of the situation and success of such measures cannot be generated for now. In this context it has to be mentioned, that locally the idea of eradication of established IAS (e.g. *Rosa rugosa* on islands of Lower Saxony) is evaluated as not promising, thus the focus is given to newly introduced species and their distribution.

4.4 Raising awareness

Within the DSF raising awareness is suggested to be realized by the production and distribution of information and educational material for different stakeholders. In Germany, the Internet Platform www.neobioata.de (BfN) provides the public with such information. Theoretical background information is given, terrestrial and aquatic alien species are listed and information about each of them is made available. Contact persons and possibilities to report on detected neobiota are given. The status quo of related projects is made public and the public is invited to help. **This site is only available in German and not Wadden Sea specific**. Additional sites (www.neobiota.info) give a platform for the help by private persons (in this case divers) in detecting neobiota but sites like these are usually not well known or distributed.

Information material for skippers' education about IAS and possibilities to take actions in this context is based on our research **commonly not publically visible/available within the harbors or marinas although the topic seems generally well present and discussed** (see Box 1). Guidelines like the IMO guidelines on biofouling are made available in German and the sailing association NS has recently published a leaflet addressing biofouling and is promoting a campaign for environmental friendly measures (pers. comment Dr. Gregor Scheiffarth). However there is no standardized educational approach. **Overall, there is no central body that is responsible for the production and distribution of such material**.

Locally, on the islands, small scale activities take place by nature conservation organizations but are also not organized centrally.

4.5 Structural arrangements and way forward

The definition under this topic in the DSF seems rather vague and the detailed underlying idea seems unclear. It is not clear who is in charge of communicating between the individual levels and nations and who coordinates it. This task needs to be defined more clearly and/or delegates must be assigned.

As presented in the DSF, at the national level different authorities are responsible for the different elements of the strategic framework. Thus it is important to include the gaps on a national level in this reflection. **For an efficient and holistic IAS approach in the German Wadden Sea**, **there is need for an organized structure that addresses the terrestrial realm**. An organized group comparable to the Fach AG Neobiota should be aspired. Likewise standardized monitoring schemes should be developed and implemented within the Federal Sates. Activities and results should be exchanged between the Wadden Sea Federal Sates. **Local activities need to be centralized** and/or registered centrally (e.g. if some small scale activities are carried out on islands etc.). Furthermore, centralization of data should also include the cooperation with **scientific studies** that address IAS. Scientific institutions and Universities should be informed and integrated. For a long term solution and lasting approach, monitoring schemes need to be institutionalized (as already planned by the ErBeM for the marine realm). The trend-indicator sets a good basis for a tool to start with. However the **drawbacks of ongoing rapid assessments and the derived trend-indicator** need to be kept in mind. The trend indicator enables to get a state-of the art picture and to resolve temporal and spatial distribution patterns of macrobiota. However, smaller organisms such as unicellular organisms and bacteria as well as plankton species (fish, jellyfish) will be missed. These organisms groups however may include specimen which, once established in a certain density may be harmful (harmful algae blooms, stinging jellyfish). Additionally, the trend indicator does not resolve the effects of IAS onto the ecosystem. Furthermore, besides the trends in numbers of new introductions, it is important to look at the species level and the probability of introduction, establishment, spread, impact on biodiversity/ ecosystem and ecosystem services and finally the nature conservation status.

For a trilateral harmonization the Fach AG Neobiota and the exchange with the authorities of neighboring countries is a good example of creating synergies. **Similar work is needed especially for the terrestrial realm**. On a trilateral level, also considerations of additional topics will become relevant and are lacking yet. Thus, for the success of IAS management **additional**

approaches should be taken into account. This concerns for example, (finding ways to) push forward the development of more efficient and environmental friendly biofouling coats.

4.6 Overarching challenges

Neobiota ≠ Invasive Alien Species

For a sustainable IAS management it will help to define, when a species within the Wadden Sea Region is considered invasive and when it is "only" neobiota and how to treat newly identified organisms. For this, an overview of species that have become invasive in the vicinity of the Wadden Sea and are likely to also enter the Wadden Sea will be helpful. This problem was already mentioned within an MSFD workshop of OSPAR in 2012 (OSPAR 2012a, b). The topic becomes especially important as early detection of neobiota does not necessarily identify them as invasive, but is nevertheless generally discussed as the only stage of sustainable eradication. For clearer definitions and ideas on how to approach neobiota it is necessary to

a) set up (standardized) programs which run for several years and can provide sufficient data that serve as background information and as a dynamic base line (e.g. as for the trend indicator), both in the terrestrial and marine realm (for the entire Wadden Sea Region) and

b) gather additionally information of species/programs/IAS monitoring outside the national and/or Wadden Sea region to be able to predict possible future IAS and which neobiota may become invasive and have negative impacts.

Another difficulty in this context is that not all invasive alien species (although changing the natural biodiversity) do necessarily bring further negative effects. It has been stated e.g. that in the case of the pacific oysters in Hamburg, this invasive species creates new substrate/habitats on which the mussels now settle again and thus do not cause a problem as originally feared. For now it rather represents a shift of dominant species. Also, the oystercatcher e.g. feeds on small individuals. However it is not clear, what this means on a long term (pers. comment Mr. Körber).

With respect to biodiversity, 21 of the species assessed in a pan-European review on IAS of Katsanevakis et al. (2014) had no effect on biodiversity whereas 81 had negative effects. However among the species assessed that were high impact species, 17 had only negative and 7 only positive impacts; both negative and positive effects were reported for the majority (62 species). It was pointed out that the "native good, alien bad" view is a misconception, and the role of most of the alien species in marine ecosystems is rather complex. This also links to previous elaborations about the appearance of non-indigenous species as consequences of a natural dynamism (Reise 2013) as well as the occurrence of species as a logical consequence of changing climatic conditions. These factors need to be considered.

Prioritization

Generally within the DSF a main element seems to be missing. **Prior to any activities that can be planned or realized, a clear and more detailed prioritization and formulation of goals and aims is needed.** This will be followed up in more detail in chapter 5.

5. Trilateral management of IAS: recommendations

In the following, recommendations are given based on the knowledge gained from the national analysis (Germany), suggested actions within the DSF and detected gaps. The recommendations will mainly **focus on prioritization and prevention and realistic practices to be put into action**. Generally it is reasonable to stick to the 5-element scheme outlined in the DSF. However, some relevant factors need to be pointed out

- **a realistic prioritization of the single management elements needs to be considered**
- **eradication in the marine realm should be approached realistically; a species risk-assessment and feasible options should be endeavored**
- **if the trilateral strategic framework stays voluntary and will not become legally binding, activities should be planned in such a way that can be realized on a voluntary basis in each of the involved countries;** alternatively an covenant agreement between stakeholders, NGOs and governmental parties could be aspired
- **for a timely realization of a trilateral management approach, the concept should be based upon already developed approaches such as the trend-indicator in Germany and the least common, yet sufficient denominator/possibilities of the single nations so that the framework can be put into practice uniformly.**

The core of this chapter is summarized by Table 7 which can be found at the end of this chapter. This table puts together the major elements with respective detailed suggestions for a further development of the trilateral approach. Additional information for each element with condensed recommendations is given in the following paragraphs.

5.1 General remarks

Before all, **a prioritization and clear definition of goals is needed but not concretized in the DSF so far**. Efficient management is only possible if the basics are clear. Whereas e.g. the Terms of Reference speak of invasive alien species management in its headline, the strategic framework headline addresses alien species. **It needs to be cleared what is targeted (IAS, which vectors)** by which means (money & manpower) and within which frame (time) it can be realistically achieved. Within this consideration it may also be necessary to discuss the establishment of species in the Wadden Sea due to natural (climate) change. **Overall, single elements should be considered in more detail and given different prioritization**. Thus in the suggested recommendations the elements are not weighed equally. The suggested management approach focuses on prioritization (Table 7, *0*) and prevention (Table 7, *1*) and includes a reviewing and reporting step (Table 7, *6*) as e.g. suggested by the Canadian strategy (page 15) that was not part of the framework so far.

5.2 Specific Remarks

Table 7 summarizes suggestions and is categorized into management steps (5 key elements of DSF + Prioritization + Review/Reporting process), guiding questions, responsible bodies that are suggested to address the topic, required activities to meet the aims, further suggestions & recommendations and the links to the DSF.

5.2.1 Prevention

The main focus within the management approach should lie on the prevention (Table 7, *1*). This is the only stage in which the introduction of IAS/(NIS) can be controlled most sustainable, least time consuming, effectively and long-term cost efficient. In the marine realm this mainly focuses on ships and aquaculture. A surveillance strategy allowing for inspection and interception in these areas is essential to verify authorized introductions, detect illegal and unintentional introductions. For intentional introductions (aquaria, floristics and aquaculture), prevention focuses on the application of risk analysis - risk assessment, risk management, and risk communication - for the prior approval of all proposed introductions. Prevention also means to focus on

- e.g. prompt realization of laws (e.g. BWMC) and controls after laws are in force
- monitoring at hot-spots (e.g. harbors, aquaculture plants that import biota from somewhere else, ballast water)
- education
- continuation of rapid assessments and early detection as dynamic monitoring and feedback controls.

A substantial step for the development of a trilateral strategy lies within the **weighting of vectors or pathways that will help to point out the most relevant ones** for each nation and thus the trilateral Wadden Sea region, making subsequent steps much more efficient.

Recommendation:

1. *Specify AS list for Wadden Sea (all concerned states to have a baseline/ status quo) including potential future AS from surrounding waters.*

2. *Initiate a project that will allow for weighting/prioritization of vectors and pathways.*

3. *Educate specifically where necessary and reasonable following the outcome of prioritization of introductory pathways.*

4. *Approach the IMO guidelines on hull fouling, and introduction & immigration of terrestrial species realistically (building land-barriers/artificial structures e.g. as suggested in the DSF does not seem to be a long lasting and efficient solution).*

5.2.2 Early detection/ Rapid response

Setting up a common monitoring program will be a major part of the early warning/detection of the trilateral approach. It was shown for New Zealand that a newly established terrestrial plant species could be removed cost-efficient; an eradication of a well-established and spread species was 40 times more costly (Augst Bericht SH). After a nationwide survey in Germany, most of the invested money was used unavailingly (e.g. *Prunus serotina*). In only 2.3 % of all cases, the problem could be solved (Schepker 2004). Because shipping and aquaculture are considered the primary vectors for introductions, ports, marinas and aquaculture facilities, and their vicinity, should be the priority areas for surveys and monitoring (Lehtiniemi et al. 2015 and references therein).

Similarly, spots have to be chosen for the terrestrial realm. To increase efficiency, the gathering and training of taxonomic experts with an easy possibility for inter-collegial exchange on a trilateral level (if not yet the case) should be aspired. For more transparency, a central unit that collects and administers the data on IAS on a national level (like e.g. Fach AG Neobiota) which then should be transferred onto the trilateral level would have to be set up.

For the trilateral solution, developments can be linked the approaches developed within Germany: developments towards a nationally harmonized monitoring approach are made and the (inter-) nationally addressed and agreed upon trend-indicator will be used as a main tool for future NIS/IAS monitoring (of macrozoobenthos within Germany/ likely the OPSAR areas). Although this monitoring within Germany is not yet institutionalized as such that there is a clear plan on selected sites, sampling frequency and monitoring duration, the applied and planned strategy offers a good starting point that can flow into a trilateral approach.

Recommendation:

1. *Decide on type of monitoring and find least common denominator for realistic 'put-into-practice' plan for all countries.*
2. *Base monitoring on/make use of the already developed trend-indicator.*
3. *Determine terrestrial and marine hot spots.*
4. *Define responsible people and set time frame for risk assessments.*

5.2.3 Eradication and control

Eradication in the marine realm is very difficult and focus should be given to less laborious and more promising, long-lasting and preventive actions. It should be mainly practiced preventively (Ballast Water) and designed case-specific. Although eradication in the terrestrial realm is generally more feasible, it should be only targeted specifically. For controlling an overview of IAS in the Wadden Sea and surroundings is needed. It is important to decide where

actions should take place- it may be necessary to evaluate where mitigation is still possible/ realistic/ reasonable and where the status rather asks for acceptance due to unpromising/ negative cost vs. effect calculations.

Recommendation:

1. *Take distance from general eradication ideas in marine realm as being an equally weighted possibility like e.g. preventive measures or equally weighted like eradication in the terrestrial realm.*

2. *If eradication in the marine realm is considered it should be reduced to activities in small/ enclosed places (e.g. marinas) and needs to be designed highly case-specific.*

3. *Focus on Prevention and individualized/targeted eradication in terrestrial realm.*

5.2.4 Raising awareness

Raising awareness is important but should be organized well. A task group could be set-up to address this element, which is in charge of e.g. distributing guidelines in harbors/marinas/sailing clubs and/or making information boards to be set up where feasible and worthwhile. However, addressing public in bulk may not be efficient, thus raising awareness should be target-group specific aiming at reaching those stakeholders which by implementing guidelines or by passing on information and taking action can really help. Decisions on which groups should be targeted primarily will also depend on the results of a weighting of vectors. Thus it could be thinkable, that specific information for Wadden Sea incoming private crafts or internationally travelling outgoing crafts may be necessary to raise the awareness of NIS/IAS introduction. Tourist information, local schools and similar could be provided with information material/ panels on how to minimize NIS introduction and on the most common terrestrial IAS that can still be mitigated and give contact details to where sightings can be reported. Local plant distributers can be contacted to educate them and they in turn their customers in such as not to distribute potentially invasive plants.

Recommendation:

Raising awareness should be target-group specific and linked to the results of the suggested vector analyses/prioritization.

5.2.5 Structural arrangements and way forward

A structure needs to be set up that coordinates the cooperative work and communication between the different responsible authorities at the different levels from each country. It needs to be clear which institutions are involved and who the contact persons or groups in charge are. These should be named and listed for each country- a trilateral organigram

should be included showing the institutions, their role and position and how they are expected to interact within this trilateral approach. For clearer communication and understanding this could be forwarded to the individual people/institutions involved. Where possible, responsible contact persons should be assigned and/or contact details should be given.

Also secondary levels of management should be discussed. Specifically this would mean getting in contact with e.g. science and developers and expressing the need for pushing forward the development of rapid test methods for ballast water control and non-toxic highly efficient antifouling coatings which would help solving the problems at the roots.

Monitoring should be the main element of the trilateral approach as the baseline for actions (re-evaluation of vectors/pathways, control, taking actions where feasible). On a national level, it was shown that activities which are supported by different ministerial levels but which are cumulatively addressed in assigned groups (Fach AG Neobiota) lead to substantial steps forward towards a common approach, as illustrated by the development of a common trend indicator. It should be considered to examine this national approach and trend indicator that has already been communicated to an international level (OSPAR/HELCOM) to evaluate whether it is feasible to extend its application on a trilateral level.

Furthermore a project could be initiated that analyses Wadden Sea relevant vectors in their relevance to enable a prioritization of subsequent activities.

Recommendation:

1. *Create organigram with contact institutes/contact persons for each country and distribute to relevant bodies.*

2. *Focus on monitoring and take already existing approaches to examine feasibility for trilateral approach (RAS and trend indicator).*

5.2.6 Reviewing and reporting

A Wadden Sea specific report on alien species was included within the Quality Status Report of the CWSS (2009). However, the reporting on IAS on a more regular basis and a corresponding concept are so far not present within the DSF and should be included. This step will allow for a long term overview and feedback-control of ongoing projects within a trilateral IAS management approach. On the one hand focus should be given to IAS developments in the Wadden Sea (Region of interest) over time; on the other hand, reviewing steps should be done to detect necessities for amendments of the existing approach.

Recommendation:

Include regular reviewing and reporting processes in the DSF to enable long-term overview and control/feedback-mechanisms of the approaches in place.

Table 7 - Summary of recommendations with detailed feasibility and implications of the proposals contained in the strategic framework. Elements within the framework (1-5, column 1) are guided by leading questions (column 2) the suggested responsible bodies (column 3) and required activities needed to reach the aspired aims (column 4). Further comments and recommendations are given and links are made to the strategic framework were feasible. The different elements are branded according to being rather categorized under planning or implementing activities. For more information and details see chapter 5.

	MANAGEMENT STEP	LEADING QUESTIONS	RESPONSIBLE BODIES	REQUIRED ACTIVITIES	*further comments/ recommendations*	*link to strategic framework*
PLANNING	**0) Defining main goals/ Prioritization**	How do we differentiate NIS and IAS? Will NIS/ IAS be treated in the same manner? (How) Do we define when a NIS becomes an IAS and what are the consequences?	CWSS TG-M & Federal Agencies for Nature Conservation of each country	Clearly define what will be addressed. Define approaches for NIS and IAS: define if and how the management approach and/or in which elements the management approach should differ for NIS an IAS.	*Except for those species known to have become invasive already somewhere else under similar climatic conditions a differentiation is not possible. Management should be the same for both with the exception that eradication only takes place preventively in the Ballast Water and for already know harmful species in the terrestrial realm where eradication is still feasible.*	*The DSF speaks of taking actions when a NIS is being categorized as IAS. However it is not clear what this categorization is based on. Whereas the Terms of Reference talk of Invasive Alien Species Management in the Wadden Sea Region, the strategic framework speaks of Alien Species. It needs to be clear what is meant.*
		What are the main vectors influencing the region of interest?	CWSS TG-M & Science	Define main vectors that should be targeted: weighing of vectors for the terrestrial and marine realm should be done (as already in place by the BWMC). Make a priority list.	*For marine realm: 1.Ballst water 2.biofouling 3.aquaculture. Weighting of vectors should include to realistically evaluate if recreational crafts have the impact as feared/suggested (see section Prevention). Approaches like these will make the entire*	*There is no prioritization of vectors defined within the DSF.*

				management approach more effective and clear.	
	What is the main "driving force" for finding a trilateral solution and what are the limiting factors?	CWSS TG-M	Define how the importance is distributed with respect to e.g. how quickly the DSF should be realized vs. how long-lasting/holistic/sustainable can and shall it be; include cost/time calculations (how much money would be needed, how much money, time, manpower is realistically available in the single nations)	*This will make the entire management approach more effective and clear if it does not become legally binding but remains voluntary*	*"Frame Facts" are not mentioned in DSF (timeframe- until when is it aspired to be realized?)*
1) Prevention	Which NIS and/or IAS are of interest so far? Which species from outside the Trilateral Wadden Sea Region could become of importance?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	Take EU list/National lists (DK,NL,GER) as basis, develop Wadden Sea specific list including potential future NIS/IAS in near time	*The uniqueness of the Wadden Sea with its Islands could be addressed with a Wadden Sea specific list for a more efficient approach*	*DSF additionally suggests making the cleaning of all hard substrates mandatory upon recognition of IAS. This is unrealistic. There is no legal basis for this yet which was suggested to be developed. Infrastruc-ture/money/manpower for this will cost much, take very long and does seem very difficult. Focus should be given to BW treatments. Making it mandatory for recreational boats to clean their hulls before entering the Wadden Sea would have to be fixed "in a law". Before making it mandatory it should be inquired how many indeed travel beyond Wadden*
	How can the impact of main vectors be minimized?	CWSS TG-M & Federal Agencies for Nature Conservation of each country	Make the regulations that target main vectors more transparent and/or binding and make problem more transparent for public	*Make approaches towards binding IMO guidelines if approach is feasible; agree on a trilateral level how and where "public" should be educated: trilateral task group "public outreach" could be set up. This is all part of the DSF "Raising awareness"(point 4) but should be given priority*	

IMPLEMENTATION		Are all countries addressing shellfish aquaculture in the same manner?	CWSS TG-M & Federal Agencies	Create an overview and find the least common denominator making realistic outlines of regulations that should be made mandatory for all Wadden Sea Countries regarding seed bivalve import		*Sea Region and could be potential vector (weighting of vectors)*
		Who is in charge of control?	CWSS TG-M & Federal Agencies	Inquire on control mechanisms that are linked to preventive steps and regularly active to ensure that control is there		
	2) Early Detection/ Rapid response	How do we approach the trilateral monitor-ing?	CWSS & Federal Agencies for Nature Conservation of each country & Science	Clear which kind of monitoring should be followed. Find the least common denominator possible with most efficient output to put into practice for all included countries, make suggestions for fixed hot-spots	*Ask each country for hot-spot suggestions. There are already approaches in Germany in place, aiming at all suggested targets within the DSF: selected har-bors/marinas, Islands and on mussel beds, use these as example. Compare approaches and discuss pros/cons; e.g. Take Trend Indicator as example for marine monitoring as it is in practice within the RAS in Germany as an example and funnel this approach into a trilateral strategy*	*The DSF suggests again to immediately clean all hard substrates in a marina or harbor after risk assessment when a NIS has been detected. This is rather unrealistic. A timeframe or allocated durations for risk assessments are not mentioned within the DSF*

	Are all involved parties (taxonomists) on the same level of knowledge?	CWSS TG-M with help of National authorities/persons in charge/delegates	give access to national expert groups for an international exchange and create platform	*at the moment the Fach AG Neobiota is contact for this issue in Germany (mainly marine realm)*	
	How do we approach NIS/IAS in the terrestrial realm?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	gather national approaches towards terrestrial IAS and outline most efficient possibilities	*set up specific task group for terrestrial realm or create sub group*	
	How do we transport/forward gathered information and new detections?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	create centralized platform for reports of each nation (alert system?) including e.g. a "newsletter" to respective people in charge if someone reports something new	*DSF suggests early warning and reporting system on CWSS website. This should be enforced*	
	How much time is allowed for risk assessment?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	Discuss and if possible define a maximum time for a risk assessment is needed. It is crucial if immediate measures are aspired for eradication. In marine more than in terrestrial realm (2 days, 2 months or 2 yrs. can make a big difference)		
3) Eradication and Control	Where does eradication make sense?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	Focus on terrestrial realm	*DSF suggests eradication/removal of plant species and animals. It should be cleared who is in charge for this and on which scale.*	*The DSF suggests again to immediately clean all hard substrates in a marina or harbor after risk assessment when a NIS has been detected. This is very unrealistic and one should*

		Are there any successful eradication methods known/ available for the marine realm?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	gather national approaches and outline possibilities (terrestrial)/ gather international examples for the marine realm and successful methods	*DSF often names eradication, however, no successful methods for marine realm are known, this is very important to keep in mind. Take distance from (large-scale) eradication in marine realm.*	*distance oneself from this approach*
PLANNING	**4) Raising awareness**	Where is raising awareness necessary?	CWSS TG-M & Federal Agencies for Nature Conservation of each country	Define who needs to be educated and informed more	*Education especially in the public sector can be unselective and not efficient. Raising awareness needs to be target-group specific and in those sectors and for those people who by acting accordingly really can make a change*	*The DSF is not specific enough in this topic.*
	5) Structural arrangements & way forward	Which kind of (additional) cooperation can be useful?	CWSS TG-M & Federal Agencies for Nature Conservation of each country	Target secondary levels	*Include to push forward the develop-ment of non-toxic efficient antifouling coatings*	*Not included in DSF so far.*
		Who is responsible for what?	CWSS TG-M	Define task groups	*Task groups or sub-groups/persons in charge are needed that target different elements of the DSF and are responsible for their coordination*	

	What are concrete topics we can focus on now?	CWSS TG-M	Define main topics to start with and lean on already existing "templates".	*Examine trend indicator and approach in Germany for feasibility within a trilateral approach, compare with other approaches if these exist. Initiate a project that addresses relevance of singe vectors for a prioritization*	
6) Reviewing and reporting	What is the status quo and development of (I)AS (management) in a defined time frame?	CWSS TG-M & responsible representatives of each county	Create trilateral overview (map & list) based on national information with respect to most dominant/ important NIS/IAS in a regular manner (annually? every two years?)	*use e.g. Lackschewitz et al 2015 for Germany*	*So far this part is not included within the DSF but important if approaches are aimed at to be long-lasting and sustainable. By reporting and reviewing, the monitor-ing approaches can be optimized and a certain self-control is being kept alive*
	Which NIS/IAS have established where?	CWSS TG-M & Federal Agencies for Nature Conservation of each country & Science	gather information of already developed species in Wadden Sea Countries and inform neighboring countries of NIS/IAS upon detection so these can be alarmed for preventive measures		
	Are taken actions effective both in terms of organizational structures and activities?	CWSS TG-M & responsible representatives of each county	Create time-dependent maps (trend indicator)		
	(How) do we need to amend/redefine our goals?	CWSS TG-M & responsible representatives of each county	review and amend management strategy according to success and failure and newly released laws/regulations etc. …on a regular basis		

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Annex

Table A1 - Interviewed persons, their affiliations and contact details

Name	Affiliation	Fon	E-mail
David Kopetsch	BioConsult	+49 (0421) 6392798-15	kopetsch@bioconsult.de
Dr. Christian Buschbaum	Alfred Wegener Institute Helmholtz Center for Polar and Marine Research	+49(4651)956-4228	Christian.Buschbaum@awi.de
Manfred Rolke	BSH	+49 40 31903511	Manfred.Rolke@bsh.de
Kai Hoppe	Leibniz-Institute for Baltic Sea Research (IOW Warnemünde) (chair of Fach AG Neobiota)	+49 381 5197 169	kai.hoppe@io-warnemuende.de
Dr. Stefen Nehring	BfN	+ 49 (0261) - 13303-98	Stefan.Nehring@BfN.de
Detlef Henning	BioConsult	+49 (0421) 69498120	henning@biocomsult.de
Bernd Oltmanns	Nationalpark Wattenmeer (NS)	+ 49(04421) 911 156	Bernd.Oltmanns@nlpv-wattenmeer.niedersachsen.de
Dr. Gregor Scheiffarth	Nationalpark Wattenmeer (NS)	+ 49(04421) 911 155	Gregor.Scheiffarth@nlpv-wattenmeer.niedersachsen.de
Herr Olischläger	Nationalparkverwaltung Wattenmeer (SH)	+49 (04861) 616 20	
Mr. Augst	LLUR, Biodiversität (SH)	+49 (04347) 704 325	Hans-Joachim.Augst@llur.landsh.de
Mr. Körber	Freie und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt (BSU)	+49 (0171) 33 07076	peter.koerber@bsu.hamburg.de
Christof Herrmann	LUNG Meck Pomm, Dezernat 210: Natura 2000, Lebensraum- und Artenschutz	+49 (03843) 777 - 210	christof.herrmann@lung.mv-regierung.de
Bernd Presch	LUNG Meck Pomm	+49 (03843)777 201	bernd.presch@lung.mv-regierung.de
Dr. Roland Lemcke	MELUR Landesregierung SH (Referent für Binnenfischerei, Angelfische-rei, Aquakultur)	+49 (0431) 988-4973	roland.lemcke@melur.landsh.de
Herr Maarten Ruth	Obere Fischereibehörde SH	+49 (04347) 704 377	Maarten.Ruth@llur.landsh.de
Heike Büttger	BioconsultSH, Muschelmonitoring (SH)	+49 (0) 48 41 66 329 14	h.buettger@bioconsult-sh.de
Holger Banik	Geschäftsführung Niedersachsen Ports (NS)	+49 (44 1) 3 50 20 - 100	hbanik@nports.de
Mr. Wilhelm	Port of Wilhelmshaven	+49 (4421) 44700	
Christine Burgmann	Sekretärin der Geschäftsführung Port of Kiel (SH)	+49 (0431) 9822 102	direktion@portofkiel.com
Dr. Thomas Scharschmidt	Landesamt für Landwirtschaft Lebensmittelsicherheit und Fischerei Meck Pomm LALLF-MV	+49 381 4035-0	Thomas.Schaarschmidt@lallf.mvnet.de

Mr. Paulsen	GEOMAR	+49 431 600 4567	mpaulsen@geomar.de
Mr. Leitz	Hamburg Port Authority	+49 (040) 428 47 2496	
Dr. Dagginus	IB, Freie und Hansestadt Hamburg,Behörde für Stadtentwicklung und Umwelt (BSU)	+49 (040) 428 40 2620	
Dr. Alexander Schröder	NLWKN, Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz	+49 (0441) 799 - 2057	alexander.schroeder@nlwkn

Questionnaire A2- Guiding questions for interviews with harbor port authorities/ captains/ marinas

- Is the topic of invasive alien species known?
- Is it known in context with ships' traffic?
- Do you know what invasive alien species are; do you know what biofouling is?
- Are these topics being addressed in your harbor somehow?
- Are you aware of the corresponding IMO regulations/guidelines, do you know that they exist and/or what they address?
- How relevant are these IMO formulations in your harbor?
- Is anything with respect to these IMO formulations planned?
- Is there in any way training of awareness with respect to these topics?