Neobiota in the Wadden Sea

Including recommendations for a trilateral strategy

><((((°>
GoConsult
><((((°>
<°))))><

Bureau Waardenburg bv
Consultants for environment & ecology

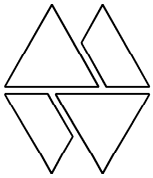
Neobiota in the Wadden Sea

Including recommendations for a trilateral strategy

S. Bouma
S. Gollasch
W. Lengkeek

Pictures front cover:
(small, top picture) hull sampling bow propeller: Stephan Gollasch
(small, middle picture) ballast water release: Stephan Gollasch
(small, bottom picture) multiflora rose: Menno Soes
(large, main picture) Pacific oysters as substrate for other (alien) species: Wouter Lengkeek

Suggested citation:
Bouma, S., Gollasch, S., Lengkeek, W. (2011). Neobiota in the Wadden Sea including recommendations for a trilateral strategy. Report nr 11-097. Prepared for Programma Rijke Waddenzee and the Common Wadden Sea Secretariat, Wilhelmshaven, Germany. 80 pp.



Bureau Waardenburg bv
Consultants for environment & ecology
P.O. Box 365, 4100 AJ Culemborg The Netherlands
Tel. +31 345 51 27 10, Fax +31 345 51 98 49
E-mail wbb@buwa.nl Website: www.buwa.nl

commissioned by: Programma Rijke Waddenzee and the Common Wadden Sea Secretariat (CWSS); contactperson Dr. F. de Jong.

13th of September 2011
report nr 11-097

Status:	Final report
Report nr.:	11-097
Date of publication:	13th of September 2011
Title:	Neobiota in the Wadden Sea
Subtitle:	Including recommendations for a trilateral strategy
Authors:	S. Bouma S. Gollasch (GoConsult) W. Lengkeek
Number of pages incl. appendices:	80
Project nr:	11-222
Project manager:	S. Bouma
Name & address client:	Programma Rijke Waddenzee and the Common Wadden Sea Secretariat (CWSS), Dr. F. de Jong, Virchowstrasse 1, D-26382, Wilhelmshaven, Germany
Reference client:	Letter from18th of May 2011 with reference L11034
Signed for publication:	Adjunct-director Bureau Waardenburg bv drs. S. Dirksen
Initials:	

Bureau Waardenburg bv
Consultants for environment & ecology

P.O. Box 365, 4100 AJ Culemborg The Netherlands
Tel. +31 345 51 27 10, Fax +31 345 51 98 49

E-mail wbb@buwa.nl Website: www.buwa.nl

Table of contents

Summary

At the 11th Trilateral Governmental Wadden Sea Conference (Sylt, Germany March 2011) the three countries bordering the Wadden Sea decided to develop a common strategy for dealing with alien species in the Wadden Sea. As part of the 'Programma Rijke Waddenzee' the Common Wadden Sea Secretariat (CWSS) commissioned Bureau Waardenburg to establish an inventory of policy and research concerning neobiota in the international Wadden Sea. The aim was to collect state of the art information on the following five topics related to introductions of alien species in the international Wadden Sea: Ballast Water, Aquaculture, Biofouling, Wadden Sea Islands and Secondary introductions through natural routes of dispersal.

This inventory was carried out in cooperation with GoConsult (Hamburg, Germany) between May and August 2011. For each of the five topics mentioned above (developments in) policies & legal aspects and monitoring & research programmes were addressed and main gaps and recommendations were identified. Several experts in the field of alien species in Denmark, Germany and The Netherlands were contacted to provide input into this inventory, but most information was gathered at scientific meetings, interviews with expert groups, and through a literature review and Internet search.

It is strongly recommended to set up a clear organisational structure for the development and implementation of a trilateral strategy to ensure commitment and funding. This requires cooperation between different authorities and organisations at various levels including ministerial, provincial and regional levels both trilateral and national.

Many international and/or regional conventions, codes of conduct and other instruments have been developed to address new introduction and the spread of alien species. However, through various reasons (including the use of different terminologies, the complexity of different institutional mechanisms and decision-making procedures and the lack of practical guidance for implementation) these documents do not always provide a clear framework how to deal with alien species. At present international policies and guidelines are implemented in the three Wadden Sea countries using different national strategies and legislations. A Trilateral Strategy may be used to develop a common approach for the implementation of international EU-law, policies and/or guidelines. National strategies and legislations can still or have to be used for the actual implementation in the three countries, but these should meet the common approach laid down in a Trilateral Strategy. To avoid misunderstandings it is recommended to develop and use one set of definitions in policies related to alien species in the international Wadden Sea. This set should be based on already existing sets of definitions.

Contents of a trilateral strategy should be based on a policy cycle consisting of prevention, early warning & monitoring, assessment, decision about management

actions, management actions and evaluation. To give effect to this policy cycle the trilateral strategy should focus on prevention (highest priority), early warning / detection through monitoring & assessment and eradication and/or control measures. Raising awareness with managing authorities, companies, scientists and the public is an important tool for prevention. Several existing websites (e.g. DAISIE, NOBANIS) and scientific and public presentations may be used for this purpose, but it may also be considered to hand out flyers, to refer to alien species on displays at coastal attractions (such as aquariums) and to pay special attention to alien species in various nature guides for the Wadden Sea.

Adequate monitoring and risk assessments are necessary to aid early warning and early detection of new introductions. In 2009 several specific inventories were carried out in the Wadden Sea focusing on the presence of alien species. It is recommended to repeat and standardise such inventories by including them in the Trilateral Monitoring and Assessment Programme (TMAP) for the Wadden Sea. It should also be considered to carry out additional 'biosecurity checks' for new alien species as part of already existing monitoring programmes (such as the monitoring programmes for blue mussels and Pacific oysters and programmes assessing bathing water quality standards) or to slightly expand existing programmes to include zones where new alien species are likely to be discovered first (e.g. routine sampling stations in ports where ballast water is discharged).

Various policies and guidelines require the identification and use of control measures to prevent the introduction and further spread of new alien species. Several of such control measures are already in use or are under development in the three Wadden Sea countries, i.e. immersion of blue mussels in freshwater before spreading them on the culture plots, development and use of ballast water treatment systems, other ballast water management control measures such as Ballast Water Exchange and/or development of guidelines to control transfer of alien species through hull biofouling. Identification and implementation of such measures are urgently needed.

Once an invasive alien species has been introduced into the Wadden Sea and exists with a self-sustaining population, the perspective for eradication and control measures is limited. If a new alien species is only identified in a specific and confined area, such as harbours, attempts should be undertaken to isolate that area and eradicate the species using techniques such as fishing, cleaning structures, filtering the water, trapping, dredging, hand-pulling of organisms etc. If a new alien species is only discovered after it has been able to spread itself and has become more common (most cases), then eradication will probably not be feasible. Efforts should then go into the identification of measures to prevent further spread to areas where that species may have severe negative impacts (e.g. threaten biodiversity in marine protected areas, lowering the yield of aquaculture products, interference with recreational activities).

The following main gaps and recommendations were identified:

Ballast Water

1. The IMO Ballast Water Management (BWM) Convention and its ratification by the three Wadden Sea Countries should be promoted. The Netherlands has already ratified this instrument. A trilateral approach is needed for the actual implementation to avoid different requirements in the three Wadden Sea countries. A suitable platform could be the existing platform of the Ballast Water Opportunity (BWO) Project[1].
2. There is a strong need for a regional concentrated effort to promote and facilitate scientific and technical research on BWM and to monitor the effects of BWM after the Convention comes into force. Port States should further provide for adequate training of their personnel.
3. Monitoring programmes to identify alien species in ballast water are developing. However ships may not only transport alien species in ballast water, but can also transfer alien species attached to their hulls, in sediment accumulated at the bottom of ballast tanks, on the walls on the inside of ballast tanks, on anchor chains, in sea chests and in the engine cooling water system. It should be considered to expand monitoring programmes to include these vectors.
4. A harmonised approach is needed for taking and processing compliance control samples to avoid that the same vessel's ballast water is proven to be in compliance in one port, but not in another simply due to different methods used.
5. Warnings could be released to avoid ballast water uptakes in zones where new alien species have been discovered.
6. A harmonized risk assessment process to exempt vessels from ballast water management requirements, based upon IMO recommendations, needs to be developed.

Aquaculture

7. Council Regulation No. 708/2007 of the European Commission concerning the use of alien and locally absent species in aquaculture requires member states to take all appropriate measures to avoid adverse effects on biodiversity resulting from the movement of aquatic organisms for aquaculture purposes and from the spreading of those organisms. The actual implementation of this regulation in the Wadden Sea is currently done at a national level using different national policies and legal instruments. A trilateral approach is needed to improve consistency between the different Wadden Sea countries.
8. Monitoring programmes and risk assessments of introducing alien species by activities related to aquaculture are mandatory under the European regulation concerning the use of alien and locally absent species in aquaculture. Various monitoring programmes have already been set up in all three Wadden Sea countries, but a trilateral approach could be undertaken to implement these

[1] http://www.northseaballast.eu/northseaballast

requirements to improve consistency. With respect to identifying the risk of transporting new alien species by shellfish transports, it could be considered to develop a standard trilateral monitoring protocol based on the Dutch protocol developed in 2010.

9. It is recommended to include regular inventories of alien species on aquaculture plots and/or ropes in the Trilateral Monitoring and Assessment Programme (TMAP) for the Wadden Sea and to carry out additional checks for new alien species as part of already existing monitoring programmes (e.g. the monitoring programmes for blue mussels and Pacific oysters).
10. Several inventories have been carried out focusing on the presence of alien species on culture ropes, culture plots and big-bags used for mussel transports. Ships used for aquaculture activities may also transport alien species that are attached to their hulls. It may be considered to expand monitoring programmes to include this vector i.e. by making this additional monitoring part of license conditions.
11. Although several studies have focussed on the identification and quantification of mussel transports from and to the Wadden Sea and all mussel transports should be entered in the European TRACES system, no overview of all mussel transports from and to the Wadden Sea or within different areas of the Wadden Sea is available at this stage.

Biofouling

12. At present there are no obligatory regulations to prevent the spread of alien species by hull biofouling, but recently IMO agreed on guidelines for hull biofouling management in international shipping. It should be considered to adopt this guideline as mandatory for the Wadden Sea similar to the European regulation concerning the use of alien and locally absent species in aquaculture. The practical implementation of this guideline in the international Wadden Sea should be discussed and organised at a trilateral level.
13. To address hull biofouling on recreational crafts user-friendly management guidelines should be developed, based upon the recently adopted IMO guidelines, and provided to any tourist or recreational facility in the international Wadden Sea area (e.g. marinas and ship yards for recreational vessels). These guidelines should be developed at trilateral level and should not only be valid for recreational vessels in the Wadden Sea, but also for vessels travelling from other areas to the Wadden Sea. Raising awareness of recreational skippers is an important step to address this issue.
14. A standardised and long-term trilateral monitoring programme should be developed focusing not only on the presence of alien species on ship hulls and man-made structures, but also on the role of fouling on these structures as a vector (i.e. collecting information on ship movements, hull husbandry including cleaning records etc.). The monitoring programme developed for New Zealand may serve as an example for the development of this programme.
15. Since the ban on antifouling paints with TBT by IMO in 2001 several tin-free antifouling paints and other methods (e.g. ultrasonic antifouling systems) have

been developed to prevent fouling on ship hulls. It is recommended to follow these developments both nationally and internationally and consider the applicability of these new methods for vessels in the Wadden Sea.

Wadden Sea Islands

16. At present, no specific policy exists that addresses alien terrestrial species on the islands. National law is used to address this topic. This is a gap, because the situation on islands differs markedly from that on the mainland. Should species native to the mainland, such as foxes, reach the islands this may be a real threat to island biodiversity in particular to colonial ground breeding birds. Furthermore, because of the small scale of the islands, early warning and successful control measures may be more feasible compared to the mainland.
17. It is recommended that an island specific policy is developed and implemented through a trilateral strategy. This implementation should include an adequate early warning system, an overview of current native and alien species, a list of most harmful species and the identification of control and/or eradication measures including a cost-benefit analysis.

Secondary introductions through natural routes of dispersal

18. Once a species has been introduced into the Wadden Sea it will be hard to control further spread through various natural routes of dispersal, including the transport by water currents and/or wind, climate change, transport by mobile animals and the presence of already established alien species providing suitable habitat for other new alien species (invasive meltdown). Monitoring further spread of such a species and identifying impacts and control measures (which is currently done) is then probably the only thing that can be done. However, joint eradication effort may be undertaken.
19. Human activities are the main vectors responsible for primary introductions, but efforts should also go into the identification of alien species that may be able to reach the Wadden Sea in the future as a result of changes in natural conditions. Using up to date information about sea currents and climate change, lists of alien species present in areas surrounding the Wadden Sea and life history traits of these species may give an early indication, which alien species we may expect to arrive in the future.

1 Introduction

1.1 Background

The Guiding Principle of the trilateral Wadden Sea policy is "to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way". Invasive alien species pose a particularly serious threat to such nature conservation interests. Many alien species remain insignificant additions to the native flora and fauna, but several invasive species can alter habitats and have long lasting effects on native biota in the Wadden Sea. Reise *et al.* (2005) mentioned that the occurrence of the cord-grass *Spartina anglica*, the brown algae *Sargassum muticum*, the polychaete *Marenzelleria cf. wireni* as well as the three molluscs *Crepidula fornicata*, *Ensis directus* and *Crassostrea gigas* have already irreversibly modified the Wadden Sea ecosystem and that there is no indication that these alien species will ever leave the Wadden Sea again.

More than fifty international and regional conventions, codes of conduct and other instruments exist that directly or indirectly deal with the spread of alien species. Through various reasons, including the use of different terminology (sometimes inconsistently or without adequate definitions), the complexity of different institutional mechanisms and decision-making procedures and the lack of practical guidance for implementation, these documents do not always provide a clear framework how to deal with alien species. To date a purposeful strategy on how to deal with alien species introduced into the Wadden Sea is lacking (Nehring & Klingenstein, 2005 in Nehring *et al*., 2009).

In June 2009 the Wadden Sea was added to the World Heritage list. Together with this inscription the World Heritage Committee encouraged the Wadden Sea Countries to implement monitoring and management strategies to control invasive alien species.

At the 11th Trilateral Governmental Wadden Sea Conference (Sylt, Germany March 2011), the three Wadden Sea states decided to develop a common strategy for dealing with alien species in the Wadden Sea. As a first step in developing this strategy a trilateral conference entitled 'Neobiota in the Wadden Sea – Challenges for Nature Conservation' was held in Wilhelmshaven on the 26th of August 2010. One of the outcomes was to collect state of the art of information regarding neobiota in the international Wadden Sea. Programma Rijke Waddenzee and the Common Wadden Sea Secretariat (CWSS) commissioned Bureau Waardenburg in cooperation with GoConsult to collect this information that will contribute to the development of a trilateral strategy on neobiota in the Wadden Sea.

1.2 Objective

The objective of this study is to provide an overview of the state of the art regarding the following five topics related to introductions of neobiota in the international Wadden Sea: 1. Ballast Water; 2. Aquaculture (including the transport of shellfish); 3. Biofouling on ship hulls and other hard substrates, including man-made structures); 4. Wadden Sea Islands; 5. Secondary introductions by natural routes of transport. This overview will form a basis for the development of a trilateral strategy on neobiota in the Wadden Sea. Recommendations for the main elements of such a strategy are also provided in this study.

1.3 Inventory: desk-study and interviews

For each of the five topics mentioned above most relevant information for the development of a trilateral strategy was collected about:

- (developments in) policies and legal instruments both at international (e.g. EU, trilateral) and national (Denmark, Germany and The Netherlands) level;
- monitoring & research programmes focusing on the relation between neobiota and the specific topic.

More specific information can be found using the references and URL's listed in chapter 9.

The information was collected by conducting a literature review and an Internet search in combination with interviewing key persons and experts in the field of invasive species in Denmark, Germany and The Netherlands. Several persons who presented research results at the Trilateral Conference 'Neobiota in the Wadden Sea' in August 2010 and various authors of reports and/or articles with relevance for neobiota in the Wadden Sea (e.g. authors of various reports used for the Quality Status Report 2009; authors of peer reviewed scientific articles) were selected for the interviews. These experts were contacted by phone and/or email and asked to provide input to this inventory by answering a series of questions sent to them by e-mail. The interview questions varied per person depending on their expertise and required input. However despite best efforts input received from the contacted persons was limited. Most information was collected through the literature review and Internet search.

Results of the Internet search, the literature review and the interviews were also used to identify the main gaps within the five topics, to develop recommendations for each topic, and finally to identify recommendations and main elements for a trilateral strategy.

2 Policies & legal instruments

Acronyms used in this chapter are listed in Appendix 1.

In the past more than 50 international and/or regional conventions, codes of conduct or practice and other instruments have been developed to address alien species (reviewed by Shine *et al*., 2000). It should be noted that only the minority of such instruments refers to aquatic species. Nearly all such instruments follow a unique application of the recommended or required procedures, provisions, and measures. Some of these binding or voluntary instruments provide the starting point from which national legislation may develop.

Regionally, many multilateral environmental agreements require Parties to regulate alien species introductions jointly and in a harmonized way. The strongest coverage is found in Europe and the Antarctic.

In the beginning the instruments aimed to avoid the introduction and spread of pests, diseases and parasites to protect human, animal and plant health. Conservation treaties reference alien species for their possible impacts on native species and ecosystems. Technical guidance has been developed for some transport and production sectors that present known risks of unintentional introductions or escapes from containment, as well as from transport vectors such as ships. Some of these instruments are briefly introduced below.

In 2006 most EU Member States (MS) had legislation in place in relation to some aspects of invasive alien species (IAS)(which are a subset of all alien species), but very few have a comprehensive and streamlined national framework[2]:

- twenty had some provisions in place in relation to import/export of IAS;
- sixteen had some provisions in relation to possession/trade of IAS;
- twenty-six controlled introduction to the wild of some IAS within their borders;
- nineteen had some provisions for statutory control and/or eradication of IAS.

MS provisions in all areas varied widely in terms of scope and purpose. There were no mechanisms to support harmonisation or basic consistency of approach between neighbouring countries or countries in the same sub-region. The fragmented measures in place did not likely appear to make a substantial contribution to lowering the risks posed by IAS to European ecosystems. Some MS with Federal systems lacked measures at the national level to promote consistency in control of introductions by sub-national authorities, or even the constitutional authority to introduce such measures. To date many of these identified issues are still valid.

Although MS are required to control introductions to the wild of potential IAS where these may affect native habitats and species (e.g. under the Birds and Habitats

[2] Miller *et al.*, 2006

Directives), the measures actually implemented to date varied significantly between MS. In some cases there were exceptions for introductions of alien species for commercial uses (e.g. forestry, agriculture) even though species introduced for these purposes may still be invasive. There were also no formal requirements for risk analysis for this type of species introductions. Accidental and negligent introductions remained largely unregulated at MS level.

Ten MS had IAS policies, either as stand-alone Strategies or integrated in their National Biodiversity Strategies. Six other had policies under development. Updates since 2006 on IAS related measures and strategies in MS and other European countries were summarized in Shine *et al.* (2010) (see Table. 1 for the Wadden Sea countries).

Table 1. Existing legal and policy frameworks in Denmark, Germany and The Netherland, reflecting the 2010 status (modified from Shine et al. 2010).

COUNTRY	Introduction of species addressed	Control and/or eradication addressed	National database / inventory of aliens species	Early warning system for alien species	Alien species strategy
Denmark	Yes	Yes	Yes	No	IAS Action Plan
Germany	Yes	Yes	Under development	Under development	Under development
The Netherlands	Yes	Yes	Yes	Yes	National IAS Policy

2.1 International

2.1.1 Conventions, European directives and communications

Conventions (ordered by date)

The main international instruments for nature conservation that specifically address alien species include the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, Bern, 1979), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention; Bonn, 1980), the United Nations Convention on the Law of the Sea (UNCLOS, 1982), Convention on Biological Diversity (Rio de Janeiro, 1992), and the Convention on Wetlands of International Importance as Waterfowl Habitat (Ramsar Convention, Paris, 1994).

The **Bern Convention** (or Convention on the Conservation of European Wildlife and Natural Habitats) was adopted in 1979. This Convention, to which 39 European states and the EC are party, provides a regional framework for implementation of the Convention on Biological Diversity in Europe (Council of Europe, 2003). Article 11.2.b of the Bern Convention states, that Contracting Parties should "strictly control the introduction of alien species". Bern Convention Parties should also inform governments of neighbouring countries if accidental introductions have occurred (Recommendation No. R (84) 14, 1984) and set up mechanisms for inter-State co-

operation, notification and consultation in order to co-ordinate precautionary and control measures for invasive species (Recommendation No. 77, 1999).

In 2000, the Bern Convention's expert group on invasive alien species began developing elements for a European Strategy on Invasive Alien Species. The finalized European Strategy, approved by the Bern Convention Standing Committee in 2003, is a comprehensive document addressed to nature conservation agencies and all other sectoral agencies with responsibility for activities relevant to the prevention or management of invasive alien species (Council of Europe, 2003). The European Strategy promotes the development and implementation of national strategies, coordinated measures and cooperative efforts throughout Europe to prevent or minimize adverse impacts of invasive alien species on Europe's biodiversity, as well as their consequences for the economy and human health and well-being (Council of Europe, 2003).

The **Bonn Convention** (or Convention on Migratory Species of Wild Animals (CMS) was adopted in 1979 and highlights in Article III.4.c that the Contracting Parties agree "to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger [migratory] species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species."

The **United Nations Convention on the Law of the Sea** (UNCLOS, 1982), explicitly places a general requirement for Parties to take measures "to prevent, reduce and control pollution of the marine environment resulting from 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" (Article 196). The rights and responsibilities agreed in UNCLOS have created the legal basis for subsequent marine legal regimes, including those concerning European marine environment (as EC has ratified the Convention in 1998).

The aims of the **Convention on Biological Diversity (CBD)**, which was adopted in 1992 and enforced in 1993, are the conservation of biological diversity, the sustainable usage of biological resources, and the fair and equitable sharing of benefits arising from the use of genetic resources. Article 8 of the Convention requires all Contracting Parties "as far as possible and as appropriate, to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". This statement was specified by the decision VI/23 "Guiding Principles on Invasive Alien Species" by the 6th Conference of the Parties to the Convention in 2002. However, how Parties should implement this requirement is not specified, but other provisions provide general indicators on strategic and cross-sectoral planning, regulation or management of potentially damaging processes and categories of activities, involvement of local populations and the private sector, incentives and environmental impact assessment, transboundary notification and emergency planning.

For coastal and inland wetlands, the **Ramsar Convention**, established in 1971, has recognized the threat to their ecological character and to terrestrial and marine wetland species if alien species become invasive. In Resolution VII.14 (1999) on invasive species and wetlands Contracting Parties are urged, where necessary, to adopt legislation or programmes to prevent introduction of "new and environmentally dangerous alien species" into their jurisdiction and to develop capacity for identifying such alien species. In Resolution VIII.18 (2002) the Conference of the Parties to the Ramsar Convention urged Contracting Parties to address the problems posed by invasive species in wetland ecosystems in a decisive and holistic manner.

European Directives (ordered by date)

The **Birds Directive** (adopted in 1979) provides a framework for the conservation and management of wild birds in Europe with a broad objective regarding non-native birds. However, how the Directives objectives are achieved is to be agreed in each Member State. Article 11 of the Directive addresses that all Member States should ensure that the introduction of birds, which do not occur naturally in its territory, does not negatively impact on the local flora and fauna.

Article 22 of the **Habitats Directive** (EC, 1992) Primarily aimed at conservation of species and habitats. Projects that may negatively impact the conservation goals of Natura 2000 areas (or areas designated under the EU Habitats Directive) should be assessed and/or mitigated. If certain projects (such as shellfish imports) have a risk of introducing invasive alien species which can have a significant impact on the conservation goals of a Natura 2000 area, then a proper impact assessment should be carried out and/or mitigation measures taken to prevent this impact. Other specific provisions of this directive in relation to alien species are the need for an assessment before the re-introduction of species into areas where they are no longer present, ensuring that alien species are not introduced into the wild (including prohibiting such actions) and promoting education and information regarding the protection of the natural environment and species.

The recent **Marine Strategy Framework Directive** (European Parliament and Council, 2008) extends EU water legislation to the marine environment and follows an approach similar to that of the Water Framework Directive (European Parliament and Council, 2000). It came into force on 15 July 2008 and establishes a comprehensive structure within which Member States are required to develop and implement cost effective measures, necessary to achieve or maintain Good Environmental Status (GES) in the marine environment. GES must be achieved by the year 2020 at the latest. Within the Directive, GES is defined by eleven qualitative descriptors, one of them being "Non-indigenous species". The key attributes of the descriptor include:

- Number of non-indigenous species recorded in an area,
- Abundance and distribution range of non-indigenous species,
- Non-indigenous species impact on native communities,
- Non-indigenous species impact on habitats, and
- Non-indigenous species impact on ecosystem functioning.

Efforts should be made to record all non-indigenous species known in the assessment area; however attention should be paid primarily to assessments of invasive aquatic species impacts. Methods for aggregating indicators for GES assessments need to take into account the known effects of invasive aquatic species in other world regions or in neighbouring areas. One of the approaches may be estimation of the magnitude of bioinvasion impacts or "Biopollution level" (BPL) index which takes into account the abundance and distribution range of non-indigenous species in relation to native biota in the invaded area and aggregates data on the magnitude of the impacts these species have on: native communities, habitats and ecosystem functioning (free access to BPL assessment system is provided at: www.corpi.ku.lt/~biopollution). BPL aggregates the results of the assessment into five categories: "No bioinvasion impact", "Weak", "Moderate", "Strong" and "Massive". The first two categories may indicate acceptable levels of biopollution for GES. The assessment has to be done for defined assessment units (a particular water body or parts thereof) and certain periods of time.

Communications (ordered by date)

In 2006, the **EC Biodiversity Communication**[3] committed the Community to substantially reduce impacts of IAS and alien genotypes by:

- developing a Strategy in line with the CBD Guiding Principles[4] and the Bern Convention's European Strategy on IAS[5] (which recognise that prevention of unwanted introductions is the most cost-effective, efficient and least environmentally damaging approach, followed by eradication where feasible or long-term containment/control);
- establishing an Early Warning System for the prompt exchange of information between neighbouring countries on the emergence of IAS and cooperation on control measures across national boundaries; and
- calling on Member States (MS) to develop and implement national IAS strategies and to ratify and implement the International Convention for the Control and Management of Ship's Ballast Water and Sediments, adopted under the auspices of the International Maritime Organisation (BWM Convention).

The communication "**Towards an EU Strategy on Invasive Alien Species**" (EC, 2008) has indicated the magnitude of the invasive species problems for various economic sectors and made it clear that the problem will exponentially increase unless appropriate action is taken urgently. It was stated that a coordinated approach at EU level is indispensable, as the impacts are transboundary. Therefore the development of an EU Strategy on tackling invasive species is the most appropriate way to address the problems to meet the policy objectives set. Such a strategy should take into account the biogeographical provinces of the European marine environment to reduce species exchange within EU waters (e.g. Ponto-Caspian spread to other European Seas, and vice versa).

[3] Objective 5, Biodiversity Communication (COM(2006)216) and Action Plan (SEC(2006)621).
[4] Guiding Principles For The Prevention, Introduction And Mitigation Of Impacts Of Alien Species That Threaten Ecosystems, Habitats Or Species (Annex to CBD Decision VI/23, 2002).
[5] Available for download a http://www.coe.int/t/dg4/cultureheritage/conventions/Bern/T-PVS/sc24_inf01_en.pdf

2.1.2 OSPAR activities

The OSPAR Quality Status Report 2010 provides an up-to-date evaluation of the quality status of the marine environment of the North-East Atlantic, summarising 10 years of assessment work under the OSPAR Joint Assessment and Monitoring Programme. Introductions of non-indigenous species (NIS) are identified as a relevant pressure of human activities in the OSPAR Maritime Area (OSPAR, 2009). The ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO, see below) made an overview assessment of alien species in the OSPAR maritime area, as a contribution to the OSPAR Quality Status Report 2010 (www.ospar.org). This document provides information on the distribution and abundance of NIS introduced into the OSPAR maritime area as a result of human activities, including information related to adverse impacts on marine ecosystems if available.

WGITMO analyzed data on the presence and distribution of marine NIS collated from the Delivering Alien Invasive Species Inventories for Europe database (DAISIE) and from ICES member countries. Over 160 marine alien species have been identified in OSPAR regions and ca. 20% were identified as problematic invaders, which have human health, economic, and/or ecological impacts.

OSPAR has agreed to apply voluntary ballast water exchange areas in line with the relevant IMO requirements (see ballast water chapter).

At the CBD Meeting in Bonn in June 2010, it was agreed that the EU (the European Maritime Safety Agency (EMSA) should circulate the "Ballast Water Management Strategy for North West Europe: Ballast Water Management on Ships operating between Ports in the North East Atlantic" as early as possible to OSPAR Contracting Parties for further commenting, in particular with regard to the lists of species and ports and the risk assessment methodology. This risk assessment study will most likely be developed in-house at EMSA.

To reduce the risk of spreading non-indigenous species already present in the waters of the OSPAR Contracting Parties, parties should:

- Identify and rank the major problematic non-indigenous species (or native species that can cause harm) with specific risk assessments within the OSPAR Region that Contracting Parties know as present in the North East Atlantic, and whose distribution within OSPAR can be controlled through the management of ballast water discharges. Once the species have been nominated then it can be decided whether a top ten list of species be developed for each of the OSPAR Areas;
- Identify which ports should be included in the assessment. These should be the major ballast water exporting or importing ports in each Contracting Party;
- For the first four of these species, identify a simple distribution map focussing on the nominated ports, indicating if the species is present or not;
- Build a simple risk assessment of a vessels ballast water discharge based on existence in a port;

- Identify appropriate voluntary management measures for vessels on routes where there is a high-risk discharge that will not disadvantage vessels;
- Develop appropriate literature to promote the guidelines; and,
- Identify whether this strategy will be appropriate and that the applicability of a risk assessment in this format will not exacerbate problems caused by other non-indigenous species, or increase their distribution.

These actions need to be complemented with a scheme that identifies new non-indigenous species and immediately puts into practice measures to reduce the risk of translocation through ballast water. This can be achieved through the following proposed actions.

- Identify the major problematic non-indigenous (=invasive or nuisance) species that the Contracting Parties know they do not want in the OSPAR Region;
- Develop guidance and information packs for Contracting Parties to enable those undertaking existing monitoring schemes and other stakeholders/users of the marine environment to be aware of these species, their biology and appearance and act as an early warning system for these species;
- Set up a central reporting system to record these sightings and for Contracting Parties to notify others of any new invasion; and
- Develop a contingency plan to enable appropriate management options to be put into place quickly (in line with IMO Guidelines) to reduce the risk of further invasion of these species after their presence has been identified. This plan may be based on the potential impact of the spread of the organism in question. This will complement the pro-active risk reduction provided by the existing OSPAR/HELCOM guidance.

The HELCOM Contracting Parties (Helsinki Commission, Baltic Sea are; see also § 2.1.3) have also agreed to participate in this process so that the risk assessment can be extended to vessels operating between the OSPAR and HELCOM areas.

2.1.3 HELCOM Activities

HELCOM has established a Working Group (WG) to develop a road map towards harmonised implementation of the IMO International Convention on the Control and Management of Ships' Ballast Water and Sediments (BWMC) within the HELCOM area. Additionally, this WG should have a look at other specific regional actions to address the problem of introduction of invasive species, such as a mandatory reporting system on ballast water, promotion and use of technical equipment for treatment of ballast water onboard ships and also consider a proposal for registration of ballast water passing Denmark. The working group also should evaluate steps to be taken before the entry into force of the convention to avoid the spreading of NIS such as risk assessment, mandatory reporting system, ballast water exchange, designation of ballast water exchange zones and a ballast water management decision support system. As a part of the HELCOM Baltic Sea Action Plan (BSAP), the road map towards ratification

and harmonized implementation of the BWM Convention was adopted in 2007. According to BSAP, HELCOM countries agreed to ratify the BWM Convention as soon as possible, but by 2013 at the latest. The WG will continue its work in order to guide and monitor the implementation of the road map and acts also following a mandate given in the Road Map "to establish a correspondence group that regularly updates the current status in implementing the road map and that offers a forum to discuss relevant developments".

HELCOM was the first regional convention to use the bioinvasion impact assessment (BPL) method (Olenin *et al*., 2007) for estimating the magnitude of the alien phytoplankton species effects on local phytoplankton community, pelagic habitat and ecosystem functioning on the scale of the entire Baltic Sea (Olenina *et al*., 2009). HELCOM has also assessed the distribution of alien species in 60 areas in the Baltic Sea and is currently applying the BPL method to assess all the IAS in the convention area.

HELCOM has agreed to apply voluntary ballast water exchange in line the relevant IMO requirements (see ballast water chapter).

Although HELCOM addresses the Baltic Sea only, their activities may be consulted when working out details for the Wadden Sea.

Currently HELCOM is undertaking a risk assessment regarding ballast water movements within the Baltic Sea. If feasible and time permitting this initiative also looks at shipping routes connecting North and Baltic Seas ports. A similar study is ongoing for the North Sea. This work is funded by the Federal Maritime and Hydrographic Agency, Hamburg, Germany. Both studies are ongoing in parallel and first results are expected in late 2011.

2.1.4 ICES activities

ICES noted the risks associated with uncontrolled species introductions and transfers almost 40 years ago. Today ICES has two working groups to address the issue, i.e. the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) to deal with the movement of NIS for e.g. aquaculture purposes and the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors which focuses on species movements with ships (see ballast water chapter for further details).

ICES, through its WGITMO and in cooperation with other ICES Working Groups and with the European Inland Fisheries Advisory Commission (EIFAC) of the Food and Agriculture Organization of the United Nations (FAO), has addressed the concerns of introducing alien species which resulted in the preparation of a Code of Practice. The first version of this code was adopted by ICES in 1973 as Code of Practice on the Movement and Translocation of Alien Species for Fisheries Enhancement and Mariculture Purposes. The Code was set forth to reduce the risks of adverse effects arising from introductions of non-indigenous marine species. This code was frequently

updated and the most recent version was published in 2005, i.e. ICES Code of Practice on the Introduction and Transfers of Marine Organisms. It includes all concerns expressed in the 1994 Code and follows the precautionary approach adopted from the FAO principles, with the goal to reduce the spread of alien or exotic species. It addresses the risks associated with current commercial practices including trade of ornamental species and bait organisms, research, and the import of live species for immediate human consumption. It also includes species that are intentionally imported to eradicate previously introduced invasive species (biocontrol), as well as genetically modified organisms (GMOs) and polyploids (specifically triploids and tetraploids). The latter sections were prepared together with WGITMO and the ICES Working Group on the Application of Genetics in Fisheries and Mariculture. The code outlines a consistent, transparent process for the evaluation of a proposed new introduction, including detailed biological background information and an evaluation of risks.

ICES Member Countries planning new species introductions are requested to present to the ICES Council a detailed prospectus on the rationale and plans for the introduction. The prospectus content is described in Section II of the Code of Practice and in the detailed code appendices. ICES may request WGITMO and/or other Working Groups to evaluate the prospectus and, if needed, more information may be requested from the proponent. In case a species introduction is approved, ICES requests to update the Council on the progress of this initiative. ICES views the voluntary Code of Practice as a guide to recommendations and procedures (see aquaculture chapter for further details).

2.2 International Wadden Sea Area

2.2.1 Trilateral Wadden Sea Plan

In the Trilateral Wadden Sea Plan (1997) no specific targets were formulated with respect to alien species issues. However, in recent years, invasive alien species have become a high-profile policy topic for the international community, which has emphasized the need for cross-sectoral coordination between competent institutions and stakeholders at all levels. In the Evaluation Report about the Trilateral Wadden Sea Cooperation, invasive alien species are specified as one emerging challenge that needs an effective cooperation in the future to conserve the unique Wadden Sea ecosystem. It was suggested that an alien species management plan on the level of the Trilateral Cooperation on the Protection of the Wadden Sea should be developed.

A revised Wadden Sea Plan was adopted in 2010 and this document updates the trilateral policies and management since the first Wadden Sea Plan was adopted in 1997. It is stated that the Trilateral Cooperation will support and intensify efforts of a harmonised approach to the prevention, management and monitoring of both aquatic and terrestrial alien species introductions. Furthermore a common strategy for addressing invasive alien species associated with ballast waters and aquaculture will be

developed also taking into account the request of the UNESCO World Heritage Committee.

An inventory (Gollasch, 2002) documented that many introduced species arrived in the North Sea with international ship traffic, especially by ballast waters, and also by aquaculture activities. More than fifty alien species also occur within the Wadden Sea. According to today´s knowledge many of the marine alien species cause minor impacts on the Wadden Sea biodiversity, but specific information is often lacking. Several species have shown or are likely to have a substantial negative impact on the existing biota in the Wadden Sea (see also chapter 1).

2.2.2 Wadden Sea Countries

The three countries are at different stages to regulate alien species.

The Netherlands

The Flora- and Fauna Law prohibits the introduction of native and non-native species into the wild.

The Habitats and Birds Directive is implemented in the Nature Conservation Law. Every project which impacts the conservation goals of areas designated under the Habitats and Bird Directive should be assessed before a licence is given.

In October 2007 the current Ministry of Economic Affairs, Agriculture and Innovation (ELI) sent a policy statement (Beleidsnota Invasieve Exoten) to the Dutch parliament. It mentions several of the international agreements indicated in the previous paragraphs and also the IMO Ballast Water Management Convention (which was recently ratified by The Netherlands), but not the RAMSAR convention, which is specifically important for the Wadden Sea. This statement submitted to Parliament in 2007 is based on 3-stage hierarchical approach: prevention, eradication and management. A fourth option is doing nothing if risks are absent or management actions unfeasible. A general conclusion of this statement is that preventing introductions of invasive alien species is the most important and (cost) effective policy option. Possible management options that contribute to prevention are creating public awareness of this problem and making agreements with stakeholders, such as companies that import plants, plant products or animals.

To implement this statement the establishment of a Team Invasive Alien Species within the Ministry of Economic Affairs, Agriculture and Innovation was initiated and the formal starting date for this team was January 2009. In cooperation with an expert network this team works on:
a) gathering information on (new) alien species,
b) setting up monitoring programs (early detection of new alien species),
c) risk analysis (carried out by experts),
d) advising the Ministry on invasive species (risks and possible management options),

e) informing the public on invasive species (raising awareness).

The Invasive Alien Species Team of the Food and Consumer Product Safety Authority (nVWA) focuses on invasive alien species that (potentially) impact biodiversity, but also takes impact on human and animal health, safety and economy into consideration. The management of the (invasive alien) organisms that threaten human, animal and plant health or the economy is dealt with by the larger nVWA and other ministries. If an initial analysis indicates possible impacts on biodiversity and more information is needed, a risk analysis will be carried out by experts. If needed, further monitoring will be carried out to determine the spread of the alien species. Based on this information the Invasive Species Team will inform the Ministry on the possible impacts of the alien species and possible management actions. Cooperation on management projects for shared water catchments with the neighbouring countries Belgium and Germany is initiated where possible.

Mussel seed transport from the Eastern Scheldt to the Wadden Sea is a topical issue, high on the political agenda. This is not (yet) allowed because of potential risk of introducing high impact species. An assessment procedure is part of the licensing procedure of the imports from UK and Ireland under the Nature Conservation Law (Gittenberger, 2010). Shellfish imports can be granted a license on the basis of a standardised screening procedure and certain strict conditions.

A national policy framework for the coastal area is under development, integrating the legal framework and policies regarding ballast water, aquaculture and hull fouling. Because of the high political relevance, the policy for mussel seed transports must be ready by the end of 2011. Currently an audit is carried out which respect to risks, compliance and law enforcement.

Denmark

In Denmark a National Action Plan for Alien Species of 2009 applies. This is, however, mainly terrestrial focused. The Action Plan gives a number of recommendations on prevention, eradication, control and research on alien species. Regarding the marine environment, prevention is much preferred as eradication most often is impossible. Therefore one of the recommendations is the implementation of the Ballast Water Management Convention.

The Action Plan also includes the first Danish "black list" of species regarded as the "worst" alien invasive species in Denmark. Furthermore there is an "observation list" of species either not yet present in Denmark, but known to be invasive in neighbouring countries or present in Denmark but still rare. The "black-list" contains a few marine species, such as Pacific oyster and *Mnemiopsis leidyi*.

The European Network on Invasive Alien Species (NOBANIS) is a gateway to information on alien and invasive species in North and Central Europe. As stated on the NOBANIS homepage (www.nobanis.org) release of animals that do not naturally

occur in Denmark into natural environment is prohibited under the Protection of Nature Act. The Act states that animals alien to Denmark are not to be released to nature without permission. Other effected instruments include:

- The Hunting Act (release of the game animals)
- Fishing Act (fish for maricultural purposes)
- Protection of Nature Act (focus on terrestrial plants)
- Forestry Act (terrestrial plants).

The organisms released into freshwater environments are regulated by the Forest and Nature Agency. Guidance is given in form of a "positive list", i.e. species that may be introduced and further a "negative list" for species not to be released was prepared (see also above).

Germany

The National Biodiversity Strategy (2007) sets specific IAS targets, including preparation of a National IAS Strategy. Discussions are ongoing on the feasibility of developing an overarching strategy across separate sectoral approaches. However, there is not yet a policy scheme like in NL, although such an instrument is under discussion. The Federal Nature Agency (BfN) is currently developing black and grey species lists. For all selected species a "Steckbrief" (brief case history account) will be prepared. A cooperation with Austria was established on the development of the black list system.

In accordance with the CBD's guiding principles (CBD, 2000), Germany has recently (2007) been preparing a national strategy on invasive alien species. The overall strategy for alien species comprises two main components: dealing with the problem of alien species already present, and the prevention of further introductions including the response if prevention should fail. Depending on the species, efforts should target one of the five categories: (a) prevention of introductions through education and regulations; (b) monitoring and early detection by effective monitoring programs; (c) rapid measures to eliminate newly introduced invasive alien species; (d) minimization of impacts of established invasive alien species by eradication and control; and (e) acceptance of established non-invasive species.

A draft National Strategy for the protection and sustainable use of the seas also addresses IAS. The German Länder (Federal States) are responsible for alien species policies in the coastal area under their jurisdiction (12 nm zone) and the federal government is responsibility for offshore areas in the German EEZ. According to the national park laws it is not allowed to introduce alien species. Removal of alien species may, however, contradict with the policy principle of natural dynamics. The approach is to deal with alien species introductions on a case-by-case and project-like basis as illustrated by the case of the Pacific Oyster. The first step towards a combined approach of the federal states agencies and the federal agencies is the establishment of a shared information exchange platform.

An inventory of alien species has been commissioned by the coastal Länder.

2.3 Identification of main gaps and recommendations

2.3.1 International

Many international and/or regional conventions, codes of conduct and other instruments have been developed to address alien species. However, through various reasons (including the use of different definitions[6], the complexity of different institutional mechanisms and decision-making procedures and the lack of practical guidance for implementation) these documents do not always provide a clear framework how to deal with alien species.

2.3.2 Wadden Sea

At present international policies and guidelines are implemented in the three Wadden Sea countries using different national strategies and legislations (§ 2.2.2). The proposed trilateral strategy on alien species should be used to develop a common approach for the implementation of international EU-law, policies and/or guidelines. National strategies and legislations can still be used for the actual implementation in the three countries, but should meet the common approach laid down in a Trilateral Strategy.

To ensure commitment and funding it is strongly recommended to set up a clear organisational structure for the development and implementation of the Trilateral Strategy (see also chapter 8).

To resolve the issue on the use of different definitions it is strongly recommended to develop and in policies related to alien species in the international Wadden Sea. When drafting these definitions one should take advantage of conventions, earlier projects, agreements and other instruments which include such definitions (see also chapter 8).

For the development and implementation of a trilateral strategy it is recommended to use already existing knowledge within OSPAR, HELCOM and ICES.

[6] One of the unresolved issues is the difficulty with the legal definition of 'alien' and "invasive" species. This issue is still not resolved.

3 Ballast water

Ballast water is assumed to be one of the key transport vectors to carry species to new aquatic environments, mainly marine areas but also brackish and fresh water areas. There are more than 50,000 vessels which carry annually 2.2 to >10 billion tonnes of ballast water around the world. Some 7,000 species are estimated to be in transit with ballast water daily.

When released, non-indigenous organism may survive and establish self-sustaining populations in the new environment. Already a few non-indigenous species have had significant almost catastrophic and irreversible impacts. Consequently, a precautionary approach assumes that each vessel that transports ballast water should be treated as a potential vector of species that may become introduced to a new environment.

Noting the negative impact of organisms when transported by ballast water into a new environment the International Maritime Organization (IMO) developed the "International Convention on the Management of Ships' Ballast Water and Sediments" (BWM Convention) which was adopted in 2004. This convention will come into force after ratification of 30 IMO Member States with more than 35% of the world fleet tonnage. As per today 28 countries with ca. 25% tonnage have ratified the BWM Convention (see below and Policy chapter).

3.1 Policies & legal aspects

3.1.1 The Ballast Water Management Convention

The prime international instrument regarding ballast water management is the Ballast Water Management (BWM) Convention of the International Maritime Organization (IMO). More details regarding this instrument may be considered in the Policy chapter. When planning to implement the BWM Convention the following (selected) aspects regarding port and ship owner obligations need to be addressed.

Obligations for ship owners

Ballast water management will become a major consideration also in the design and equipment of new vessels with the aim to prevent, minimize and ultimately eliminate introductions of harmful aquatic organisms and pathogens with ballast water. Ships will need to record all ballast water operations in the ballast water record book. Should ballast water treatment systems be installed onboard vessels, these systems will have installed equipment that will record all operations of the system, including a documentation of system failures. The information should be made readily available to appropriate authorities upon request. The BWM Convention will require all ships to have onboard an implemented Ballast Water and Sediments Management Plan, which should be vessel specific, and need to be approved by the administration or a recognised classification society (e.g. Det Norske Veritas, Germanischer Lloyd, or Lloyds

Register) on their behalf. The ballast water record book onboard vessels will need to contain records for at least the last two years, and for the next three years it will need to be kept under the ships company control (all together five years).

Obligations for Port States

The proposed regulations of the BWM Convention also impose requirements on the Port States. Port States should be prepared and equipped for monitoring of compliance of ships (see below) that discharge ballast water in their waters, including

- which documents or certificates need to be checked;
- how to check records in the ballast water record book;
- how to identify that the crew is familiar with their obligations in regards to the implementation of the BWM plan;
- how to check if a vessel has conducted Ballast Water Exchange (BWE);
- how to sample for checking compliance with the Ballast Water Exchange Standard D-1, or with the Ballast Water Performance Standard D-2.

The violation of the requirements of this Convention shall be prohibited and sanctions shall be established under national law. These sanctions should be adequate in severity to discourage violations. If a violation is identified, the ship and the administration shall be notified, and evidence should be provided.

Ports and terminals, where cleaning or repair of ballast tanks occurs, should have adequate reception facilities for sediments (see relevant IMO Guideline). Reception facilities for ballast water may also be considered.

Port States are also encouraged to identify, assess and designate areas where ships may conduct ballast water exchange in accordance with the BWM Convention in case ships, when calling to their ports, do not have had the possibility to carry out a BWE as required, i.e. outside the 200/50 nm limit from the nearest land and in waters of at least 200 meters depth (see below and relevant IMO Guideline).

Port states may exempt low risk ships from the BWM requirements, or to impose more stringent measures to high-risk vessels. This should be done by conducting a relevant risk assessment (see below and relevant IMO Guideline).

Port states are also encouraged to monitor their waters where ships may uptake ballast water and to inform mariners when they should not do so because of e.g., an outbreak of harmful organisms or pathogens, or that there are shallow or turbid waters with poor flushing and / or high nutrient concentrations that should be avoided for ballast water uptakes.

Port States should promote and facilitate scientific and technical research on BWM and monitor the effects of BWM in waters under their jurisdiction.

Port States should further provide for adequate training of their personnel and to cooperate at the regional level, e.g., in joint R&D programmes and action, for implementation of the BWM Convention.

Ballast Water Management

Today the current practice adopted to manage the introduction of harmful aquatic organisms and pathogens is BWE at sea. In any case BWE should only be undertaken when safety of the ship is guaranteed. BWE results in coastal ballast water taken up in a port to be exchanged with oceanic water from a sea area with a water depth of at least 200 m and at least 200 nautical miles from the nearest land. The rationale for this is that organisms taken up with the coastal water in the ports are released in the open ocean where they are unlikely to survive, because they are not adapted to living in oceanic conditions. When subsequently the coastal water is exchanged with oceanic water then it is unlikely that organisms taken up with the oceanic water will survive during ballast water release in the next port, because these organisms are not adapted to living in coastal conditions. If it is impossible to do BWE in 200 nm distance and at 200 m depth, the BWE should be undertaken in water depths of at least 200 m and at least in 50 nautical miles distance from the nearest land. However, the ship does not have to deviate from its intended route nor should it be unnecessarily delayed. If this is also not possible, port states may designate a ballast water exchange area (BWEA) which is closer to the nearest land and in less deep waters considering the IMO Guidelines for designation of such BWEAs (IMO Guideline G14). Ships may use such areas and may be required to deviate from their intended voyage. The requirements for BWE imply that vessels operated on many intra-European shipping routes within shallower or smaller seas, (i.e., North and Baltic and Seas), cannot meet the IMO BWE requirements.

Other than The Netherlands, the Wadden Sea countries have not yet signed or ratified the BWM Convention.

3.1.2 Ballast Water Opportunity

Further developments relevant for ballast water are ongoing, for example the project "Ballast Water Opportunity (BWO)" (www.northseaballast.eu). All North Sea countries are partners in this five year programme. The project is co-funded by the INTERREG IVB North Sea Region Programme of the European Regional Development Fund (ERDF) and is coordinated by the Royal Netherlands Institute for Sea Research (NIOZ), an institute with long-standing expertise and scientific background knowledge in testing of ballast water management systems.

The key objectives of BWO include:

- to strengthen regional cohesion;
- to provide an open research and innovation programme for the North Sea Region;
- to provide future strategies for the North Sea Region; and

- dissemination.

The project will deliver:

- coherence and harmonisation in implementation, monitoring and enforcement of ballast water management policies;
- innovation based on scientific knowledge for implementation, enforcement and development of ballast water certification and port state control;
- advancement of future strategies to reduce ship-borne bio-invasions; and
- involvement of all stakeholders in the North Sea Region, while stimulating open exchange of knowledge, ideas and expertise.

The key project group consists of NIOZ, The Federal Maritime and Hydrographic Agency of Germany (BSH), GoConsult, World Maritime University (WMU) and CaTO Marine Ecosystems (CaTO).

3.1.3 European Maritime Safety Agency (EMSA)

EMSA is active in the field of BWM by e.g. co-ordinating the currently ongoing IMO correspondence group which is tasked to provide additional information regarding ballast water sampling for compliance control with BWM Convention standards.

EMSA monitors and examines international, regional and sub-regional developments in this field in order to enable the Member States and the Commission to identify any need for further action at EU-level to:

- promote the effective management of ballast water on board ships in European waters; and
- to ensure a coherent approach within different European regions.

EMSA provides information and coordinates activities on risk assessment methodology and its use, sampling methodologies and enforcement, additional measures (as defined under the Convention) and interim measures, to support Member States to ratify the Convention and develop interim strategies through the four regional seas conventions around Europe.

In November 2008, EMSA organised a workshop to identify how the EU Member States, the European Commission and EMSA can work together to provide a cohesive approach in implementing the ballast water management strategies of the regional forums and ratifying the Ballast Water Management Convention. In February 2010, EMSA held a Workshop on sampling for enforcement, including compliance control sampling with the standards of the BWM Convention. At that Workshop the need to develop guidance on many issues concerning sampling for enforcement was identified.

Subsequently EMSA has developed this guidance through research and liaison with global experts in the fields of ballast water sampling, water analysis, statistical analysis, Port State Control (PSC) experts and plankton biology. In the process of submitting this guidance to the IMO Sub-committee Bulk, Liquid and Gases (BLG) for

consideration, four papers were submitted to the European Council's Shipping Working Party Meetings.

3.1.4 BWM related risk assessment

The risk related to ballast water and sediment discharge can be defined as the likelihood of an undesired event (e.g. a species introduction) occurring as a consequence of ballast discharge from a ship.

The IMO BWM Convention allows exempting certain ships from ballast water management (BWM) requirements should a low risk be identified. In contrast, additional BWM measures may be applied in case of (very) high risks. The exemption process should be based on risk assessments (RA) according to the Regulation A-4 Exemptions, of the BWMC and needs to be in line with the IMO Guidelines for Risk Assessment (G7).

The RA was developed to provide tools for a selective approach in the implementation of the BWM Convention. The RA has three different methods, i.e., "environmental matching", "species' biogeographical" and "species specific" risk assessment.

Different RA projects were undertaken addressing this issue on a regional basis, e.g.

- Nordic Countries Risk Assessment (completed already in 1999);
- OSPAR Scoping Study (completed);
- HELCOM Risk Assessment Study (first study completed);
- BSH Risk Assessment Study (first study completed).

Currently two additional RA projects are ongoing, one to address intra-Baltic shipping. This project was initiated by HELCOM. The second project will address North Sea RA and is undertaken in the framework of the BWO project mentioned above.

3.1.5 Voluntary Ballast Water Exchange Areas (OSPAR Agreement)

The Contracting Parties of HELCOM and OSPAR worked towards a voluntary interim application of the BWE Standard in Regulation D-1 of the BWM Convention for shipping in the northeast Atlantic and the Baltic Sea. The relevant HELCOM documentation is not outlined in detail here, but may be consulted at www.helcom.fi.

From the 1st of April 2008 OSPAR suggests, on a voluntary basis, and provided safety permits, BWM requirements for vessels entering those regions of the Atlantic and Arctic oceans and adjacent seas, including the Baltic Sea, north of 36° north latitude as well as between 42° west longitude and 51° east longitude, and the Atlantic ocean north of 59° north latitude and between 44° and 42° west longitude.

In short, the requirements include:

- vessels entering the area should carry a BWM Plan which complies with the relevant IMO guideline;

- all ballast water operations should be recorded on all vessels entering the area;
- ballast water of all tanks should be exchanged according to the requirements outlined in the D-1 Standard of the BWM Convention; i.e. at least 200 nautical miles from nearest land and in waters of more than 200 m depth. These requirements apply to vessels on trans-Atlantic voyages, and those entering the OSPAR area on shipping routes passing the West African coast before entering the northeast Atlantic.

Sediment releases from cleaned ballast tanks should only occur outside 200 nautical miles of the northeast Atlantic coast.

3.2 Monitoring and research

3.2.1 EU projects

VECTORS

A recently launched project in the European Union funded Seventh Framework Programme (FP7) will address BWM. This is the project Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors (VECTORS[7]). VECTORS aims to improve our understanding of how environmental and manmade factors are impacting marine ecosystems now and how they will do so in the future. The project will also examine how these changes will affect the range of goods and services provided by the oceans, the ensuing socio-economic impacts and some of the measures that could be developed to mitigate or adapt to these changes.

VECTORS will address a complex array of interests comprising areas of concern for marine life, biodiversity, sectoral interests, regional seas, and academic disciplines as well as the interests of stakeholders. The project will also ensure that the links and interactions between these areas of interest are explored, explained, modelled and communicated effectively to the relevant stakeholders.

BWM related activities include:

- a summary of ballast water treatment systems;
- the application of Risk Assessment models; and
- the development of a Decision Support System.

Dutch, German and Danish partners are included in the VECTORS project.

ALARM, DAISIE and IMPASSE

Experts from The Netherlands, Germany and Denmark were involved in three other completed projects on alien species with funding of EU Framework Programmes:

- Assessing large scale risks for biodiversity with tested methods (ALARM) (http://www.alarmproject.net);

[7] http://www.marine-vectors.eu

- Delivering Alien Invasive Species Inventories for Europe (DAISIE) (http://www.europe-aliens.org/);
- Environmental impacts of alien species in aquaculture (IMPASSE) (http://www2.hull.ac.uk/discover/hifi/impasse.aspx);

It should be noted that all these programmes were more targeted to document alien species rather than addressing introduction vectors and their importance. Ballast water sampling programmes and/or projects specifically focusing on transport of ballast water as a vector for alien species in the three Wadden Sea countries are limited (see also § 3.2.2).

3.2.2 Wadden Sea countries

The Netherlands

- NIOZ has an outstanding expertise as a test site for candidate ballast water treatment systems;
- NIOZ is coordinating the BWO project (see above);
- Annually many ballast water treatment systems are tested at NIOZ to proof their efficacy and environmental acceptability. This work is done according to the IMO guidelines G8 and G9;
- The Netherlands has ratified the BWM Convention as the only country so far in the Wadden Sea region;
- A Dutch company has completed the development of a ballast water treatment system.

Germany

- The German administration (BSH) has a long lasting experience to certify ballast water treatment systems according to the IMO Guidelines G8 and G9;
- Several German companies have completed the development of ballast water treatment systems, e.g. Hamann, RWO, Mahle and Aquaworx. Other companies consider the development of such systems;
- The BSH is co-coordinating the BWO project;
- Research regarding ballast water began already in 1992 with a ballast water sampling study funded by the Federal Environmental Agency;
- The BSH funded a study on how to take representative samples of ballast water;
- The Federal State Schleswig-Holstein earmarked funds to develop a ballast water treatment system (the JETSAM project);
- BSH funded a study to develop a Ballast Water Risk Index - a tool for assessing the risk of ballast water exchange in the North Sea;
- A background project on ballast water risk assessment was completed (funded by BSH);
- Currently a study to assess the risk posed by ballast water between North Sea ports is ongoing (funded by BSH).

Denmark

- Denmark is a member in the BWO project;
- A new facility to test ballast water treatment systems for their efficacy and environmental acceptability according to the IMO guidelines G8 and G9, was opened at DHI near Copenhagen;
- The Danish administration has recently started to prepare for the certification process of ballast water treatment systems according to the IMO Guidelines G8 and G9;
- A Danish company has started to develop a ballast water treatment system.

3.3 Identification of main gaps and recommendations

Policies

The IMO Ballast Water Management (BWM) Convention and its ratification by the three Wadden Sea Countries should be promoted. In contrast to a national approach, a trilateral or even a wider geographic approach is needed for the actual implementation to avoid different requirements in the three Wadden Sea Countries. A suitable platform for harmonisation could be the existing platform of the Ballast Water Opportunity (BWO) Project.

Further port states have certain obligations that need to be (at the latest) addressed once the BWM Convention comes into force. These obligations are outlined above and will not be repeated here. There is a strong need for a regional concerted effort to promote and facilitate scientific and technical research on BWM and to monitor the effects of BWM. Port States should further provide for adequate training of their personnel. This may be undertaken as a joint initiative with other countries.

Warnings may also be released to avoid ballast water uptakes in zones with newly found alien species. A communication platform for such data would then be needed to inform the shipping business where to avoid ballast water uptakes.

Research, monitoring and assessment

Ballast water is only one shipping vector to introduce alien species. Other shipping vectors include organism transports:

- in the sediment accumulated at the bottom of the ballast tanks;
- in the fouling on the walls inside ballast water tanks;
- in the hull fouling on the outside of the vessel;
- in sea chests (this is the compartment where the ballast water intake and discharge line openings are located. Sediment and organisms accumulate here);
- with anchor chains; and
- in the engine cooling water system.

Ballast water studies have been undertaken in many EU Member States, more than 1,000 different species were identified. We do not see the urgent need to repeat these

studies as practically all life forms were found in samples taken from ballast tanks. Hull fouling, sea chest and tank sediment studies were also undertaken in the past, but it should be considered to expand existing monitoring programmes to include all shipping vectors as listed above.

Another timely aspect is to evaluate ballast water sampling methods with the aim to recommend approaches to take a biological representative sample from the ballast water. This is important for compliance control tests with the standards of the ballast water management convention. Initial studies were done already (see above), but a larger number of tests would increase the robustness of the findings and would also allow a more comprehensive statistical analysis of the samples.

The IMO Convention recommends not taking up ballast water in zones with known outbreaks of (potentially) harmful organisms or in sewage outfall areas. As most ballast water is taken up in ports it would be beneficial to extend ongoing monitoring programmes and to establish sampling stations in ports to identify such events.

A joint strategy by the three Wadden Sea countries regarding compliance control samplings of the IMO Convention standards (or even a wider geographic approach) would be beneficial. This study may include addressing how many vessels should be sampled and how to target such vessels as well as what methods to use to identify organisms in the water. A harmonized approach in this regard would be essential to avoid that the same vessel's ballast water is proven to be in compliance in one port, but not in another – simply due to different methods used. This would be a very unsatisfactory situation.

4 Aquaculture

At present cultivation of blue mussels is the most important form of marine aquaculture in the Wadden Sea and only occurs in the Dutch and German Wadden Sea. In the Danish Wadden Sea cultivation plots are not allowed. In the past mussel fishery in the Danish Wadden Sea did take place, but due to the low abundance of consumption mussels this fishery was stopped between 2004 and 2008. In 2008 new licenses were granted, but at present the fishery has not resumed as a result of various protests.

At present several transport routes are involved with the cultivation of mussels in the Dutch and German Wadden Sea (source: Kools *et al.,* draft 2011):

1. Seed mussels are collected from wild subtidal banks in the Dutch and German Wadden Sea to cultivation plots in the Dutch and German Wadden Sea and the Eastern Scheldt;
2. Seed mussels are imported from the British Isles (mainly UK, Ireland) to the Dutch and German Wadden Sea and the Eastern Scheldt, because of the low availability of seed mussels in the Wadden Sea and increased demand in recent years;
3. Mussels are regularly transported between cultivation plots in the Wadden Sea (within the same area);
4. Mussels are transported from plots in the Dutch Wadden Sea to plots in the Eastern Scheldt. At present transport from the Eastern Scheldt to the Dutch Wadden Sea is not allowed to prevent the risk of introducing/spreading invasive species.

These transports, mainly carried out by ships with the mussels generally stored in so-called big bags, may facilitate the introduction and spread of alien species in the Wadden Sea. The cultivation plots itself can provide a suitable habitat for the establishment of alien species. Alien species such as Pacific oysters and slipper limpets were for example found on subtidal mussel beds during an inventory carried out in 2009 (Gittenberger *et al*., 2009) and such species may in turn provide habitat for other alien species (also known as a process called invasion meltdown; see chapter 7).

4.1 Policies & legal aspects

International (European level)

On the 11th of June 2007 the European Commission introduced Council Regulation (EC) No 708/2007 concerning use of alien and locally absent species in aquaculture[8]. Under this regulation Member States must take all appropriate measures to avoid

[8] This instrument applies to open and closed aquaculture facilities under all MS jurisdictions. The instrument does not apply to movements of organisms within MS (except if there is a risk to the environment); to pet-shops, garden centres or aquaria where there is no contact with EU waters and to selected species, which are listed in Annex IV to this document.

adverse effects on biodiversity resulting from the movement of aquatic organisms for aquaculture purposes and from the spreading of those organisms. The voluntary alien species rules originating from the International Council for the Exploration of the Sea (ICES) 'Code of Practice on the Introductions and Transfers of Marine Organisms 2005' and the European Inland Fisheries Advisory Commission (EIFAC) are made compulsory by this Regulation. Some of the requirements of this Regulation are:

- Aquaculture operators intending to undertake the introduction of an alien species or the translocation of a locally absent species not covered by Article 2(5) shall apply for a permit from the competent authority of the receiving Member State. Applications may be submitted for multiple movements to take place over a period of not longer than seven years.
- In the case of routine movements, the competent authority may grant a permit, indicating, where applicable, the requirement for quarantine or pilot release as set out in Chapters IV and V. In the case of non-routine movements, an environmental risk assessment shall be carried out. The competent authority shall decide whether the applicant or an independent body is responsible for conducting the environmental risk assessment and who shall bear the cost.
- On the basis of the environmental risk assessment, the advisory committee shall give its opinion on the risk to the competent authority. If the advisory committee finds that the risk is low, the competent authority may grant the permit without further formalities. If the advisory committee finds that the risk associated with the proposed movement of aquatic organisms is high or medium in the sense of Annex II, part 1, it shall examine the application in consultation with the applicant to see if there are mitigation procedures or technologies available to reduce the level of risk to low.
- Where the potential or known environmental effects of a proposed movement of an organism are liable to affect neighbouring Member States, the competent authority shall notify the Member State or States concerned and the Commission of its intention to grant a permit by sending a draft decision, accompanied by an explanatory memorandum and a summary of the environmental risk assessment.
- Alien species shall be monitored after their release into open aquaculture facilities for a period of two years or a full generation cycle, whichever is longer, to assess whether the impacts were accurately predicted or if there are additional or different impacts. The level of spread or containment of the species shall be studied in particular. The competent authority shall decide, whether the applicant has the adequate expertise or whether another body is to carry out the monitoring.

In October 2009 a proposal for an amendment to exempt biosecure 'closed aquaculture facilities' from the permit requirement of this regulation was adopted by the European Commission.

At European level a TRACES (TRAde Control and Expert System) has been developed for monitoring the movement of animals and certain products of animal origin within the European Union (EU) and from third countries, as well as providing all the reference

data relating to trade in such goods. Although all mussel transports mentioned above should be entered into this system no overview of mussel transports from and to the Wadden Sea or within different areas of the Wadden Sea is available at this stage (Kools *et al*., draft 2011).

All aquaculture activities take place in Nature 2000 areas. In The Netherlands mussel beds are considered as a quality parameter in habitat type 1140 (intertidal sand- and mudflats), in the subtidal (habitat type 1110)) and in the estuary of the Ems (habitat type1160) (Nehls *et al*., 2009). Regulations from the Habitats Directive oblige the fisheries to prove that their business does not significantly affect conservation targets of these Nature 2000 areas. Appropriate assessments have been carried out in Denmark and The Netherlands. In Denmark this led to a ban on mussel fishery, in The Netherlands this assessment was judged to be insufficient (Nehls, presentation Wilhelmshaven, 2010).

An approach to include mussel beds of the Wadden Sea into quality assessments according to the EU Water Framework Directive has been made in Sleswig-Holstein (Büttger & Nehls, 2009) and this subject is in discussion in other parts of the Wadden Sea as well.

The Netherlands

In October 2008 a covenant was agreed between the Ministry of Agriculture, Nature & Food Quality, the mussel fisheries sector and three nature NGOs, setting out the main principles for a nature restoration program and a transition of the mussel fishery towards sustainable fisheries. The intention of the so-called 'Mussel Transition in the Dutch Wadden Sea' is to gradually phase out fishing of seed mussels from the sea floor by replacing this fishery by the use of mussel seed collectors (SC) suspended in the water column. In February 2010 an implementation plan was published. The transition of the mussel fishery is part of the restoration programme 'Towards a rich Wadden Sea' that aims to achieve a rich Wadden Sea by 2030 for nature and for users.

Import from mussels in The Netherlands is subject to the so-called 'Verordening Quarantainevoorzieningen'. Under this regulation imported shellfish from areas not mentioned in this regulation must be treated in an approved quarantine treatment plant before they can be spread on the cultivation plots. Exceptions are made for import of shellfish from areas with minimal or no risk of introducing exotic dinoflagellates or their cystes responsible for the production of biotoxines (Kools *et al.*, draft 2011). For such transports a licence is required under the Nature Conservation law (in Dutch: Natuurbeschermingswet). For the mussel transport from the Dutch and German Wadden Sea and from the British Isles (UK and Ireland) to the Eastern Scheldt and from the British Isles to the Dutch and German Wadden Sea such a licence has been granted. For the transport of mussels within the international Wadden Sea no such licence is required.

In 2010 a monitoring protocol was developed for the import of mussels to The Netherlands (Gittenberger, 2010a). This protocol prescribes inventories in export areas and inspections of big-bags used in mussel transports. Using results of these inventories and inspections the risks for the introduction or spread of exotic species is evaluated and management decisions are taken. This protocol has recently been made mandatory (Kools *et al.,* draft 2011).

The sector organisation 'Productschap Vis' is responsible for the enforcement of the 'Verordening Quarantaine-voorzieningen' in the province of Zeeland. The actual inspections with respect to this regulation are carried out by CBD (in Dutch: Centrum voor Bedrijfsdiensten). The 'Waddenunit' of the Ministry of Agriculture, Nature and Food Quality is responsible for the enforcement of legislation related to mussel cultivation in the Wadden Sea. At present inspectors focus on the enforcement of the ban on transport of seed mussels from the Eastern Scheldt to cultivation plots in the Wadden Sea. On the water this is done by the deployment of four vessels in different regions of the Wadden Sea. Fines can rise up to 100.000 Euro and fishermen can loose their license for cultivation plots.

Denmark

Aquaculture is not allowed in the Danish Wadden Sea. Mussel transports from the Danish Wadden Sea to the Eastern Scheldt did occur in the past, but at present this transport route is not used as a result of the ban on mussel fishery in Denmark. Mussels are transported from Denmark to the Eastern Scheldt, but these mussels originate from Limfjord and Ilsefjord that are not part of the Danish Wadden Sea (Wijsman & de Mesel, 2008). These mussels are treated in a quarantaine station, before they are spread on cultivation plots in the Eastern Scheldt.

Germany

In Germany mussel cultivation is strongly regulated by the different states. Since 2005 seed mussels are imported from the UK and Ireland under strict conditions (e.g. mussels have to be submersed in freshwater for minimal two hours before they can be spread on the cultivation plots). Enforcement is done through deployment of a black-box system onboard of the ships. Through this system it is possible for the authorities to follow the movements of the ships involved in mussel cultivation. In addition to this black-box system inspectors also physically carry out inspections in the field.

Bivalve fishery in the National Park Schleswig-Holstein is regulated as follows (input provided by Thomas Borchardt):

§ 6 (2) and (3) National Park Law

In Zone 1 (= core zone), except in the zero-use area, mussel fishing is permitted in the framework of a permit pursuant to § 40 (1) and § 41 of the State fisheries act (Landesfischereigesetz), and fishing shall conform to the national park's protection purpose. But in fact, due to other regulations (see below), bivalve fishery in zone 1 is not allowed.

In Zone 2 (rest of the park) mussel fishing is permitted below the mean spring-tide low-water line in keeping with §40 and §41 of the State fisheries act (Landesfischereigesetz), within the 3-sea-mile zone. In the water-mixing zone, use of existing oyster aquaculture facilities is permitted.

§ 40 and § 41 State Fishery Act
In the National Park bivalve fishery permits can only be granted in agreement with the highest nature protection administration. Details are regulated by a bivalve fishery program. Regulations of the bivalve fishery program regulations are:
- No bivalve fishery in the core zones (= zone 1)
- No mussel fishery in the intertidal area
- No fishing of wild mussels; only mariculture is allowed.
- Max. 2000 ha mussel cultures in the subtidal area.
- Max. 30 ha oyster cultures in the intertidal area.
- Max. 8 mussel vessels.
- Control by a black box system on the vessels.
- Monitoring and management.

To prevent the import of bivalve diseases and parasites, it is not allowed to bring in bivalves from coastal waters outside Schleswig-Holstein. Exemptions can be granted (nowadays after FFH-assessment). In the so-called "Befreiung" the conditions are listed under which imports from the UK and Ireland are possible. Examples of these conditions include that it must be guaranteed that no alien species and/or diseases and parasites are introduced into the Wadden Sea and that mussels must be submersed in freshwater for minimal two hours before they can be spread on the cultivation plots.

4.2 Monitoring and research

Several projects focusing on alien species in relation to natural mussel beds and (transports associated with) mussel cultivation have been carried out in all three Wadden Sea countries:

<u>The Netherlands</u>
- In 2009 an inventory of hard substrate communities on 83 locations in the Dutch Wadden Sea was carried out (including several intertidal mussel- and oysterbeds). Special attention was paid to the presence of exotic species. A total of 129 species were found including 28 exotic species (Gittenberger *et al.*, 2009).
- In 2009 a study was carried out focusing on the risks of the unintentional introduction of new exotic species[9] with shellfish transports from other countries to The Netherlands (Wijsman & Van Mesel, 2009). As part of this study the risks of transporting shellfish from the southern part of The Netherlands to the Dutch

[9] Exotic species were defined as species that are non-indigenous for the Northeast Atlantic continental shelf area and are introduced into this area by human activities.

part of the Wadden Sea and from the German and Danish parts of the Wadden Sea to the Dutch part of the Wadden Sea were evaluated. Risks were identified by the preparation of list of known exotic species in the different areas and identification of the risks of new introductions by means of a literature review and consultation of 11 national and international experts. As part of this study 30 samples were taken from mussels in the water column (rope culture and mussel seed collectors) and from the bottom (culture plots and natural beds) both in the Eastern Scheldt and the Voordelta in the summer of 2008. The samples were analysed for associated flora and fauna with special attention for alien species (Wijsman *et al*., 2009). About 13% of identified species on mussels were alien. In addition a literature review was undertaken in September 2009 focusing on exotic species in the Eastern Scheldt (Gittenberger, 2009). The results of this study will be used by the Dutch Ministry of Agriculture, Nature and Food Quality to develop a new national policy for the transfer of shellfish.

- In 2010 a monitoring protocol was produced for the import of shellfish to The Netherlands (Gittenberger, 2010a).
- Two oyster drills (*Urosalpinx cinerea* and *Ocinebrellus inornatus*) have been identified in the Eastern Scheldt, but at this stage not in the Wadden Sea. If mussel transports from the Eastern Scheldt to the Wadden Sea are allowed in the future then these species could be introduced into the Wadden Sea. In 2010 a simple experiment was carried out to test whether immersion in freshwater for $\leq$ 24 hours would kill these two oyster drills. Freshwater failed to kill any individuals of either species, but did cause them to detach from the substratum for the entire time of immersion. Immersion in freshwater was therefore not recommended as a method to control the drills. Rinsing in freshwater was regarded as an option to remove the drills without killing the mussels, but no guarantee of 100 % success was given (Brink & Wijsman, 2010).
- Several risk analyses are carried out for species that potentially could be spread by mussel transports including a risk assessment of the possible introduction of three predatory snail species (*Ocinebrellus inornatus*, *Urosalpinx cinerea* and *Rapana venosa*) in the Dutch Wadden Sea (Fey *et al.,* 2010) and the invasive tunicate *Didemnum vexillum* (Gittenberger 2010). These assessments showed that these species can have an impact on both the conservation goals of the Natura 2000 area and mussel cultures in the Wadden Sea.

Germany

- The invasion of mussel beds in the German Wadden Sea by Pacific oysters and slipper limpets are documented (Nehls *et al*., 2006).
- Results of recent research into the bio-invasion of the Pacific oyster in the German Wadden Sea were presented at the Wadden conference on the 26th of August 2010 by Wehrmann & Markert from the Forschungsinstitut Senckenberg, Department of Marine Science. The results provided not only insight into the colonization and distribution of Pacific oysters in the German Wadden Sea, but also on aspects like the competition with blue mussels for food and space, the biodiversity of oyster reefs in comparison to the biodiversity

of blue mussel beds, influences of climate change and ice winters and oyster reefs facilitating new bio-invasions.

Denmark

- The Technical University of Denmark and the National Institute for Aquatic Resources investigated the spread of Pacific oysters in the Danish Wadden Sea and assessed impacts of different management strategies on the ecosystem. Dolmer presented results at the Wadden Sea conference on the 26th of August 2010.
- Jensen K.R., & Mikkelsen (2011). On shellfish activities and invasive species in the Danish Wadden Sea. January 2011. Grontmij Carl Bro report, 18 January.
- In 2008 a risk analysis was carried out on the import of mussels from the Limfjord and the Iisefjord (Denmark) to the Oosterschelde (Wijsman & de Mesel, 2008).

Other monitoring programmes

Apart from these projects specifically focusing on exotic species related to mussel cultivation several monitoring programmes and research projects have been carried out that could be used to identify the presence of exotic species on mussel banks. Mussel beds are monitored annually in The Netherlands, Niedersachsen and Schleswig-Holstein (Germany). In the Danish Wadden Sea a regular monitoring programme of all mussel beds in areas open for fishery is conducted every second year (Nehls *et al*., 2009). The main effort of these programmes is concentrated on intertidal beds. Monitoring of subtidal beds is undertaken annually in The Netherlands and subtidal beds received much attention within the Dutch research projects PRODUS. In the German states Niedersachsen and Schleswig-Holstein projects have started to detect, classify and map different subtidal habitats in the Wadden Sea by means of acoustical remote sensing techniques (Nehls *et al*., 2009), but the effort to monitor subtidal beds in Germany and Denmark is much lower than the effort to monitor intertidal beds.

4.3 Identification of main gaps and recommendations

Policies

- The Council Regulation of the European Commission concerning the use of alien and locally absent species in aquaculture requires Member States to take all appropriate measures to avoid adverse effects on biodiversity resulting from the movement of aquatic organisms for aquaculture purposes and from the spreading of those organisms. The actual implementation of this Regulation in the Wadden Sea is currently done at a national level using different national policies and legal instruments. A trilateral approach is needed to avoid discrepancies between the different Wadden Sea Countries.

Research, monitoring and assessment

- Monitoring programmes and risk assessments of introducing alien species by activities related to aquaculture are mandatory under the European Regulation mentioned above. Various monitoring programmes have already been set up in all three Wadden Sea countries, but a trilateral approach could be undertaken to implement these requirements to improve consistency.
- It is recommended to include regular inventories for alien species on aquaculture plots and/or ropes in the Trilateral Monitoring and Assessment Programme for the Wadden Sea. It should also be considered to carry out additional checks for new alien species as part of already existing monitoring programmes (e.g. the monitoring programmes for blue mussels and Pacific oysters).
- With respect to identifying the risk of transporting new alien species by shellfish transports it should be considered to develop a standard trilateral monitoring protocol based on the Dutch protocol developed in 2010.
- Several inventories have been carried out focusing on the presence of alien species on culture ropes, culture plots and big-bags used for mussel transports. Ships used for aquaculture activities may also transport alien species that are attached to the hulls of these ships, but there are no regulations requiring regular checks of alien species on ship hulls. It may be considered to develop such regulations, possibly based upon the IMO biofouling Guideline (chapter 5).

5 Biofouling

Biofouling on hard substrates mainly facilitates the introduction, settlement and spread of alien species in three ways:

1. Biofouling on ship hulls serves as a vector to bring species from one area to another and can be responsible for new introductions;
2. Man-made static structures may provide a habitat for alien species that have been introduced by other vectors such as aquaculture or hull biofouling. Man-made structures may also serve as 'stepping stones' overcoming barriers for alien species (e.g. absence of hard substrates for settlement) to colonise new areas (e.g. foundations of offshore-wind farms).
3. Translocation of static structures such as oilrigs or shipping lane marker buoys.

Ad 1) In the North Sea, ships (both commercial and recreational) are probably responsible for more introductions than any other vector (Gollasch, 2002). Although ballast water is more widely recognised as a vector for alien species, biofouling on ship hulls is responsible for two-third of all neobiota introductions by ships (Gollasch, 2002). This makes biofouling on ship hulls one of the main sources of species introductions into the North Sea ecosystem. Table 6.1 from Reise *et al.* (2005) shows that 'shipping' also introduced more alien species in the Wadden Sea than 'aquaculture' (33 versus 17 species). Although Wadden Sea harbours are smaller than some other European Sea ports, they do accommodate international shipping (Butt *et al.*, 2009). In addition, recreational ships move frequently between the Wadden Sea and more southern harbours, for instance the Eastern Scheldt.

Sessile organisms such as barnacles can stay on ship hulls for long periods of time and withstand the harsh conditions of a ship moving through rough seas. These organisms can also provide refuge for mobile species. Gollasch (2002), for example, found individuals of the alien crab species *Hemigrapsus penicillatus* on ship hulls sheltering in empty barnacle shells.

The use of anti-fouling paint with TBT (since 1970) reduced introductions by biofouling on ship hulls. This was originally developed to reduce the biofouling of vessels with the aim to reduce friction, but not to avoid species introductions. This presumably is one of the reasons why ballast water received earlier attention as a vector for new introductions by shipping. However, research indicates that since 1970 ship hulls and ballast water have had equivalent importance for introductions in the North Sea (Nehring, 2005). The use of TBT has thus not ruled out biofouling on ship hulls as an important vector for introductions of alien species. Noting the adverse effect of TBT, which impaired the reproduction of molluscs, the use of this substance was banned by IMO in 2001. Since this ban replacement antifouling coatings have to be environmentally acceptable as well as maintain a long life. Modern approaches to environmentally effective antifouling systems and their performance are described in Chambers *et al*., 2006 including the use of tin-free self-polishing copolymer (SPC) and foul release technologies. Apart from the development of TBT free, antifouling paints

also other methods are being developed to prevent biofouling on ship hulls. An example is the development of ultrasonic antifouling systems. These systems emit low frequency sonic waves / vibrations which are radiated through the boat's hull in order to destroy algae that are the basis of all weed growth and micro organisms such as, barnacles, zebra mussels, oysters, clams and tube worms from attaching themselves to the boat's hull and drive system. Examples can be found on websites such as www.cleanseaco.com and www.hullguard.com.

Ad 2) Static man-made structures in the sea, such as offshore installations, wind turbines, sea walls, buoys and harbour structures can be used by alien species for establishment and further spread once they have been introduced into the Wadden Sea. However the contribution of man-made static structures to further spread is somewhat tentative, because natural hard substrates such as mussel beds, oyster reefs and gravel banks in the Wadden Sea can also function as stepping stones. But in certain areas, such as where offshore wind parks are built, no or little hard-substrates may be available especially in upper water layers.

Ad 3) A third, perhaps less common potential pathway for alien species to reach new areas, is the transportation of static structures such as oilrigs, dredging gear or buoys that are removed and reinstalled in another location. This mechanism for the introduction of alien species does not occur as frequently as shipping transport. However, more extensive biofouling is usually present on static structures than on ship hulls. Already in 1910s it became known that during the first improvement works of the Kiel Canal construction heavy work equipment was transported from the Netherlands to Germany. This equipment had previously been used in the Netherlands for water works in canals and it is assumed that several alien species have been moved with this gear (Redeke, 1937; Nehring & Leuchs 2000).

5.1 Policies & legal aspects

International (European level)

No current specific policy or legal instruments exist that addresses biofouling on ship hulls or man-made structures as a vector for the introduction and/or further spread of alien species in the region.

However, the IMO has been attending to the lack of policy on this topic since 2008. IMO first founded a Biofouling Working Group and this group recently finished developing a guideline for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species by international shipping (IMO BLG report 15/19), which was adopted by MEPC in July 2011. States can voluntarily choose to implement these guidelines, which provide a full management strategy for how to manage the hull fouling and the possible invasive species risks involved. At this stage it is not clear if the Wadden Sea countries are going to implement these guidelines (see also paragraph 'Trilateral Wadden Sea' below).

Specific requirements from the IMO BLG report 15/19 to minimize the transfer of invasive aquatic species through biofouling can be summarised as follows:

- Each ship should imply hull husbandry, that is, to hold a biofouling management plan and a biofouling record book;
- Each ship should have and maintain an anti-fouling system (i.e. biofouling preventions systems and / or biofouling resistant materials);
- Ships should regularly undergo in-water inspections, cleaning and maintenance by accredited biofouling inspection divers or other means;
- Ships' masters and crews should be trained in biofouling management and treatment procedures;
- Biofouling prevention should be considered in the design and construction of new ships;
- States should maintain and exchange relevant information related to the management of biofouling.

In addition, the Biofouling Working Group agreed that a user-friendly biofouling management guideline should be developed especially for recreational shipping. It has been recognised that recreational shipping can be a major vector for species introductions in some areas. New Zealand and Australia have developed a guideline for managing ship hull fouling on recreational craft that was accepted by IMO in July 2011. This guideline could be implemented in the international Wadden Sea area and may be used to develop a European guideline. In The Netherlands it is proposed to implement this guideline as a mitigation measure for the implementation of the Marine Strategy Framework Directive (personal comment Tom van der Have).

The guideline for managing ship hull fouling on recreational craft can be summarised as follows:

- Explanation in lay mans terms for what biofouling is, how it occurs and why the spread of alien species is a problem;
- Explanation that all boats and trailers can be affected;
- Explanation that specific anti-fouling systems should be used for specific applications;
- Explanation of 'niche' areas and biofouling control in those areas ('niche areas' are specific areas susceptible to biofouling such as propulsion units, rope guards, outlets, sea chests etc.);
- Detailed explanation of in-water and out-water cleaning procedures and legislation;
- Recommendations for recording biofouling related activities.

It should further be addressed what to do with material scraped from vessel hulls. This should not re-enter the aquatic environment without treatment.

Trilateral Wadden Sea

At present no current specific policy or legal instruments exist to address biofouling on ship hulls or on man-made structures as a vector for the introduction and/or further spread of alien species in the region. However in The Netherlands an expert working group has been formed focusing on the potential implementation of the IMO guideline described above. It has been proposed to include the IMO guideline in the list of measures as part of the implementation of the MSFD in The Netherlands aiming to prevent introductions of invasive alien species in marine areas. All three countries actively contributed to the ongoing IMO discussion group on biofouling.

5.2 Monitoring and research

Very few projects have been carried out in the international Wadden Sea focusing on biofouling (ship hulls and man-made structures) as a vector for the introduction and spread of alien species.

The Netherlands

In 2009 an inventory of hard substrate communities was carried out on 83 locations in the Dutch Wadden Sea including many man-made structures. Special attention was paid to the presence of alien species. A total of 129 species was found including 28 alien species (Gittenberger *et al*., 2009). Of these 28 aliens, 12 species and 1 subspecies were new to the Dutch Wadden Sea.

In 2011 the data originating from the Gittenberger *et al.,* (2009) study, have been re-analysed for a risk analysis of hull biofouling on recreational craft in the Wadden Sea (Gittenberger *et al.,* draft 2011). They found that marinas are hot spots for alien species. Recreational craft that travel from one marine port to another are likely vectors for the spread of alien hard-substrate species. Furthermore, recreational craft harbours provide an optimal habitat for settlement of newly introduced species, because of the sheltered water, high nutrients levels and the floating docks (which provide a good hard substrate to settle on).

Recommended means of risk management from Gittenberger *et al*. (draft 2011) are: cleaning of floating docks, switching between fresh-water and salt-water harbours, frequent inspection and cleaning of hulls (cleaning before departure not upon arrival in a new port).

In 2008 the development of flora and fauna on the hard substrates of the monopiles and rocks of the scour protection layers of the offshore windfarm Egmond aan Zee was recorded using video footage and samples collected by divers. The samples were collected around three monopiles and the species composition, covering percentages and numbers and biomass of species present, was established (Bouma & Lengkeek, 2009; Lindeboom *et al*., 2011). Several alien species including the Pacific oyster (*Crassostrea gigas*), the Titan barnacle (*Megabalanus coccopoma*) and the skeleton

shrimp (*Caprella mutica)* were identified in the samples. Sample collection is repeated in 2011.

Denmark

In 2003 and 2004 Leonhard and Pederson (2005) carried out a monitoring programme for algae, fish and benthos in the Horns Rev wind farm in Denmark. Horns Rev is situated 14-20km offshore from Blavands Huk. Blavands Huk marks the northernmost boundary of the Wadden Sea Area. Although monitoring of alien species is not a main goal in this study, artificial hard substrates in the form of monopiles and the scour protection are sampled and species lists are presented. Alien species such as *Jassa marmorata* and *Telmatogeton japonicus* were found. These species lists can be used to produce an overview of alien species present in the Horns Rev wind farm and may signal the species that may be able to reach the Wadden Sea in the future.

Germany

In 2009 a pilot project 'rapid assessment of neobiota' was carried out at eight selected sites in the German Wadden Sea. Biofouling communities attached to pontoons, organisms associated to artificial structures and endobenthic organisms were investigated for the presence of neobiota (presentation Buschbaum from the Alfred-Wegener-Institut für Polar- und Meeresforschung; Wadden Sea conference 26th of August 2010).

From 1992 to 1996 a shipping study was undertaken in Germany, focusing on the fauna transported by ships, to assess the importance of species introductions by international shipping traffic. Ballast water, tank sediment or hull fouling of 186 vessels was sampled. A total of 257 species were identified, ranging from Foraminifera to Teleostei, and 57% of the species sampled were considered to be non-native to the North Sea region, originating from elsewhere in the world including the north eastern Atlantic (west of the English Channel). Non-native species were recorded in 38% of all ballast water samples, 57% of all sediment samples and 96% of all hull samples, indicating that hull fouling is an important vector of introduction (Gollasch, 2002).

5.3 Identification of main gaps and recommendations

Policies

Considering that the vector ship hull biofouling is believed to be one of the most important vectors for introductions of alien species in the North Sea ecosystem (Gollasch, 2002), the lack of policy and legal instruments to address this issue and the very few monitoring and research programmes focusing on this topic, it is strongly recommended to put more effort into identifying risks and control measures to prevent new introductions and / or further spread of alien species through biofouling on ship hulls and man-made structures (both at global level and at the level of the international Wadden Sea).

Specific recommendations are:
Concerning ships and ship owners:

- Adopt the IMO guidelines for hull biofouling management in international professional shipping (IMO BLG report 15/19) as mandatory;
- Provide the user-friendly management guidelines for hull biofouling on recreational craft to any tourist or recreational facility in the international Wadden Sea area. Guidelines for all vessels were recently adopted at IMO. It is foreseen that additional IMO guidance for recreational vessels will be given after discussions in BLG in 2012 and it is recommended to consider these when developing such a policy for the Wadden Sea.

Concerning ports:

- Each commercial harbour should have accredited biofouling inspection divers available;
- Recreational ports should regularly clean floating docks (as recommended by Gittenberger *et al.* (draft 2011);
- Recreational ports should provide out-water cleaning facilities.
- Should in-water cleaning be undertaken then the material scraped off the vessels should be collected and should not re-enter the aquatic environment without proper treatment.

Research, monitoring and assessment

Adequate monitoring programmes are necessary to aid early detection and determination of the status of newly introduced species. This is essential for taking rapid measures of eradication and control especially in the case of newly observed invasive species, because these species can spread quickly and cause unwanted negative effects (Nehring, 2005).

Until present very few studies have been carried out focusing on the presence of alien species on ship hulls and man-made structures in the Wadden Sea and none of them focus on the role of biofouling on these structures as a vector for new introductions and/or further spread. For example no information is collected about the origin of an identified species in the current programmes (e.g. ship movements).

It is recommended that a standardised and long-term trilateral monitoring programme is developed focusing not only on the presence of non-invasive species on ship hulls and made-made structures, including stepping stones (e.g. wind farms) and buoys, but also on the role of fouling on these structures as a vector.

Since the ban on antifouling paints with TBT by IMO in 2001 several tin-free antifouling paints and other methods have been developed to prevent antifouling on ship hulls (e.g. the use of tin-free self-polishing copolymer (SPC) and development of ultrasonic antifouling systems). It is recommended to follow these developments both nationally and internationally and consider the applicability of these new methods for vessels in the Wadden Sea.

Example: Standard monitoring protocol New Zealand

In New Zealand, an extensive monitoring programme for ship hull biofouling is carried out by the government institute 'MAF Biosecurity New Zealand'. The monitoring programme developed for New Zealand may serve as an example for the long-term trilateral programme that should be developed for the Wadden Sea.

The MAF Biosecurity New Zealand technical paper nr: 2010/11 (Piola & Conwall, 2010) describes the standard monitoring protocol that is used for international fishing vessels, which is in compliance with biofouling surveys of other vessel classes. The monitoring protocol includes the following main elements:

- *Vessel questionnaire*
  This questionnaire is completed by the ships' master or representative and provides information on the ships history, maintenance and voyage details.
- *Above water biofouling assessment*
  All parts of the ship susceptible to biofouling and visible from above water are inspected. This applies to the entire hull and niche areas. All biofouling is recorded and photographed.
- *In-water biofouling assessment in quadrants*
  Divers perform quadrant transects on the ship hull (a total of 27 quadrants per vessel). They record the state of the anti-fouling mechanism, any biofouling, a digital image and they sample the biofouling for further analysis.
- *In-water biofouling assessment niche areas*
  In addition to the quadrant transect divers performed similar sampling on all niche areas.
- *Waterline to keel video transects*
  Divers record waterline to keel video transects.
- *Lab analysis of biofouling samples*
- *Data management, analysis and reporting*

6 Wadden Sea Islands

Introduction by humans intentional and unintentional

This chapter focuses on terrestrial alien species actually or potentially present on the Wadden Sea Islands. The introduction of terrestrial species by humans can be both intentional (e.g. introduction of feral cats, deliberate transfer or release of species such as deer) and unintentional (e.g. plant seeds from other areas present in luggage of tourists, species imported for gardening (including garden ponds), dispersal via man-made infrastructure). The importance of human activities as a vector for the introduction of alien species differs per island. Introductions by humans are more likely to occur on islands visited by large numbers of tourists and with many permanent residents than on islands with generally less people. In Denmark and Germany several roads or causeways connect the islands with the mainland. These structures can provide an easy access for terrestrial alien species to reach these islands (e.g. Sylt, Rømø, Mandø).

Bird species, native plants and mammals on Wadden Sea Islands are vulnerable

Large ground predators and herbivores are generally absent on the Wadden Sea Islands as a result of their isolation from the mainland. This has given several ground breeding bird species (including the Eurasian spoonbill, several species of tern and gulls) a chance to establish large, successful breeding colonies. For the reproduction of such species the Wadden Sea Islands are therefore of great importance and often part of the Natura 2000 status and conservation goals. The introduction of feral cats, foxes, American mink to the Wadden Sea Islands can have huge negative impacts on these special Natura 2000 bird values and may even lead to the complete disappearance of these successful breeding colonies (Krijgsveld et al., 2008). No specific research is known about the effects of the introduction of feral cats on the Wadden Sea Islands, but a five-state review of New York, New Jersey, Florida, California and Hawaii stated that domestic cats are considered primarily responsible for the extinction of 33 bird species since the 1600s (Winter & Wallace, 2006). A recent review of 72 studies of insular feral cat diet from 40 islands worldwide showed that cats feed on a wide range of species from large birds and medium sized mammals to small insects with at least 248 species consumed (27 mammals, 113 birds, 34 reptiles, 3 amphibians, 2 fish and 69 invertebrates) (Bonnaud *et al*., 2011). Cats are therefore considered among the most successful and damaging invasive alien species on islands and a significant threat and driver of extinction (Bonnaud *et al*., 2011).

In addition to special bird values the Wadden Sea Islands also contain special types of vegetation, which are different from the mainland (e.g. vegetation types in dune systems, tidal inlets and salt marshes). These vegetation types can be threatened by the introduction of herbivores such as goats and rabbits, but also by the introduction of invasive alien plant species which can overgrow native plants and change the habitat for example by sediment entrapment. Examples of such invasive alien plant species that are already present on some of the Wadden Sea Islands include the Japanese rose (*Rosa rugosa*), the heath star-moss (*Campylopus introflexus*) and the cordgrass

(*Spartina anglica*). The North-American black-cherry (*Prunus serotina*) is also increasing in certain dune areas (Quist & Weeda, 2009).

On the Wadden Sea Islands, species may occur in habitats where they cannot occur on the mainland due to competition with other species. A good example is the general occurrence of the Eurasian water shrew (*Neomys fodiens*) on the Dutch island of Texel in dry biotopes. On the mainland this species does not occur in such biotopes, because of competition with other species of shrews such as the common vole (*Microtus arvalis*) or the white-toothed shrew (*Crocidura russula*). When these other shrew species are introduced to the island of Texel, this could threaten the populations of the Eurasian water shrew (Dekker & Koelman, 2007).

6.1 Policies & legal aspects

Specific policies to deal with terrestrial alien species on the Wadden Sea Islands do not exist, but islands do fall under the more general national policies such as the National Action Plan for Invasive Species in Denmark, the National Strategy on invasive alien species in Germany and the Flora- and Fauna law and the 'Beleidsnota Invasieve Exoten' in The Netherlands (see chapter 2).

Despite the lack of specific policies the three Wadden Sea countries use various methods to deal with unwanted (alien) species on the islands:

The Netherlands

In The Netherlands the so-called national 'Flora- and Faunawet' provides the legal framework to eradicate introduced red deer and/or foxes on the islands. Under this law it is prohibited to release animals into the wild intentionally.

Although no specific policies concerning terrestrial alien species on the Wadden Sea Islands exist on a national level, the managers of local nature conservation areas do have specific policies. 'Natuurmonumenten', for instance, owns and manages areas on Schiermonnikoog and Texel. Their general policy concerning alien species is: Measures are only taken when the alien species actually threatens indigenous biodiversity or causes other forms of trouble. Two recent examples are the control of the alien plant species *Rosa rugosa* and *Prunus serotina*. Where larger areas on islands become dominated by these plant species then they are physically remove. Physical removal of plants has for example been carried out on the island of Schiermonnikoog (personal comment B. van Tooren, Natuurmonumenten).

State Forrestry Service 'Staatsbosbeheer' also manages large terrestrial nature conservation areas on the islands. They are currently developing a specific guideline (protocol) on management of alien species. The main outcome of this guideline will be similar to that of 'Natuurmonumenten': Measures are only taken when the alien species actually or potentially threatens indigenous biodiversity or causes other forms of

trouble, or in case of a new settlement. Although the protocol will be new, measures are already taken for some years as part of routine management of the conservation areas.

Escaped and wild feral cats can threaten colonies of ground breeding birds. On Texel, 'Staatsbosbeheer' cooperates with the 'dierenbescherming' (Dutch animal welfare trust) to catch and relocate cats without owners that enter conservation areas which are important to bird colonies. They have also had a campaign to stimulate tourists to provide their pet with an identification chip before taking it on holiday.

On Vlieland a family of foxes was introduced by humans and they were functionally eradicated to prevent damage to local biodiversity. It took two years to catch 8 foxes.

On Terschelling a small group of red deer was introduced by men. Although this species is alien to the islands, it is native and protected nationally. Therefore it was first attempted to capture the deer alive. However, live capture proved impossible and the deer where ultimately shot.

The plant species *Rosa rugosa* is also by 'Staatsbosbeheer' considered as an invasive species and measures (such as physical removal of plants) are taken as part of routine management of areas (personal comment M. Rijks, Staatsbosbeheer).

Denmark

In Denmark no policy exists that concerns the spread of alien species specifically on the Danish Wadden Sea islands. The spread of alien species is addressed on a national level. A specific 'Handling plan for invasive species' is part of national environmental policy. No detailed information from this plan, however, is available in English.

Local managers do implement this plan on the Wadden Sea Islands and they have a list of species that are considered invasive on the islands (personals comment O. Knudsen and H.L. Sørensen, Danish Nature Agency):

Species group	Scientific name	English name
Trees and plants	*Pinus mugo (var. rostrata)*	Swiss mountain pine
	Pinus uncinata	Mountain pine
	Pinus contorta	Lodgepole pine
	Prunus serotina	Black cherry
	Fallopia japonica	Japanese knotweed
	Fallopia sachalinensis	Giant knotweed
	Rosa rugosa/ Rosa kamtchatica	Japanese rose
Birds	*Alopochen aegyptiacus*	Egyptian goose
Mammals	*Mustela vison*	American mink
	Ondatra zibethica	Musk rat
	Rattus norvegicus	Brown rat
	Nyctereutes procyonoides	Raccoon dog

	Myocastor coypus	Nutria
	Procyon lotor	Northern raccoon
Molluscs	*Arion lusitanicus*	Potuguese slug
Other species	*Campylopus introflexus*	Heath Star-moss

Clear examples of control measures carried out by local managers are the removal of *Prunus serotina, Pinus contorta* and *Rosa rugosa* on several islands. Foxes are generally not considered as alien species, but they are removed from places where they disturb breeding bird colonies. This has been the case on the Island Langli.

Germany

In Germany no policy exists that concerns the spread of alien species specifically on the German Wadden Sea islands. However, the new national law 'Bundesnaturschutzgesetz' (since 2010) does address the spread of alien species on a national level. In a report written by H.J. August (2010) it is explained how Schleswig-Holstein, a German state with many Wadden Sea Islands, acts to control the spread of alien species:

In this report it is stated that an alien species is only a problem when it is invasive and threatens native biodiversity. If an alien species is a problem then it must be evaluated if the chance of successfully eradicating the alien species is acceptable given the effort needed before any measures are taken. With a small chance of success and large effort it is not justified to take control measures. If the success / effort ratio is acceptable, the following next steps can be taken (source: H.J. August, 2010):

1. Make a list of invasive species;
2. Monitor the presence of the invasive species;
3. Prevent unintentional introductions and releases of alien species;
4. Aim for early detection and immediate eradication;
5. Carry out species-specific control measures;
6. Raise awareness of the public.

The control of alien invasive species is regulated through federal nature conservation policy. One example of measures taken to prevent the spread of alien species comes from the small island Oland. The island lies within close proximity of the mainland and it was recently connected to the mainland by a dam. Measures where taken to prevent colonisation of the island by foxes.

6.2 Monitoring and research

Several monitoring and research projects have focussed on the presence of already established and notably invasive alien plant species on the Wadden Sea Islands in all three countries. Examples include studies focusing on the presence and effects of the English cordgrass *Spartina anglica* (see table 1 in Nehring *et al*., 2009 for examples of references), the Japanese rose *Rosa rugosa* (e.g. Bruun, 2005; Kollmann *et al*., 2007;

Kollmann *et al.,* 2009; Isermann, 2008) and the black-cherry *Prunus serotina* (e.g. Ehrenburg *et al*., 2008). In The Netherlands a remote sensing approach was developed that delivers detailed and standardised maps of (alien) shrub cover (Hantson *et al*., 2010). This study was carried out in the dunes of the Dutch island of Vlieland.

Further information on alien plant species will be available through various monitoring and research programmes carried out under the Trilateral Monitoring and Assessment Programme (TMAP) including the monitoring of salt marshes and monitoring of beaches and dunes (see TMAP monitoring handbook 2009) and more general (voluntary) inventories of flora and fauna on Wadden Sea Islands. However alien species are generally not the main focus of such programmes and data will be stored in numerous databases and libraries of different (voluntary) organisations. A full list of all alien plant species present on the Wadden Sea Islands is therefore not available yet.

6.3 Identification of main gaps and recommendations

No specific policy for the Wadden Sea islands exists and nature managers refer to general national policy on alien species as a basis for their management and control strategies. This is an important gap, because the situation differs markedly from that on the mainland. The main differences are: 1) Species that are native to the mainland can be harmful alien species on the islands. One clear example are foxes. On the Wadden Sea islands there are originally no large land based predators such as foxes, which makes the islands particularly suitable for some colonial, ground breeding bird species. The introduction of foxes, although native to the mainland, may have devastating consequences for native island biodiversity. 2) Because of the small scale of the islands, early warning and eradication is probably more feasible than on the mainland. Although proven difficult, some newly introduced alien species have been eradicated successfully (e.g. foxes Vlieland, red deer Terschelling).

A trilateral strategy for the Wadden Sea islands should be considered. The success of eradication measures strongly increases when new introductions are discovered in an early stage. It is therefore recommended to set up an early warning system for alien species specific for the Wadden Sea islands. Records of alien species identified as part of already existing and regular monitoring programmes should be collected into one database providing regional administrations with an overview of the current presence of alien species on the Wadden Sea islands. In addition to the development of such a database it is recommended to produce a list of alien species that are considered being (potentially) most harmful to the biodiversity of the Wadden Sea Islands and to carry out a risk analyses to identify pathways for these species to reach the islands. Based on these lists and risk analyses regional administrations should identify preventive measures (e.g. monitoring pathways) or (in case species are already present) eradication and/or control measures.

7 Secondary introductions through natural routes of dispersal

A secondary introduction is the dispersal of an alien species beyond its primary location of introduction. A distinction can be made between secondary introductions facilitated by human activities (e.g. a species was introduced to the Wadden Sea by mussel transports and is further spread by mussel transports to other areas in the Wadden Sea) and secondary introductions through natural routes of dispersal (e.g. a species was introduced to the Wadden Sea and is further spread through water currents). This chapter focuses on secondary introductions through natural routes of dispersal. Various natural routes can be distinguished including the transport by currents and/or wind, rising water temperatures, transport by mobile animals and the presence of already established alien species providing suitable habitat for other new alien species (invasion meltdown).

Transport by currents and/or wind

Once introduced in the Wadden Sea certain life stages of alien plants and animals can easily be transported to other areas through currents caused by tidal movement and wind influences. Notable examples of invasive plants and seaweeds that have used this natural route of dispersal to colonise large parts of the Wadden Sea are English cordgrass *Spartina anglica* and Japanese wireweed *Sargassum muticum*.

Larvae of many marine organisms are released in the water column and can also use currents to spread themselves and colonise areas other than the area where they were first introduced. One of the most notable examples is the introduction of the Pacific oyster. After its introduction by humans in The Netherlands (Texel, 1983) and Germany (Sylt, 1970s and 1980's) this species rapidly colonised the entire Wadden Sea. At present this species forms solid reefs in various parts of the international Wadden Sea with subsequent generations attached to each other. Other notable examples of invasive species in the Wadden Sea that may have used currents to spread their larvae are sea squirts like the Asian sea squirt (*Styela clava*), the American razor-shell (*Ensis americanus*) and the slipper limpet (*Crepidula fornicata*).

Increasing water temperatures due to climate change

A relatively recent study showed that surface water temperature of the North Atlantic, including the North Atlantic Current (NAC), was more than 1°C warmer in the last five years than the historical means (Hughes & Holliday, 2006 cited in Olivera, 2007). The North Sea also showed an increase in mean water temperatures of more than 2°C in the last five years (Hughes & Holliday, 2006 cited in Olivera, 2007).

As a result of this increase in temperature several species, including invasive alien species, may have been able to expand their natural range. Loebl *et al*. (2006) assumed for example that increasing temperatures may have helped the English cordgrass *Spartina spp*. to colonise more exposed sandy tidal shores where it has been

absent before. Oliveira (2007) expected increasing temperatures may also have helped to the ctenophora *Mnemiopsis leidyi* to expand its range to the Wadden Sea. Based on starvation experiments of *Mnemiopsis leidyi* in the laboratory and the time needed to drift from the northern Gulf Stream to the North Sea (15-60 days, depending on the season and wind oscillations (Siedler *et al.,* 2001)) he expected that this species may have been able to reach the Wadden Sea by this natural route of dispersal.

Transport by mobile organisms

Alien species may be able to colonise new areas and spread themselves through transport by mobile organisms, but this natural route of dispersal is much less important than dispersal via currents and/or wind.

Many plant species have a variety of adaptations for dispersal by animals including adhesive mucus, various hooks, spines and barbs. Using these adaptations alien plants can attach themselves to mobile animals (e.g. birds, mammals) making it possible for them to colonise new areas. Seeds can also be dispersed via ingestion by animals.

Aquatic alien species can be transported to new areas by attaching themselves to mobile organisms such as crabs (e.g. slipper limpet, barnacles, anemones), fish (e.g. parasites) birds or marine mammals.

Invasion meltdown

The term invasion meltdown refers to the presence of exotic species that facilitate the establishment and spread of other alien species. Pacific oysters in the Wadden Sea provide for example suitable substrate for slipper limpets, the Japanese wireweed *Sargassum muticum* and the ascidian *Styela clava*. In turn the presence of the wireweed creates a new suitable habitat for the Japanese skeleton shrimp (*Caprella muticum*).

7.1 Policies & legal aspects

Existing policies and legal instruments used to prevent further spread of already introduced species focus on introductions to new areas facilitated by human activities such as ballast water (see chapter 2), aquaculture (chapter 3) and biofouling (chapter 3). Specific legislation to prevent further spread through the natural routes of dispersal described above does not exist, but several species-specific control measures have been identified to control further spread. The removal of Pacific oysters by fishing will for example prevent the release of larvae that can be transported to new areas by currents and may reduce the process of invasive meltdown.

7.2 Monitoring and research

Monitoring and research programmes related to secondary introductions through natural routes of dispersal can be divided into two categories: 1) monitoring the further spread of alien species that have already been introduced into the Wadden Sea and 2) identification of alien species that may be introduced into the Wadden Sea in the future.

7.2.1 Species that have already established themselves

Monitoring programmes of secondary introductions of already introduced species in the Wadden Sea mainly focus on the determination of further spread of a particular species, impacts (ecological, social and financial) and identification of control measures. Notable examples include the Pacific oyster (*Crassostrea gigas*), the sea walnut (*Mnemiopsis leidyi*) and the English cordgrass (*Spartina anglica*).

Pacific oyster

The spread of the Pacific oyster for example has received much attention since its first detection and research projects have been conducted in all parts of the Wadden Sea. In The Netherlands oysters are nowadays sampled and registered in blue mussel inventories (Fey *et al*., 2009a in Nehls *et al*., 2009). In Germany Pacific oysters have also been monitored as part of the blue mussel monitoring in Schleswig-Holstein since 1998 and 12 intertidal mussel beds in Niedersachsen have been under investigation since 2003. In Denmark surveys on Pacific oyster development are carried out biannually (Kristensen & Pihl, 2006, 2008). The spread of Pacific oysters has been documented in a report commissioned by the CWSS in 2007 (Nehls & Büttger, 2007). This report was based on various reports including for example two reports describing the spread of the Pacific oyster in Germany as well as their impact on intertidal mussel beds in terms of ecological functioning (Wehrmann *et al*., 2009).

Sea walnut

The introduction of the sea walnut *Mnemiopsis leidyi* also received much attention in all three Wadden Sea countries. Risk analyses for this species in the Dutch, German and Danish Wadden Sea are provided in Gittenberger (2008), Fischer (2008) and Tendel *et al*. (2007).

English cordgrass

Since the introduction of English cordgrass into the Wadden Sea many projects in all three Wadden Sea countries have focussed on the life history traits of this species (e.g. physiological thresholds for germination), further spread of this species and effects on the habitat and other organisms (see for example table 1 in Nehring *et al*., 2009).

7.2.2 Species that may become established

Identification of alien species that could be introduced in the Wadden Sea is done through risk assessments. Most of these risk assessments focus on species that are likely

to be introduced through human activities (e.g. the risk assessment of the introduction of oyster borers through mussel transports (see chapter 3)) as human activities are regarded as the main vectors for further spread of primary introductions. Secondary introductions through natural routes of dispersal (e.g. what is the chance that an introduced species in the Eastern Scheldt can spread itself to the Wadden Sea) generally receive little to no attention in these assessments.

7.3 Identification of main gaps and recommendations

Once a species has been introduced into the Wadden Sea it will be hard to control the further spread through natural routes of dispersal. Monitoring the further spread of such a species and identifying impacts and control measures (which is currently done) is then probably the only thing you can do.

Human activities are seen as the main vectors responsible for the further spread of primary introductions. Therefore risk assessments generally focus on the risk of further spread by human activities (e.g. ballast water, aquaculture (mussel imports) and biofouling) and identification of control measures. In addition to risk assessments related to human activities efforts should also go into the identification of primary introductions that have the potential to reach the Wadden Sea by natural routes of dispersal (e.g. from the southern North Sea to the Wadden Sea, from Scandinavian waters to the Wadden Sea). Using up to date information about sea currents and climate change, lists of alien species present in areas surrounding the Wadden Sea and life history traits[10] of these alien species (e.g. are there any barriers for a species to reach the Wadden Sea?) an early indication may be given what alien species we may expect.

[10] E.g. salinity and temperature tolerance, feeding behaviour, reproduction, the presence of natural enemies, physical and natural barriers etc. etc.

8 Recommendations for a trilateral strategy

8.1 Organisational structure

Developing and implementing a trilateral strategy requires cooperation between different responsible authorities and organisations at various levels, including ministerial, provincial and regional levels both national and trilateral. To ensure commitment and available funding at all levels, it is recommended to set up a clear organisational structure for the development and implementation of a trilateral strategy. Various authors have recommended organising activities related to alien species in the Wadden Sea by the establishment of a trilateral working group on alien species (e.g. Reise, 2010; Nehring *et al*., 2009), but only a trilateral working group will not be sufficient to achieve cooperation and commitment at all levels.

Once the organisational structure has been set up, work activities need to be embedded in the organisational structure for marine monitoring and assessment in the three Wadden Sea countries. In 2008 an overview was produced of the organisational structure of marine monitoring and assessment in all OSPAR countries including Denmark, Germany and The Netherlands (Bouma & Lengkeek, 2008). In 2011 this overview was updated as part of an OSPAR inventory looking at the implementation of the Marine Strategy Framework Directive (Bouma & Liefveld, 2011). A brief summary of these organisational structures is provided in appendix 2.

8.2 Contents trilateral strategy

Several documents provide recommendations for management of alien species in the Wadden Sea (e.g. national strategies and/or action plans[11] and various articles such as Reise, 2010; Nehring *et al.,* 2009, 2005). In these documents there is general agreement that efforts to address alien species in the Wadden Sea should focus on three main elements:

1. Prevention;
2. Early warning / detection;
3. Eradication and/or control.

Methods to give effect to these elements include raising awareness, implementation of regulations and guidelines, monitoring and risk assessments and identification of eradication and control measures. In the following paragraphs these methods are described in more detail.

[11] Denmark (2009): National Action Plan for Alien Invasive species. Germany (2007): National Strategy on invasive alien species. The Netherlands (2007): Beleidsnota Invasieve exoten.

8.2.1 Raising awareness

General

An important part of prevention for all topics is raising awareness of potential problems with alien species in the Wadden Sea by managing authorities, companies (e.g. shipping, marina operators, aquaculture facilities), scientists and the public.

Several websites already exist that are used for raising awareness. Examples at European level include a website developed as part of the Delivering Alien Invasive Species In Europe (DAISIE) project (www.europealiens.org) and a website developed by the European Network on Invasive Alien Species (NOBANIS) (www.nobanis.org). The DAISIE website contains information on biological invasions in Europe. Information on this website[12] is delivered via an international team of leading experts in the field of biological invasions, latest technological developments in database design and display, and an extensive network of European collaborators and stakeholders (including The Netherlands, Denmark and Germany). The NOBANIS website contains common databases, fact sheets and information on legislation regarding alien species in participating countries (at present 19 countries including all three Wadden Sea countries).

Other options for raising general awareness of alien species include presentations in the scientific world and for the public and paying special attention to alien species in various nature guides of the Wadden Sea. It may also be considered to refer to alien species on displays etc. at coastal tourist attractions, such as public aquariums.

Topics

It is well known that ballast water and aquaculture are very important vectors for the introduction and spread of invasive species. Bio-fouling on ship hulls (both commercial and recreational shipping) has also been recognised as a major vector. This vector has received less attention so far, but this may change with the newly adopted IMO guidelines.

Raising awareness of recreational skippers about bio-fouling being an important vector for the introduction and spread of alien species and potential problems this may cause should receive high priority and can be done through:

- Handing out flyers with pictures to identify potential new alien species and provide contact details for reporting;
- Inform skippers that they can bring alien species to the Wadden Sea islands and spread alien species from one to another area (secondary introduction);
- Provide guidelines what skippers can do to prevent new introductions and spreading of alien species (see § 8.2).

[12] Data has been collated for vertebrates, invertebrates, marine and inland aquatic organisms as well as plants from up to 94 countries/regions (including islands) in the wider Europe. Over 248 datasets have been assembled and verified by experts, representing the largest database on invasive species in the world.

8.2.2 Implementation of regulations and guidelines

General

More than 50 international and/or regional conventions, codes of conduct or practice and other instruments have been developed to address alien species (see chapter 2). However these documents not always provide a clear framework for dealing with alien species. One of the reasons is the use of different terminology, sometimes inconsistently or without adequate definitions. A consensual set of definitions regarding alien species is essential in order to facilitate discourse among the science, policy and management communities dealing with the issue (Nehring *et al*., 2009). Therefore it is recommended to develop and use one standard set of definitions in policies related to alien species in the international Wadden Sea area. Examples of existing (but different) sets of definitions that may be used as a basis are a proposed set of key terms and definitions in Nehring *et al.,* 2009 (based on terms and definitions mainly used in work done under the Convention on Biological Diversity) and a set of definitions used by the Team Invasive Alien Species of the Ministry of Economic Affairs, Agriculture and Innovation (ELI) in the Netherlands.

Table 1. Examples of different sets of terms and definitions related to alien species.

Term	Definitions	
	Nehring et al., 2009	Team Invasive Alien species
Species	No definition given.	A group of individual organisms identified on the basis of shared characters which is described as a species in scientific taxonomic literature.
Native species	A species, including genetically distinct populations, occurring within its natural range (past or present) and dispersal potential (i.e. within the range it occupies naturally or could occupy without direct or indirect introduction or care by humans).	Species occurring naturally (in a wild state) in a geographically specified area.
Alien species	No definition given.	Species occurring non-naturally in a geographically specified area.
Alien species	A species, including genetically distinct populations, occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans); includes any part, gametes or propagules of such species that might survive and subsequently reproduce.	A alien animal, plant, fungus or micro-organism of a species, subspecies or lower taxon, that cannot arrive in an area on its own but can (or has) arrived there only through human activities (transport, infrastructure); includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.
Established alien species	No definition given.	An alien species, which reproduces sustainably in an area.
Invasive alien species	An alien species which is known or expected to exert effects on native populations and species, natural habitats and ecosystems beyond of which can be considered to be within the range of average regional conditions.	An established alien species, which spreads from the introduction area and threatens biodiversity.
Problem or nuisance species	No definition given.	A species for which it can be assumed that based on the best available scientific evidence it will have a (significantly) negative impact on the conservation goals of a Natura 2000 area.
Introduction	The transfer, by direct or indirect human agency, of a species or genetically distinct population outside of its natural range (past or present) and dispersal potential; this movement can be either within a country or between countries or areas beyond national jurisdiction. Human involvement here does not include habitat changes, climate change, eutrophication, etc.	No definition given.
Intentional introduction	Deliberate transfer and/or release by humans of a species or genetically distinct population outside its natural range (past or present) an dispersal potential (such introductions may be authorised or unauthorised); this includes also species which subsequently escape or which are released into the environment.	No definition given.
Unintentional introduction	All other introductions which are not intentional; this also includes parasites, symbionts etc. of intentionally introduced species.	No definition given.

Topics

Specific mandatory regulations have been developed to prevent further spread of alien species by ballast water and aquaculture (e.g. IMO Ballast Water Management Convention and Council Regulation Aquaculture). These regulations should be implemented in trilateral policies and the practical implementation at national levels should be discussed at trilateral level. Specific recommendations for the implementation

of the IMO Ballast Water Management Convention, which is not in force yet, are provided in chapter 3.

Currently there are no obligatory regulations to prevent the spread of alien species by hull fouling but a voluntary IMO guideline was adopted in July 2011). It may be considered to adopt the IMO guidelines for bio-fouling management in international professional shipping (IMO BLG report 15/19) as mandatory, similar to the European regulation concerning the use of alien and locally absent species in aquaculture (voluntary codes of practices were made mandatory by this regulation). The practical implementation of this guideline in the international Wadden Sea should be discussed and organised at a trilateral level.

To address biofouling on recreational craft, user-friendly management guidelines should be provided to any recreant or recreational facility (e.g. marinas and ship yards for recreational vessels) in the international Wadden Sea area. These guidelines should be developed at trilateral level and should not only be valid for recreational craft in the Wadden Sea, but also for recreational craft travelling from other areas to the Wadden Sea.

8.2.3 Early warning / detection through monitoring and risk assessments

General

Adequate monitoring programmes and risk assessments are necessary to aid early detection and determination of the status of alien species. This is essential for taking rapid measures of eradication and control especially in the case of newly observed invasive alien species, because these species can spread quickly and cause unwanted negative effects (Nehring, 2005). In 2009 an inventory of hard substrate communities on 83 locations in the Dutch Wadden Sea was carried out, focusing on the presence of alien species. In the same year a pilot project 'rapid assessment of neobiota' was conducted at eight selected sites in the German Wadden Sea. The inventory in The Netherlands will be repeated in 2011 and the programme in Germany will become an ongoing programme (personal comment Christian Buschbaum).

It is recommended to include such specific inventories in the Trilateral Monitoring and Assessment Programme for the Wadden Sea, because they are of great importance for the early detection of new introductions.

It should also be considered to carry out additional checks for new alien species as part of already existing monitoring programmes (e.g. the monitoring programmes for blue mussels and Pacific oysters, programmes assessing bathing water quality standards). This can be done by producing a list of potential new alien species in the Wadden Sea based on (already existing) risk assessments and checking the presence of these species part of already existing programme(s) (so called bio-security checks). Further, existing monitoring programmes may be slightly expanded to include sampling points in ports

where ballast water is discharged. It is likely that alien species will be recorded in these ballast water discharge zones first.

Topics

The inventories and specific checks mentioned above only provide insight in the presence or absence of alien species and do not give any information about the origin of species. To identify the source of a specific alien species and possible transport routes to the Wadden Sea (e.g. transported by human activities or secondary introductions by natural routes of dispersal) specific monitoring of vectors is needed. Monitoring programmes to identify alien species in ballast water were undertaken in the past and are also occasionally carried out today. However at present these programmes mainly focus on the presence of alien species in ballast water (water samples are taken and analysed in a laboratory). These ships may not only transport alien species by transporting ballast water, but may also transport alien species that are attached to their hulls, in sediment accumulated at the bottom of ballast tanks, on the walls on the inside of ballast tanks, on anchor chains, in sea chests and in the engine cooling water system. It should be considered to expand the monitoring programme to include these other vectors.

Currently there are no specific monitoring programmes for alien species on ship hulls in the Wadden Sea, but a voluntary guideline is adopted by IMO. It should be considered to implement the IMO guideline in the Wadden Sea using a trilateral approach. A standardised and long-term trilateral monitoring programme should be developed focusing not only on the presence of alien species on ship hulls and man-made structures, but also on the role of fouling on these structures as a vector. The monitoring programme developed for New Zealand may serve as an example for the development of this programme.

It should be noted that hull fouling may become more into focus as the foundations of offshore wind parks may offer an additional habitat for such organisms where no suitable habitat occurred in the past. Possibly these may serve as stepping-stones for the spread of alien species into areas where they were previously absent.

Monitoring programmes and risk assessments of introducing alien species by activities related to aquaculture are mandatory under the European Regulation concerning the use of alien and locally absent species in aquaculture. Various monitoring programmes have already been set up in all three Wadden Sea countries, but to improve consistency a trilateral approach should be undertaken to implement these requirements. These guidelines do not require the monitoring of hulls of vessels used for aquaculture activities, but it should be considered to regularly check the hulls for alien species similar to planned commercial ships inspections.

The vital early detection of new alien species may also be facilitated by the prompt publication of new records in scientific journals. As publication in journals may sometimes take more than a year between submission of a manuscript and its

publication, a new free open access journal was initiated. Newly found species records are published rapidly here and this open access journal is free for the reader. For more information visit www.aquaticinvasions.net.

8.2.5 Eradication and/or control measures

Several policies and guidelines require the identification and use of control measures to prevent the introduction of new alien species. Several of such control measures are already in use (e.g. immersion of mussels in freshwater before spreading them on marine aquaculture plots to reduce fouling on e.g. oyster shells) or are under development (e.g. management of ballast water). For biofouling on ship hulls no specific approach or control measures have yet been identified to prevent new introductions in the region. Identification of such measures is urgently needed. Measures that could be taken into consideration include a ban on cleaning ship hulls of recreational vessels on tidal sand flats, cleaning of vessels before they are trailered to other Wadden Sea areas and mandatory cleaning of ship hulls before entering the Wadden Sea. All material scraped from vessel hulls should not re-enter the sea without treatment. It is also recommended to follow developments of new antifouling paints and other methods (e.g. ultrasonic antifouling systems) to prevent biofouling on ship hulls and consider the applicability of these new methods for vessels in the Wadden Sea.

Once an invasive alien species has been introduced into the Wadden Sea eradication and control measures are limited. If a species has only been identified in one specific and confined area, attempts should be undertaken to isolate that area to prevent further spread. The most suitable method to physically remove a species from its new habitat will depend on the species, but examples of methods include fishing, cleaning structures, filtering the water, trapping, dredging, hand-pulling plants, treatment using chemicals etc.

However most alien species are only discovered when they have already established during spread and when they have become more common. In such cases eradication will most likely be impossible[13]. Efforts should then go into the identification of measures to prevent further spread to areas where that species may have severe negative impacts (e.g. threaten biodiversity in marine protected areas, lowering the yield of aquaculture products, interference with recreational activities).

[13] There are positive examples, such as *Mytilopsis sallei* in Darwin Harbour (Australia) and *Caulerpa taxifolia* in California (USA).

9 References and URL's

August, H.J., 2010. Chapter 4 Neobiota in: Jagd und Artenschutz, Jahresbericht 2010. Ministerium for landwirtschaft, Umwelt und Landliche Raume des Schleswig-Holstein.

Bonnaud, E., Medina, F.M., Vidal, E., Nogales, M., Tershy, B., Zavaleta, E., Donlan, C.J., Keitt, B., Le Corre, M. & Horwath, S.V., 2011. The diet of feral cats on islands: a review and a call for more studies. Biological Invasions 13: 581-603.

Bouma S. & Liefveld W.M., December 2010. Identification of ecological monitoring parameters to assess Good Environmental Status of marine waters. An inventory in all OSPAR Contracting Parties. Report nr. 10-225.

Bouma S. & Lengkeek W., 2009. Development of underwater flora and fauna communities on hard substrates of the offshore wind farm Egmond aan Zee (OWEZ) Bureau Waardenburg bv. Report number: 08-220.

Bouma S. & Lengkeek W., January 2008. Marine Biodiversity Monitoring and Assessment: Activities to improve synergies between EU directives and international conventions. Activities in all OSPAR Contracting Parties. Report nr. 08-023. Document to be presented at OSPAR BDC meeting (BCD 2008).

Brink A. van den, Wijsman JWM, 2010. Freshwater immersion as a method to remove *Urosalpinx cinerea* and *Ocinebrellus inornatus* from mussel seed. Report No. C020/10, IMARES.

Bruun, H., 2005. *Rosa rugosa* Thunb. ex Murray Journal of Ecology 93: 441-70.

Butt N., Wright P. & Vigar N., 2009. Harbors and shipping. In: Marencic H., & de Vlas J. (eds.), Wadden Sea Quality Status report 2009. Wadden Sea Ecosystem 25. Common Wadden Sea Secretariat, Wilhelmshaven.

Büttger H., & Nehls G., 2009. Assessing the good ecological status of blue mussel beds in the North-Frisian Wadden Sea – according to the EU Water Framework Directive and EU Habitats Directive. Report on behalf of Schleswig-Holstein Agency for Coastal Defence, National Park and Marine Conservation - National Park authority. Husum, Bioconsult SH: 81.

Chambers L.D., Stokes K.R., Walsh F.C. and Wood R.J.K., 2006. Modern approaches to marine antifouling coatings. Surface & Coatings Technology 201 (2006) 3642–3652.

David, M. and Gollasch, S., 2008. EU shipping in the dawn of managing the ballast water issue. Marine Pollution Bulletin, 56(12), 1966-1972.

Dekker D.L. & Koelman R.M., 2007. Inhaalslag Verspreidingsonderzoek Nederlandse Zoogdieren (VONZ).

Ehrenburg, A., H. van der Hagen and L. Terlouw, 2008. Amerikaanse vogelkers als invasieve soort in de kustduinen. De Levende Natuur 109: 240-45.

Fey F., Van den Brink A.M., Wijsman J.W.M., Bos O.G., 2010. Risk assessment on the possible introduction of three predatory snails (*Ocinebrellus inornatus, Urosalpinx cinerea, Rapana venosa*) in the Dutch Wadden Sea. Report number: C023/10.

Fischer R., 2008. Populationsentwicklung der invasiven Ctenophoreart *Mnemiopsis leidyi* in der Sylt-Romo Bucht. Thesis, FU Berlin.

Gittenberger A., 2008. Riscoanalyse van de Amerikaanse langlob-ribkwal *Mnemiopsis leidyi* A. Agassiz, 1865. Team Invasieve Exoten, ministerie van LNV, Den Haag. GiMaRIS rapport 2008.13, 21pp.

Gittenberger A., 2009. Exoten in de Oosterschelde. In opdracht van het ministerie van LNV, Directie Visserij. GiMaRIS rapport 2009.08.

Gittenberger A., Rensing M., Stegenga H., & Hoeksema B.W., 2009. Inventarisatie van de aan hard substraat gerelateerde macrofauna en macrofauna in de Nederlandse Waddenzee. In opdracht van het ministerie van LNV, Team Invasieve Exoten. Rapport nummer; GiMaRIS 2009: 11, Leiden.

Gittenberger A., 2010a. Schelpdier monitoring protocol. In opdracht van de Vereniging van Importeurs van Schelpdieren. GiMaRIS rapport 2010. 10, 9pp.

Gittenberger A., Rensing M., Dekker D., draft June 2011. Risk analysis of hull fouling on small to medium sized boats as an import vector of exotic species in the Wadden Sea. Issued by The Ministry of Economic Affairs, Agriculture and Innovation. Report GiMaRIS 2011.07.

Gollasch, 2002. The importance of ship hull fouling as a vector of species introductions into the North Sea. Biofouling 18(2): 105-121.

Hantson, W., L. Kooistra and P.A. Slim, 2010. Alien and invasive woody species in the dunes of the Wadden Sea Island of Vlieland: A remote sensing approach. Wageningen, Alterra, Alterra-report 2101. 54 pages.

Hughes S.L. & Holliday N.P. (eds) (2006). ICES Report on Ocean Climate 2005. ICES Cooperative Research Report 280: 1–49.

Isermann, M., 2008. Expansion of *Rosa rugosa* and *Hippophaë rhamnoides* in coastal grey dunes: effects at different spatial scales. Flora 203: 273-280.

Jensen K.R., & Mikkelsen (2011). On shellfish activities and invasive species in the Danish Wadden Sea. January 2011. Grontmij Carl Bro report, 18 January.

Kollmann, J., L. Frederiksen, P. Vestergaard and H. Bruun, 2007. Limiting factors for seedling emergence and establishment of the invasive alien *Rosa rugosa* in a coastal dune system. Biological Invasions 9: 31-42.

Kollmann, J., R. Jørgensen, J. Roelsgaard and H. Skov-Petersen, 2009. Establishment and clonal spread of the alien shrub *Rosa rugosa* in coastal dunes: a method for reconstructing and predicting invasion patterns. Landscape and Urban Planning 93: 194-200.

Kools S.A.E., Burger E.M., Hermsen A.P., Verduin E., concept 4 april 2011. Audit Schelpdiertransporten. Analyse beleid, regelgeving en handhaving. Grontmij. Rapportnummer: 302019.

Krijgsveld, K.L. et al. (2008). Beschermingsplan duin- en kustvogels : basisrapport deel A : achtergronddocument. Vogelbescherming Nederland, Zeist.

Krijgsveld, K.L. et al. (2008). Beschermingsplan duin- en kustvogels : basisrapport deel B : soortteksten. Vogelbescherming Nederland, Zeist.

Kristensen P.S. & Pihl N.J., 2006. Blamuslinge- og stillehavsosterbestande i det danske Vadehav efteraret 2006. DFU-rapport nr. 167-07.

Kristensen P.S. & Pihl N.J., 2008. Blamuslinge- og stillehavsosterbestande i det danske Vadehav efteraret 2007. DTU-rapport nr. 181-08.

Leonhard S.B., & Pedersen J., 2005. Hard bottom substrate monitoring. Horns Rev offshore Wind Farm. Annual status report 2004. Bio/consult. Report commissioned by Elsam Engineering: 1-79.

Lindeboom H.J., Kouwenhoven H.J., M J N Bergman M.J.N., Bouma S., Brasseur S., Daan R., Fijn R.C., de Haan D., Dirksen S., van Hal R., Hille Ris Lambers R., ter Hofstede R., Krijgsveld K.L., Leopold M., and Scheidat M., 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environonmental Research Letter 6 (2011) 035101 (13pp).

Loebl M., Van Beusekom J.E.E., Reise K., 2006. Is spread of the neophyte *Spartina anglica* recently enhanced by increasing temperatures. Aquatic Ecology 40: 315-324.

Miller M.L. & Fabian R.N., 2004. Harmful invasive species: legal responses. Environmental law institute ISBN:1-58576-073-0.

Miller, C., Kettunen, M. & Shine, C., 2006. Scope options for EU action on invasive alien species. Final report for the European Commission. Institute for European Environmental Policy, Brussels, Belgium. 109 pp + Annexes.

Mulder J., 1996. Vossen op waddeneilanden? Zoogdier 7(1): 23-25, 1996.

Nehls G., Diederich S., Thieltges D.W., Strasser M., 2006. Wadden Sea mussel beds invaded by oysters and slipper limpets: competition or climate control? Hegol. Mar. Res. 60: 135-143.

Nehls G., Witte S., Büttger H., Dankers N., Jansen J., Millat G., Herlyn M., Markert A., Kristensen P.S., Ruth M., Buschbaum C., Wehrmann A., 2009. Beds of blue mussels and Pacific oysters. In: Marencic H., & de Vlas J. (eds.), Wadden Sea Quality Status report 2009. Wadden Sea Ecosystem 25. Common Wadden Sea Secretariat, Wilhelmshaven.

Nehring S., 2005. International shipping - A risk for aquatic biodiversity in Germany. Neobiota 6: 125-143.

Nehring S., & Klingenstein F., 2005. Alien species in the Wadden Sea - A challenge to act. Wadden Sea Newsletter 31: 13-16.

Nehring S., Reise K., Dankers N., Kristensen P.S., 2009. Alien species. In: Marencic H., & de Vlas J. (eds.), Wadden Sea Quality Status report 2009. Wadden Sea Ecosystem 26. Common Wadden Sea Secretariat, Wilhelmshaven.

Nehring, S. & Leuchs, H. 2000. Neozoen im Makrobenthos der deutschen Brackgewässer an der deutschen Nordseeküste. Lauterbornia 39, 73-116

Oliveira, O.M.P., 2007. The presence of the ctenophore *Mnemiopsis leidyi* in the Oslofjorden and considerations on the initial invasion pathways to the North and Baltic Seas. European Research Network on Aquatic Invasive Species. Aquatic Invasions 2(3): 185-189.

Piola R. & Conwall C., March 2010. Vessel biofouling as a vector for the introduction of non-indigenous marine species to New Zealand: Fishing vessels (08-10840). MAF Biosecurity New Zealand Technical Paper No: 2010/11.

Quist, C. and E. Weeda, 2009. Exoten en invasieve soorten: nieuwe uitdagingen voor het natuurbeheer. p.166-87 In: Schaminée, J. and E. Weeda, 2009. Natuur als nooit tevoren. Zeist: KNNV.

Redeke, H.C. 1937. Über die Vebreitung einiger Malakostraken in niederländischen Gewässern. Int. Rev. ges. Hydrobiol. Hydrogr. 35, 217-228.

Reise K., Dankers N., Essink K., 2005. Introduced species. In: Essink K., Dettmann C., Farke H., Laursen K., Luerssen G., Marencic H., Wiersinga W (eds.), Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem 19: 155-161.

Shine, C., Williams, N. and Gündling, L. 2000. A Guide to designing legal and institutional frameworks on alien invasive species. IUCN Environmental Policy and Law Paper No.40. IUCN Gland, Switzerlan00d and Cambridge, UK.

Shine, C., Kettunen, M., Genovesi, P., Essl, F., Gollasch, S., Rabitsch, W., Scalera, R., Starfinger, U. and ten Brink, P. 2010. Assessment to support continued development of the EU Strategy to combat invasive alien species. Final Report for the European Commission. Institute for European Environmental Policy (IEEP), Brussels, Belgium.

Siedler G., Church J. and Gould J. (eds) (2001). Ocean Circulation and Climate: Observing and Modelling the Global Ocean. Academic Press, San Diego, USA.

Tendal O.S., Jensen K.R., Riisgard U., 2007. Invasive ctenophore *Mnemiopsis leidyi* widely distributed in Danish waters. Aquatic invasions 2: 455-460.

Wehrmann A., Esser W., Markert A., Narkus S., Rabe K., 2009. Management der Bioinvasion der Pazifischen Auster (*Crassostrea gigas*). Abschlussbericht Projekt 25/05 der Niedersachsischen Wattenmeer-Stiftung.

Wijsman J.W.M. & De Mesel I., 2008. Risk analysis on the import of mussels from the Limfjord and the Ilsefjord (Denmark) to the Oosterschelde. Report number C068/08, October 2008, Wageningen IMARES, Yerseke.

Wijsman J.W.M. & De Mesel I., 2009. Duurzame schelpdiertransporten. Rapport C067/09, 111pp. Wageningen IMARES, Yerseke.

Winter L. & Wallace G.E., 2006. Impacts of feral and free-ranging cats on bird species of conservation concern. A five-state review of New York, New Jersey, Florida, California, and Hawaii. American Bird Conservancy.

URL's cited:
Website ALARM project:
www.alarmproject.net

DAISIE website:
www.europe-aliens.org

IMPASSE website:
www2.hull.ac.uk/discover/hifi/impasse.aspx

VECTORS website:
http://www.marine-vectors.eu/

NOBANIS website:
www.nobanis.org

International journal focusing on biological invasions in inland and coastal waters of Europe, North America and other regions:
www.aquaticinvasions.net

Biopollution Assessment System:
www.corpi.ku.lt/~biopollution

Bern Convention's European Strategy on IAS:
www.coe.int/t/dg4/cultureheritage/conventions/Bern/T-PVS/sc24_inf01_en.pdf

OSPAR website:
www.ospar.org

Ballast Water Opportunity project:
www.northseaballast.eu

Ultrasonic antifouling systems:
www.cleanseaco.com and www.hullguard.com

Appendix 1 Acronyms

ALARM:	EU-project Assessing large scale risks for biodiversity with tested methods
BLG:	Bulk Liquids and Gases (Sub-Committee of MECP)
BPL:	Biopollution Level
BSAP:	Baltic Sea Action Plan
BSH:	Bundesamt für Seeschifffahrt und Hydrographie
BWE(A):	Ballast Water Exchange (Area)
BWM:	Ballast Water Management
BWMC:	Ballast Water Management Convention
BWO:	Ballast Water Opportunity Project
CBD:	Convention on Biological Diversity
CWSS:	Common Wadden Sea Secretariat
DAISIE:	EU-project Delivering Alien Invasive Species Inventories
EC:	European Council
EIFAC:	European Inland Fisheries Advisory Commission
ELI:	Ministry of Economic Affairs, Agriculture and Innovation
EMSA:	European Maritime Safety Agency
ERDF:	European Regional Development Fund
EU:	European Union
FAO:	Food and Agriculture Organization of the United Nations
GES:	Good Environmental Status
GMOs:	Genetically Modified Organisms
HELCOM:	Helsinki Commission
IAS:	Invasive Alien Species
ICES:	International Council for Exploration of the Sea
IMO:	International Maritime Organization
IMPASSE:	EU-project Environmental impacts of alien species in aquaculture
MS:	Member States
MSFD:	Marine Strategy Framework Directive
NAC:	North Atlantic Current
NGO:	Non Governmental Organisation
NIS:	Non-indigenous Species
NIOZ:	Netherlands Institute for Sea Research
NOBANIS:	European Network on Invasive Alien Species
OSPAR:	Oslo-Paris Convention
PSC:	Port State Control
RA:	Risk Assessment
SC:	Seed Collectors
TMAP:	Trilateral Monitoring and Assessment Programme
TRACES:	Trade Control and Expert System
UNCLOS:	United Nations Convention on the Law of the Sea
UNESCO:	United Nations Educational, Scientific and Cultural Organization

VECTORS: EU-project Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors.
WGITMO: Working Group on Introductions and Transfers of Marine Organisms
WMU: World Maritime University

Appendix 2 Organisational structure marine monitoring & assessment

Organisational structure for marine monitoring and assessment in Denmark, Germany and The Netherlands (source: Bouma & Liefveld, 2011; Bouma & Lengkeek, 2008).

In **Denmark** the Nationwide Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment (called NOVANA) is used to fulfil many of Denmark's national and international monitoring and reporting obligations resulting from different European directives, international agreements and national legislations. NOVANA is adjusted when new directives (e.g. the Marine Strategy Directive) are to be implemented. The Nature Agency (merged from The Danish Forest and Nature Agency and the Agency for Spatial and Environmental Planning in early 2011) is responsible for the operation of NOVANA in cooperation with the Danish Environment Protection Agency (EPA) and the National Survey and Cadastra. There will also be a contractually based cooperation with the National Environmental Research Institute (NERI) and the Geological Survey of Denmark and Greenland (GEUS) through their role as topic centres and scientific institutions. We refer to Bouma & Liefveld (2011) for an overview of existing programmes carried out under NOVANA.

In 2007 a new monitoring and assessment programme was implemented by respective decisions of the **German** Water and Nature Directors integrating the former 'Bund/Länder-Messprogramm (BLMP)' for the North Sea and the Baltic Sea and already existing ecological monitoring programmes. In this new programme 'Marine Monitoring in Germany' monitoring obligations of HELCOM, OSPAR, the Water Framework Directive, the Trilateral Wadden Sea Cooperation, the Birds & Habitats and the Marine Strategy Framework Directive are harmonised. The programme is carried out by a Steering Group (with representatives of various ministries including Hamburg, Mecklenburg-Vorpommern, Niedersachsen and Schleswig-Holstein) assisted by a secretariat and three main working groups: 1. Monitoring and assessment; 2. Data management; 3. Quality assurance. The 'Monitoring and Assessment' working group coordinates the objectives of the monitoring programs, up-date and further development of the monitoring specifications, scientific discussion about marine assessments and development of templates for graphs and text for reports and assessments. During the last few years this group prepared a Marine Monitoring Manual consisting of 31 summary sheets (covering various themes) containing detailed information about the coverage of the specific summary sheet (which species and or habitats are included), organisations involved, legislative drivers, marine areas, monitoring methods and parameters, monitoring frequency, assessment, quality assurance and activities needed to implement the specific concept.

In **The Netherlands** two departments are responsible for the main marine monitoring programs, i.e. the Ministry Infrastructure and Environment (EenI) and the Ministry of Economic Affairs, Agriculture and Innovation (ELI). Data collection and storage is also bipartited: Marine monitoring by EenI is part of the national MWTL (Monitoring van de Waterstaatkundige Toestand des Lands) monitoring programme and stored in the

national databases DONAR and (since 2004) WADI. This includes physical, chemical, morphological and biological data. ELI is responsible for monitoring under TMAP (Trilateral Monitoring and Assessment Programme for the Wadden Sea, i.e. seals, birds, shellfish and estuarine vegetation) and supplementary statutory monitoring projects (WOT) (e.g. fish stocks for the assessments under the EU Common Fisheries Policy). These data are collected and stored in several databases by the Institute for Marine Resources and Ecosystem Studies (IMARES). Existing monitoring programs of ecological parameters concern both species (vegetation (i.e. seagrass and salt marshes), phytoplankton, zoöplankton, macro-evertebrates, fish, mammals, birds) and hydrological, physical and chemical parameters (e.g. wave action, heavy metals, organic micro-compounds, temperature, oxygen-content, etc.). A complete overview of metadata on ecological marine monitoring programs covered by MWTL, T-MAP and WOT was prepared by Smit *et al*. (2010; respectively table 3.2, 3.3 and 3.7).

Bureau Waardenburg bv
Consultants for environment & ecology

P.O. Box 365
4100 AJ Culemborg The Netherlands
Tel +31 345 512 710
Fax + 31 345 519 849
E-mail: info@buwa.nl
Website: www.buwa.nl