Pilot risk assessments of alien species transfer on intra-Baltic ship voyages

by

Stephan Gollasch[1]
Matej David[2]
Erkki Leppäkoski[3]

for

Helsinki Commission – Baltic Marine Environment Protection Commission HELCOM

(HELCOM Project No. 11.36)

Final Report

25.10.2011

Version 1.3

[1] GoConsult, Grosse Brunnenstr. 61, 22763 Hamburg, Germany
sgollasch@aol.com

[2] Faculty of Maritime Studies and Transport, University of Ljubljana
Pot pomorščakov 4, 6320 Portorož, Slovenia
matej.david@siol.net

[3] MeriEko Consulting, Ruuhitie 10, 21100 Naantali, Finland
erkki.leppakoski@gmail.com

EXECUTIVE SUMMARY

This risk assessment study focuses on intra Baltic Sea shipping. The HELCOM *Guidance to distinguish between unacceptable high risk scenarios and acceptable low risk scenarios – a risk of spreading of alien species by ships on Intra-Baltic voyages* (HELCOM Risk Assessment (RA) Guidance) was taken as a starting point to develop the RA concept. In addition the three different risk assessment approaches as outlined in the IMO *Guidelines for risk assessment under regulation A-4 of the BWM Convention* (IMO G7 Guideline) were evaluated for their applicability in the region. The application of the HELCOM RA Guidance and consistency with the IMO Guideline G7 was studied, and comments are provided.

The biogeographic risk assessment approach of IMO Guideline G7 is not applicable as the ballast water movements considered here are not undertaken between different biogeographical regions. IMO Guideline G7 further states a species-specific risk assessment may be best suited to situations where the assessment can be conducted on a limited number of harmful species within a biogeographic region.

It became clear that essentially needed data (*i.e.*, on already introduced species in the Baltic Sea ports) are missing to undertake a species-specific and target species risk assessment as no port baseline surveys were undertaken yet. However, a target species selection process may be conducted based upon harmonized selection criteria. Target species can thereby be identified, but a risk assessment based upon target species is only possible with the knowledge on their occurrence in ballast water donor areas – highlighting the need to undertake port baseline surveys. Therefore it is of utmost importance to agree upon R&D priorities. The priority should be placed on undertaking port baseline studies and monitoring programmes and only thereafter *e.g.* physiological and experimental studies of different life stages of species, as proposed under Guidance "*6.3 Comparisons of known physiological tolerances…*" may be conducted.

The risk assessment based upon an environmental match may also be applied considering water salinity as key feature in this approach. It should be noted that the more environmental parameters are being included the lesser robust and reliable becomes this assessment which is in conflict with the precautionary principle. The salinity is believed to be a relatively solid

indicator for species compatibility and survival in a new environment, and on the other side, this information is easily available for ballast water source and discharge areas. A high risk is assessed should the salinity match between ballast water donor and recipient regions, *e.g.*, marine to marine, marine to brackish or freshwater to brackish environments. A mismatch of salinity, *i.e.*, waters with high salinity difference, *e.g.*, freshwater (< 0.5 PSU) to marine (> 30 PSU), indicates a lower risk. This generic approach however needs a bit caution in regards to human pathogens, which in general do not survive in marine waters or brackish waters with higher salinities, but may survive in a host animal or debris. In conclusion such a salinity difference does not occur for intra-Baltic shipping and therefore this environmental match approach alone cannot be applied as RA concept.

Temperature was also considered as risk assessment quantifying factor in the environmental match approach, but it was agreed that this is of lesser reliability to identify low risk scenarios. This view is based upon the assumption that organisms are more flexible regarding temperature tolerances compared to salinity. One reason for this assumption is the greater temperature difference compared to salinity difference over the seasons in the Baltic region which the species need to tolerate.

A combination of both, the target species approach together with an environmental match, is to be considered. Should the selected target species occur in the ballast water donor area and both the ballast water donor and recipient ports show matching salinities, a high risk is assessed. However, if a high mismatch of salinity is identified between donor and recipient ports, the ballast water may be identified as low risk. All these low risk scenarios are acceptable only provided the ballast water is in no instance mixed with ballast water from other sources.

It should be noted that low risks can only be identified provided reliable data are available. This at present may be a key limiting factor of the risk assessment in the Baltic Sea as especially no port profiles are available for Baltic ports.

The following shipping routes were selected for a more detailed risk assessment:

- St. Petersburg (RU) – Gothenburg (SE),
- Klaipëda (LT) – Kiel (DE),

- Kiel (DE) – Gothenburg (SE), and
- Terneuzen (NL) – Mönsterås (SE) – Karlshamn (SE).

In the IMO "same location concept" chapter the report also recommends how ferries and other vessels may approach ballast water management exemptions provided they are solely operated on a constant shipping route.

TABLE OF CONTENT

Executive Summary ... 2

1 INTRODUCTION ... 7

2 THE IMO "SAME LOCATION" CONCEPT ... 10

3 RISK ASSESMENT IN BALLAST WATER MANAGEMENT ... 12

3.1 RISK ASSESSMENT (ra) UNDER IMO G7 ... 12

3.1.1 RA key principles ... 12

3.1.2 RA methods ... 13

3.2 HELCOM RA Guidance ... 14

3.2.1 Introduction ... 14

3.2.2 Guidance part ... 15

3.2.3 Recommendations ... 16

3.2.4 Decision making ... 25

3.2.5 Explanatory notes ... 26

4 APPLICATION OF BWM RA IN THE BALTIC SEA AREA ... 26

4.1 Baltic sea specifics ... 26

4.1.1 Gradients ... 27

4.1.2 Secondary spread ... 29

4.1.3 SPECIES' ABILITY TO SPREAD WITHOUT HUMAN ASSISTANCE ... 30

4.1.4 Alien species ... 32

4.1.5 Origin ... 34

4.1.6 Vectors ... 36

4.2 Secondary vs. primary introductions ... 36

4.3 Identification of the area ... 37

4.4 Which RA method to apply in the Baltic Sea? ... 37

4.4.1 Species Specific assessment in the Baltic Sea ... 38

4.4.2 Environmental matching component ... 41

4.4.3 Combined environmental and species –specific approach ... 42

4.5 RA MODEL for granting bwm exemptions in intra-baltic shipping ... 44
4.5.1 RA framework ... 44
4.5.2 RA model background ... 48
4.5.3 The main RA premises ... 50
4.5.4 The RA Model for granting exemptions in the intra Baltic Sea shipping ... 52

4.6 Port selection criteria ... 55

4.7 RA for selected Baltic Sea Ports ... 56
4.7.1 RA for route 1 ... 58
4.7.2 RA for route 2 ... 60
4.7.3 RA for route 3 ... 63
4.7.4 RA for route 4 ... 63

5 CONCLUSIONS ... 67

ANNEX I RISK ASSESSMENT (RA) ... 69

ANNEX II IMO RA METHODS ... 76
Environmental matching related risk identification ... 76
Species' Biogeographical risk assessment ... 78
Species specific risk identification ... 79

ANNEX III APPLICATION OF THE BWM CONVENTION ... 83

ANNEX IV BALLAST WATER MANAGEMENT IN THE AREA ... 86

ANNEX V SPECIES' ABILITY TO SPREAD WITHOUT HUMAN ASSISTANCE. 88

REFERENCES ... 96

1 INTRODUCTION

In total 119 alien species have been found in the Baltic Sea and several of those are known as negatively impacting the environment and economy of stakeholders. In consequence one of the management objectives of the maritime segment of the HELCOM Baltic Sea Action Plan (BSAP) (2007[4]) is "*No introductions of alien species from ships*". In addition, the biodiversity segment of the BSAP includes a specific target: "*To prevent adverse alterations of the ecosystem by minimising, to the extent possible, new introductions of non-indigenous species*".

In 2007, the HELCOM Contracting Parties agreed upon a Road map[5] in order to structure the joint efforts towards ratification of the BWMC. The 2010 HELCOM Moscow Ministerial Meeting adopted the HELCOM Guidance on how to distinguish between high and low risk – a risk of secondary spreading of alien species through ballast water and sediments – by ships engaged in intra-Baltic voyages. This Guidance has been developed to support transparent and consistent risk assessments for regional ship voyages and to allow a unified Baltic Sea system on exemptions from applying ballast water management requirements in accordance with Ballast Water Management Convention Regulation A-4, *i.e.*, risk assessment based exemptions.

The Guidance, however, has not been tested yet on real cases, and there is a growing need to gain the knowledge among national administrations and provide best practices on how to conduct and/or evaluate and consult risk assessments as set in the Ballast Water Management Convention. To test the Guidance, HELCOM MARITIME 9/2010 and HELCOM HOD 34/2010 agreed on conducting the project "Pilot risk assessments of alien species transfer on intra-Baltic ship voyages".

[4] HELCOM Baltic Sea Action Plan 2007 adopted at HELCOM Ministerial Meeting Krakow, Poland, 15 November 2007, 101 pp.

[5] Road map towards harmonised implementation and ratification of the 2004 International Convention for Control and Management of Ships' Ballast Water and Sediments www.helcom.fi/BSAP/ActionPlan/otherDocs/en_GB/roadmap/

The IMO Convention on the Management of Ships' Ballast Water and Sediments (BWM Convention) 2004 has not particularly been designed to serve small and shallow seas like the Baltic Sea, which may create some challenges for the HELCOM countries. One of the questions is how and if to manage ballast water on intra-Baltic voyages, taking into account that species are likely to spread within the Baltic Sea to proportionally wide areas on their own, without shipping acting as a vector, unless salinity, temperature or other factors limit their natural range of dispersal.

The pilot project group was further tasked to address the implications of Regulations A-3 (Exceptions) and A-4 (Exemptions) of the BWM Convention for intra-Baltic voyages (see also Annex III Application of the BWM Convention).

The HELCOM Contracting Parties have agreed that ballast water exchange is not a suitable management option to reduce the risk of harmful species' transfer within the Baltic Sea because the distance to nearest land and water depth as required by IMO for ballast water exchange cannot be met along the majority of the Baltic shipping routes (Annex IV Ballast water management in the area). Thus, once the BWM Convention enters into force, ships on intra-Baltic voyages will be required to implement the remaining ballast water management options (ballast water treatment or discharge and disposal of ballast water and sediments to reception facilities) unless an exemption has been granted following a risk assessment to assess whether a ship is on a voyage posing a low risk of spreading harmful species.

The BWM Convention allows exempting certain ships from ballast water management (BWM) requirements. The exemption process should be based on risk assessments (RA) according to the Regulation A-4, Exemptions, of the BWM Convention and this needs to be in line with the IMO Guidelines for Risk Assessment (G7) (see further below) as proposed in the HELCOM Road map (2007).

This project report is not the first ballast water related risk assessment study undertaken in the Baltic Sea area. The first risk assessment was undertaken for the Nordic Council of Ministers in 1999 (Gollasch, Leppäkoski 1999). From today´s perspective this is more considered to be a hazard analysis report and a contribution to raise awareness on the subject. The second study (Leppäkoski, Gollasch 2006**,** Gollasch, Leppäkoski 2007) considered the issue more in details, but the work was undertaken prior the risk assessment guideline (G7) of IMO was adopted. Therefore, the second study can also be considered as preliminary, thereby highlighting the need for this project report to consider the IMO Guideline G7 principles and consider its applications for intra-Baltic shipping.

For reasons of comparison two risk assessments initiatives will be referred to, undertaken in the North Sea, *i.e.* the OSPAR Scoping Study (Dragsund *et al.* 2005) and more recently a study for the German Federal Agency for Shipping and Hydrography (BSH) was undertaken (David, Gollasch 2010). In this study the principles of the IMO Guideline G7 were also considered and parts of this BSH study were taken as a starting point for this project report.

In invasion biology, many definitions exist on alien, non-indigenous, exotic, non-native species and are published elsewhere. However, in risk assessments, and in accordance with the IMO philosophy, one should not put the focus on those species only, what should be considered are species which cause a negative impact. These include native species and also those species where it is unclear if they are native or alien (or cryptogenic) species. IMO uses the following definition *Harmful Aquatic Organisms and Pathogens means aquatic organisms or pathogens which, if introduced into the sea including estuaries, or into fresh water courses, may create hazards to the environment, human health, property or resources, impair biological diversity or interfere with other legitimate uses of such areas.*

The authors believe that for the Baltic Sea risk assessment approach the terminology used should be as close as possible to the IMO BWM Convention and the risk assessment guideline G7. However, for reasons of simplicity the term “harmful organisms” or “harmful species” will be used instead of “harmful aquatic organisms and pathogens”.

The transfer of human pathogens is one key concern when planning to identify low risk ballast water movements. Many of such species cannot easily and accurately be identified. As a compromise, IMO refers to “indicator microbes” as a human health standard. The species considered in this approach are Enterococci and *Escherichia coli*. This is in line with European Union bathing water quality standards. In addition the IMO Ballast Water Performance Standard also addresses the toxic strains of *Vibrio cholerae*.

In IMO terminology two different reasonings are given for vessels not to undertake any ballast water management measure: (i) Regulation A-3 Exceptions and (ii) the exceptions listed in Article 3 Application. Risk assessment based exemptions (Regulation A-4) are subject this project report.

For reasons of comparison the authors have indicated below what their understanding of the concept of "same location" is as referred to in *Regulation A-3 Exceptions*. Again, this is not risk assessment related, but is one of the cases where vessels may be exempted from ballast water management requirements.

2 THE IMO "SAME LOCATION" CONCEPT

As per HELCOM agreement the Baltic is divided in several larger regions with more than 50 sub-regions thereby implying that the entire sea cannot be considered as the same location. However, under certain circumstances the same location concept of IMO may result in vessel exceptions from ballast water management requirements even if the Baltic as a whole cannot be seen as the same location.

Regulation A-3.5 "Exceptions" of the IMO Ballast Water Management Convention states that exceptions from ballast water management shall apply in cases when

…the discharge of Ballast Water and Sediments from a ship at the ***same location*** *where the whole of that Ballast Water and those Sediments originated and provided that no mixing with unmanaged Ballast Water and Sediments from other areas has occurred. If mixing has occurred, the Ballast Water taken from other areas is subject to Ballast Water Management in accordance with this Annex.*

The above stated regulation means that the same location applies only when ballast water, planned to be discharged, originates from exactly the same location where the discharge is planned as it was taken up here previously provided the vessel is operated on an international route.

The same location refers to a small scale area where the ballast water originates. This includes any ballast water uptake location, including a port or its approaches. In smaller ports the entire port, possibly also including the anchorage, may be seen as the same location, especially when the salinity is not fluctuating (see above). In larger ports, and in particular when a salinity difference occurs between port basins, or when port basins are separated by locks, the same location may only apply when the ballast water to be discharged in a certain port basin originates from exactly this port basin (in this case a port basin is same location, not entire port area). As an example the salinity in the Port of Rotterdam increases from < 5 PSU in the inner port to approximately 30 PSU in the port basins near the North Sea (*e.g.*, Euromax Terminal), and the salinity also fluctuates depending on the tides.

Considering this, the same location concept may be applied to *e.g.* passenger ferries, which always call for the same terminal in each port no matter if they are operated on shorter or longer routes. For example, a ferry operated between Helsinki and Tallinn may uptake ballast water in Helsinki, calls for Tallinn without discharging ballast water originating from Helsinki, and when being back in Helsinki can discharge the ballast water, which was at an earlier port call taken up in this location without any ballast water management.

The same location concept may also apply to *e.g.* fishing vessels, which operate only between one port (port basin) and the high seas.

The authors strongly recommend that the entire Baltic can by no means be agreed to be the same location. Should this be the case unmanaged ballast water movements would be permitted between all Baltic ports and this would result in an unacceptable high risk situation. Shipping in any case amplifies the transfer of harmful species, what is an unwanted event.

A biologically meaningful definition how to identify the dimension of the same location needs to be developed. As the entire concept of ballast water management is to avoid species introductions, *i.e*. a biological focus, one way to identify the limits of the same location is to consider the species diversity and their abundance in a location. Should all species be identical and their abundance very similar this may be considered as the same location. In consequence the same location is as large as the similarity of species determines.

3 RISK ASSESMENT IN BALLAST WATER MANAGEMENT

Risk assessment principles and approaches agreed in the IMO Guideline G7 and Regulation A-4 may be used to adapt BWM requirements to the level of risk posed by a single vessel or a shipping route selected for the risk assessment, providing a basis for adequate BWM requirements when the risk is identified as high, as well as exempting vessels from BWM if enough evidence is provided that the ballast water to be discharged is of low risk.

This chapter addresses some of the key principles and elements of risk assessment under the IMO Guideline G7 (more in Annexes I and II) and the HELCOM *Guidance to distinguish between unacceptable high risk scenarios and acceptable low risk scenarios – a risk of spreading of alien species by ships on Intra-Baltic voyages* (HELCOM RA Guidance).

3.1 RISK ASSESSMENT (RA) UNDER IMO G7

3.1.1 RA KEY PRINCIPLES

The RA can be defined by the following key principles, which are to be followed through all the RA process, leading to a decision to exempt or not a vessel from BWM requirements (MEPC 2007):

- **Effectiveness -** That risk assessments accurately measure the risks to the extent necessary to achieve an appropriate level of protection.
- **Transparency -** That the reasoning and evidence supporting the action recommended by risk assessments, and areas of uncertainty (and their possible consequences to those recommendations), are clearly documented and made available to decision-makers.
- **Consistency -** That risk assessments achieve a uniformly high level of performance, using a common process and methodology.
- **Comprehensiveness -** That the full range of values, including economic, environmental, social and cultural, are considered when assessing risks and making recommendations.

- **Risk Management -** The risk scenarios may exist, but zero risk is not obtainable, and as such risk should be managed by determining the acceptable level of risk in each instance.
- **Precautionary -** That risk assessments incorporate a level of precaution when making assumptions and recommendations, to account for uncertainty, unreliability, and inadequacy of information. The absence of, or uncertainty regarding, any information should therefore be considered an indicator of potential risk.
- **Science based -** That risk assessments are based on the best available information that has been collected and analysed using scientific methods.
- **Continuous improvement -** Any risk model should be periodically reviewed and updated to account for improved understanding.

3.1.2 RA METHODS

The RA developed in the framework of the BWM Convention and is the latest, understood as worldwide agreed, RA framework. It has been developed to provide tools for a selective approach in the implementation of the BWM Convention and it is presented in the IMO Guideline G7 Guidelines as is outlined in the following chapters. It has three different methods, “environmental matching”, “species biogeographical” and “species-specific” risk assessment see Annex II).

The risk estimation on the assessment of environmental matching between the areas of ballast water origin and discharge considers salinity and temperature as surrogates for the species capability of survival in the new environment. Species’ biogeographical risk assessment identifies overlapping species in the donor and recipient ports and biogeographical regions, and these are direct indications of the similarity of environmental conditions. The risk identification in the species-specific approach is focused on the assessment of the potential invasiveness of each species and anticipations of the harm that it could cause in the new environment.

3.2 HELCOM RA GUIDANCE

When preparing the grounds for conducting RA according to the HELCOM RA Guidance, some points were felt to need further discussion or explanation to remain inline with IMO Guideline G7 Guideline and some other international instruments or with expert views (*i.e.*, risk assessment, shipping and invasions biology). These points are first referred to the HELCOM GA Guidance, followed by comments and explanations. This part is also meant to be instructive for future possible improvements of the HELCOM Guidance.

3.2.1 INTRODUCTION

Introduction, 4th paragraph

*"Once the BWM Convention enters into force, ships will be required to implement the remaining ballast water management options (**ballast water treatment** or discharge and disposal of ballast water and sediments to suitable reception facilities) unless an exemption has been granted following a risk assessment to assess whether **a ship** is **on a voyage** posing a high or low risk of spreading alien species."*

Comment 1: A requirement for **ballast water treatment** after the BWM Convention entry into force is a bit overstated, as the treatment of ballast water is not required by the convention nor this is stated in the convention, and there might be some other management options arising, *e.g.*, continuous BW exchange.

Comment 2: A statement for granting exemption *following risk assessment to assess whether **a ship** is **on a voyage** posing a high or low risk of spreading alien species* is a bit inexact when it is not included here that this is only valid "between specified ports or locations without mixing ballast water or sediments with those from other ports or locations" (route specific assessment). As written currently it may be misunderstood that an exemption may be given for a certain voyage (any vessel operated between the ports considered), but instead the exemption is only given to a vessel exclusively operated on a certain route (i.e. the vessel does not ballast in no other ports than those considered in the RA).

Introduction, last paragraph

"The shipowner or operator should follow the IMO Guidelines and submit relevant information to the Party. Both the risk assessing, and the evaluation and decision-making processes should use best available expertise."

Comment: Use of "best available expertise" should at no means be understood that the "use of best available data" is good enough to conduct RA. The critical point here is that RA can be conducted only if "good enough" (*i.e.* reliable) data exist. This is directly referred to the IMO Guideline G7 RA key principles – the Precautionary principle (MEPC 2007), as well as in the Communication from the Commission on the Precautionary principle (EU Commission, 2000) (more in 4.5.1.1).

3.2.2 GUIDANCE PART

Guidance part, 2nd paragraph

"The Baltic Sea is recognised as a one Biogeographical Region[6] in the context of Ballast Water Management Convention, defined as; "a large natural region defined by physiographic and biologic characteristics within which the animal and plant species show a high degree of similarity. There are no sharp and absolute boundaries but rather more or less clearly expressed transition zones"."

Comment: This paragraph defines the Baltic Sea as on bioregion according to the LME concept. The Large Marine Ecosystem scheme was, for different reasons, found not directly applicable to the Baltic Sea, mainly as the LMEs are based on salinity and were prepared for **marine** ecosystems, while Baltic Sea has no such profile (more in 4.3).

The RA model

[6] Large Marine Ecosystems (LME) scheme, used in the IMO BWM Convention Guideline G7

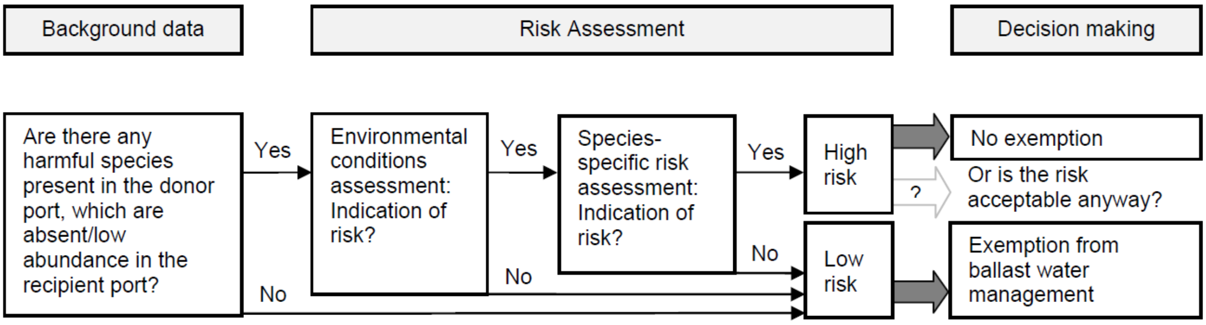

Fig. 1. HELCOM risk assessment and decision making model.

A new model is being developed which includes all elements needed for a detailed RA according to the HELCOM RA Guidance, also being in-line with the IMO Guideline G7 Guideline requirements. Regarding the last stage of the HELCOM RA assessment scheme (Fig. 1), the model still suggests "Or is the risk acceptable anyway". This creates a loop, which is not needed after a detailed environmental and species-specific RA.

3.2.3 RECOMMENDATIONS

Recommendation 1. A risk assessment must be sufficiently robust

*"1.1 in order to distinguish between high and low risk scenarios where the discharge of ballast water or sediments not meeting requirements of **ballast water treatment**, is unlikely to impair or damage the environment, human health, property or resources of the granting Party and of adjacent or other States,"*

Comment: The authors understand and agree with this, but do note that there are no ballast water **treatment** requirements in the BWM Convention, but there are only ballast water **management** standards D-1 and/or D-2 that need to be met.

"1.2 should follow the risk assessment 8 key principles as defined in IMO Guidelines G7; effectiveness, transparency, consistency, comprehensiveness, risk management, precautionary, science based and continuous improvement."

Comment: The project team agrees with this statement.

For decision-making it is important to recognise that:

"1.3 low risk scenarios may exist, but zero risk is not obtainable, and as such risk should be identified by determining the acceptable levels of risk in each instance. The absence of, or uncertainty in, any information should be considered an indicator of potential risk."

Comment: This view is strongly supported as it is in the context of Precautionary approach.

"1.4 level of uncertainty is recorded in a transparent way."

Comment: This is a very important point to be considered throughout all the RA and decision making process. It is also important to understand, that uncertainty has its limitations. In consequence it is not only enough to record the uncertainty, but that a too high level of uncertainty is converging in an unacceptable uncertainty. The precautionary approach is also a limiting factor for acceptability of uncertainty.

Recommendation 2. Species-specific Risk Assessment (IMO Guideline G7)

"2.1 is recognised as the most effective assessment method, describing risk within a Biogeographical area most sophisticatedly;"

Comment: The authors support this view.

*"2.2 and should be used with supportive information from **environmental conditions** and **shipping activities**."*

Comment: According to environmental specifics of the Baltic Sea only salinity was identified as relevant **environmental** factor to be used in a combined approach in the RA model (see 4.4.2). However **shipping** factors (*e.g*., length of voyage, quantity of ballast water discharged) were found less relevant especially when considering Baltic Sea shipping specifics (see 4.5.1.2).

Recommendation 3. Scale of risk assessments

"3.1 It is recommended that the Parties responsible for carrying out risk assessments employ individual ports and their surrounding area with similar environmental conditions as the primary units of the assessments. These are the starting and end point of ships' voyages. If two or more ports are close to one another (similar species communities and environmental conditions), a joint risk assessment may be carried out."

Comment: The first sentence of this paragraph nicely defines the area to be considered for RA, and also for the term "same location". The third sentence needs more caution, as the proximity of ports *(i.e.,* are close to one another) is not easily to be defined/distinguished by "*similar species communities and environmental conditions*", unless port baseline surveys were conducted in all ports considered for a joint RA.

Recommendation 4. Species to be included in the risk assessments
"4.1 Taking note that not all non-indigenous species pose a similar level of invasion, ***only harmful non-indigenous and cryptogenic species can contribute to unacceptable high risk voyages****. For this, parties taking the risk assessment should initially identify all non-indigenous and cryptogenic species that are present in the donor and recipient ports and their surrounding areas."*

Comment: The statement that "***only harmful non-indigenous and cryptogenic species can contribute to unacceptable high risk voyages***" is right, but the problem in invasion biology is that it is very difficult or impossible to predict the harmful behaviour of a species in a new environment before it has been introduced and caused harm, and at this point after an introduction it is too late to understand this. Consequently the potential to cause harm is a priory enough not to accept the risk to allow an introduction, unless it has been proven that the species is not harmful. It should be noted that it is also impossible to proof that a species introduction will be harmless before this species is introduced and no harm is caused. Furthermore, some introduced species did not cause any harm for several years after they were first recorded, and afterwards a population literally exploded (*e.g.* the spiny water flea *Cercopagis pengoi* in the Baltic) (see 4.4.1 and 4.5.1.3). Some species also occur with oscillating densities and their negative impact is only shown during the mass developments. Here the Chinese mitten crab is an example as it shows abundance peaks with strong negative impacts approximately every 15 years. With this, and having in mind also the precautionary principle, the RA model considers that any potentially harmful species (non-indigenous or cryptogenic) selected as target species present in the source port triggers unacceptable high risk, if this species is not also present in the recipient environment in same or higher abundance.

*"4.2 The authority responsible for granting exemptions should be in the position to determine, whether **all potentially harmful non-indigenous and cryptogenic species, should be included in the risk assessments** or **only species which have been reported to use ballast water or sediment as a vector**. However, decision to leave some harmful non-indigenous and cryptogenic species outside a risk assessment should be made with great caution and based on real evidence of these species not being able to deploy ballast water or sediments as a vector."*

Comment: The enigma about which species should be included in RA is solved with the determination of "target species" according to the selection criteria, which is defined in IMO Guideline G7 and further defined in this report in paragraph 4.4.1. The specified selection criteria regarding the vector require "relationship with ballast water as a vector" (*cf*. also Annex V). It can be further noted that in this assessment attention should be given especially to the overlapping of the different vectors of transfer (see also Annex I, Identification of the vector of transfer).

"4.3 The IMO Guidelines (G7) for risk assessment allow removal of a harmful nonindigenous and cryptogenic species - present both in the donor and the recipient port in high abundance - from the overall risk assessment. However, potentially harmful non-indigenous and cryptogenic species present in the recipient port and its surrounding area only in low abundance should not be excluded from the risk assessment. In low abundance such a species might have a lower potential to become harmful but its continual introduction increases the probability that it will become established and/or invasive."

Comment: This will be covered in the RA model. If there will be the same target species in the donor and recipient port in same abundance, the risk will be acceptable, while if the species of concern will be in a lower abundance in the recipient than in the donor port, the risk

will be unacceptable. However, no reference to organism numbers (= abundance) was located in IMO Guideline G7. Instead the IMO Guideline G7 includes number of species (= diversity) aspects. The view to include abundance as risk factor was very much appreciated and included this in the model presented here.
Further, the lack of data is a key problem: not only abundance of organisms but even the presence/absence of species is unknown in almost all Baltic Sea ports.

"4.4 If a harmful species is under active control or eradication in the recipient port, actions to prevent its further introductions should be taken."

Comment: This will be covered in the RA model. If a species is under active control or eradication in the recipient port, the risk will be unacceptable.

"4.5 Specific lists of species to be taken into account in the risk assessments should be made available regionally."

Comment: The authors agree with this view.

Recommendation 5. Environmental conditions in donor and recipient ports in the Baltic Sea

"5.1 A starting point of a successful intra-Baltic risk assessment should be collection of data on the seasonal variation of environmental conditions throughout the water column from surface to bottom."

Comment: This approach makes very good sense.

"5.2 All environmental conditions, that might be predictive of ability of the harmful nonindigenous and cryptogenic species (Recommendations 4 & 6) to successfully establish and cause harm in the new locations, in particular salinity and temperature, but also other parameters e.g. nutrients, habitats available and oxygen should be taken into account."

Comment: Salinity was found relevant in combination with species-specific RA, while temperature was found not enough relevant factor (see 4.4.2). Other parameters "*e.g. nutrients, habitats available and oxygen should be taken into account*" are considered by the species-specific assessment (see 4.4.1). However, it should be noted that the level of nutrients and oxygen are considered as of minor importance to evaluate whether or not a species can survive and colonize a new Baltic subregion/port. This view stems from the fact that the nutrient levels in the Baltic are not as strongly different to limit the colonization of species. In a similar way it is assumed that the oxygen level along the Baltic coasts and ports, where ballast water is discharged, is not depleted to critical values below which oxygen dependent organisms cannot survive. It should also be noted that some species can "switch" their energy demand from oxygen to other sources, thereby not being affected at all in low oxygen conditions. In contrast the availability of habitats may be a limiting factor for new species to become introduced. As an example, should a hard-bottom living organism be introduced in an area without any hard-bottom substrates, this species will not be able to settle and may have difficulties to survive. However, it is questionable if such a situation would occur as all Baltic ports have some hard-bottom habitats. Although these hard-bottom habitats may be man-made they can be used as habitat. This situation may change for soft-bottom dependent organisms when introduced to rocky shores. However, in summary, the team believes that salinity is the key risk quantifier (see also other relevant chapters of this report for explanations).

"5.3 In the lack of information on how non-indigenous and cryptogenic species' respond to these variations in environmental conditions, the best available expert judgement should be used to compare species' success to disperse from donor to the recipient port and their surrounding areas, and to become established in the recipient environment and spread."

Comment: This expert judgement is considered in the species-specific assessment and the process of target species selection (see 4.4.1).

"5.4 Data on average, maximum and minimum salinity and temperature in water column, within ports and surrounding areas, throughout the year should be the minimum requirement for risk assessments. Both the temperature and salinity have direct impacts on the

development and reproductive success of any individuals. Conditions in a larger water body must be taken into account, since this will affect the dispersal ability of mobile species (active or passive dispersal).”

Comment: Salinity was identified as of key relevance in combination with species-specific RA, while temperature was found of lower relevance (see 4.4.2).

Recommendation 6. Species-specific risk assessment data requirements

“6.1 Data to be included in species-specific risk assessments (G7) – as far as available - should include, but is not limited to;

• Life history information on the harmful non-indigenous and cryptogenic species and physiological tolerances, in particular salinity and temperature, of each life stage;

a. The ability of the adults to survive would be indicated by the physiological limits for both temperature and salinity that fall within the environmental ranges observed in the recipient port and larger water body. As a check, a comparison could be made with the native and/or introduced ranges of the species to determine if the predicted tolerances (based on laboratory or field studies) reflect actual distributions.

b. For other life stages the physiological requirements of each stage in the life cycle should be compared against the environmental conditions during the season(s) of reproduction, noting that these stage(s) may live in different habitats to complete their life cycle (e.g. coastal pelagic larvae of estuarine benthic invertebrates).

c. Comparisons of known physiological tolerances for other conditions should be conducted if the data are available and relevant.

• Habitat type required by the harmful species and availability of such in the recipient port.”

“6.2 The risk assessments should have great emphasis on reproductive potential of harmful non-indigenous and cryptogenic species. The young stages’ survival is also important to assess.”

“6.3 Comparisons of known physiological tolerances from the Baltic Sea especially, but also from other regions, should be taken into consideration.”

Comment: All these elements are considered in the species-specific RA for the Baltic Sea and are included in the selection criteria for target species (see 4.4.1), hence are considered in the RA model (see 4.5.4).

The physiological tolerances of species are of key importance for the RA. This implies a complex RA study and underlines the need to agree upon R&D priorities, *e.g.* port baseline data being of utmost priority for further and more detailed RA.

Recommendation 7. Background information on shipping activities

"7.1 The overall probability of a successful invasion also depends in part on the number of organisms and the frequency with which they are introduced over the entire period of the exemption. Therefore, it is recommended that a risk assessment should consider estimates of the following factors:

• the total volume of water discharged

• the volume of water discharged in any event (voyage)

• the total number of discharge events

• the temporal distribution of discharge events."

Comment: These factors were considered when selecting cases for this study. In terms of RA, these factors were identified as not enough relevant to change the decision between acceptable or unacceptable risk (see 4.5.1.2), hence are not considered by the RA model. As an example should the salinity mis-match completely (*i.e.* freshwater to marine), it is irrelevant how frequently organisms are introduced and how large the inoculation size of a founder population is, they simply cannot survive and will not establish. Therefore data on the volume of discharged ballast water and the number of discharge events are meaningless.

Recommendation 8. Species' ability to disperse between ports without human introduced vector

"8.1 Some harmful species in the Baltic Sea might have an ability to spread from one port to another across larger water bodies without human introduced vector, 'naturally' by means of active swimming or passively with water currents e.g. the species having a small maximum diameter, floating ability or buoyant offspring."

Comment: This is addressed in chapter 4.1.3 and 4.2 and, more in detail, in Annex V. As long as no (salinity-) barrier occurs between ports in close proximity species may be moved by natural means. As addressed in 8.2, should all alien and cryptogenic species be able to be transported by natural means between the considered ports, a requirement for BWM may be irrelevant in those cases. However, it is unclear how likely this may be the case.

"8.2 If a harmful species has an ability to spread by these 'natural' means between the ports in question - taken that there are no natural barriers (environmental or distance related) preventing such - ballast water management might not grant additional protection from such species."

Comment: However, if the species is selected as a target species and is in lower abundance in the recipient port, it should still be an unacceptable event to be transferred also by BW.

"8.3 Only if this ability to disperse from donor to a recipient port 'naturally' can be based on information of high quality (scientifically proven or reliable expert judgement), the Guidance for high and low risk voyages authorities responsible for granting exemptions, may reserve a right to exempt ships on specific voyages (See Decision making). *This is only valid if no other species poses a further threat."*

Comment: See previous comment.

"8.4 In the case of having even one harmful species in the donor port, for which the only vector of dispersal and means of overcoming a natural barrier is the ballast water or sediment, and for which environmental conditions and species-specific risk assessment indicate high risk of dispersal, an exemption should not be granted."

Comment: This statement and approach are considered in the species-specific RA for Baltic Sea (see 4.4.1) and by the RA model (see 4.5).

3.2.4 DECISION MAKING

"For a species-specific risk assessment, an assessment should be deemed high risk if it identifies at least one harmful non-indigenous or cryptogenic species that satisfies all of the following:

- *likely to cause harm (potential to become invasive in the recipient port)*
- *present in the donor port or surrounding area*
- *likely to be transferred to the recipient port through ballast water; and*
- *likely to survive in the recipient port."*

Comment: All this is considered in the species-specific RA for Baltic Sea and is included the target species selection criteria (see 4.4.1).

Second paragraph, before last sentence

"Clear indication of information, which might be relevant to the risk assessment but cannot be obtained, should be made."

Comment: The critical point of RA is to have reliable data. In the case of this Baltic Sea study it was recognised that there is no reliable data on species present in ports areas, which are the basic information required for the RA (*i.e.*, donor and recipient environments). Hence it is suggested that port baseline surveys are conducted and monitoring introduced in ports planned to be included in Baltic Sea RA. This could include also more detailed capturing of relevant abiotic parameters. **Due to the unavailability of reliable data no BWM exemption could be recommended** (see relevant report chapters below).

Second paragraph, last sentence

"An independent peer review (by independent third party) of the risk assessment method, data and assumptions is recommended to be undertaken."

Comment: This study covers this.

3.2.5 EXPLANATORY NOTES

"The IMO Risk Assessment Guidelines G7 suggest that the three approaches could be used either individually or in any combination. Information from risk assessments carried out for oceanic voyages (GloBallast Risk Assessment 2004, Leppäkoski, Gollasch 2006) are recommended to be used as a supportive material for Intra-Baltic assessments."

Comment: The mentioned risk assessment approaches were developed before the IMO Guideline G7 Guideline was agreed at IMO. They have a different scope, as well they did not take into account of reliability of data, but relied on the concept of "best available information". For the scope of the HELCOM RA based on the IMO Guideline G7 Guideline for exempting vessel from BWM requirements, **the best available data are not found enough reliable, hence it is not suggested that the HELCOM RA is based upon such data**.

4 APPLICATION OF BWM RA IN THE BALTIC SEA AREA

This chapter contains the options to apply RA to exempt vessels from BWM requirements under the IMO Guideline G7 and HELCOM Guidance.

4.1 BALTIC SEA SPECIFICS

The Baltic Sea consists of a series of sub-basins (Fig. 2). The Baltic is further divided into 60 smaller sub-regions. For these sub-regions an inventory of alien species exists which was used in this risk assessment study report. This is addressed further below in the case studies.

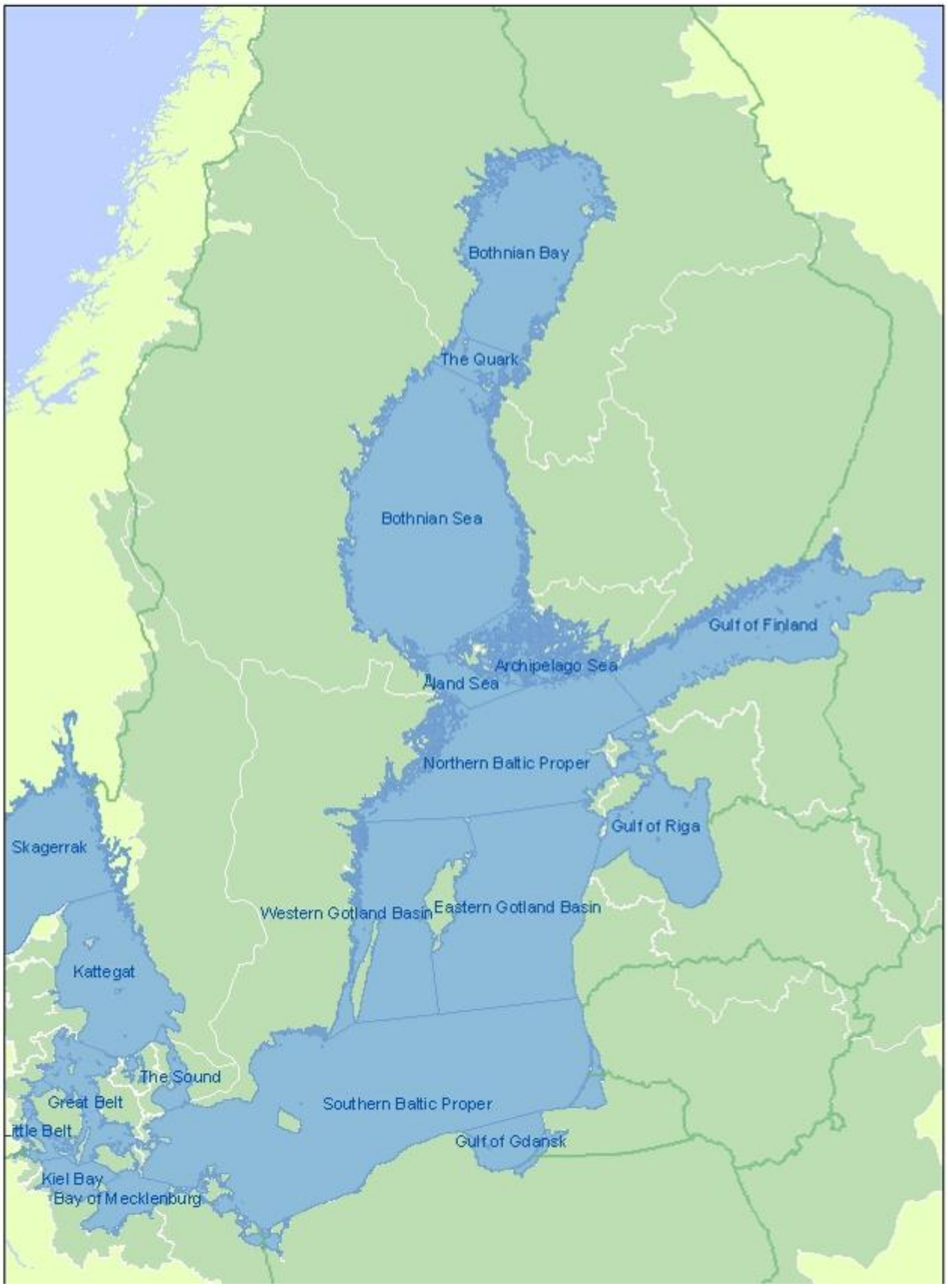

Fig. 2. The Baltic Sea sub-basins (www.helcom.fi/environment2/nature/en_GB/facts).

4.1.1 GRADIENTS

One of the Baltic Sea characteristcs are the gradients of abiotic factors, and in particular the salinity gradients from SW to NE and N (Fig. 3). The presence of both horizontal and vertical gradients makes the Baltic an interesting field laboratory for the study of species spread and bioinvasions. These gradients provide alien species of different origin an extended repertoire of hospitable abiotic conditions within a salinity range of up to > 20 PSU. For example, in the 400 km long Gulf of Finland, salinity increases gradually from almost 0 PSU at the surface in the easternmost basin to > 11 PSU at the bottom of the entrance area. Consequently most highly euryhaline and eurythermal species are potential invaders.

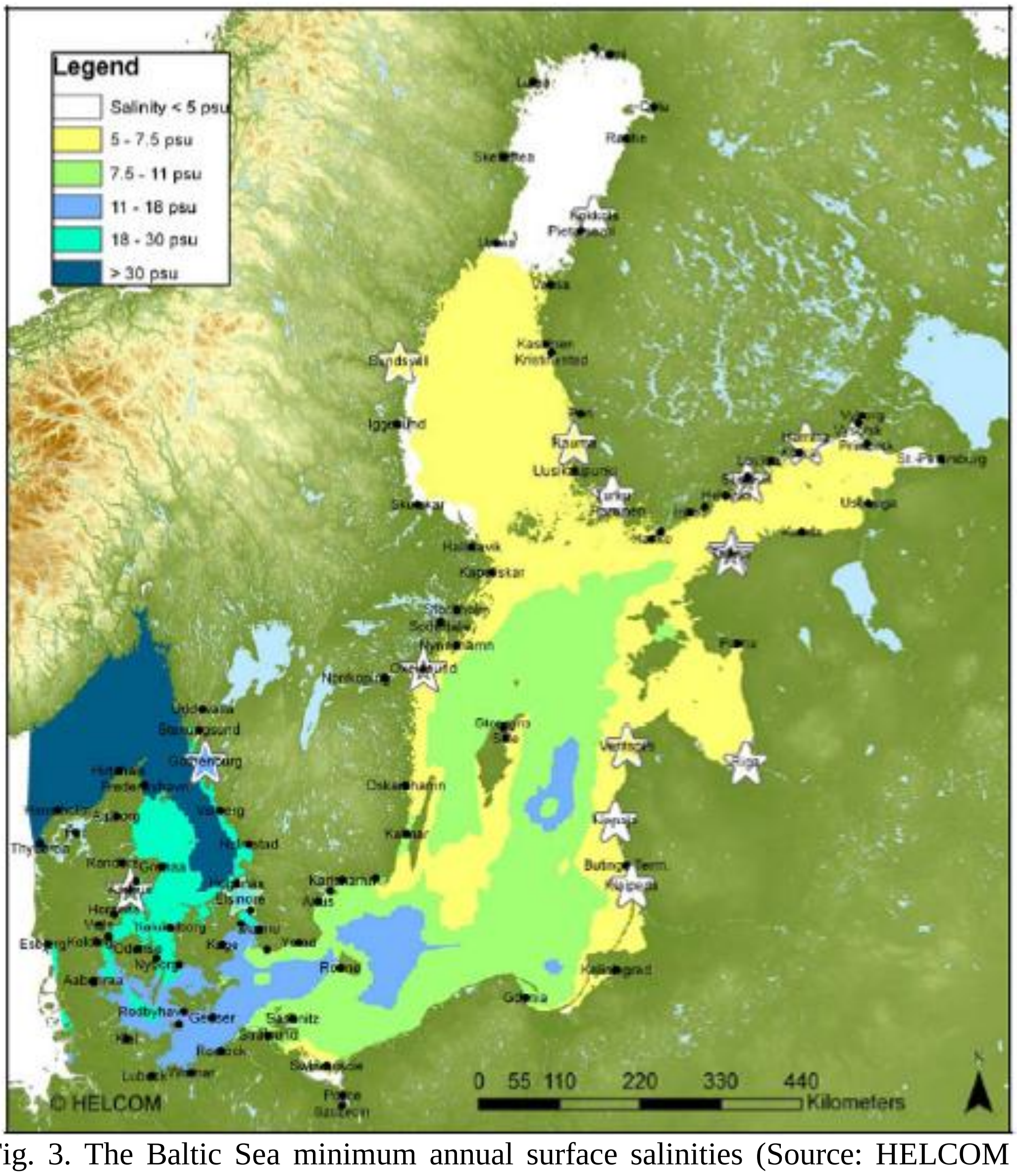

Fig. 3. The Baltic Sea minimum annual surface salinities (Source: HELCOM MARITIME 8/2009).

4.1.2 SECONDARY SPREAD

Within-the-sea dispersal of species appeared to be rapid as demonstrated, *e.g.*, by the recent dispersal history of the most successful invaders. Once transported with man's aid over physical and ecological barriers into an ecosystem, the secondary spread may be easy for aquatic species as water movements (Fig. 4; 4.1.3; Annex V) facilitate dispersal and fewer dispersal barriers may occur (Lodge *et al.* 1998).

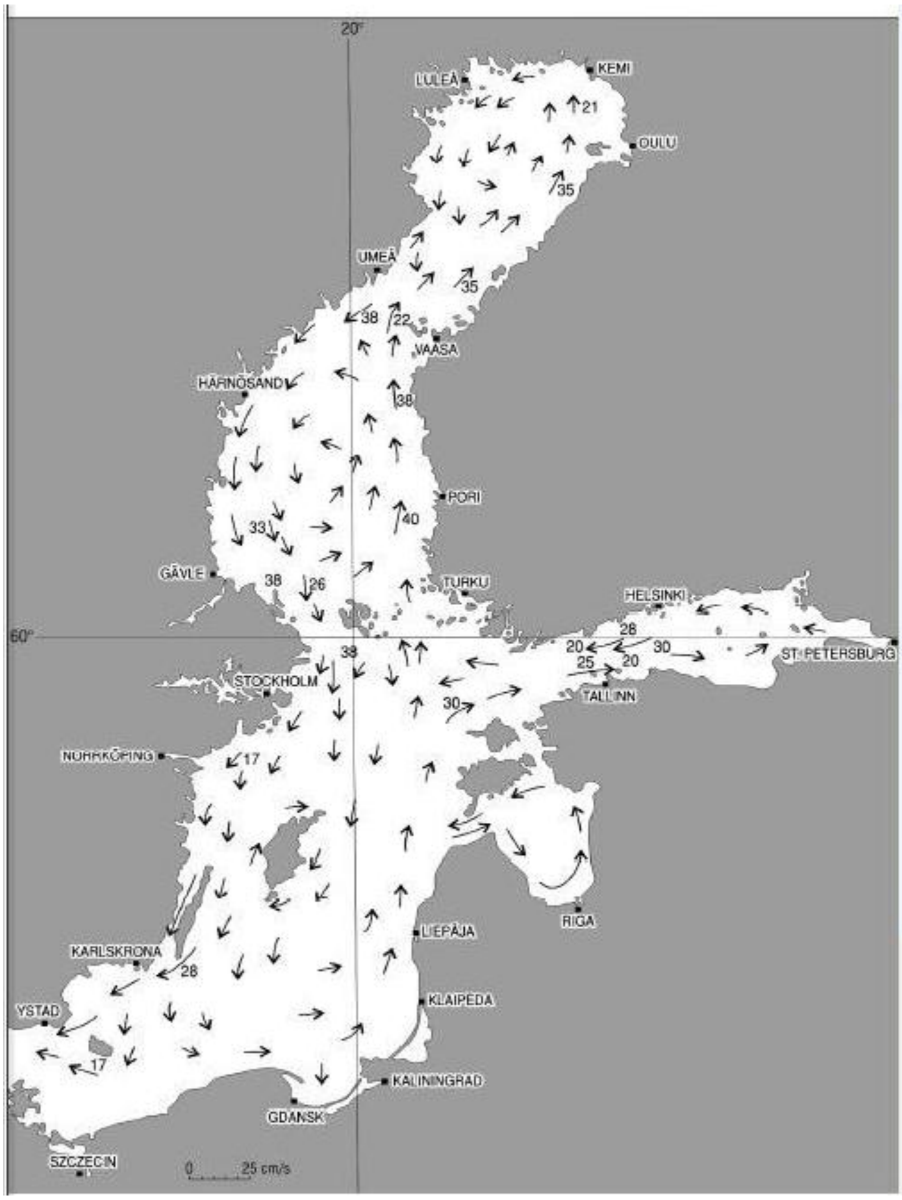

Fig. 4. Surface water currents (from Leppäranta, Myrberg 2009).

4.1.3 SPECIES' ABILITY TO SPREAD WITHOUT HUMAN ASSISTANCE

Natural spread of aquatic species depends on several factors such as (i) recruitment strategies (does the species produce planktonic larvae or other floating propagules or not), (ii) time and timing (duration of larval stages in the water phase, seasonality (larvae present or not in loaded ballast water, abundance of them), (iii) prevailing current conditions (direction, velocity, persistency), and (iv) presence of environmental barriers (*e.g.*, low temperature, steep salinity gradients between donor and recipient ports) (see Annex V).

***Reproductive strategies*.** Due to different modes of reproduction (budding, embryos carried in a brood pouch, bottom-living larvae, planktonic larvae, etc), life forms and habitats (free water, shallow/deep water, soft/rocky bottom, parasitic life, etc), not all species are equally available for ballast-mediated transportation. Therefore, the species were classified according to their life cycle and potential to be spread with ballast water. Annex V (Table 1) includes the alien species listed on the HELCOM list of non-indigenous, cryptogenic and harmful native species[7], the salinity tolerance of which is known[8]. A planktonic life form or larvae as a part of the life cycle is no prerequisite for organisms being transported with ballast water nor a straightforward criterium helping decision-makers to distinguish between species to be transported with ballast water or not. There are several groups of organisms, which as adult individuals or juveniles can be loaded with ballast water, among them crustacean species that are known to have traveled in ballast tanks (or in some cases and/or as fouling organisms outside the hull).

***Seasonality – larvae present or not*.** In a preliminary search, data on wintertime abundances for zooplankton were found for the Finnish, Estonian and Latvian coastal waters. Abundances of bacterioplankton, phytoplankton and zooplankton were reported for Klaipëda (LT) harbour area in 1995-1996. In Estonian coastal waters, abundances of water fleas (Cladocera) were very low in spring and autumn months but rather high for Rotifera and Copepoda. In no cases the abundances (even if very low compared with those during the growing season), were low enough to meet those organism standards as stated in Regulation D-2 of the IMO Ballast

[7] www.helcom.fi/stc/files/shipping/Version2_HELCOM%20lists%20of%20non-indigenous,%20cryptogenic%20and%20harmful%20native%20species%20and%20HELCOM%20target%20species.pdf
[8]http://meeting.helcom.fi/c/document_library/get_file?p_l_id=18816&folderId=1240906&name=DLFE-42563.pdf

Water Management Convention.

Duration of larval stages. The larval development is temperature and salinity dependent and therefore possibly of longer duration for marine species in the Baltic Sea than in, e g., the East Atlantic conditions. The results of studies of North American or other remote populations cannot be applied directly to the populations in the Baltic, which can differ not only in the timing of the reproductive season, but also in the duration of larval development. Some international examples of which are presented in Annex V. For instance, larvae of the red gilled mud worm *Marenzelleria* spp. stay in plankton for 4-12 weeks, those of the softshell clam (*Mya arenaria*) and the bay barnacle (*Balanus improvisus*) for 2-5 weeks.

Prevailing current conditions. The mean surface circulation in all sub-basins of the Baltic Sea is cyclonic (see Leppäranta, Myrberg (2008) for a comprehensive discussion). Alien species discharged with ballast water at a SE Baltic port will be transported by currents northward and, in similar way, westward from a port in southern Sweden (Fig. 4). The overall pattern is, however, largely modified by the broken shoreline in particular in the northern part of the Sea (Finnish and Swedish coasts) and by forcing functions (winds and atmospheric pressure gradients), which cause water level fluctuations. Due to instability of the currents, the counter-clockwise mean circulation is more a statistical property than a constant phenomenon (Alenius *et al.* 1998, Elken *et al.* 2011).

There seems to be scattered information only of currents in coastal inlets and harbor areas, characterized by quite dynamics. Much of the currents in the semi-enclosed bays and inlets are seesawing, caused by irregular water level fluctuations. Therefore, the **following examples and conclusions are of limited use for real-world assessment** of alien species' ability to spread from one port to another across larger water bodies without any human-introduced vectors, *i.e.*, naturally by means of active swimming or passively with water currents (*cf*. Recommendation 8.1).

In the open Baltic Proper, current speeds are at (mainly) less than 10 cm/s (*i.e.* < 240 km/month) have been observed (Fig. 4). In an experimental study to estimate the potential for *Mnemiopsis leidyi* spread, satellite-tracked drifters were released in the Bornholm Basin (S Baltic) area at 60-85 m depth (Lehtiniemi *et al.* 2011). The drifters resided mainly in the basin, while some of them were tracked 6 months later away in the northern Baltic Proper, at a distance of about 500 km from the point of release. In the Gulf of Finland, the average speed of water particles for the 5-year period of 1987-1991 was estimated at 7 cm/s; the highest speeds occur in the windy period (Oct-March 7-10 cm/s) and the lowest in the calm season (March-May 3-5 cm/s) (Soomere *et al*. 2011). The stability of currents in the Gulf is rather high: the outflow on the northern side of the Gulf is a distinct feature with persistence ranging between 50-80% (Andrejev *et al.* 2004). In summary, taking a surface current velocity at 7 cm/s as an average for the offshore waters of the Gulf of Finland, we can calculate the westward transportation rate for surface water (and organisms with it) at ca 250 m/h = 6 km/24h day = 180 km/month. However, assuming a residual current velocity at *e.g.* 3 cm/s, the transportation rate would be at the level of about 110 m/h, *i.e.*, less than 80 km/month.

Presence of environmental barriers. See the RA part of this report for a discussion.

Conclusions. It is clearly stated in Recommendation 8.3 that the authorities responsible for granting exemptions may reserve a right to exempt ships on specific voyages only if the ability to disperse from donor to a recipient port 'naturally' can be based on **scientifically proven information of high quality** (which is most often totally lacking or exists from remote coasts only) or **reliable expert judgement**). This is **only valid if no other species poses a further threat**. Further, there is very scarce information on e g detailed life histories of (potentionally) harmful species, duration of their pelagic larval stages, details on currents (e g deviations from general patterns of direction, velocity and stability) and, in particular, practically no knowledge of currents (direction, speed and duration) which link the water masses in port basins (including discharged BW) with the currents prevailing outside the harbor areas and in the open sea. A more detailed species spread assessments would only be possible with reliable and geographically more comprehensive data.

4.1.4 ALIEN SPECIES

According to the most recent overviews available in 2011, the invasion status of the Baltic Sea can be summarized as follows. The number of alien species, including cryptogenic species, already present in the Baltic is based upon the HELCOM lists and the Baltic Sea Alien

Species Database (update 25.10.2010[9]). The Baltic Sea is badly and increasingly inhabited (biopolluted) by alien and often very invasive animal species, while the number of alien algae is low. In the Sea, 22 new alien species were recorded during the last 20 years, of which 11 species are known or believed to be introduced by shipping. Total number of alien species recorded is 119 of which 79 species are considered as established ones. The rest (40 species) being unestablished or with unknown status have been excluded in this report. The majority of all alien species recorded belong to zoobenthos (43), fish (29, of which 8 only are known as established species), and macroalgae (12), followed by zooplankton (8) and phytoplankton (6).

It is interesting to note that a higher number of alien species are found towards both, freshwater and more marine conditions, but not in the brackish central Baltic waters (Fig. 5). This follows Remane´s species minimum concept (Remane 1934, Paavola *et al.* 2005), which was originally based upon native species.

[9] www.corpi.ku.lt/nemo/mainnemo.html

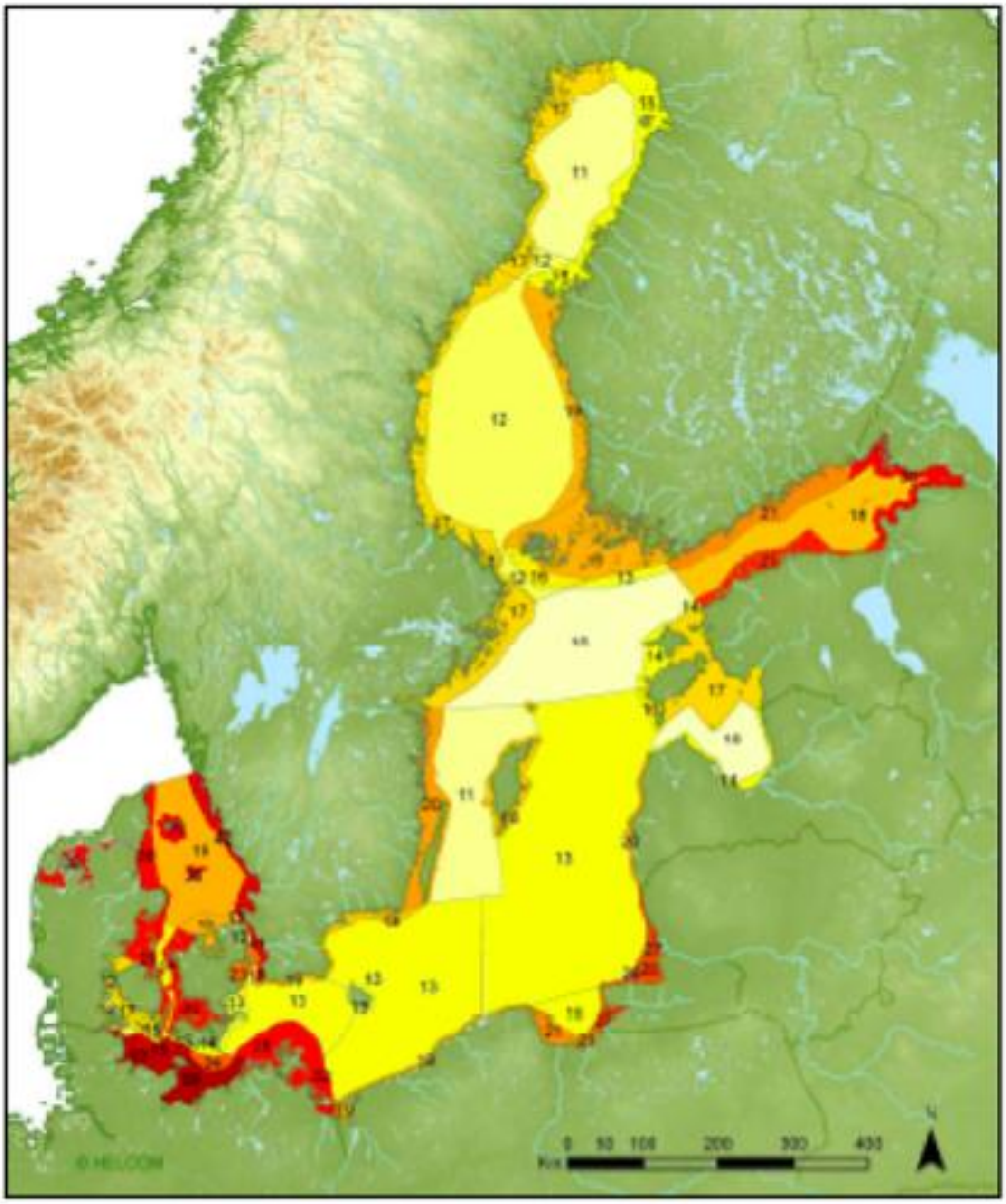

Fig. 5. Number of alien species according to Baltic sub-regions (Source HELCOM: MONAS, 12-2009, document 7/4).

4.1.5 ORIGIN

In this chapter, the arrival history of alien species already present in the Baltic is briefly reviewed in order to see whether the biogeographical origin of these species could have any predictive value for study of intra-basin (secondary) spread of newcomers now and in the future.

History of the Baltic biota differs fundamentally from that of the area outside the Baltic. Here faunal and floral elements of different origin have been mixed during the past 10 000 years of its post-glacial history. In their classic reviews Ekman (1953), Segerstråle (1957) and Zenkevich (1963) distinguished the following main components of the Baltic fauna: (i) North Atlantic boreal marine fauna, (ii*)* Arctic relicts, (iii) brackish water species of North Sea origin, (iv) brackish water species of Sarmatian origin, and (v) freshwater species. Here the recent Sarmatian element typically represents intra-continental alien species native to the Ponto-Caspian basins (the Black and Caspian Seas, the Sea of Azov and their catchment areas) that have spread and become established in watersheds of inland Europe and the Baltic Sea (see, *e.g*., Leppäkoski, Olenin (2001) and Gollasch *et al*. (2009) for reviews). The globalization of the Baltic Sea biota has continued. Screening of HOLAS[10] and Baltic Sea Alien Species[11] databases revealed 93 alien species with known or estimated area of origin (approx. 40 of them being ship-mediated). Of the more than 90 species, 24 are native to the Ponto-Caspian seas or rivers. In total, there are species originating from 16 LME's (+ inland Asia/Siberia) represented among the recent Baltic Sea fauna and flora. This is a minimum estimate: for most species, their native range has not been described in detail. *E.g.* "Atlantic coast of North America" or "Western Pacific" cover several bioregions.

A bioregion (or biogeographical region) has been defined, *e.g*., as *an area constituting a natural ecological community with characteristic flora, fauna, and environmental conditions and bounded by natural rather than artificial borders*; www.thefreedictionary.com). The present state of the Baltic Sea belongs to one marine bioregion (Eastern Atlantic Boreal, *sensu* Watling and Gerkin (http://marine.rutgers.edu/OBIS/index.html) based on Briggs (1953) and Springer (1982) that covers all of the Baltic Sea, the Norwegian coast, the North Sea and Icelandic waters. This bioregion streches from the fully marine (even Arctic) seas to coastal inlets of the brackish Baltic Sea. Such a huge unity may be usable as a tool for, *e.g*., planning purposes but does not reflect any degree of similarity of abiotic and biotic conditions. The concept of bioregion simply does not fit in this case.

Based on the multitude of known or potential origins of ship-mediated aliens, our conclusion is that the biogeographical risk assessment does not provide any indication of the potential of

[10]Holistic assessment of the Baltic marine environment, including a thematic assessment of hazardous substances (HELCOM HOLAS). http://www.helcom.fi/projects/Archive/en_GB/HOLAS/
[11] www.corpi.ku.lt/nemo/alien_species_directory.html

alien species to be transferred with ballast water into the Baltic Sea, to get established there and spread with intra-Baltic shipping.

4.1.6 VECTORS

Vectors for intentional introduction of alien species into the Baltic Sea include those for stocking and aquaculture (43), while unintentional introductions have been carried by ships (54) or associated with intentional ones (12) ; for 10 species the vector remains unknown (Baltic Sea Alien Species Database 2010).

4.2 SECONDARY *VS*. PRIMARY INTRODUCTIONS

This report is focussed on the RA of species movements (*i.e.*, primary or secondary introductions) with ballast water within the Baltic Sea region as defined in paragraph 4.4. A primary introduction is a movement of a species between different bioregions, *e.g.*, from Japan or North Sea to the Baltic Sea. A secondary introduction in this case would than be a movement of this species inside the Baltic Sea, *e.g.*, from the German Baltic Sea coast to Finland.

The ports in which ballast water from other bioregions is being discharged can be considered as major hubs for secondary introductions of harmful species, within the bioregion. For example, should a harmful species from outside the Baltic Sea region become established in a Baltic hub port (*e.g*. Gothenburg or Copenhagen) (primary introduction) it can than be spread by ballast water to all ports with shipping routes where ballast is transported and discharged. It should be noted that when shipping routes exist between ports this does not necessarily reflect the risk situation as ballast water transports and discharge is the risk assessment indicator, *i.e.*, a ship may sail to a port but not discharge ballast water, or sail between ports and discharge just in some. This is why ballast water discharge pattern needs to be studied. Whether or not the species may become introduced in these ports (secondary introduction) needs to be evaluated, as ports inside a region may be similar enough to support this (*e.g.*, transfer among marine ports inside a bioregion), or these may be different to a certain degree to still support this or not (*e.g.*, transfer between marine and brackish or freshwater ports).

4.3 IDENTIFICATION OF THE AREA

As the application of different RA methods used are inherently related to biogeographical areas, it needs to be identified what covers the study area (Baltic Sea).

Various concepts exist to divide the world's oceans into bioregion and after considerable discussions[12] the IMO recommends the use of Large Marine Ecosystems (LME, see *e.g.*, http://www.edc.uri.edu/lme/) for risk assessment based exemptions from ballast water management requirements. LMEs are relatively large regions that have been defined according to continuities in their physical and biological characteristics. For the RA this means that ports inside each LME have high biological similarity and environmental compatibility, but ignores the salinity differences as the LME concept focuses on marine waters. However, the salinity differences are a key feature in the Baltic and therefore the LME concept cannot fully be applied. Therefore, the HELCOM limits of the Baltic were considered for this study (see also chapter Baltic Sea specifics) (Fig. 2).

4.4 WHICH RA METHOD TO APPLY IN THE BALTIC SEA?

For this report the focus was laid on species movements within the same biogeographical region, *i.e.*, inside the Baltic Sea, which is considered to be one bioregion. Therefore the IMO Guideline G7 biogeographical approach, which is aimed to undertake a RA between two or more bioregions, is rendered useless (see 4.1.5).

Any risk assessment may operate at two levels: (i) the environmental matching approach is used (in a global context) if the source and destination ports are located in different bio-regions. In the case that the source and destination ports are in the same bio-region (*i.e.*, in the

[12] on the basis of the WGBOSV meeting report (ICES WGBOSV 2005) and in line with the IMO Guidelines G7 on RA (MEPC 2007).

Baltic Sea context), it is assumed that environmental conditions are similar, hence (ii) species-.specific risk assessment is needed.

Nevertheless, ports in the same area may have very different environmental conditions. In the Baltic Sea the ports may be located in areas with different salinities and differences in other environmental conditions. This suggests that at least salinity regimes should be considered as an essential RA factor among Baltic Sea ports.

4.4.1 SPECIES-SPECIFIC ASSESSMENT IN THE BALTIC SEA

In most risk assessments the species-specific approach has been based upon so called **target species** (see above). A **target species** per IMO definition is a “species identified by a Party that meets specific criteria indicating that they may impair or damage the environment, human health, property or resources and are defined for a specific port, State or biogeographic region" (IMO Guideline G7).

The target species approach was considered useful as a risk assessment component for shipping routes between biogeographical regions, *i.e.*, to avoid primary species introductions. This risk assessment study focuses on intra Baltic Sea shipping routes inside the same biogeographical region. Therefore the target species approach is limited to the secondary spread of earlier introduced species.

Knowledge on the presence of harmful species, including target species, in Baltic Sea ports would enable a risk assessment evaluation for the secondary spread of such species. However, such reliable data, *i.e.*, port baseline surveys and monitoring for harmful species, are not available. It is obvious that alien species are only occasionally registered in the continuous biological monitoring programmes. For instance, a recent review (Ljungberg *et al.* 2011) of data on alien species produced by regular programmes run in the Finnish coastal and sea areas revealed that one third of all known alien species have never been detected in the programmes, and the existing monitoring data gives a fair picture of only a few species' distribution. The programmes cover phyto- and zooplankton, bottom-living invertebrates, macroalgae, aquatic seed plants, and fish. Three species only (out of 24 established aliens in the Finnish Baltic Sea) were classified as being well represented in monitoring studies: the North American polychaetes *Marenzelleria* spp., the New Zealand mud snail *Potamopyrgus antipodarum*, and the Ponto-Caspian fishhook waterflea *Cercopagis pengoi*. A large share of the alien species sightings have been made in projects and individual studies that are not part of the regular monitoring, such as the study of macroinvertebrates on soft and hard bottoms in four port areas along the northern coast of the Gulf of Finland (Naantali, Koverhar, Porvoo, Hamina; Paavola *et al.* 2008).

Further, there are very few regular monitoring programmes targeted on alien species occurring in harbour areas. For the major Estonian ports and/or adjacent waters, operational monitoring (focused on phytoplankton, phytobenthos and macrozoobenthos) is carried out in four waterbodies: Narva-Kunda Bay, Muuga-Tallinn, Haapsalu Bay and Pärnu Bay (Anonymous 2011). Here the monitoring strategy is based on the requirements of the EU Water Framework Directive and the overall aim is to survey the ecological quality of coastal waters.

Further, it may be argued that the harmful species, as they have been introduced already by a vector into the region, may spread by their own means across the Baltic Sea. This may be the case when a suitable environment for these species occurs in larger dimensions (no natural migration barrier), *i.e.*, over longer times the species may colonise this area by its on distributional behaviour and mechanisms (Annex V). However, ballast water movements of such species would speed up the distribution considerably which should be avoided. Further, should toxic algae become introduced in one of the Baltic Sea ports the spread of such should be avoided by all means. Even if management measures (only) slows down the spreading of these species, this time lag of occurrence may enable appropriate management measures to secure the industry at risk, *e.g.*, aquaculture facilities could harvest their products before arrival of such a species.

Some of the major Baltic Sea ports (*e.g.*, St. Petersburg and north Finnish ports) are uniquely located in almost freshwater. In contrast to other seas the Baltic does not have a port located in fully marine conditions. The salinity gradient in the Baltic stretches from freshwater in the northernmost and easternmost parts to higher brackish conditions in the west (Fig. 3). It will not be possible for harmful species when introduced in these freshwater environments to spread from one of these ports to the others as the more marine waters between them will likely prevent the spread by natural means. It is further unlikely that marine species will colonize the freshwater ports and vice versa.

Another scenario where a species-specific risk assessment delivers a risk evaluation between two ports within the same sea applies to marine species, which have a very short larval time, or no planktonic larval stages at all (see 4.1.3, Annex V), or otherwise have limited natural means to spread. Even if the waters surrounding the area the harmful species has colonised, its slow spreading potential will result in a long time for the species to colonize the entire potentially suitable area. If such a species is than transported by vessels the spread is considerably promoted which increases the impact of such a species.

In general target species are defined by agreed criteria, which are outlined in the following section. Those species are especially undesirable to be introduced into the Baltic Sea, as well as being transferred among Baltic Sea ports. The presence/absence of target species will determine the risk level and based on this whether or not an exemption can be granted.

Which species are successful invaders, *i.e.*, target species?

The IMO definition says that **target species** are species identified by a Party that meet specific criteria indicating that they may impair or damage the environment, human health, property or resources and are defined for a specific port, State or biogeographical region. Thereby IMO does not distinguish between target species which were already introduced or which one wants to avoid to become introduced in the future. As this study report focuses on intra-Baltic shipping target species can only be identified from native, cryptogenic or already introduced harmful species, *i.e.* target species not yet being found in the Baltic are not addressed. However, the same target species selection criteria may apply to both.

For the purpose of this study, based upon the IMO definition in the IMO Guideline G7, all following factors will be considered when identifying target species, but not be limited to:

- evidence of prior introduction; *i.e*. thereby the species shows its capability to become introduced outside its native range;
- potential impact on environment, economy, human health, property or resources;

• strength and type of ecological interactions, *i.e.* severeness of its impact;

• current distribution within the biogeographic region and in other biogeographic regions;

• relationship with ballast water as a vector, *i.e.*, was the species already found in a ballast tank or has a larval phase which makes a ballast water transport likely (see 4.1.3).

For the intra-Baltic approach, as considered in this study, the target species selection process starts on all harmful species that are present in the donor and recipient ports and their surrounding areas in the Baltic Sea.
For future risk assessments all newly introduced species are to be evaluated according to the target species selection criteria.

4.4.2 ENVIRONMENTAL MATCHING COMPONENT

The environmental matching approach uses environmental parameters instead of using species. The two most frequently used environmental parameters are water temperature and salinity; however the latter is the only parameter that is common to all. This actually reflects the difficulties and uncertainty while using other or too many parameters. Given the lack of knowledge already mentioned, the assignment of influence (*i.e.*, weight) to each of the parameters becomes very difficult or even impossible. Furthermore, the more variables there are, the less transparent becomes the decision process. In light of this, salinity seems to offer the most “straight forward” way. However, also the use of salinity shows its weakness when two ports may have totally different salinity ranges and the RA result will be low risk, but the species salinity tolerance may cover both environments (Hewitt, Hayes 2002, Hayes, Sliwa 2003). Considering all this, **salinity was decided to be the only reliable environmental parameter used in this RA**.

The minimum salinity difference to assume a low risk of species transfer was agreed and this will be done in a two-step approach. A low risk is assumed when ballast water is moved between freshwater (< 0,5 PSU) and fully marine conditions (> 30 PSU). Such a situation does not occur in the Baltic and would also be rare when including North Sea ports as most ports are located in river mouth areas with lower salinities. The salinity aspect was addressed by considering the Venice system (Table 1), which is also in-line with the EU Water Framework Directive.

Table 1. The Venice salinity system (Venice System 1959).

Zone	**Salinity [PSU]**
Hyperhaline	> ±40
Euhaline	±40 - ±30
Mixohaline	(±40) ±30 - ±0,5
Mixoeuhaline	> ±30 but < adjacent euhaline sea
(Mixo-) polyhaline	±30 - ±18
(Mixo-) mesohaline	±18 - ±5
(Mixo-) oligohaline	±5 - ±0,5
Limnetic	< ±0,5

4.4.3 COMBINED ENVIRONMENTAL AND SPECIES –SPECIFIC APPROACH

As such conditions would not be applicable to intra-Baltic shipping other possibilities were discussed, and it was agreed that it may be still acceptable, although posing a bit higher risk, when ballast water is moved between freshwater ports and brackish ports with salinities higher than 18 PSU, in which case a species-specific approach would be also required especially considering the species that have known higher salinity tolerance than < 0,5 PSU and > 18 PSU (see below). Should such species occur in only one of considered donor ports a low risk cannot be assumed. Further, should both the ballast water donor and recipient regions have the same high salinity tolerant species, but they occur in much different densities, a low risk indication needs to be evaluated on a case-by-case study.

The "freshwater to fully marine approach" is seen as a better risk reduction measure as only very few species are able to tolerate such a wide salinity difference. Examples of such species may be found further below. In consequence, the "freshwater (< 0,5 PSU) to marine water (> 30 PSU) approach" provides a general acceptance for no ballast water management (no species-specific assessment needed), while the “freshwater (< 0,5 PSU) to brackish water (> 18 PSU)” is a combined approach with species-specific considerations (*i.e.*, high salinity tolerant species).

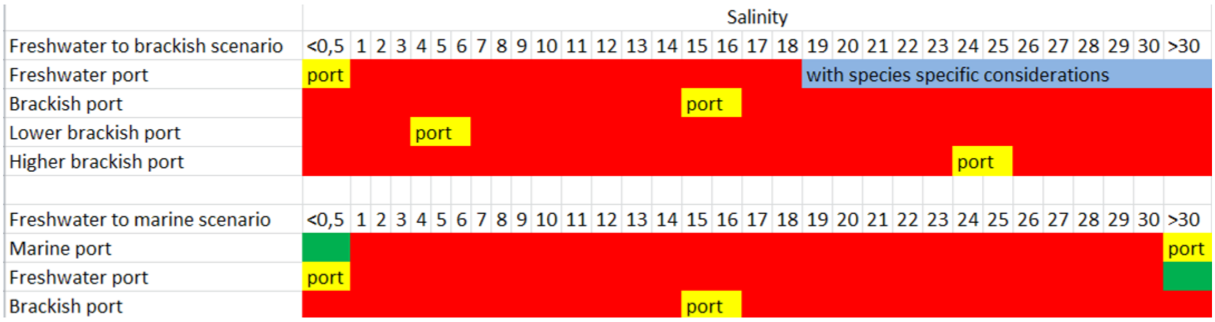

Fig. 6. Port (yellow) to port risk comparison, low risk indication (blue and green) and high risk (red). Top = freshwater (< 0,5 PSU) to brackish water (> 18 PSU) approach, low risk only indicated when addressing a species-specific consideration on high salinity tolerant species. Bottom = freshwater (< 0,5 PSU) to fully marine conditions (> 30 PSU) approach = environmental mismatch. Ballast water movements between brackish water ports cannot be exempted.

4.4.3.1 High salinity tolerant species

High salinity tolerant species are those species, which tolerate a very wide salinity range. Examples of such species may be found in Annex III of document 7/5 of 29.10.2009 submitted to HELCOM MARITIME 8/2009. This list states all known salinity tolerances of non-indigenous and cryptogenic species in the Baltic. The majority of the species listed show the tolerance between lower and higher brackish water salinities, but do not extend the tolerance to freshwater (< 0,5 PSU) and/or fully marine (> 30 PSU) conditions. Table 2 shows the 19 species, which tolerate freshwater (< 0,5 PSU) to brackish water (> 18 PSU) or fully marine conditions (> 30 PSU). Only one alga is known in this category, the phytoplankton species *Gymnodinium catenatum*. The widest tolerance in invertebrates shows *Cordylophora caspia* and in fish *Oncorhynchus* spp. *Oncorhynchus* spp. were not considered in detail as several Pacific salmonids were intentionally introduced last century but never established reproducing stocks (listed with a salinity tolerance ranging from freshwater (< 0,5 PSU) to fully marine conditions (> 30 PSU)).

Table 2. Grey fields show Baltic alien or cryptogenic species, which tolerate freshwater (< 0,5 PSU) to brackish water (> 18 PSU) or fully marine conditions (> 30 PSU). Based on Annex III of document 7/5 of 29.10.2009 submitted to HELCOM MARITIME 8/2009. The likely introduction vector also indicated: AC = aquaculture, BW = ballast water and HF = hull fouling.

	Salinity																																Vector
Species	<0,5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	>30	
Cordylophora caspia																																	HF
Eriocheir sinensis																																	BW
Gammarus tigrinus																																	BW
Mytilopsis leicophaeta																																	HF
Potamopyrgus antipodarum																																	BW
Anguillicola crassus																																	AC
Marenzelleria arctica																																	BW
Ctenopharyngodon idella																																	AC
Huso huso																																	AC
Mugil labrosus																																	AC
Acipenser gueldenstaedti																																	AC
Acipenser stellatus																																	AC
Oncorhynchus clarki																																	AC
Oncorhynchus keta																																	AC
Oncorhynchus mykiss																																	AC
Oncorhynchus nerka																																	AC
Oncorhynchus tshawytcha																																	AC
Salvelinus fontinalis																																	AC
Gymnodinium catenatum																																	BW

4.5 RA MODEL FOR GRANTING BWM EXEMPTIONS IN INTRA-BALTIC SHIPPING

4.5.1 RA FRAMEWORK

4.5.1.1 Data reliability

It is absolutely critical to have reliable input data for the RA process as the decision taken has cost and legal consequences. However, there are known uncertainties, unpredictable stochastic events, as well as lack of knowledge and data, which all characterises the introductions of harmful species via ballast water. Therefore, to keep the selective BWM (*i.e.*, BWM based on RA) effective as much as possible, **the precautionary principle**[13] **needs to**

[13] Communication from the Commission on the Precautionary Principle, Brussels, 02.02.2000

be applied as a fundamental principle[14] **in this RA process** (EU Commission 2000, MEPC 2007).

The critical issues identified regarding knowledge and data needs for RA are:

- lack of data on harmful species presence in ports (*i.e.*, source environment);
- lack of knowledge on the voyage survival of species;
- lack of knowledge on their possible behaviour in the new environment.

There have been relatively few studies (*i.e.*, baseline surveys) conducted around the world that have focused on collecting data on the presence of harmful species in ports and surrounding environments; *i.e.*, >100 port baseline surveys in over 19 countries (Campbell *et al*. 2007) which cover only ca. 1 % of the more than 9,400 ports in the world (Lloyd's Register 2007). In the Baltic Sea region no such biological port baseline surveys were undertaken yet. In fact, the knowledge on cryptogenic and alien species in Baltic ports is limited. The HOLAS list of such species is the best dataset available. Here, alien and cryptogenic species presence and absence is presented for the 60 Baltic subregions. Considering the location of the ports selected in this risk assessment (see below) a port specific knowledge on such species is limited. As an example, the Port of Kiel is located in subregion 50 which stretches along the German coast from Fehmarn Island to Denmark. Any species found in this region would then be included for the entire subregion without enabling to identify the species relevant for the RA of the port of Kiel. Therefore, most available biological data relies on studies of indigenous species in their native environments. This data is especially important when a BW source port is in a different region (*i.e.*, biogeographic region) or subregion (of the Baltic) than the receiving one.

Introductions of new harmful aquatic species occur almost every day, which was also proven by different studies around the world (*e.g.*, Carlton 1985, Williams *et al*. 1988, Macdonald, Davidson 1997, Gollasch *et al*. 2000, 2002, Olenin *et al.* 2000, Carlton 2001, David *et al*. 2007, Flagella *et al*. 2007). For instance, during the ballast water sampling study conducted in the Port of Koper (SI), BW from the same region (*i.e.*, Mediterranean, and mostly Adriatic) contained harmful species, that were not yet recorded in that area or listed in literature (David

[14] In the EU should be implemented when RA concerns environmental and human health protection and in the lack of robust scientific evidence (EU Commission 2000).

et al. 2007). This also leads to a conclusion that a port baseline survey by itself cannot last forever, but should be followed by a monitoring program for harmful species and the full comprehensive port baseline study may further need to be repeated (*e.g.*, Hewitt, Martin 2001). In light of these, **data on a BW source can be considered as reliable only if a baseline survey for harmful species** has been conducted, *e.g.*, in the last year, **and a regular monitoring program for harmful species**[15] **is in place**.

4.5.1.2 Shipping vector factors

A species, to get from a source to a receiving port in BW, first needs to enter the vessel when BW is taken onboard, then survive the ballasting process, survive unfavourable conditions in the tank during the voyage, be discharged and survive the deballasting process (process also so called "chain of events"; *cf*. Fig. Annex I:2). The survival of some species during a voyage was studied (Gollasch *et al.* 2000a, b), as well as the RA model as the chain of events was prepared (Hayes 2000). However, in relation to all the potential species, as well as having in mind their stochastic behaviours (*i.e.*, some species reproduced inside the tank (Gollasch *et al.* 2000a), it can be assumed that this parameter is not robust or reliable enough to be used as a risk lowering factor. In light of these, and applying the precautionary principle, the RA process may **assume that if one species is present in the BW source port it will be discharged alive with BW in the receiving port**.

A high risk is assumed when the ports are connected with high **frequent shipping** lines and further when they are close to each other with short voyage times between them. More frequent ship arrivals from one donor port may increase the risk of more frequent ballast water discharges from that port thereby increasing the likeliness of a species establishment in the recipient port. However, one voyage arrival may already be sufficient to introduce a species.

Short **voyage durations** in general result in higher organism survival during transport thereby also contributing to the risk evaluation. The latter may not be a risk triggering factor in the

[15] The lowest frequency of (x) surveys per (y) time need to be decided upon depending of the target group (*e.g.*, harmful algae, indicator species for pathogens).

region as the voyage durations in intra Baltic Sea shipping are all relatively short with the majority of them being less than one day.

The **quantity of BW discharge** is also one of the factors related to the level of risk. However, considering that also a small quantity of harmful organisms present in the discharged BW may end up in critical consequences, the RA does not relate level of risk to the quantity of discharged BW. Further, should the environmental parameters and especially the salinity mismatch (transport of BW between freshwater and marine environments) the transported species are unlikely to establish populations because they cannot tolerate the salinity difference. This is a qualitative assessment and not seen quantitative, *i.e.*, no matter how much ballast water and no matter how high the number of individuals is, an establishment is unlikely between truly freshwater and marine habitats.

4.5.1.3 Definition of potential impacts

Studies have also proven that organisms even after entering a new environment may not survive, reproduce or cause harm. However, studies of introduction of *e.g.*, the Chinese mitten crab *Eriocheir sinensis*[16] in Europe (Marquard 1926, Panning 1938), *Asterias amurensis* (Buttermore *et al*. 1994, Grannum *et al*. 1996)[17] in Australia and *Dreissena polymorpha* (Hebert *et al*. 1989)[18] in USA and Canada have shown that the process of introduction and species adaptation to the new environment, before causing harm, may last for years. A Baltic example of this phenomenon may be the fishhook waterflea *Cercopagis pengoi.* If a species is not being studied in depth case by case (*i.e.*, for each recipient environment) it is very difficult, if not almost impossible, to predict species behaviour in the new environment with an acceptable reliability. Hence, a prediction of these stochastic events seems impractical and almost impossible.

Based on all these, the precautionary approach for the **RA decision process considers all aquatic non-indigenous organisms as harmful**, and **assumes that all harmful species, if**

[16] The species was first found in 1912 and it took ca. 20 year to develop its first massive migration event in the mid-1930. Since every 15 to 20 years a high and sometimes massive density of crabs is reported

[17] After the first record the sp. was present for approximately five years in the Australian sea in small numbers, and at a certain point the population virtually exploded (Hayes, pers. comm., CSIRO Marine Researches 2003)

[18] Shipping lines existed for decades also before the species successfully invaded the Great Lakes and Mississippi river.

present in the BW source port, if discharged, will cause harm in the receiving environment. Actually this means that already **discharge of BW from a donor port that contains harmful species is an undesirable event**.

4.5.2 RA MODEL BACKGROUND

The grounds and requirements for preparation of a common RA model to be used by all HELCOM States are laid down in the IMO Guideline G7 Guideline.

The need for a common agreed approach/model is stipulated in the 6.5 **Evaluation and decision-making.** The paragraph 6.5.1 requires that "*The port State granting exemptions shall, in both the evaluation and consultation processes, give special attention to regulation A-4.3 which states that any exemptions granted under this regulation shall not impair or damage the environment, human health, property or resources of adjacent or other States. Regulation A-4.3 also states that States that may be adversely affected shall be consulted, and Parties should refer to section 8 regarding consultation.*"

The need for a RA model that is to be made available to applicants for Exemptions is included in the paragraph 7.4 of the **Procedures for granting exemptions,** and stipulates that "*Where a **Party has determined that the shipowner or operator should undertake the risk assessmen**t, the **Party should provide** relevant information, including any application requirements, **the risk assessment model to be used**, any target species to be considered, data standards and any other required information. The shipowner or operator should follow these Guidelines and submit relevant information to the Party.*"

Basically, RA may be conducted by a Party, or the applicant can be asked to do it. Having in mind the above paragraphs, in both cases the Party which receives the application needs to have available a common RA model, as well as all necessary data and arrangements to conduct a RA and grant or not an exemption from BWM requirements.

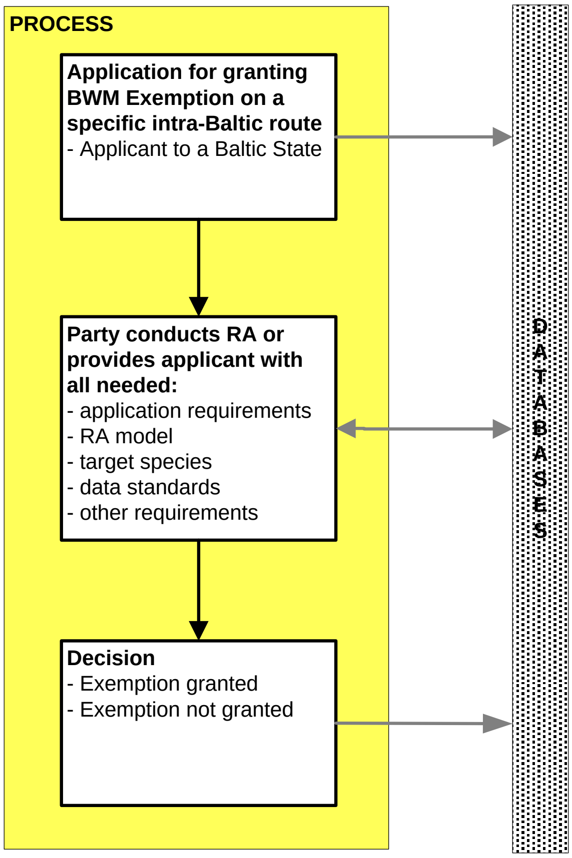

Fig. 7. General process and parties involved in the application for BWM exemptions.

The HELCOM Guidance includes an initial step-by-step model for selecting the appropriate scale for the risk assessment, including environmental conditions and species-specific information, that are to be taken into account (see Fig. 8).

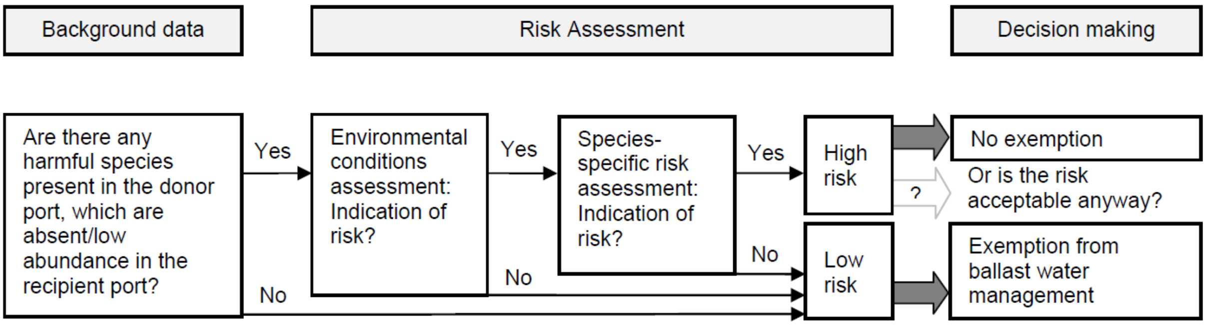

Fig. 8. The HELCOM model addressing background information, risk assessment and the decision making.

The HELCOM model mainly presents the logic of the step-by-step approach. Due to its generic and slightly simplified character not addressing all RA aspects, it can only be considered as a limited RA model for guidance to support granting an exemption. Hence a RA model, for a common approach in granting exemptions in the HELCOM area is being prepared here according to the IMO Guideline G7 and the HELOCOM guidelines.

4.5.3 THE MAIN RA PREMISES

The RA model in the decision making process considers different premises, which are based on best available scientific knowledge and expertise from different fields (*i.e.*, invasion biology, maritime transport, ballast water management, risk assessment, regulatory affairs, environment and human health protection). The premises on which this RA model is based are:

- The input data for the RA must be reliable.
- Biological data can be considered as reliable if a port baseline survey for HAO has been conducted recently, and a regular monitoring program for HAO and P is in place.
- If a species is present in the BW donor port it will be discharged alive with BW in the recipient port.
- The quantity of BW discharged and the frequency of discharges as RA factors are difficult to be defined to a reliable level to change the RA result.
- Salinity is the only enough reliable parameter for the environmental matching RA.
- RA would result in acceptable low risk only if the donor and recipient ports are located one in freshwater (< 0,5 PSU) and the other in fully marine conditions (> 30 PSU).
- If donor and recipient ports are located one in freshwater (< 0,5 PSU) and the other in polyhaline conditions (> 18 PSU), than a combined approach with species-specific RA is needed to consider high salinity tolerant species.
- If the salinity difference between donor and recipient ports is less than between freshwater (< 0,5 PSU) and polyhaline conditions (> 18 PSU), than species-specific RA is needed.

- Species-specific RA should consider non-indigenous, cryptogenic and harmful domestic species to identify target species, and human pathogens.
- The presence of any human pathogens in the donor port means unacceptable risk.
- The presence of any target species in the donor port not yet present in the recipient port, and which could not easly spread to the recipient port naturally, means unacceptable risk.
- The presence of any target species in the donor port and its occurrence in lower abundance in the recipient port, and which could not easly spread to the recipient port naturally, means unacceptable risk.
- The presence of any target species in the donor port also present the recipient port, which could not easly spread to the recipient port naturally, but is under a control or eradication program in the recipient port, means unacceptable risk.

For a species-specific risk assessment, an assessment is deemed **unacceptable risk** if it identifies at least one **target species** that satisfies all of the following:

• likely to cause harm;

• present in the donor port or biogeographic region, but not in the recipient port;

• likely to be transferred to the recipient port through ballast water; and

• likely to survive in the recipient port.

Principles are presented in the model in Fig. 9.

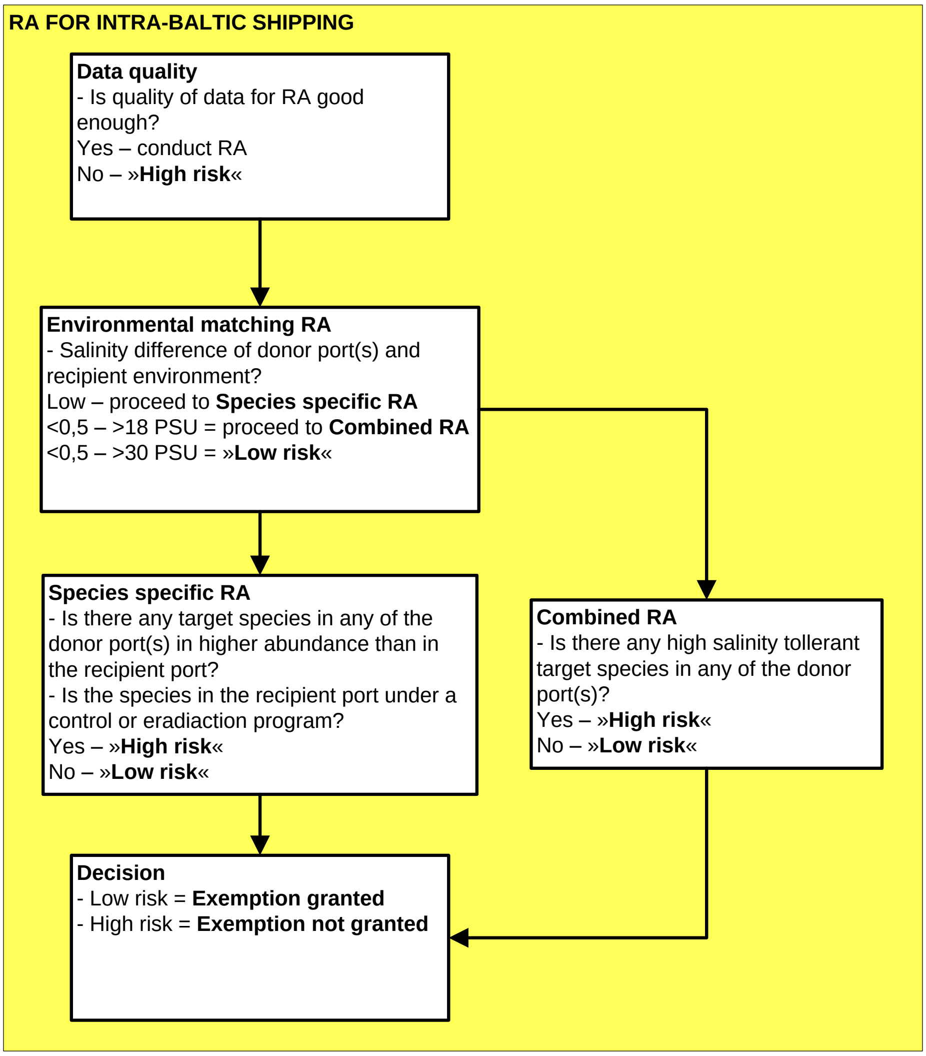

Fig. 9. Basic principles for the intra-Baltic risk assessment.

4.5.4 The RA Model for granting exemptions in the intra Baltic Sea shipping

In the first step the **data reliability** (see 4.5.1.1) is checked to ascertain, that this is at the required level. If the data are not reliable the process ends with unnaccaptable risk. If the data quality is adequate, than the model proceeds the environmental matching RA with verification of the water salinity in the donor and recipient ports. If the salinity is of an acceptable difference, *i.e.*, between freshwater (< 0.5 PSU) and fully marine conditions (> 30 PSU), the process ends with an acceptable risk result (see 4.4.2). If this condition is not met, than the model proceeds to verify if the salinity is of difference between freshwater (< 0,5 PSU) and euhaline conditions (> 18 PSU) (see 4.4.3). If this condition is met than the model proceeds with a species-specific approach, but considering human pathogens and only **high salinity tolerant target species** (see 4.4.3.1). While if none of the environmental (miss)-matching conditions are met, than the process proceeds with a complete species-specific approach, *i.e.*, considering all **target species** (see 4.4.1 and 4.5.3) and human pathogens (see below) The model in the next steps checks if species could **spread naturally** to the recipient port (see Annex 5), if these are already present in the recipient port and in which **abundance** (see below), and if these are under any **control or eradication program**. The RA result depends on answers to all these questions.

For use of this model **human pathogens** were defined as microbes or microorganisms (*e.g.* a virus, bacterium, prion, or fungus) that cause a disease in humans. It should be noted that many human pathogens are difficult to identify in water. Therefore IMO suggested to use "indicator microbes" such as *Escherichia coli* and enterococci and to limit their numbers in ballast water discharges. Although these indicator microbes themselves are usually harmless, natural mutations may result in human diseases, as recently shown with by a strain of bacteria known as enterohaemorrhagic *E. coli* (EHEC), a natural mutation of *E. coli*. Further, the presence of human faecal bacteria like *E. coli* and enterococci in water indicates an unproper wastewater treatment system and the water may consequently also include other more problematic species, such as disease agents. This approach is in-line with the water analysis for bathing water quality. IMO further includes the toxic strains of *Vibrio cholerae*, the agent of the Cholera disease, in this standard.

In the contect of this model **less abundant target species in the recipient port** means a considerable difference in species abundance, *e.g.*, if in the donor port a species occurs with 100 ind/m^2 and in the recipient port with 10 organisms, the recipient port clearly inhabits a less abundant target species. However, should the target species occur in the donor port with 2000 ind/m^2 and in the recipient port with 1500 individuals this can be considered as a comparable abundance. These numbers should give an indication only, but need to be reconsidered as per the species concerned.

The BWM RA model in the form of a flow chart is presented in Fig. 10.

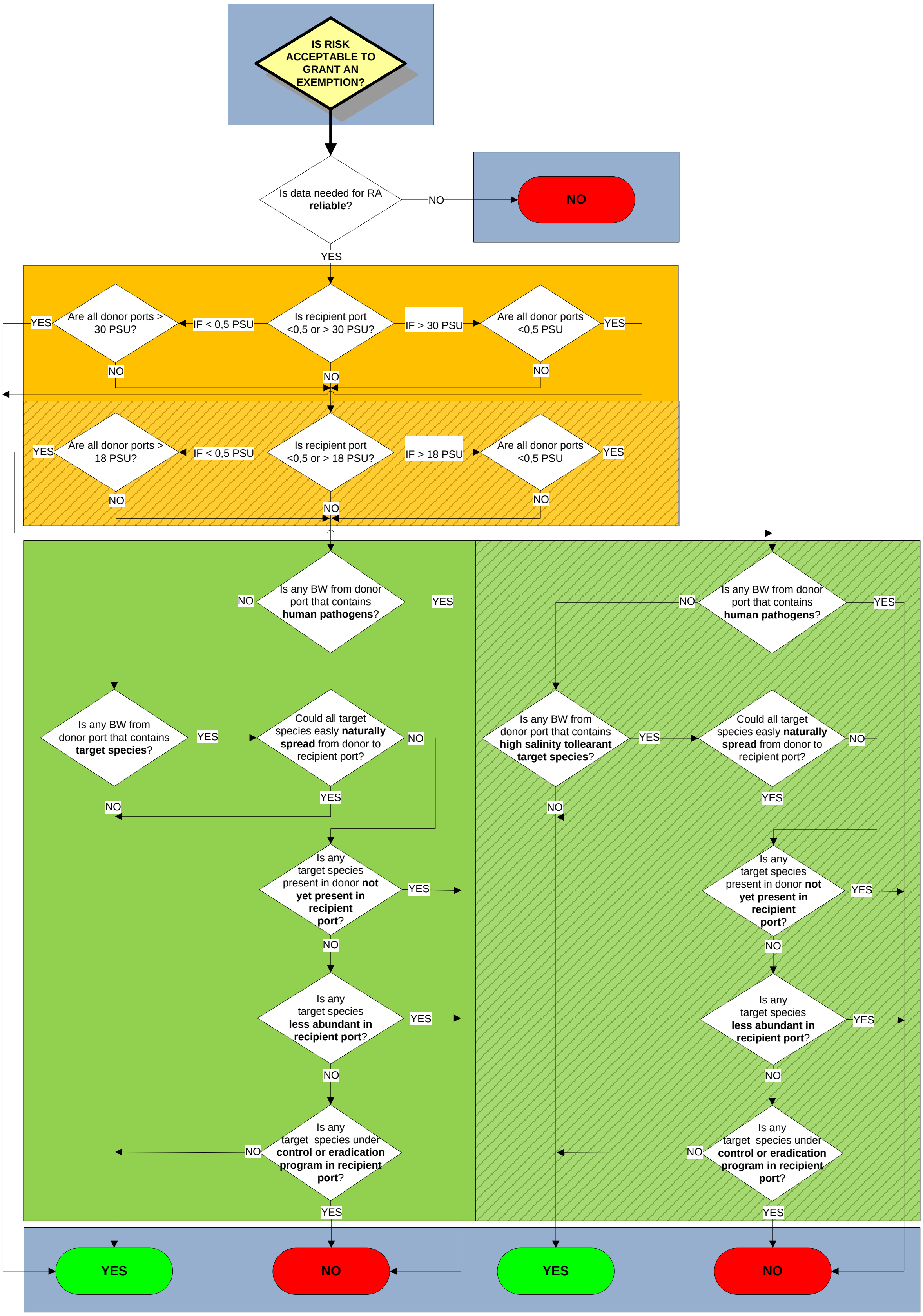

Fig. 10. Intra-Baltic Sea RA Model for granting exemptions from BWM requirements based on the HELCOM RA Guidance and the IMO BWM Convention. The orange box area is the environmental matching RA process, in the green box area is the species-specific RA process, in the shaded area is the combined RA approach, and in the grey boxes areas are decisions.

4.6 PORT SELECTION CRITERIA

The ports for the detailed consideration in this risk assessment were selected based upon the following criteria with the aim to select representative scenarios:

- Baltic shipping pattern
    - Shorter and longer vessel sailing times between ports to address different profiles of local short sea shipping,
    - The ports should be connected with regular shipping activities.
- Baltic cargo pattern
    - Ports with known cargo pattern are to be preferred. However, intra-Baltic cargo documentation is unavailable. At best the total annual cargo turnover per port and summarizing several cargo categories are available, but the cargo origin is usually not documented.
- Similar and different environmental regimes in the ballast water donor and recipient regions
    - The agreed key factor to assess the risk is salinity. Therefore ports with more similar and different salinity regimes were selected.
    - The salinity is usually given as (seasonal or annual) mean values. Should minimum and maximum salinities for the ports be available, such data will be used in the risk assessment.
- Similarity and difference of occurrence of alien, cryptogenic or harmful native species in the ports
    - Crucial is the data availability. The key problem here is the lack of data of alien, cryptogenic or harmful native species for most Baltic ports. Monitoring programmes may be ongoing in most Baltic countries to meet the need as agreed on the European Union level to monitor bathing water quality standards. However, these monitoring programmes only in very rare cases have sampling points in ports. Further, most of such programmes do not list alien or cryptogenic species (*cf.* 4.4.1).
    - A risk assessment should only be undertaken when the data available are appropriate. For a species-specific approach port surveys should be undertaken

to document species of all habitats, *i.e*. plankton, benthos and fouling species. No such study was yet undertaken in Baltic ports.

- In the absence of port surveys, the non-indigenous and cryptogenic species list as provided in a HOLAS document will be taken as a starting point. This list is divides the Baltic into 60 subregions and shows the presence/absence of 114 species including established and unestablished species.

All ports as suggested by HELCOM Countries were considered. When applying the above mentioned port selection criteria and also considering data availability, the following chapter describes the port cases selected for in depth consideration.

Further, a route connecting two Baltic ports was considered with also one port being located in the North Sea:

- Terneuzen (NL) – Mönsterås (SE) –Karlshamn (SE).

Vessels operate on this route in current commercial practice, but not all Baltic ports listed may be called at for each voyage and the order of ports may also change.

4.7 RA FOR SELECTED BALTIC SEA PORTS

For the purpose of this report, it was planned to apply the above outlined RA for the Baltic Sea region on a limited number of ports. As explained above the RA should be route specific and the ports selected here cover different salinity regimes, are different in size and show different shipping patterns.

With the limitations faced, the following case study chapters provide the most comprehensive RA as possible. The key limitations not enabling a more comprehensive RA include:

- limited availability of reliable abiotic data. As suggested the key abiotic risk qualifier is the water salinity. However, discrepancies were found here between the quality of port salinity data according to the HELCOM Questionnaire 2009 and those found in Lloyds Register – Fair-play (2003). Further, seasonal salinity fluctuations are practically unknown. This enabled only a general salinity approach for the RA.

- limited availability of reliable biological data. No biological port baseline studies were undertaken in any Baltic port. Biological monitoring programmes are ongoing in many countries, but they usually lack sampling points in ports.

In the absence of better biological data, the HOLAS alien species list of the 60 Baltic subregions was used to create a simulation of possible RA case studies. This enables a “regional” comparison of alien and cryptogenic species, but not a port specific assessment. As an example, the Port of Kiel is located in sub-region 50 which stretches along the German coast from Fehmarn Island to Denmark. Any species found in this region even if found only with marginal distribution would than be included for the entire subregion without enabling to identify the species relevant for the RA, *i.e.* those species known to occur in the Port of Kiel. However, the recommended RA approach is explained by using the HOLAS dataset as no other comprehensive dataset is available.

Should exemptions be asked for it is recommended that this should be based on port profiles to be undertaken in all ports considered. It may be possible that only after having undertaken comprehensive port profiles in all ports to be considered it turns out that no exemption can be granted. This is a risk the proponent needs to be aware off.

Further some RA factors were identified as not enough relevant to change the decision between acceptable or unacceptable risk (see 4.5.1.2). This refers, *e.g.*, to the cargo pattern and amount of ballast water being discharged between the ports. Therefore, these factors have not been considered by the RA model. As an example, should the salinity mis-match completely (*i.e.* freshwater to marine), it is irrelevant how frequently organisms are introduced (ship arrivals, ballast water discharge events) and how large the inoculation size of a founder population is (number of organisms discharged), they simply cannot survive and will not establish.

In the following, some Baltic Sea cases of shipping routes will be analysed to see the results with a hypothesis, that baseline surveys and monitoring is conducted in the studied ports. As this is not the case it should be noted that the **results are hypothetical, and in the present data situation the analysis does not support granting exemptions for any of these**. To compare the presence, absence and overlap of target species in the selected ports the HOLAS lists of alien and cryptogenic species was considered. **As by our definition all alien and cryptogenic species which can be transported by ballast water and show a (potential) negative impact are target species.** Therefore, species, which were unlikely to be introduced by ballast water were dropped from the HOLAS lists, which were unlikely to be introduced by ballast water. The HOLAS list provides data on a regional basis, *i.e.* not port specific. However, without the HOLAS list not even a hypothetical risk assessment would not have been possible.

4.7.1 RA FOR ROUTE 1

- St. Petersburg (donor port) – Gothenburg (recipient port)

This shipping route has the highest salinity difference possible in the Baltic (freshwater to waters with more than 18 PSU). In the case of such an environmental mis-match it was agreed to further consider high salinity tolerant target species.

Table 3. Target species in the HOLAS regions where the ports of St. Petersburg and Gothenburg are located (data source HELCOM HOLAS, see Table 2 above). High salinity tolerant species are shown in bold.

Species	St Petersburg	Gothenburg
Acartia tonsa	1	1
Aglaothamnion halliae		1
Alexandrium tamarense		1
Ameira divagans		1
Balanus improvisus (bay arnacle)	1	1
Bonnemaisonia hamifera (pink cotton wool)		1
Bougainvillia rugosa		1
Callinectes sapidus (blue crab)		1
Cercopagis pengoi (fish-hook water flea)	1	1
Chaetogammarus ischnus	1	
Chara connivens (convergent stonewort)		1
Cheliocorophium (Corophium) curvispinum		1
Clavopsella navis		1
Codium fragile (dead man’s fingers)		1
Colpomenia peregrina (oyster thief)		1
***Cordylophora caspia* (brackish water hydroid)**	**1**	**1**
Cornigerius maeoticus maeoticus	1	
Coscinodiscus wailesii		1
Crassostrea gigas (Pacific oyster)		1
Dasya baillouviana		1
Dreissena bugensis (quagga mussel)	1	

Species	St Petersburg	Gothenburg
Dreissena polymorpha (zebra mussel)	1	
Elminius modestus		1
Ensis americanus (American jack knife clam)		1
***Eriocheir sinensis* (Chinese mitten crab)**	**1**	**1**
Evadne anonyx	1	
Ficopomatus enigmaticus (Australian tubeworm)		1
Fucus evanescens		1
Gammarus tigrinus	**1**	**1**
Gymnodinium catenatum		**1**
Gmelinoides fasciatus	1	
Gonionemus vertens (clinging jellyfish)		1
Gracilaria vermiculophylla		1
Hemimysis anomala (bloody red shrimp)	1	
Heterosiphonia japonica		1
Jaera sarsi	1	
Karenia mikimotoi		1
Maeotias marginata (Black Sea jellyfish)	1	
Marenzelleria neglecta	1	1
Marenzelleria viridis		1
Mastocarpus stellatus		1
Mnemiopsis leidyi (American comb jelly)	1	1
Molgula manhattensis		1
Mya arenaria (soft-shell clam)	1	1
***Mytilopsis leucophaeata* (Conrad's false mussel)**	**1**	
Neogobius melanostomus (round goby)	1	1
Neosiphonia harveyi		1
Odontella sinensis		1
Palaemon elegans	1	1
Paramysis lacustris	1	
Paranais frici	1	
Percottus glehni (Amur sleeper)	1	
Petricola pholadiformis (American piddock)		1
Boccardiella ligerica		1
Polysiphonia harveyi		1
Pontogammarus robustoides	1	
Potamopyrgus antipodarum	**1**	**1**
Potamothrix vejdovskyi	1	
Protomonostroma undulatum		1
Rhithropanopeus harrisii (Harris mud crab)		1
Sargassum muticum (japweed)		1
Stenocuma graciloides	1	
Styela clava (stalked sea squirt)		1
Thalassiosira punctigera		1
Tharyx killariensis		1
Tubificoides pseudogaster	1	
Verrucophora farcimen		1
Total	**29**	**50**

High salinity tolerant species

High salinity tolerant target species are known to occur in both port regions. The following high salinity tolerant target species are found in both port regions:

- *Cordylophora caspia*,
- *Eriocheir sinensis*,
- *Gammarus tigrinus*, and
- *Potamopyrgus antipodarum*.

In contrast *Mytilopsis leucophaeata* is only known from St. Petersburg whereas *Gymnodinium catenatum* is only found in Gothenburg.

Conclusion

With the salinity mis-match between the two ports from freshwater to above 18 PSU, and as high salinity tolerant target species occur in both ports of which some are only found in the donor port, this indicates a high risk that target species are able to establish when transported from one port to the other, and that new target species could establish. As a result **an exemption cannot be granted**.

Target species of particular concern are the high salinity tolerant species (see above) as they may become established in the recipient port of Gothenburg.

4.7.2 RA FOR ROUTE 2

- Klaipëda (donor port) – Kiel (recipient port)

No exemption can be granted based upon environmental comparison as the salinity difference is too small, *i.e.*, smaller than between freshwater and waters with more than 18 PSU. In such a case the assessment proceeds to the species-specific approach, *i.e.*, verification of presence of target species in the donor port. If there is/are any, it needs to be checked if these are present also in the recipient port. Table 4 clearly shows the target species in both ports. From Klaipëda 22 such species are known and in Kiel 50. Approximately half of these species known to occur in the Klaipëda region are also found in the Kiel region, *i.e.* the other target species could become introduced from Klaipëda to Kiel.

Table 4. Target species in the HOLAS regions where the ports of Klaipëda and Kiel are located (data source HELCOM HOLAS, see Table 2 above). High salinity tolerant species are shown in bold.

Species	Klaipëda	Kiel
Acartia tonsa		1
Aglaothamnion halliae		1
Alexandrium tamarense		1
Alkmaria rominji (tentacled lagoon worm)	1	
Ameira divagans		1
Balanus improvisus (bay barnacle)	1	1
Boccardia (Polydora) redeki	1	
Bonnemaisonia hamifera (pink cotton wool)		1
Bougainvillia rugosa		1
Callinectes sapidus (blue crab)		1
Cercopagis pengoi (fish-hook water flea)	1	1
Chaetogammarus ischnus	1	
Chaetogammarus warpachowskyi	1	
Chara connivens (convergent stonewort)	1	1
Cheliocorophium (Corophium) curvispinum		1
Clavopsella navis		1
Codium fragile (dead man’s fingers)		1
Colpomenia peregrina (oyster thief)		1
Cordylophora caspia **(Brackish water hydroid)**		**1**
Coscinodiscus wailesii		1
Crassostrea gigas (Pacific oyster*)*		1
Dasya baillouviana		1
Elminius modestus		1
Ensis americanus (American jack knife clam)		1
Eriocheir sinensis (Chinese mitten crab)	**1**	**1**
Ficopomatus enigmaticus (Australian tubeworm)		1
Fucus evanescens		1
Gammarus tigrinus		**1**
Gymnodinium catenatum		**1**
Gonionemus vertens (clinging jellyfish)		1
Gracilaria vermiculophylla		1
Hemimysis anomala (bloody red shrimp)	1	
Heterosiphonia japonica		1
Karenia mikimotoi		1
Marenzelleria arctica	**1**	
Marenzelleria neglecta	1	1
Marenzelleria viridis		1
Mastocarpus stellatus		1
Mnemiopsis leidyi (American comb jelly)	1	1
Molgula manhattensis		1
Mya arenaria (soft-shell clam)	1	1
Neogobius melanostomus (round goby)	1	1
Neosiphonia harveyi		1
Obessogammarus crassus	1	
Odontella sinensis		1
Orchestia cavimana	1	
Palaemon elegans	1	1

Species	Klaipëda	Kiel
Palaemon longirostris	1	
Paramysis lacustris	1	
Petricola pholadiformis (American piddock)		1
Boccardiella ligerica		1
Polysiphonia harveyi		1
Potamopyrgus antipodarum	**1**	**1**
Prorocentrum minimum	1	
Protomonostroma undulatum		1
Rhithropanopeus harrisii (Harris mud crab)	1	1
Sargassum muticum (japweed)		1
Styela clava (stalked sea squirt)		1
Thalassiosira punctigera		1
Tharyx killariensis		1
Verrucophora farcimen		1
Total	**22**	**50**

High salinity tolerant species

High salinity tolerant target species are known to occur in both port regions. The following high salinity tolerant target species are found in both port regions:

- *Eriocheir sinensis*, and
- *Potamopyrgus antipodarum*.

In contrast *Marenzelleria arctica* is only known from Klaipëda whereas *Cordylophora caspia, Gammarus tigrinus* and *Gymnodinium catenatum* are only found in Kiel.

In conclusion, due to different compositions of target species in the source and recipient ports and the high risk to transfer these between the ports due to similar salinities of both ports **no exemption can be recommended.**

Target species of particular concern include the species which may cause a significant negative impact to the recipient environment should they become established. In this scenario several such species occur in the source port but are unknown from the recipient port, including *Chaetogammarus* spp., *Hemimysis anomala* and *Palaemon longirostris* who all have the potential to compete with native species and may further show a predatory impact.

4.7.3 RA FOR ROUTE 3

- Kiel (donor port) – Gothenburg (recipient port)

No exemption can be granted based on environmental comparison as the salinity difference is too small, *i.e*. smaller than between freshwater and waters with more than 18 PSU. In such a case the assessment proceeds to the species-specific approach, *i.e*., verification of presence of target species in the donor port. If there is/are any, it needs to be checked if these are present also in the recipient port.

As seen in the tables above (Route 1 shows the species data for Gothenburg and Route 2 for Kiel), both port regions have a completely identical set of target species (50 species) and it is not known that one of the ports has a particular control or eradication programme to address one of these species. In the case of overlapping target species in donor and recipient port, the abundance of these has to be compared.

Unfortunately there is no abundance data for all 50 target species in both ports, but it is highly unlikely that all these species occur in both ports in comparable abundances. In this case, **when assuming the target species are identical in both ports/regions and that they further occur in different abundances an exemption may not be given.**

It is interesting to note that several ferries are operated between these 236 miles apart ports, in summer with multiple daily arrivals. As no ballast water management was required in the past it may well be that the frequent ferry connections have contributed to the spread of the alien and cryptogenic species between these two ports/regions, so that these species are now identical in both port regions.

4.7.4 RA FOR ROUTE 4

- Terneuzen, NL (donor port) – Mönsterås, SE (recipient port) – Karlshamn, SE (recipient port).

No exemption can be granted based on environmental comparison as the salinity difference is too small, *i.e*. smaller than between freshwater and waters with more than 18 PSU. In such a case the assessment proceeds to the species-specific approach, *i.e.*, the verification of presence of target species in the donor port. If there is/are any, it needs to be checked if these are present also in the recipient port. In this scenario the North Sea port Terneuzen is considered as ballast water donor port as the vessel would be only loading cargo in different Baltic Sea ports. Table 5 shows the target species in all three ports. From Mönsterås 18, from Karlshamn 50 such species are known and in Terneuzen 45. In total 19 target species are known from Terneuzen, which are not found in the ballast water recipient ports Mönsterås and Karlshamn, *i.e.* they may become introduced to the Baltic ports.

The presence of target species in the Baltic ports on this ship route was based upon the HOLAS dataset. Unfortunately for the Port of Terneuzen such a dataset does not exist. As the HOLAS data are also not port specific, but are regional, information on Dutch alien and cryptogenic species near the Port of Terneuzen was gathered, based upon Wolff (2005) and the DAISIE database[19]. However, it should be noted that the Port of Terneuzen clearly shows that regional data are of limited use, this is especially the case as this port has locks and different environmental water parameters and therefore has most likely a different biological community compared to the surrounding waters. This highlights the need to undertake port profiles for a proper risk assessment.

Table 5. Target species in the HOLAS regions where the ports of Mönsterås and Karlshamn are located (data source HELCOM HOLAS). Data on aliens and cryptogenic species for the Port of Terneuzen to identify target species are also based on the knowledge of such species from near this port. Data sources include Wolff (2005) and the DAISIE database. High salinity tolerant species are shown in bold.

Species	Mönsterås	Karlshamn	Terneuzen
Acartia tonsa		1	1
Aglaothamnion halliae		1	
Alexandrium tamarense		1	1
Alkmaria rominji (tentacled lagoon worm)	1		
Ameira divagans		1	
Atherina boyeri			1
Balanus improvisus (bay barnacle)	1	1	1
Boccardia (/Polydora) redeki	1		
Bonnemaisonia hamifera (pink cotton wool)		1	1
Botrylloides violaceus			1
Bougainvillia rugosa		1	

[19] DAISIE database www.europe-aliens.org/

Species	Mönsterås	Karlshamn	Terneuzen
Callinectes sapidus (blue crab)		1	1
Caprella mutica			1
Cercopagis pengoi (fish-hook water flea)	1	1	
Chattonella marine/antiqua			1
Chara connivens (convergent stonewort)	1	1	
Cheliocorophium (Corophium) curvispinum		1	
Clavopsella navis		1	
*Codium fragile (*dead man's fingers)		1	1
Colpomenia peregrina (oyster thief)		1	
***Cordylophora caspia* (Brackish water hydroid)**		**1**	**1**
Coscinodiscus wailesii		1	1
Crassostrea gigas (Pacific oyster)		1	1
Dasya baillouviana		1	
Elminius modestus		1	1
Ensis americanus (American jack knife clam)		1	1
***Eriocheir sinensis* (Chinese mitten crab)**	**1**	**1**	**1**
Fibrocapsa japonica			1
Ficopomatus enigmaticus (Australian tubeworm)		1	
Fucus evanescens		1	
Gammarus tigrinus		**1**	**1**
Garveia franciscana			1
Gymnodinium catenatum		1	1
Gonionemus vertens (clinging jellyfish)		1	
Gracilaria vermiculophylla		1	
Haliplanella lineata			1
Hemigrapsus penicillatus			1
Hemimysis anomala (bloody red shrimp)	1		
Heterosiphonia japonica		1	
Incisocalliope aestuarius			1
Karenia mikimotoi		1	
Marenzelleria arctica	**1**		
Marenzelleria neglecta	1	1	1
Marenzelleria viridis		1	
Mastocarpus stellatus		1	
Megabalanus tintinnabulum			1
Melita nitida			1
Mnemiopsis leidyi (American comb jelly)	1	1	1
Molgula manhattensis		1	1
Monocorophium sextonae			1
Mya arenaria (soft-shell clam)	1	1	1
Mycale micracanthoxea			1
Mytilopsis leucophaeata			**1**
Nemopsis bachei			1
Neogobius melanostomus (round goby)	1	1	1
Neosiphonia harveyi		1	
Odontella sinensis		1	1
Orchestia cavimana	1		
Palaemon elegans	1	1	
Palaemon longirostris	1		
Petricola pholadiformis (American piddock)		1	1
Boccardiella ligerica		1	

Species	Mönsterås	Karlshamn	Terneuzen
Polysiphonia harveyi		1	
Potamopyrgus antipodarum	**1**	**1**	**1**
Prorocentrum minimum	1		
Protomonostroma undulatum		1	
Rhithropanopeus harrisii (Harris mud crab)	1	1	1
Sargassum muticum (japweed)		1	1
Styela clava (stalked sea squirt)		1	1
Thalassiosira punctigera		1	1
Tharyx killariensis		1	
Tricellaria inopinata			1
Tubificoides heterochaetus			1
Undaria pinnatifida			1
Verrucophora farcimen		1	
Victorella pavida			1
Total	**18**	**50**	**45**

High salinity tolerant species

High salinity tolerant target species are known to occur in all three port regions. The following high salinity tolerant target species are found in all three port regions:

- *Eriocheir sinensis*, and
- *Potamopyrgus antipodarum*.

In contrast *Marenzelleria arctica* is only known from Mönsterås whereas *Mytilopsis leucophaeata* is only found in Terneuzen. *Cordylophora caspia* and *Gammarus tigrinus* are found in Karlshamn und Terneuzen.

In conclusion, due to different compositions of target species in the source and recipient ports and the high risk to transfer these between the ports due to similar salinities of all three ports **no exemption can be recommended.**

Highly concerning target species known from the Terneuzen as a ballast water donor region include *Undaria pinnatifida* (potential impact is fouling), *Mytilopsis leucophaeata* (fouling), *Botrylloides violaceus* (fouling), *Caprella mutica* (predation and competition with native species), *Chattonella* sp. (potentially toxic algae) and *Hemigrapsus penicillatus* (predation and competition with native species).

5 CONCLUSIONS

The outcome from this report is that ballast water management should not be applied as a blanket approach for all vessels operated in the Baltic Sea. Based on risk assessments certain vessels on specific and not changing routes may be exempted when reliable data are provided. Non-marine areas or areas with lower environmental similarity need to be specifically defined for the RA purposes. This is particularly the case for inland seas such as the Baltic and Black Seas.

Additional exemptions may be granted following the same location concept, when a vessel would be ballasting and deballasting in the same port, *i.e.*, although sailing to other ports. However, it should be noted that the same location concept is only applicable in unique situations and that the Baltic Sea as a whole cannot be seen as the same location.

It is concluded that one of the most critical points for a RA-based exemptions is lack of reliable of data. This in particular refers to the documentation of the species diversity (including native, alien and cryptogenic species) in the ballast water uptake and discharge regions/ports. To ensure data reliability so called port profiles should be undertaken, and monitoring programs need to be established, which is in line with the HELCOM Roadmap towards a harmonized implementation and ratification of the 2004 IMO Ballast Water Management Convention. Protocols to undertake such studies were developed and used in Australia, New Zealand, USA and by the GloBallast Programme.

When undertaking port baselines surveys, a harmonized approach for the sampling standards and protocols would be helpful that (at least) all European studies generate comparable results. In this harmonization process the following points may be considered:

- frequency of studies,
- number of sampling stations, and
- harmonized taxonomical analysis (if possible).

Studies have shown that every 9 weeks a new species is found (in ICES member countries). This includes newly introduced species as well as secondary spread of earlier introduced aliens. Other studies showed an increasing trend of newly found alien species since the middle of the last century. Noting this, it is important to understand that these port baseline studies should not only be undertaken once during the RA time period. A newly introduced target species in the ballast water source port results in a discontinuation of the ballast water management exemption. Although new species may become introduced so frequently, such comprehensive port baseline studies should (for pragmatic reasons) be undertaken on a biannual basis during the exemption period. A less comprehensive study of the biota, especially in the ballast water uptake region/port, should be considered to be undertaken more frequently.

It may further be considered to make use of existing biological monitoring programmes as much as possible. These initiatives are carried out in many European countries for several purposes, but alien species are usually not addressed by these programmes. An awareness campaign may be initiated to solve this problem and also to establish close linkages between the institutions undertaking the regular monitoring programmes and the authority to grant ballast water management exemptions.

Due to the absence of reliable biological data it should be noted that the results expressed in this report are hypothetical, and project team would not suggest granting exemptions for any shipping route unless reliable data become available.

ANNEX I RISK ASSESSMENT (RA)

Risk can be defined as the probability of an undesired event occurring and the level of impact of that event as a consequence of hazardous behaviour or action. Risk assessment (RA) is the means to identify the likelihood, frequency and consequences of such events, accompanied by an expression of all uncertainties in the assessment process (Hewitt, Hayes 2002).

RA key elements

The first steps in assessing the risk of a harmful introduction in an area are the identification of the transfer vector, followed by hazard assessment relative to the identified vector and species. The RA approach should be selected depending on goals to be achieved and data (resources) available. All these determine the selection of the RA endpoint.

Identification of the vector of transfer

More than a decade ago, thirteen anthropogenic vectors of transfer of harmful species around the world, including unintentional and intentional introductions, were identified (Hewitt, Hayes 2002) (see Table 1). It can be assumed that this list of identified vectors is not final.

Table 1. Anthropogenic vectors responsible for the transfer of aquatic organisms around the world (after Hewitt, Hayes 2002).

Among different geographical areas the shares of individual vectors vary. Nevertheless, the most important three are (not always in this order): ballast water, hull fouling, and aquaculture. A highly reliable identification of the introduction vector for each species is an extremely challenging task to undertake as species transports can be related to more than one vector. Further vectors overlap among them (Fig. Annex I:1), making many of them indistinctive (Minchin 2007).

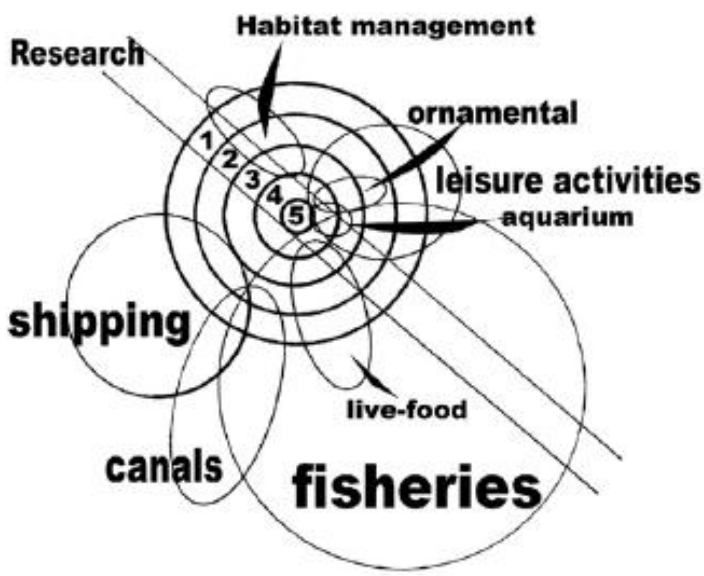

Fig. Annex I:1. Overlap of different vectors (Minchin 2007).

All this overlapping and multiple possibilities often create uncertainty regarding the identification and assignment of a vector to species introduction. However, this information is very critical for management purposes, *e.g.* the identification of target species if these need to be related to ballast water as a vector.

INTRODUCTION OF SPECIES – A STEPWISE PROCESS

The implication inherent to RA of introductions of harmful species is that the assessment of the probability of the establishment of an organism and its potential invasiveness depends on the species (*i.e.*, its fundamental properties) and the recipient environment (*i.e.*, circumstances).

The introduction of a species and its possible invasiveness can be divided into several phases or a chain of events (Fig. Annex I:2) presence of the organisms at the donor point, vector "infection", transport survival, survival of the discharge to a novel environment, survival in the new environment, establishment in the new environment, as well as spread and harm (invasiveness) in the new environment. The uncertainty relative to each step increases upon each following – from the initial presence in the donor environment to the final invasiveness in the recipient environment. When the degree of uncertainty is high, quantitative methods for the definition of probability are inappropriate. Therefore, not all phases of the invasion cycle have to be quantified but instead a combination of the empirical approach (selected on the basis of acceptable criteria) and the documented history of invasiveness and adverse influences can be adopted.

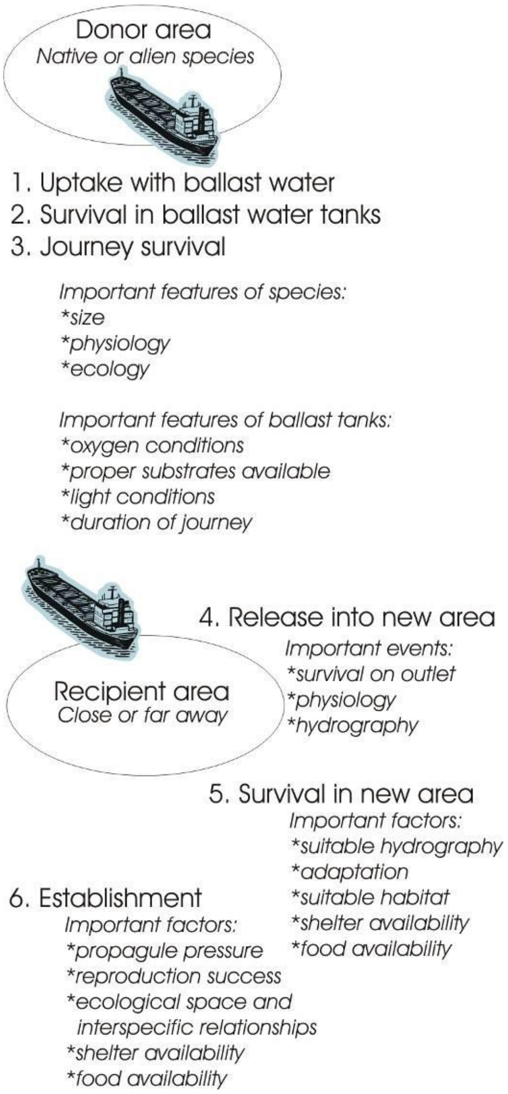

Fig. Annex I:2. Review of the fundamental stages in ballast water introduction of aquatic species, starting from the uptake of a species in the donor area and ending in possible establishment in the recipient area. Under each main stage (1-6) there are lower level processes of importance in determining introduction and establishment success. These lower level processes can be further divided into more specific events mentioned in Hayes (1997) and Gollasch (2002), among others. From stage 6 onwards, complex ecological interactions determine whether the species becomes invasive or not (from Paavola 2005).

Endpoint of RA

The risk inherent to ballast water and sediment discharge can be defined as the likelihood of an undesired event occurring as a consequence of ballast discharge from a ship. The interpretation of the presented definition entirely depends on the assessment endpoint: the endpoint can be defined either as (i) the probability of discharge of potentially harmful organisms via ballast water, or (ii) their establishment in the new environment, or (iii) their invasiveness in and impact on the new environment.

When the identified endpoint is the probability of impacts[20], the risk would need to be accurately defined through all RA stages from the bottom up (starting with the probability of introduction and establishment of new organisms). The RA process is defined by the IMO Guidelines G7 as “a logical process for objectively assigning the likelihood and consequences of specific events, such as the entry, establishment, or spread of harmful aquatic organisms and pathogens”.[21]

The cases presented below explicate the dependence of RA on the identified endpoint under the assumption that the RA endpoint is:

1. the discharge of harmful species via ballast water from a ship;
2. the establishment of those species in a novel environment;
3. the impact in a novel environment.

In Case 1 each record of the presence of harmful organisms in the discharged ballast water is understood as an undesired event. In Case 2 an undesired event is defined as the establishment of a species, which means that the discharge of organisms *per se* is not recorded as an undesired event. In Case 3 the undesired event is the impact while the discharge and establishment of a species are not recorded as undesired events.

Many of the species discharged into a new environment do not survive. In case they do survive and establish themselves, harm is not necessarily generated. However, considering the stochastic and complex array of factors that science is still unable to anticipate, one of the key points is that it is extremely difficult or practically unfeasible to produce highly reliable assessments as to whether a new organism introduced to a novel environment will cause harm

[20] *i.e.*, various aspects of risk to human health, the natural environment, or the economy/resources
[21] G7 guidelines, paragraph 5.1

or not. There are also cases of recorded establishments of species that had not caused harm for years but then, under certain circumstances, suddenly turned invasive (*e.g.*, the Chinese mitten crab *Eriocheir sinensis* in Europe (Marquard 1926, Panning 1938). These data reveal that the conservativeness of the approach descends from the first to the third point presented above as does the degree of certainty of identification of an event.

The decision as to the identification of the RA end-point is made by the assessor[22] and depends on the assessor's objectives, values, and abilities. The perception of harmful species can be highly variegated (Cothern 1996, Kirchsteiger *et al*. 1998, Souvorov 1999) - *e.g.*, the preservation of the native biological diversity in an environment will bear extraordinary value to a biologist whereas it might have lower value to other stakeholders. An inverse relation would probably be observed in relation to economic effects (*e.g.*, effects on fishing and aquaculture), which leads us to the conclusion that the perception of the degree of risk within a broader circle of stakeholders - exerts a significant influence on the degree of acceptability of each risk.

RA errors

RA includes potential errors that can occur at any assessment step. The errors can be divided into two groups:

- Type I errors – cause overestimates of the real situation;
- Type II errors – cause underestimates of the real situation (Hayes 2000).

RA provides the basis for the implementation of preventive measures. Therefore, it can be assumed that a Type I error (false positives) will result in higher protection from negative impacts yet concurrently laying the additional burden of preventive measures on the shipping industry. On the contrary, a Type II error (false negatives) will result in a potentially lower degree of protection from negative impacts yet a lighter burden on the shipping industry.

The aim of RA certainly is to reflect the real situation as accurately as possible and implement appropriate measures in relation to the obtained results. However, given that the ballast water

[22] Given that the objective of RA is the prevention of undesired events via state regulation, the 'assessor' is to be understood as a state.

issue has not been extensively researched yet, the likelihood of error is high. In these cases the precautionary approach should be adopted, with primary emphasis to avoid Type II errors.

An essential point is the implementation of the precautionary approach through the entire RA and ballast water management process. In some cases Type II errors simply cannot be prevented (*e.g.*, sampling on-board ships, data collection with Ballast Water Reporting Form (BWRF) and all possible measures aiming towards their reduction have to be undertaken while the presence of the error has to be clearly recorded to allow for correct assessment data interpretation and the consideration of the error during the next step, the adoption of measures (Kirchsteiger *et al.* 1998, Hayes 2000).

ANNEX II IMO RA METHODS

The RA developed in the framework of the BWM Convention and is the latest, understood as worldwide agreed, RA framework. It has been developed to provide tools for a selective approach in the implementation of the BWM Convention and it is presented in the IMO Guideline G7 Guidelines as is outlined in the following chapters. It has three different methods, “environmental matching”, “species’ biogeographical” and “species-specific” risk assessment.

The risk estimation on the assessment of environmental matching between the areas of ballast water origin and discharge considers salinity and temperature as surrogates for the species capability of survival in the new environment. Species’ biogeographical risk assessment identifies overlapping species in the donor and recipient ports and biogeographic regions, and these are direct indications of the similarity of environmental conditions. The risk identification in the species-specific approach is focused on the assessment of the potential invasiveness of each species and anticipations of the harm that it could cause in the new environment.

ENVIRONMENTAL MATCHING RELATED RISK IDENTIFICATION

The identification of vector-related risk can be based on two fundamental elements:

- the likelihood of organism transfer (*i.e.*, the quantity and origin of the discharged ballast water[23]),
- the likelihood of organism survival in the novel environment (matching of selected environmental parameters of donor and recipient regions; the degree of similarity between the donor and recipient region indicates the likelihood of survival and establishment of species transferred between these regions).

[23] The length of the voyage could also be a factor (*i.e.*, longer containment in tank negatively affects species survival). However, the results of the Slovenian BWS study (David *et al.* 2007) didn’t confirm this; hence, its use is not suggested.

These regions are typically defined as biogeographic regions, but all existing biogeographical schemes were developed for different purposes and not for risk assessments regarding biological invasions. IMO suggested to use the Large Marine Ecosystems (LME) approach (http://www.edc.uri.edu/lme) as this was considered the best available information when drafting the IMO Risk Assessment Guideline G7. Local and regional adaptations may be necessary, what is outlined below. Should this scheme not be appropriate other recognized biogeographical schemes may be considered[24]. An outline of the biogeographical risk assessment approach of IMO Guideline G7 is given below.

The IMO Guideline G7 environmental matching was determined to assess the likelihood that species found in the donor biogeographic region are able to survive in the recipient port in another biogeographic region.

However, some uncertainty remains, namely the difficulty in defining the environmental conditions that are predictive of the species to establish and cause harm in the new location. Another key point is the determination whether the risk of ballast water discharge is sufficiently low to be exempted from ballast water management requirements. Environmental matching risk assessment is of limited use in cases where the differences between a donor biogeographic region and a recipient port are small. In these cases, such as shipping within one biogeographic region, high similarity between donor and recipient region is likely and indicates a high likelihood of successful species establishment.

In addition to comparing the environmental conditions of biogeographic regions, this comparison should also be undertaken between the donor and recipient ports, *i.e.* in smaller scale. A similarity in key environmental conditions between the two ports is a strong indication that species of the donor port will survive when released into the recipient port.

The necessary data to enable a risk assessment using the environmental matching approach to determine the degree of environmental similarity between the donor and recipient environments include, but are not limited to:

- the origin of the ballast water to be discharged in recipient port,

[24] Watling and Gerkin (http://marine.rutgers.edu/OBIS/index.html) based on Briggs (1953) and Springer (1982), IUCN bioregion system, Ekman (1953), and Longhurst (1998) provinces.

- the biogeographic region of donor and recipient port(s), and
- the average and range of environmental conditions, also considering seasonal differences, in particular salinity and temperature.

The analysis of environmental similarity may be followed by a consideration of species known from the donor region which tolerate extreme environmental differences. If such species occur, a species-specific approach should be used for risk assessments associated with these species. Such species include:

- species that migrate between fresh and marine environments to complete their life-cycle (anadromous species such as salmon spend most of their life in the sea and return to fresh water to spawn, whereas the catadromous species, *e.g.*, the Chinese mitten crab, do the opposite;
- species with a wide tolerance of temperature (eurythermal species) or salinity (euryhaline species).

SPECIES' BIOGEOGRAPHICAL RISK ASSESSMENT

The species' biogeographical risk assessment compares the distribution of non-indigenous, cryptogenic, and harmful native species presently occurring in the donor and recipient ports and biogeographic regions. Overlapping species occurrences in the donor and recipient ports and regions are a direct indication of environmental similarity to enable a shared fauna and flora. The biogeographical analysis may further be used to identify high risk invaders (see also the species-specific approach). For example, harmful species in the ballast water donor biogeographic region that are known to have successfully invaded other (similar) biogeographic regions but are not found in the recipient biogeographic region of the risk assessment could be considered high risk invaders for the ballast water recipient region. As a general rule, the higher the number of biogeographic regions that such species have invaded, the greater is the potential that those species would be able to become established in the recipient port or biogeographic region. Another general risk indicator is given in case where the donor biogeographic region is a major source of invaders to other areas.

The data requirements to enable a species biogeographical approach risk assessment includes but may not be limited to:

1. species invasion records in the donor and recipient biogeographic regions and ports;
2. records of native or non-indigenous species in the donor biogeographic region which may be transferred with ballast water and which that have already invaded other biogeographic regions and the number and characteristics of the biogeographic regions invaded;
3. records of native species in the ballast water donor region that have the potential to affect human health or to cause substantial negative ecological or economic impacts after introduction in the recipient region by ballast water discharges.

The species' biogeographical risk assessment may also be used to identify potential target species (see below) in the donor regions. Indicators include native species with a wide biogeographical or habitat distribution or species which are known as invaders in other biogeographic regions similar to that of the ballast water recipient port.

SPECIES-SPECIFIC RISK IDENTIFICATION

The identification of species-related risk focuses on the recognition of the potential invasiveness of each selected species and anticipations of the harm that it could cause in the new environment. Today we suffer a shortage of data and insufficient knowledge concerning the invasiveness of organisms (*i.e.*, how to predict invasiveness in a new environment? …on the species tolerance regarding environmental conditions, food availability, reproduction profile and capabilities? How to anticipate the harm that could be caused? …on empirical data from previous introductions? …from behaviour in the native environment?). In most environments (or biogepgraphical regions) the knowledge on the taxonomy of indigenous organisms is already deficient, while the identification of organisms stemming from other parts of the world is even more demanding. Consequently, after on-board ballast water analysis and sea monitoring, numerous organisms remain unidentified.

For a target list of unwanted organisms, fundamental selection criteria must be defined. One of the most advanced criteria for this process was developed in Australia in which the following parameters[25] were selected for the definition of potentially harmful organisms:

- the organism has been reported in a shipping vector or has a ship-mediated invasion history; and
- the vector still exits; and
- the organism has caused environmental or economic harm; and
- the organism is non-indigenous to Australia or is present in Australia but subject to official control (Hayes, Sliwa 2003).

The presented approach is referred to as the deductive approach. An alternative is the inductive approach, by which the determinants for invasion success derive from biological principles. Numerous attempts have been made towards the definition of a string of properties typical of an 'ideal' invasive species. It was discussed that species with high tolerances against environmental factors and those with high reproduction rates may have a higher invasion potential.

The objective of this approach is to use species life history information and physiological tolerances to define physiological limits of a certain species which leads to its potential to survive or complete its life cycle in the recipient environment under consideration. In other words, the individual species characteristics are to be compared with the environmental conditions in the recipient port, to determine the likelihood of transfer and species survival.

To undertake a species-specific risk assessment, species of concern (target species) need to be selected for a specific port, country, or biogeographical region.

As a first step to come to a target species list, (i) all species being potentially harmful and invasive (including cryptogenic species) present in the donor port(s) should be listed and (ii) be selected based on pre-defined criteria (see below).

[25] The 'Target Species List' incorporated into the Australian Decision Support System (DSS) is based on the same parameters.

Another problem is that the assessment whether or not a species should become a target species is subjective and there will be a degree of uncertainty associated with the approach, *e.g.* it is possible that species identified as harmful in some environments may not be harmful in others and vice versa.

In addition to the data referred to above the following information is needed to enable a risk assessment using the species-specific approach (based on IMO Guideline G7):

- biogeographic region of donor and recipient port(s); the presence of all non-indigenous species (including cryptogenic species) and native species in the donor port(s), port region and biogeographic region, not present in the recipient port, to allow identification of target species;
- the presence of all target species in the recipient port(s), port region, and biogeographic region;
- the difference between target species in the donor and recipient ports, port region, and biogeographic region;
- life history information on the target species and physiological tolerances, in particular salinity and temperature, of each life stage; and
- habitat type required by the target species and availability of habitat type in the recipient port.

If a target species is already found in the recipient port, but only as few individuals, it may be reasonable to exclude that species from the overall risk assessment for that port. However, even when a target species has been reported, even if its establishment status and abundance may be unknown, from the donor and recipient ports, its continued introduction into the recipient ports may increase the probability that it will become established and/or achieve invasive population densities, this is especially the case when the target species occurs in higher abundance in the donor port compared to the recipient port.

As a starting point a simple assessment may be undertaken of whether a target species is present in the donor port but not in a recipient port and that it can be transported via ballast water. In a more comprehensive approach the following points may need to be evaluated (based on IMO Guideline G7):

- Uptake – probability of viable stages entering the vessel's ballast water tanks during ballast water uptake operations;
- Transfer – probability of survival during the voyage;
- Discharge – probability of viable stages entering the recipient port through ballast water discharge on arrival; and
- Population establishment – probability of the species establishing a self-maintaining population in the recipient port.

An even more detailed scenario would be to determine the likelihood of a target species to survive each of the stages analyzed above. However, the required data may not be available, especially when considering that life stages of the target species need to be assessed also considering seasonal variations the target species presence in the donor port with seasonal conditions in the recipient port to meet the species abiotic tolerances (*e.g.,* temperature and salinity). Consequently, the overall risk assessment unmanaged ballast water discharges should be determined based on the assessment of all target species surviving all these stages.

To groundtruth the chosen species-specific risk assessment approach data may be gathered for already introduced species to check whether or not the risk assessment would have predicted this species to be able to survive in the ballast water recipient port. A failure to predict existing invaders correctly may indicate that the model underpredicts the risk.

ANNEX III APPLICATION OF THE BWM CONVENTION

The application of the BWM Convention requirements are defined in the Article 3 Application:

1 *Except as expressly provided otherwise in this Convention, this Convention shall apply to:*

(a) ships entitled to fly the flag of a Party; and

(b) ships not entitled to fly the flag of a Party but which operate under the authority of a Party.

2 *This Convention shall not apply to:*

(a) ships not designed or constructed to carry Ballast Water;

(b) ships of a Party which only operate in waters under the jurisdiction of that Party, unless the Party determines that the discharge of Ballast Water from such ships would impair or damage their environment, human health, property or resources, or those of adjacent or other States;

(c) ships of a Party which only operate in waters under the jurisdiction of another Party, subject to the authorization of the latter Party for such exclusion. No Party shall grant such authorization if doing so would impair or damage their environment, human health, property or resources, or those of adjacent or other States. Any Party not granting such authorization shall notify the Administration of the ship concerned that this Convention applies to such ship;

(d) ships which only operate in waters under the jurisdiction of one Party and on the high seas, except for ships not granted an authorization pursuant to sub-paragraph (c), unless such Party determines that the discharge of Ballast Water from such ships would impair or damage their environment, human health, property or resources, or those of adjacent of other States;

(e) any warship, naval auxiliary or other ship owned or operated by a State and used, for the time being, only on government non-commercial service.

However, each Party shall ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such ships owned or operated by it, that such ships act in a manner consistent, so far as is reasonable and practicable, with this Convention; and

(f) permanent Ballast Water in sealed tanks on ships, that is not subject to discharge.

3 With respect to ships of non-Parties to this Convention, Parties shall apply the requirements of this Convention as may be necessary to ensure that no more favourable treatment is given to such ships.

A RA based approach may be applied according to the Regulation A-4, Exemptions:

1 A Party or Parties, in waters under their jurisdiction, may grant exemptions to any requirements to apply regulations B-3 or C-1, in addition to those exemptions contained elsewhere in this Convention, but only when they are:

.1 granted to a ship or ships on a voyage or voyages between specified ports or locations; or to a ship which operates exclusively between specified ports or locations;
.2 effective for a period of no more than five years subject to intermediate review;
.3 granted to ships that do not mix Ballast Water or Sediments other than between the ports or locations specified in paragraph 1.1; and
.4 granted based on the Guidelines on risk assessment developed by the Organization.

2 Exemptions granted pursuant to paragraph 1 shall not be effective until after communication to the Organization and circulation of relevant information to the Parties.

3 Any exemptions granted under this regulation shall not impair or damage the environment, human health, property or resources of adjacent or other States. Any State that the Party determines may be adversely affected shall be consulted, with a view to resolving any identified concerns.

4 Any exemptions granted under this regulation shall be recorded in the Ballast Water record book.

For a harmonized approach and also to exchange risk assessment related information neighbouring or other states need to be contacted and consulted as stated in Regulation A-4.3 of the BWM Convention, *i.e.*, any exemptions granted under this regulation shall not impair or damage the environment, human health, property or resources of adjacent or other States.

In resume, a RA based approach for BWM requirements (*e.g.*, exemptions) in the Baltic Sea according to the BWM Convention, considering also the non-application paragraphs, applies to:

- ships constructed to carry ballast water that
- are involved in international traffic,
- considering also that domestic traffic is to be included if a Party determines that their domestic traffic may cause harm to adjacent or other states, *e.g.*, due to harmful organisms including pathogens being already present in the ports and available for a secondary spread.

ANNEX IV BALLAST WATER MANAGEMENT IN THE AREA

The IMO BWM Convention introduces two different protective regimes as a sequential implementation:

1. Ballast Water Exchange (BWE) Standard (Regulation D-1) requiring ships to exchange a minimum of 95% ballast water volume.

2. Ballast Water Performance Standard (BWPS) (Regulation D-2) requires that ballast water discharged has the number of viable organisms below the specified limits.

As required by IMO BWE should be undertaken at least 200 nautical miles from the nearest land and in water depths of at least 200 m. If this is impossible, then BWE should be undertaken as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 m in depth. Such an area does not exist of suffient dimension to undertaken a BWE in the Baltic. In sea areas where these parameters cannot be met, the port state may designate a BWE area, in consultation with adjacent or other states, as appropriate. However, such a BWE area was not identified in the Baltic Sea. In addition to the IMO requirements national BWE requirements should also be considered. It should be noted that OSPAR and HELCOM agreed on voluntary BWE requirements for vessels on intercontinental voyages. As this is only an interim solution, it is not repeated here.

In general, a ship should not be required to deviate from its intended voyage and the voyage should not be delayed. However, a port state may require a ship to deviate, which may result in a delay in case a designated BWE area has been established. Ships shall never be asked to comply with any requirements if those would threaten the safety or stability of the ship, its crew, or its passengers because of adverse weather, ship design or stress, equipment failure, or any other extraordinary condition.

BWE is seen as an interim solution because scientific studies have proven its limited effectiveness (*e.g.*, Hallegraeff 1998, Dickman, Zhang 1999, McCollin *et al*. 2001, Villac *et al*. 2001, Drake *et al*. 2002, Gray *et al*. 2007, Taylor *et al*. 2007, McCollin *et al*. 2008, Briski *et al*. 2010, Simard *et al*. 2011) and the water depth and distance from shore requirements as set forth in the BWM Convention cannot be met in many circumstances; *e.g.*, intra-European shipping or domestic shipping of many countries (David 2007, David *et al*. 2007b, Gollasch *et al*. 2007).

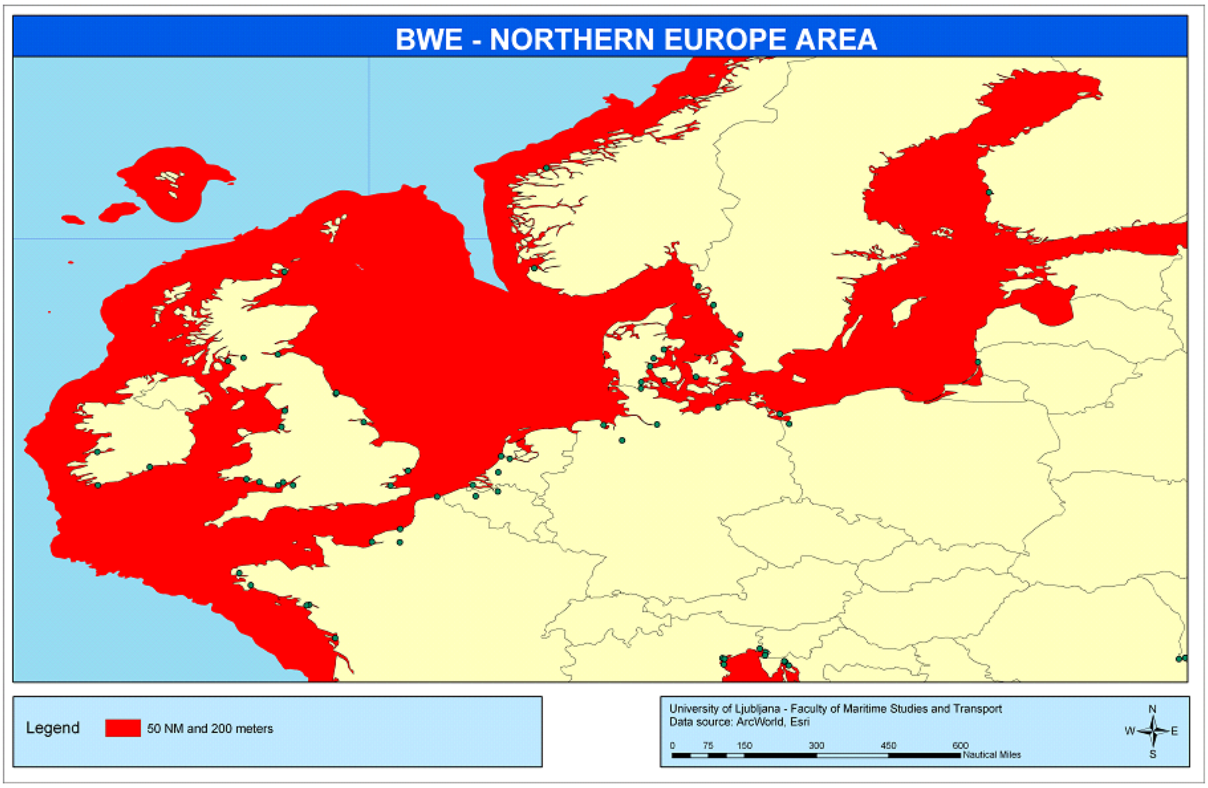

Fig. Annex III:1. The Baltic Sea and North Sea area with 50 nautical miles and 200 m depth limits shown in red (David *et al.* 2007).

ANNEX V SPECIES' ABILITY TO SPREAD WITHOUT HUMAN ASSISTANCE

Plants and animals, native as well as non-native, have the theoretical potential to spread (with *e.g.* currents, birds and fishes, floating debris and ice) all over the Baltic Sea without being assisted by any man-related vectors – it is just a question of distances and time. On the other hand, there are abiotic (*e.g.* salinity) and/or biological barriers to keep species apart: not all natives have been able to spread to all parts of the Sea during its postglacial history.

Natural spread of aquatic species depends on several factors such as (i) recruitment strategies (does the species produce planktonic larvae or other floating propagules or not), (ii) time and timing (duration of larval stages in the water phase, seasonality (larvae present or not in loaded ballast water, abundance of them), (iii) prevailing current conditions (direction, velocity, persistency), and (iv) presence of environmental barriers (*e.g.* low temperature, steep salinity gradients between donor and recipient ports).

1 Recruitment strategies

Due to different reproductive strategies (budding, embryos carried in a brood pouch, bottom-living larvae, planktonic larvae), life forms and habitats (free water, shallow/deep water, soft/rocky bottom, parasitic life, etc), not all species are equally available for ballast-mediated transportation.

Therefore, the species were classified according to their life cycle and potential to be spread with ballast water. Included in Table Annex I:1 are the alien species listed on the HELCOM list of non-indigenous, cryptogenic and harmful native species[26], the salinity tolerance of which is known[27]. Fish have been excluded, the round goby (*Neogobius melanostomus*) being the only one of them with shipping mentioned as a vector (cryptogenic in the Baltic Sea).

---

[26] www.helcom.fi/stc/files/shipping/Version2_HELCOM%20lists%20of%20non-indigenous,%20cryptogenic%20and%20harmful%20native%20species%20and%20HELCOM%20target%20species.pdf

[27] http://meeting.helcom.fi/c/document_library/get_file?p_l_id=18816&folderId=1240906&name=DLFE-42563.pdf

Table Annex V:1. Established alien species the salinity tolerance of which is known, derived from the HELCOM list of non-indigenous, cryptogenic and harmful native species. **Ship-mediated species bolded.** Taxonomy and scientific names checked and updated (as per July, 2011) according to WoRMS (World Register of Marine Species). Common names from WoRMS and other Internet sources.

1 Permanently planktonic species (holoplankton)

1.1 Planktonic algae

Gymnodinium catenatum (Dinophyceae)
Coscinodiscus wailesii (Bacillariophyceae) Assoc./**Ship**
Prorocentrum minimum (Dinophyceae)
Thalassiosira punctigera (Bacillariophyceae) Assoc./**Ship**
Odontella sinensis **(**Bacillariophyceae)

1.2 Planktonic animals

Maeotias marginata (Hydrozoa Limnomedusae)	
Cercopagis pengoi (Crustacea Cladocera)	fishhook waterflea
Mnemiopsis leidyi (Ctenophora)	American comb jelly
Cornigerius maeoticus maeoticus (Crustacea Cladocera)	
Evadne anonyx (Crustacea Cladocera)	
Acartia tonsa (Crustacea Copepoda)	

2 Animal species with planktonic larvae (meroplankton)

Bougainvillia rugosa (Cnidaria Hydrozoa)	
Cordylophora caspia (Cnidaria Hydrozoa)	freshwater hydroid
Pachycordyle *(Clavopsella)* ***navis*** (Cnidaria Hydrozoa)	
Ficopomatus enigmaticus (Polychaeta Sabellida)	Australian tubeworm
Marenzelleria arctia (Polychaeta Spionida)	
M. neglecta (Polychaeta Spionida)	
Balanus improvisus (Crustacea Cirripedia)	bay barnacle
Callinectes sapidus (Crustacea Decapoda)	blue crab
Rhithropanopeus harrisii (Crustacea Decapoda)	dwarf crab
Palaemon elegans (Crustacea Decapoda)	
Eriocheir sinensis (Crustacea Decapoda)	Chinese mitten crab
Dreissena bugensis (Mollusca Bivalvia)	quagga mussel
Crepidula fornicata (Mollusca Gastropoda)	slipper limpet
D. polymorpha (Mollusca Bivalvia)	zebra mussel
Mytilopsis leucophaeata (Mollusca Bivalvia)	dark false mussel
Mya arenaria (Mollusca Bivalvia)	softshell clam
Petricola pholadiformis (Mollusca Bivalvia)	false angelwing
Crassostrea gigas (Mollusca Bivalvia)	Portuguese oyster
Ensis directus (Mollusca Bivalvia)	American jackknife clam
Crassostrea virginica (Mollusca Bivalvia)	eastern oyster
Ruditapes philippinarum (Mollusca Bivalvia)	
Teredo navalis (Mollusca Bivalvia)	shipworm
Styela clava (Tunicata Ascidiacea)	leathery sea squirt

3 Animal species without planktonic stages

3.1 Juveniles and adults occasionally occurring in shallow water

Boccardiella (*Boccardia*) ***ligerica*** (Polychaeta Spionida)
Alkmaria romijni (Polychaeta Terebellida)
Limnomysis benedeni (Crustacea Mysida)
Paramysis intermedia (Crustacea Mysida)
P. lacustris (Crustacea Mysida)

Hemimysis anomala (Crustacea Mysida)
Dikerogammarus haemobaphes (Crustacea Amphipoda)
D. villosus (Crustacea Amphipoda) killer shrimp
Pontogammarus robustoides (Crustacea Amphipoda)
Chaetogammarus ischnus (Crustacea Amphipoda)
Gammarus tigrinus (Crustacea Amphipoda)
Obesogammarus crassus (Crustacea Amphipoda)
Chaetogammarus warpachowskyi (Crustacea Amphipoda)
Gmelinoides fasciatus (Crustacea Amphipoda)

3.2 Juveniles and adults not likely to occur in water

N.B. *Sargassum*, *Fucus* and other macroalgae are known for being transported with floating/drifting individuals, fragments or attached to objects.

Dasya baillouviana (Rhodophyta)
Codium fragile (Chlorophyceae) Assoc./**Ship** forked felt alga
Fucus evanescens (Phaeophyceae)
Sargassum muticum (Phaeophycea) Japweed
Gracilaria vermiculophylla (Rhodophyta)
Bonnemaisonia hamifera (Rhodophyta) Assoc./**Ship**
Chara connivens (Charophyceae) convergent stonewort
Elodea canadensis (Spermatophyta) Canadian waterweed
Pseudodactylogyrus anguillae (Platyhelminthes Monogenea)
Anguillicoloides (Anguillicola) crassus (Nematoda Spirurida) swim-bladder nematode
Paranais frici (Oligochaeta Tubificina)
Potamothrix heuscheri (Oligochaeta Tubificina)
Potamothrix vejdovskyi (Oligochaeta Tubificina)
Branchiura sowerbyi (Oligochaeta Tubificina)
Pseudocuma** (Stenocuma)* ***graciloides (Crustacea Cumacea)
Orconectes limosus (Crustacea Decapoda) spiny-cheek crayfish
Orconectes virilis (Crustacea Decapoda) northern crayfish
Pacifastacus leniusculus (Crustacea Decapoda) signal crayfish
Chelicorophium curvispinum (Crustacea Amphipoda) Caspian mud shrimp
Potamopyrgus antipodarum (Mollusca Gastropoda) New-Zealand mudsnail
Lithoglyphus naticoides (Mollusca Gastropoda) gravel snail

Planktonic life form or planktonic larvae as a part of the life cycle is, however, no prerequisite for organisms being transported with ballast water nor a straightforward criterium helping decision-makers to distinguish between species to be transported with BW or not. There are several groups of organisms (group 3.2 above), which as adult individuals or juveniles can be loaded with ballast water. Some crustacean species have traveled in ballast tanks (or in some cases and/or as fouling organisms outside the hull). Examples are the amphipod crustacean *Gammarus tigrinus* ("tiger shrimp"), carried from North America to NW Europe, and a couple of mysid (opossum) shrimps (the W European *Praunus flexuosus* (Ruiz *et al.* 2011) and the Ponto-Caspian *Hemimysis anomala*) established on the N American east coast and the Great Lakes, respectively. The oligochaete worms *Potamothrix heuscheri* and *P. vejdovskyi* have likely been introduced to Sweden with ballast water (www.frammandearter.se). These soft-bottom species do not have planktonic larvae. The same is true for the New Zealand mud snail (*Potamopyrgus antipodarum*), which originally reached England in drinking water barrels onboard sailing ships; its further rapid spread to the Baltic was related to ships' traffic (ballast water or fouling).

A fish species (the round goby, *Neogobius fluviatilis*), was likely transported with ballast water (as juveniles) from its native area in SE Europe to the Baltic. Some years later its ability to spread by ships was confirmed through its appearance in the N American Great Lakes.

2 Time and timing

2.1 Seasonality – adults or larvae present or not

In a preliminary search, data on wintertime abundances for zooplankton were found for the Finnish (Archipelago Sea, Gulf of Finland), Estonian and Latvian (Gulf of Riga) coastal waters. Abundances of bacterioplankton, phytoplankton and zooplankton were reported for Klaipëda harbour area in 1995-1996. In Estonian coastal waters, abundances of water fleas (Cladocera) were very low in spring and autumn months but rather high for Rotifera and Copepoda. In no cases the abundances (even if very low compared with those during the growing season), were low enough to meet those allowed according to Regulation D-2 Standard.

2.2 Duration of larval stages

Duration of the larval development is temperature and salinity dependent and therefore possibly longer for marine species in the Baltic Sea than in, e g., the East Atlantic conditions. The results of studies of North American or other remote populations cannot be applied directly to the populations in the Baltic, which can differ not only in reproductive season, but also in the duration of larval development, some international examples of which are presented in Table Annex V:2.

Table Annex V:2. Description of different phyla and their potential to survive stages of BW transportation process (Mikolajczyk (2009); modified and completed).

Phylum	**Recorded as introduced from N America NW Europe**	**Reproduction season**	**Larval life span**	**Salinity tolerance**
Cnidaria - jellyfish, sea anemones, etc	*Gonionemus vertens*	All year with peak in Jun-Jul	Continuously present in water	Needs more than 23 PSU
Ctenophora - comb jellies	*Mnemiopsis leidyi* - American comb jelly	May-Jun	All stages available in plankton	3-39 PSU; in the N Baltic Sea

				reproduction is prevented by low salinity (<10 PSU) and temperature (<12°C)[28]; tolerance limits 3°C and 4.5 PSU for survival in the Baltic Sea (Lehtiniemi *et al*. 2011)
Polychaeta - bristle worms	*Marenzelleria* spp. - red gilled mud worm		4-12 weeks	
Mollusca Gastropoda Snails	*Crepidula fornicata* - common Atlantic slippersnail	All year with peak in Aug-Sep	2-4 weeks	Preferred ~18-35 PSU. Needs 15-30°C for larval survival
Mollusca Bivalvia mussels, oysters	*Mya arenaria* - softshell clam *Rangia cuneata* - Atlantic rangia *Ensis americanus* - American jackknife clam *Mytilopsis leucophaeata*		2-5 weeks up to 7 days 10-29 days 4-6 weeks	4-40 PSU (preferred 25-35) Tolerates 5-15 PSU; larvae 2-20 (preferred 6-10 PSU) N/A Tolerates 0.1-31 PSU,larvae 3-22 PSU; larvae prefer 12-24°C
Crustacea Decapoda - crabs, crayfish, shrimps	*Rhithropanopeus harrisii* - estuarine mud crab		up to 16 days	Optimum larval growth at ~25°C
Crustacea Cirripedia - barnacles	*Balanus improvisus* - bay barnacle		2-5 weeks	

3 Prevailing current conditions

The mean surface circulation in all sub-basins of the BS is cyclonic (see Leppäranta, Myrberg (2008) for a comprehensive discussion). Alien species discharged with ballast water at a SE Baltic port will be transported by currents northward and, in similar way, westward from a port in southern Sweden.

The overall pattern is, however, largely modified by the broken shoreline in particular in the

x

northern part of the Sea (Finnish and Swedish coasts).

There seems to be scattered information only of currents in coastal inlets and harbor areas, characterized by quite dynamics. Much of the currents in the semi-enclosed bays and inlets are seesawing, caused by irregular water level fluctuations. Therefore, the following examples and conclusions are of limited use for real-world assessment of alien species' ability to spread from one port to another across larger water bodies without any human-introduced vectors, *i.e.*, 'naturally' by means of active swimming or passively with water currents (*cf.* Recommendation 8.1).

Swedish Kattegat coast. The typical current speed along the Swedish west coast is 0.4 to 0.7 kn (Sjöfartsverket 1985), *i.e.*, 2-3.5 cm/s (= 0.7-1.3 km/h), corresponding to 53-93 km/month.

The Sound. In the Sound, the velocity of the northward current can reach up to 5 kn, *i.e.*, 25 cm/s (220 km/day, 6500 km/month). Stability of the current: northward 60 % of the year.

Baltic Proper. In the open Baltic Proper, current speeds at (mainly) less than 10 cm/s (*i.e.* < 240 km/month) have been observed (Fig. 4). In an experimental study to estimate the potential for *Mnemiopsis leidyi* spread, satellite-tracked drifters were released in the Bornholm Basin area at 60-85 m depth (Lehtiniemi *et al.* 2011). The drifters resided mainly in the basin, while some of them were tracked 6 months later away in the northern Baltic Proper at a distance of about 500 km from the point of release.

Gulf of Bothnia. Surface currents in the open sea are about 5-10 cm/s (130 to 260 km/month), whereas speeds up to 15 cm/s seem to be common along the coasts on both Swedish (southgoing) and Finnish (northgoing) sides of the Bothian Sea.

Gulf of Finland. The Gulf

- is of joint interest for three HELCOM countries
- is an alongated estuarine-type basin of moderate size (400 km long)
- receives the largest freshwater input of the whole Baltic Sea (River Neva), an important factor causing water movements: the River feeds the eastermost GoF with 2400 m^3/s of fresh water, which creates steep salinity gradients
- has been actively investigated from both oceanographical and biological point of view
- is one of the major routes for ballast water transportation, due to the increasing volume of Russian crude shipped from oil terminals in the easternmost part of the GoF (in 2009, more than 150 million tn of oil was trasported in the Gulf)
- St Petersburg is one of the ports selected as targets for route-specific risk assessment in this report

In the GoF, the mean horizontal circulation is cyclonic – with average inflow of the more saline water close to the Estonian coast and outflow of less saline water along the northern, Finnish coast. Speeds of the mean circulation have been estimated a few cm/s. However, instantaneous currents may reach 20-30 cm/s or even more.

The general current pattern is largely modified by forcing functions (winds and atmospheric pressure gradients which cause water level fluctuations). Due to instability of the currents, the counter-clockwise mean circulation is more a statistical property than a constant phenomenon (Alenius *et al*. 1998, Elken *et al*. 2011).

In the GoF, current velocities for the westward outflow along the Finnish coast have been estimated at 3-5 cm/s for the coastal zone and at 5-10 cm/s for the open sea (Andrejev *et al*. 2004). On the Estonian side of the Gulf, typical velocities of the inflowing water are between 1-4 cm/s, but near the surface values ranging from 7 to 10 cm/s are found. On the Finnish side, the mean velocity of the offshore outflow can reach a magnitude of 8 cm/s. The average net transport speed can be estimated at 5 to 7 cm/s westward on the Finnish side of the GoF, while in the inner GoF the velocities are considerably lower, 2-4 cm/s[8].

The average speed of water particles for the 5-year period of 1987-1991 was estimated at 7 cm/s; the highest speeds occur in the windy period (Oct-March 7-10 cm/s) and the lowest in the calm season (March-May 3-5 cm/s) (Soomere *et al.* 2011).

The stability of currents in the GoF is rather high: the outflow on the northern side of the Gulf is a distinct feature with persistence ranging between 50-80% (Andrejev *et al.* 2004).

Summary. Taking a surface current velocity at 7 cm s as an average for the offshore waters of the Gulf of Finland, we can calculate the westward transportation rate for surface water (and organisms with it) at ca 250 m/h = 6 km/24h day = 180 km/month. However, assuming a residual current velocity at *e.g.* 3 cm/s, the transportation rate would be at the level of about 110 m/h = less than 80 km/month.

4 Presence of environmental barriers

Discussed in the RA part of this report

5 Conclusions

It is clearly stated in Rec. 8.3 that the authorities responsible for granting exemptions, may reserve a right to exempt ships on specific voyages only if the ability to disperse from donor to a recipient port 'naturally' can be based on **scientifically proven information of high**

quality (which is most often totally lacking or exists from remote coasts) or **reliable expert judgement**). This is **only valid if no other species poses a further threat**.

Further, there is very scarce information on e g detailed life histories of (potentionally) harmful species, duration of their pelagic larval stages (dependent on temperature), and details on currents (e g deviations from general patterns of direction, velocity and stability) and, in particular, practically no knowledge of currents (direction, speed and duration) which link the water masses in port basins (including discharged ballast water) with the currents prevailing outside the harbor areas and the open sea. A more detailed species spread assessments would only be possible with reliable and geographically more comprehensive data.

REFERENCES

Alenius P, Myrberg K, Nekrasov A (1998) The physical oceanography of the Gulf of Finland: a review. Boreal Env Res 3, 97-125

Andrejev O, Myrberg K, Alenius P, Lundberg PA (2004) Mean circulation and water exchange in the Gulf of Finland - a study based on three-dimensional modelling. Boreal Env Res 9, 1-16

Anonymous (2011) [Operational monitoring of the coastal sea]. Eesti Mereinstituut, Tallinn, 150 pp (In Estonian)

Briggs JC (1974) Marine Zoogeography. McGraw-Hill, New York, 480 pp

Briski E, Bailey SA, Cristescu ME, MacIsaac HJ (2010) Efficacy of ‘saltwater flushing’ in protecting the Great Lakes from biological invasions by invertebrate eggs in ships’ ballast sediment. Freshwater Biol 55, 2414-2424

Buttermore RE, Turner E, Morrice MG (1994) The introduced northern Pacific seastar *Asterias amurensis* in Tasmania. Mem Queensland Mus 36, 21-25

Campbell ML, Gould B, Hewitt CL (2007) Survey evaluations to assess marine bioinvasions. Mar Pollut Bull 55, 360-378

Carlton JT (1985) Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. Oceanogr Mar Biol Annu Rev 23, 313-374

Carlton JT (2001) Introduced species in U.S. coastal waters: environmental impacts and management priorities. Arlington, Virginia, USA, Pew Oceans Commission. 28 pp

Cothern CR (1996) Handbook for Environmental Risk Decision Making: values, perceptions and ethics. Lewis Publishers, CRC Press LLC, 432 pp

David M (2007) A decision support system model for ballast water management of vessels. PhD Thesis, Univ. Ljubljana, Portorož, 295 pp

David M, Gollasch S (2010) Ballast Water Risk Assessment for intra North Sea Shipping. Prepared for Interreg IVB Project Ballast Water Opportunity. 48 pp

David M, Gollasch S, Cabrini M, Perkovič M, Bošnjak D, Virgilio D (2007) Results from the first ballast water sampling study in the Mediterranean Sea - the Port of Koper study, Mar Pollut Bull 54, 53-65

David M, Gollasch S, Hewitt C, Jakomin L (2007) Ballast water management for European seas - is there a need for a decision support system? In: Conference proceedings, Aberdeen: IEEE, 2007, 6 pp

Dickman M, Zhang F (1999) Mid-ocean exchange of container vessel ballast water. 2: effects of vessel type in the transport of diatoms and dinoflagellates from Manzanillo, Mexico, to Hong Kong, China. Mar Ecol Prog Ser 176, 253-262

Dragsund E, Andersen AB, Gollasch S, ten Hallers-Tjabbes CC, Skogen K (2005) Ballast Water Scoping Study. Det Norske Veritas, Report 2005-0638, 82 pp

Drake LA, Ruiz GM, Galil BS, Mullady TL, Friedmann DO, Dobbs FC (2002) Microbial ecology of ballast water during a transoceanic voyage and the effects of open-ocean exchange. Mar Ecol Prog Ser 233, 13-20

Ekman S (1953) Zoogeography of the Sea. Sidgwick and Jackson Ltd, London. 417 pp

Elken J, Nõmm M, Lagemaa P (2011) Circulation patterns in the Gulf of Finland derived from the EOF analysis of model results. Boreal Env Res 16 (suppl. A), 84-102

EU Commission (2000) Communication from the Commission on the Precautionary Principle. Brussels, Com. (2000) 1, 29 pp

Flagella MM, Verlaque M, Soria A, Buia MC (2007) Macroalgal survival in ballast water tanks. Mar Pollut Bull 54, 1395-1401

GloBallast (2004) Ballast Water Risk Assessment, User guide for the BWRA Database/GIS System. GEF/UNDP/IMO, Global Ballast Water Management Program. URS Meridian-GIS. 53 pp + appendices

Gollasch S (2002) Hazard analysis of aquatic species invasions. In: Leppäkoski E, Gollasch S, Olenin S (eds) Invasive Aquatic Species of Europe. Distribution, Impacts and Management, Kluwer Academic Publishers, Dordrecht, The Netherlands, 447-455

Gollasch S, Leppäkoski E (eds) (1999) Initial Risk Assessment of Alien Species in Nordic Costal Waters. Nordic Council of Ministers, Copenhagen, 244 pp

Gollasch S, Leppäkoski E (2007) Risk assessment and management scenarios for ballast water mediated species introductions into the Baltic Sea. Aquat Inv 2, 313-34

Gollasch S, David M, Voigt M, Dragsund E, Hewitt C, Fukuyo Y (2007) Critical review of the IMO International Convention on the Management of Ships' Ballast Water and Sediments. In: Hallegraeff GM (ed), Harmful Algae 6, pp 585-600

Gollasch S, Haydar D, Minchin D, Wolff WJ, Reise K (2009) Introduced aquatic species of the North Sea coasts and adjacent brackish waters. In: Rilov G, Crooks AJ (eds) Biological Invasions in Marine Ecosystems. Springer, 507-528

Gollasch S, Lenz J, Dammer M, Andres HG (2000) Survival of tropical ballast water organisms during a cruise from the Indian Ocean to the North Sea. J Plankton Res 22, 923-937

Gollasch S, Macdonald E, Belson S, Botnen H, Christensen J, Hamer J, Houvenaghel G, Jelmert A, Lucas I, Masson D, McCollin T, Olenin S, Persson A, Wallentinus I, Wetsteyn B, Wittling T (2002) Life in ballast tanks. In: Leppäkoski E, Gollasch S, Olenin S (eds) Invasive Aquatic Species of Europe - Distribution, Impact and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands (2nd ed) 217-231

Gollasch S, Rosenthal H, Botnen J, Hamer H, Laing I, Leppäkoski E, Macdonald E, Minchin D, Nauke M, Olenin S, Utting S, Voigt M, Wallentinus I (2000) Survival rates of species in ballast water during international voyages: Results of the first workshops the European Concerted Action. In: Pederson J (ed) First National Conference on Bioinvasions. Massachusetts Institute of Technology, MIT Sea Grant Program, Center for Coastal Resources, Cambridge, USA, 24-27 January 1999. Conference Proceedings, 296-305

Grannum RK, Murfet NB, Ritz DA, Turner E (1996) The distribution and impact of the exotic seastar, *Asterias amurensis* (Lütken) in Tasmania. In: The Introduced Northern Pacific Seastar *Asterias amurensis* in Tasmania, Australian Nature Conservation Agency, 53-138

Gray DK, Johengen TH, Reid DF, MacIsaac HJ (2007) Efficacy of open-ocean ballast water exchange as a means of preventing invertebrate invasions between freshwater ports. Limnol Oceanogr 52, 2386-2397

Hallegraeff GM (1998) Transport of toxic dinoflagellates via ships' ballast water: bioeconomic risk assessment and efficacy of possible ballast water management strategies. Mar Ecol Prog Ser 168, 297-309

Hayes KR (1997) A review of ecological risk assessment methodologies. CRIMP Technical Report 13, CSIRO Marine Research, Australia, 49 pp + appendix

Hayes KR (2000) Quantitative ecological risk assessment, a ballast water case study. PhD Thesis, 292 pp + appendices

Hayes K, Sliwa C (2003) Identifying potential marine pests – a deductive approach applied to Australia. Mar Pollut Bull 46, 91-98

Hebert PDN, Muncaster BW, Mackie GL (1989) Ecological and genetic studies on *Dreissena polymorpha* (Pallas): a new mollusc in the Great Lakes. Can J Fish Aquat Sci 46, 405-409

Hewitt CL, Hayes KR (2002) Risk assessment of marine biological invasions. In: Leppäkoski E, Gollasch S, Olenin S (eds) Invasive Aquatic Species of Europe - Distribution, Impact and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands, 456-466

Hewitt CL, Martin RB (2001) Revised protocols for baseline port surveys for introduced marine species – design considerations, sampling protocols and taxonomic sufficiency. CRIMP Technical Report 22. CSIRO Marine Research, Hobart, 46 pp

ICES WGBOSV (2005) Report of ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV), 14-28 March 2005, Arendal, Norway. ACME:04, 97 pp

Kirchsteiger C, Christou MD, Papadakis A (eds) (1998) Risk assessment and Management in the Context of Seveso II Directive. Elsevier, 537 pp

Lehtiniemi M, Lehmann A, Javidpour J, Myrberg K (2011) Spreading and physico-biological reproduction limitations of the invasive American comb jelly *Mnemiopsis leidyi* in the Baltic Sea. Biological Invasions DOI: 10.1007/s10530-011-0066-z

Leppäkoski E, Gollasch S (2006) Risk Assessment of Ballast Water Mediated Species Introductions – a Baltic Sea Approach. Report prepared for HELCOM, Helsinki, Finland, 111 pp. www.helcom.fi/projects/on_going/en_GB/alienspecies/

Leppäkoski E, Olenin S (2001) The meltdown of biogeographical peculiarities of the Baltic Sea: the interaction of natural and man-made processes. Ambio 30, 202-209

Leppäranta M, Myrberg K (2009) Physical Oceanography of the Baltic Sea. Springer, 378 pp

Ljungberg R, Pikkarainen A, Lehtiniemi A, Urho L (2011) Detection of alien species in the Finnish monitoring programs of the Baltic Sea. The Finnish Environment 10/2011, Finnish Environment Institute, Helsinki, 68 pp (www.ymparisto.fi/default.asp?contentid=388398&lan=fi; in Finnish)

Lloyd's Register (2007) Lloyd's Register – Fairplay, http://www.lrfairplay.com

Lodge DM, Stein RA, Brown KM, Covich AP, Bronmark C, Garvey JE, Klosiewski SP (1998) Predicting impact of freshwater exotic species on native biodiversity: challenges in spatial scaling. Aust J Ecol 23, 53–67

Longhurst ER (1998) Ecological Geography of the Sea. Academic Press, 398 pp

Macdonald E, Davidson R (1997) Ballast water project. Final report. Fisheries Research Services Report 3/97, FRS Marine Laboratory Aberdeen, 83 pp

Marquard O (1926) Die Chinesische Wollhandkrabbe, *Eriocheir sinensis* Milne-Edwars, ein neuer Bewohner deutscher Flüsse. Fischerei 24, 417-433

McCollin T, Macdonald EM, Dunn J, Hall C, Ware S (2001) Investigations into ballast water exchange in European regional seas. In: International Conference on Marine Bioinvasions, New Orleans, April 9-11 2001, 94-95

McCollin T, Shanks AM, Dunn J (2008) Changes in zooplankton abundance and diversity after ballast water exchange in regional seas. Mar Pollut Bull 56, 834–844

MEPC (2007) Guidelines for Risk Assessment Under Regulation A-4 of the BWM Convention (G7), Resolution MEPC 162(56), IMO, London

Mikolajczyk M (2009) Species introductions with ballast water – a stepwise process. Dissertation, School of Earth, Ocean and Environmental Sciences, University of Plymouth, 63 pp

Minchin D (2007) Aquaculture and transport in a changing environment: Overlap and links in the spread of alien biota. Mar Pollut Bull 55, 302-313

Olenin S, Gollasch S, Jonusas S, Rimkute I (2000) En-route investigation of plankton in ballast water on ship's voyage from the Baltic Sea to the open Atlantic coast of Europe. Int Rev Hydrobiol 85, 577–596

Paavola M (2005) Aquatic bioinvasions: Risk assessment of alien species and their vectors in fresh and brackish northern waters. Lic. Phil. Thesis, Åbo Akademi University, 28 pp

Paavola M, Laine AO, Helavuori M, Kraufvelin P (2008) Profiling four brackish-water harbours: zoobenthic composition and invasion status. Boreal Env Res 13, 159–175

Paavola M, Olenin S, Leppäkoski E (2005) Are invasive species most successful in habitats of low native species richness across European brackish water seas? Estuarine Coastal Shelf Sci 64, 738-750

Panning A **(**1938) The Chinese Mitten Crab. Smithsonian Rep, 361-375

Remane A (1934) Die Brackwasserfauna. Verh Dtsch Zool Ges 36, 34-74

Ruiz G, Fofonoff P, Steves B, Dalhstrom A (2011). Marine crustacean invasions in North America: a synthesis of historical records and documented impacts. In: Galil BS, Clark PF, Carlton JT (eds) In the Wrong Place – Alien Marine Crustaceans: Distribution, Biology and Impacts. Invading Nature 6. Springer, pp 215–250

Segerstråle SG (1957) Baltic Sea. In: Hedgpeth JW (ed) Treatise on Marine Ecology and Paleoecology I. Ecology. Geol Soc Am Mem 67, 751-800

Simard N, Plourde S, Gilbert M, Gollasch S (2011) Net Efficacy of open ocean ballast water exchange on plankton communities. J Plankton Res 33, 1378–1395

Soomere T, Delpeche N, Viikmäe B, Quak E, Meier, HEM, Döös K (2011) Patterns of current-induced transport in the surface layer of the Gulf of Finland. Boreal Env Res 16 (suppl. A), 49–63

Souvorov AV (1999) Marine Ecologonomics, The Ecology and Economics of Marine Natural Resources Management. Elsevier, 224 pp

Springer VG (1982) Pacific plate biogeography with special reference to shore fishes: Smithsonian Contrib Zool 367, 182 pp

Taylor MD, MacKenzie LM, Dodgshun TJ, Hopkins GA, de Zwart EJ, Hunt CD (2007) Trans-Pacific shipboard trials on planktonic communities as indicators open ocean ballast water exchange. Mar Ecol Prog Ser 350, 41–54

Venice System (1959) The final resolution of the symposium on the classification of brackish waters. Arch Oceanogr Limnol 11 (suppl), 243–248

Villac MC, Persich G, Fernandes L, Paranhos R, Dias C, Bonecker S, Garcia V, Odebrecht C, Tenenbaum D, Tristao ML, De Andrade S, Fadel A (2001) Ballast water exchange: testing the dilution method (Petroras, Brazil). In: Hallegraeff GM, Blackburn SI, Bolch CJ, Lewis RJ (eds) Proceedings of 9th International Conference on Harmful Algal Blooms, IOC of UNESCO, Paris pp 470-473

Williams RJ, Griffiths FB, Van der Wal EJ, Kelly J (1988) Cargo vessel ballast water as a vector for the transport of nonindigenous marine species. Estuarine Coastal Shelf Sci 26, 409–420

Wolff WJ (2005) Non-indigenous marine and estuarine species in the Netherlands. Zool Meded 79, 3-116

Zenkevich LA (1963) Biology of the Seas of the USSR. Interscience Publishers, New York. 955 pp