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HELCOM BALSAM Project WP 4: Non indigenous species-multi disciplinary monitoring schemes to gain synergies for ballast water risk-management and environmental monitoring.

Part: Testing harmonized criteria for Risk Assessments Final Report (v1), On behalf of BSH, Federal Maritime and Hydrography Agency, Germany

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Content

1. Introduction

Regulation A-4 of the IMO (International Maritime Organization) Ballast Water Management Convention (BWMC) states that a Party or Parties may grant exemptions to requirements of the convention. Scientifically robust scientific assessment underpins the process of Parties granting exemptions under regulation A-4 of the convention. To minimize the effort and to make the risk assessment procedure practicable a pre-selection of species that have to be assessed for their risk is necessary. Therefore, the Risk Assessments (RA) for granting exemptions from ballast water treatment are mostly based on target species (TS) (e.g. NSBWO 2010, David et al.2013). TS are defined on the basis of the BWMC Guidelines for risk assessment under regulation A-4 of the G7: '*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 biogeographic region.*'

The Guidelines (G7) propose the following procedures and criteria for the identification of TS in the donor (port or location where BW is taken on board) and recipient (port or location where BW is discharged) port: 'T*o determine the species that are potentially harmful and invasive, parties should initially identify all species (including cryptogenic species) that are present in the donor port but not in the recipient port. Target species should then be selected based on criteria that identify the species that have the ability to invade and become harmful. The factors to consider when identifying target species include, but should not be limited to:*
- *evidence to prior introduction;*
- *demonstrated impacts on environment, economy, human health, property or resources;*
- *strength and type or ecological interactions, e.g. ecological engineers;*
- *relationship with ballast water as a vector.'*

In the BWMC G7 the proposed factors for defining TS are not exactly defined and therefore different assessments whether a species is or may be harmful are possible. Consequently, TS are not comparable between countries and each country uses different TS lists.

For that reason HELCOM created a project (HELCOM Alien 2 Project (HELCOM 2013)) and one task of this project was to define harmonized selection criteria for TS. Based on these criteria the decision whether a species is a TS should be more objective, so that at the end of the process the countries come to an agreement which species are TS and which are not. With the determined TS the risk assessment model (Ballast Water Decision Support Tool (HELCOM 2013)) can be run. If more than one target species is present each one has to be evaluated with the risk assessment model.

Up to now the harmonized criteria developed during the HELCOM Alien 2 Project were not tested and therefore, within the BALSAM Project (WP4, Non-indigenous species –multi-disciplinary monitoring schemes to gain synergies for ballast water risk-management and environmental monitoring) this will be done herewith.

The tasks of this part of the project are to
- test the harmonized criteria with species detected during the BALSAM port surveys;
- discuss the harmonized criteria and make amendments, if necessary and
- make a proposal how the assessment scores of the single criteria, should be used for the final decision whether a species is a TS or not.

The first results of the tests of the harmonized criteria were already published in the BALSAM interims report (November 2014). This report was circulated within the HELCOM community by the HELCOM secretariat in order to receive critics and amendments on the proposed procedure for selecting TS. Additionally, the results of the interim report were presented at the fifth Meeting of the *Joint HELCOM/OSPAR Task Group on Ballast Water Management Convention Exemptions (HELOM/OSPAR TG BALLAST 5-2014)* which took place in Madrid (1st and 2nd December 2014). All received comments are included in this version of the Final Report (WP4, part harmonized criteria).

2. Testing the harmonized criteria for defining Target Species (TS) for the purpose of the Ballast Water Decision Support Tool

2.1 Selection of the species for the test of the harmonized criteria

Within the BALSAM port surveys, the ports of Gothenburg, Kokkola, Naantali, Turku, Sköldvik, Hamina-Kotka, Muuga Bay and Gydnia were sampled for non-indigenous species (NIS). Between seven and 11 NIS were found in each port (exception Muuga Bay only one NIS) (Table 1). Of these *Boccardiella ligerica*, *Molgula manhattensis*, *Mytilopsis leucophaeata, Neogobius melanostomus* and *Rhithropanopeus harrisii* were proposed as a TS for the purpose of the Ballast Water Decision Support tool as result of the HELCOM ALIEN 2 project (HELCOM 2013). Therefore these five species were used in this study to test the proposed harmonized criteria (Table 1 and 2).

2.2 Proposed harmonized criteria

As a result of the first feasibility tests and the discussions on the BALSAM Interim report (November 2014) the proposed harmonized criteria developed within the ALIEN 2 Project (HELCOM 2013) were revised. The changes are:

- the former criterion 'dispersal by ballast water or sediments' was removed from the assessment criteria list, since according to the G7 Guideline only those species which have evidence of prior introduction and relationship with ballast water or sediment should be taken into account. Therefore, the point potentially transferred by ballast water or sediment. is defined as a precondition and only if a species fulfills this precondition, should it be further assessed,
- only those NIS which are not already established in all their ecologically potential areas of the Baltic Sea are useful as a TS with respect to the RA. Therefore the point 'not established in all their potential areas is defined as a second precondition and only if a species fulfills this precondition, should it be further assessed,
- two previous criteria 'Impact on native species' and 'Alteration of ecosystem functions' are merged to one criterion, since mostly it is not possible to distinguish between these two criteria since if a native species is impacted by a NIS, also the ecosystem functions are mostly altered.

As a TS only those NIS are of interest in respect to the RA which fulfill the above described two preconditions (a.) evidence to prior introduction and relationship with ballast water or sediment and b.) does not occur in all their potential areas of the Baltic Sea). Only if both preconditions are fulfilled the species should be further assessed with the revised harmonized criteria (Table 2).

Table 1: Findings (****) of NIS during the BALSAM port surveys. Included is information on occurrence reported in the Helcom lists (HELCOM 2010), * no findings in the Kattegat due to information based on factsheets from DAISIE, NOBANIS and/or Främmande Arter. Included are also the years of introductions and salinity tolerances reported in the Helcom lists (HELCOM 2010), ** findings in CL, according to comments from Poland, and the lists, where these species are already named (AL2=Alien2 list (HELCOM 2013), HL1, HL2= List part 1 and Target species list (HELCOM 2010), DK1, DK2, DK GL = DK TS1 established species, DK TS2 alert list, DK Gross list (NIS alien species in the Greater North Sea area and Baltic Sea) (Jensen 2013); S A1, S A2= Sweden Alien and Alert list (Främmande arter); Ports: Gothenburg (GOT), Kokkola (KOK), Naantali (NAA), Turku (TKU), Sköldvik (SKO), Hamina-Kotka (HAM-KOT), Muuga Bay (MUU) and Gydnia (GDY). N= Native, B= Baltic Sea, GoB Gulf of Bothnian, GoF Gulf of Finland, GoR Gulf of Riga, K = Kattegat and Belt Sea, OL = Odra Lagoon, BP = Baltic Proper, VL = Vistula lagoon, CL = Curonian Lagoon, LF = Limfjord, KF = Kattegat North coast of Sjælland, Isefjord, Roskilde Fjord.

NIS	Occurence	Year of intro-duc-tion	Vector	Salinity tole-rances	GOT	KOK	NAA	TKU	SKO	HAM	KOT	MUU	GDY	AL2	HL1	HL2	DK1	DK2	DK GL	S A1	S A2
					18-30	2,7-3,1	5,4-5,5	5,2-5,4	0,5-5,2	2-4	0,1-4,1		6,70								
Acartia tonsa	GoB, GoF, GoR, K, OL, BP, VL	1931	Ship	N 5-30; B 0,5-30			****	****		****	****		****								
Amphibalanus improvisus	BP, CL, GoB, GoF, GoR, K, OL, VL, LF, KF	1844	Ship	N 18-40, B 0,5-30	****	****	****	****	****	****	****	****	****								
Boccardiella ligerica	BP, GoB, GoF	1962	Ship	N 0,5-18; B 0,5-18			****	****													
Cercopagis pengoi	BP, CL, GoB, GoF, GoR, K*, VL	1992	Ship	N 0,5-18 B 0,5-10			****	****	****	****	****										
Cordylophora caspia	CL, GoB, GoF, K, OL, VL, BP	1870	Ship/hull	N 0-40; B 0-18	****	****	****	****	****	****	****										
Dreissena polymorpha	CL, GoF, GoR, OL, VL, BP, K	1800's	Ship	N<0,5, B 0-3						****											
Evadne anonyx	GoF,GoB, GoR, OL, VL, BP	1999	Ship	N 0-30; B 0-30		****				****	****	****									
Gammarus tigrinus	CL, GoF, GoR, K*, OL, VL, GoB	1975	ST	N 0-30; B 0-10		****	****	****		****	****										
Marenzelleria neglecta	BP, CL, GoB, GoF, GoR, K*, OL, VL	1985	Ship	N 18-40; B 0,5-30		****			****	****	****		****								
Marenzelleria viridis	BP, GoB, K, OL, VL, KF	2005	Ship	N 3-40; B 3-30	****																
Marenzelleria													****								
Marenzelleria sp.							****	****					****								
Molgula manhattensis	BP, K, KF, LF	?	?		****																
Mytilopsis leucophaeata	GoF, GoB, K*	2000	Ship/hull	N 0-30; B 0-10			****	****	****												
Neanthes succinea	K, cryp. DK				****																
Neogobius melanostomus	BP, CL, GoF, GoR,K VL, GoB, OL	1998	canal /ship	N 0-8; B 0-10	****		****		****			****	****								
Palaemon elegans	BP, CL, GoF, K, OL, VL, LF, KF	1920s	Ship	N 5-40; B 0,5-5			****	****			****		****								
Potamopyrgus antipodarum	BP, CL, GoB, GoF, BoR, K, OL, VL, LF, KF	1907	ship	N 0-30; B 0-10						****	****										
Prorocentrum minimum	BP, CL, GoF, K, GoR, LF, KF	1998	ship	N 10-40; B 0,5-30						****											
Rhithro-panopeus harrisii	BP, K*, OL, VL and CL**	1948	Ship/hull	N 18-30; B 0,5-18			****	****					****								
Tubifex pseudogaster	GoF, BP, K	2000s	?		****																
Tubificoides heterochaetus													****								
Victorella pavida	GoB, K*, BP, GoF	1960s	Ship	1-27				****													
Sum of NIS					7	5	11	11	8	10	8	2	9								

Table 2: Assessment criteria, which are based on the Belgium ISEIA protocol (ISEIA guidelines 2009) with additional criteria included from Swedish and Australian proposal.

	Low risk species=1	Medium risk species=2	High risk species=3
1. Dispersion potential or invasi-veness	The species does not spread in the environment because of poor dispersal capacities and low reproduction potential.	Except when assisted by man, the species does not colonize remote places. Natural dispersal rarely exceeds more than 1km per year. The species can however become locally invasive because of a strong reproduction potential.	The species is highly fecund, can easily disperse through active of passive means over distances > 1km/year and initiate new populations.
2. Coloni-sation of high conser-vation value habitats	Populations of the non-native species are restricted to habitats of no conservation value (e.g. harbor constructions as quay walls or bank and shoreline stabilization or pipes for cooling systems).	Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonize high conservation value habitats.	Non-native species often colonize high conservation value habitats, these are all biotopes where endangered species can be found. Most of the sites of a given habitat are likely to be readily colonized by the NIS when source population is present in the vicinity and poses therefore a potential threat for red-listed species.
3. Alteration of ecosystem functions and/or impact on native species	Data from invasion history suggest that the negative impact on native species and/or ecosystem functions is negligible.	A non-native species is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially among common and ruderal species and/or the impacts on ecosystem processes and structures are moderate. The modification of water and sediment properties is temporary.	The development of the non-native species often causes local serve (>80%) population declines and the reduction of local species richness. On a regional scale, it can be considered as a factor precipitating (rare) species decline. Those non-native species form long-standing populations and their impacts on native biodiversity are considered as almost non-reversible. Therefore the impact on ecosystem processes and structures is strong and difficult to reverse e.g. food web disruption (*Crassostrea gigas*) or habitat destruction (*Eriocheir sinensis*).
4. Effects on human health	Data from invasion history suggest that the species has weak toxic effects and no treatment is necessary.	Data from invasion history suggest that the species has moderate symptoms, easily treated, no permanent damage.	Data from invasion history suggest that the species has negative impact on human health, permanent damage or death.
5. Effects on natural resources (e.g. fisheries)	Data from invasion history suggest that negative impact on natural resources is negligible.	Data from invasion history suggest that the species has only slight negative impact on natural resources and is only restricted to single locations.	Data from invasion history suggest that the species causes serious loss on aquaculture or fisheries harvest.
6. Effects on property (e.g. cooling systems)	Data from invasion history suggest that the negative impact on property is negligible.	Data from invasion history suggest that the species has only slight negative impact on property and this is only restricted only to single locations.	Data from invasion history suggest that the species has high negative impact in property at many locations.

2.3 Testing the proposed harmonized criteria

Within the BALSAM port surveys *Boccardiella ligerica*, *Molgula manhattensis*, *Mytilopsis leucophaeata*, *Neogobius melanostomus* and *Rhithropanopeus harrisii* were detected (Table 1). Since these five species were proposed as a TS as a result of the HELCOM ALIEN 2 project for the purpose of the Ballast Water Decision Support tool (HELCOM 2013) they were used to test the proposed harmonized criteria (Table 2). The results of the assessments are compiled in Table 3 and the scoring is discussed below in Chapter 2.4.

It should be noted, that I made the assessments on the basis of information which is available in literature but if the assessment method will be used in practise the assessments should be done by taxonomic experts. But if experts/groups are assessing the species, it is very important that there is a common understanding of the method, e.g. DK used it in a pathway analysis, where the experts scores different species groups, otherwise it will be difficult to compare across groups at a later stage (Nyegaard Hvid, pers.comm).

Boccardiella ligerica

Preconditions:
a.) *B. ligerica* is introduced with ballast water or sediment. Gollasch et al. (2002) found larvae and juveniles Polydora sp. in ballast water and sediment.
b.) The species does not inhabit all its potential areas in the Baltic Sea. It has been known in the Baltic Sea since the 1960s. It is only found in the Gulf of Finland, Gulf of Bothnian and the Baltic Proper (HELCOM 2010) and not found in the German (pers. comm.) and Swedish part (Främmande arter i Svenska hav 2008) of the Baltic Sea.

Harmonized criteria:
1. Dispersion potential or invasiveness: *B.ligerica's* range coincided mainly with shipping channels and harbours (Leppäkoski und Olenin 2000).
Assessment 2 (medium risk): Except when assisted by man, the species does not colonize remote places. Natural dispersal rarely exceeds more than 1km per year. The species can however become locally invasive because of a strong reproduction potential
2. Colonization of high conservation value habitats: Since *B. ligerica's* range coincided mainly with shipping channels and harbours (Leppäkoski und Olenin 2000) and it has a slow natural spread this species only occasionally colonize high conservation value habitats.
Assessment 2 (medium risk): Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonize high conservation value habitats.
3. Alteration of ecosystem functions and/or impact on native species
B. ligerica can attain high densities in non-native ecosystems and become a dominant member of the benthic Infauna (National Park Service, U.S. Department of Interior; National Park Service, U.S. Department of Interior). Each introduced species influences the biodiversity of the native community, but up to now this has not been proved for *B. ligerica*.
Assessment 2 (medium risk): A non-native species is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially among common and ruderal species and/or the impacts on ecosystem processes and structures are moderate. The modification of water and sediment properties is temporary.
4. Effects on human health: No effects on human health are known.
Assessment 1 (low risk)
5. Effects on natural resources (e.g. fisheries): No effects on natural resources are known.
Assessment 1 (low risk)
6. Effects on property (e.g. cooling systems): No effects on any properties are known.
Assessment 1 (low risk)

For the assessment whether this species is proposed as a target species, see below Chapter 2.4.

Molgula manhattensis

Preconditions:

a.) *M. manhattensis* is most likely transferred by ballast water (Jensen 2010a) and hull fouling (Carlton and Hodder 1995). Ascidian adults and also larvae are found in ballast water (Gollasch et al. 2002).

b.) The species does not inhabit all its potential areas in the Baltic Sea but the decision whether *M. manhattensis* inhabits all its potential areas in the Baltic Sea is difficult to make since its identification is confused by taxonomic problems (Hiscock 2008 and citation in it). It was recorded in brackish waters (16-30psu) (Hiscock 2008 and citation in it). It is found in the Swedish Skagerrak/ Kattegat area (Främmande Arter 2013), not found in the German part of the Baltic Sea (Lackschewitz et al. 2009) and unknown in Danish Baltic waters (Jensen, pers. comm). *M. manhattensis* could live in the Kattegat and in the Kiel Bight.

Harmonized criteria:

1. Dispersion potential or invasiveness

M. manhattensis is a free spawning hermaphrodite, the embryos hatch in less than 24 hours as swimming non-feeding short-lived larvae with a functional larval variability of 20-48 hours. The larvae are gregarious settlers, which results in the establishment of large masses (Pleus et al. 2008). They occur in dense clusters. The life span is probably one year or less (Pleus et al. 2008). Larval/Juvenile dispersal potential is given by 1km-10km and the duration of the larval stage <1 day (Hiscock 2008).

Assessment 3 (high risk): The species is highly fecund, can easily disperse through active of passive means over distances > 1km/year and initiate new populations.

2. Colonization of high conservation value habitats

M. manhattensis is found especially in ports and harbors (Hiscock 2008). It prefers hard substances in very protected waters such as harbors and marinas and it is often found attached to bedrocks, boulders, cobble and shells at depths ranging from intertidal to 90m or more (Pleus et al. 2008). It also settles on sea grass (Hiscock 2008).

Assessment 2 (medium risk): Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonize high conservation value habitats.

3. Alteration of ecosystem functions and/or impact on native species

Since *M. manhattensis* settles mainly on artificial substrates near harbors and marinas it will probably have low impact on native species and will not alter the native ecosystem functions.

Assessment 1 (low risk): Data from invasion history suggest that the negative impact on native species and/or ecosystem functions is negligible.

4. Effects on human health: No effects on human health are known.

Assessment 1 (low risk)

5. Effects on natural resources (e.g. fisheries)

In hard clam (*Mercenaria mercenaria*) aquaculture nursery facilities, *M. manhattensis* often restrict clams from burrowing and feeding properly, eventually killing (Pleus et al. 2008).

Assessment 2 (medium risk): Data from invasion history suggest that the species has only slight negative impact on natural resources and is only restricted to single locations.

6. Effects on property (e.g. cooling systems)

M. manhattensis is a part of fouling communities and has therefore the same impacts as other fouling organisms (Jensen 2010a).

Assessment 2 (medium risk): Data from invasion history suggest that the species has only slight negative impact on property and this is only restricted only to single locations.

For the assessment whether this species is proposed as a target species, see below Chapter 2.4.

Mytilopsis leucophaeata

Preconditions:
a.) *M. leucophaeata* is dispersed by ballast water or as a fouling organism on the ship hull. Another fouling organism is the dreissenid bivalve *Dreissena polymorpha* with comparable development (life stages) and which has already been found in the ballast tanks in the sediment (Gollasch et al. 2002).
b.) The species does not inhabit all its potential areas in the Baltic Sea. It has been stated that it can live and establish in salinities ranging from freshwater (0,1psu) to mesohaline conditions with a maximum of 26,4psu (Verween et al. 2010). It is found in Germany (Verween et al. 2010), Finland (Florin et al. 2013), Sweden (Florin et al. 2013) and Poland (Dziubińska 2011).

Harmonized criteria:
1. Dispersion potential or invasiveness
M. leucophaeata has spread in the new environment. Although it has been present in Europe for over 170 years, it has recently spread rapidly by ballast water discharges (Verween et al. 2006). The natural dispersal is slow (Figure 1) Verween et al. (2006) and remote places are reached with assistance by man. In the Baltic Sea it has been found since 2000 in Germany, since 2004 in the Gulf of Finland near Power Plants, in Sweden (2013, Baltic Sea (Florin et al. 2013)) and Poland (2010) (Dziubińska 2011) and it is absent in Denmark (Jensen 2013). The reproduction cannot take place in fully marine or freshwater.
Assessment 2 (medium risk): Except when assisted by man, the species does not colonize remote places. Natural dispersal rarely exceeds more than 1km per year. The species can however become locally invasive because of a strong reproduction potential.
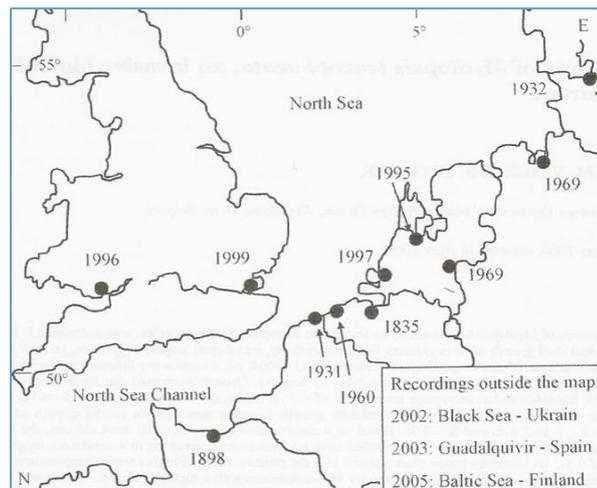

Figure 1: Distribution of *M. leucophaeata* in Europe with data of first findings from Verween et al. (2006)

2. Colonization of high conservation value habitat
The populations usually colonize habits with low (harbour constructions) or medium conservation value and may occasionally colonize high conservation habitats, e.g. Wadden Sea, where it was found only in low numbers.
Assessment 2 (medium risk): Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonize high conservation value habitats.

3. Alteration of ecosystem functions and/or impact on native species
Negative impact on native fauna may be locally high, but since this species mainly colonizes special habitats with low conservation values (see above criterion 2) the adverse impact on the native species is assumed as medium. It competes with barnacles and other filter feeders for space and food. Since the species colonizes mainly artificial structures, the impact on ecosystem functions assumed to be moderate.
Assessment 2 (medium risk): A non-native species is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially among

common and ruderal species and/or the impacts on ecosystem processes and structures are moderate. The modification of water and sediment properties is temporary.

4. Effects on human health: no effects on human health are known.
Assessment 1 (low risk)

5. Effects on natural resources (e.g. fisheries): No effects on natural resources are known.
Assessment 1 (low risk)

6. Effects on property (e.g. cooling systems)
This species is a fouling organism and its fouling problems were described as even more severe than those of the *Dreissena polymorpha* (Verween et al. 2010). It lives in cooling systems, where it is supported by the higher water temperatures. It is also found on boats and fish cages in high amounts.
Assessment 3 (high risk): Data from invasion history suggest that the species has high negative impact in property at many locations.

For the assessment whether this species is proposed as a target species, see below Chapter 2.4.

Neogobius melanostomus

Preconditions:
a) It is assumed that *N. melanostomus* was initially introduced by ballast water and it can clearly survive long trips in the ballast water of transoceanic vessels (Kornis et al. 2012. Following the initial introduction it spreads through natural but also through dispersal by shipping (Kornis et al. 2012. Gobiidae larva are found in ballast water (Gollasch et al. 2002).
b.) In its native area it is found at salinities between 0-18 psu (Paavola et al. 2005), therefore it is able to live in the whole Baltic Sea, but up to now it has not been found in every region of the Baltic Sea, e.g. the Bothnian Bay (Figure 2).

Harmonized criteria:
1. Dispersion potential or invasiveness
The distribution of *N. melanostomus* is shown in Figure 2. It lives in a limited home range ($5\pm1,2m^2$, calculated by Björklund and Almquist 2001 cited in (Kornis et al. 2012) but individuals occasionally move long distances. In streams spread is calculated ranging from 500m year^{-1} on average up to 1-4 km year $^{-1}$ (Bronnenhuber et al. 2011 cited in (Kornis et al. 2012).
Assessment 2 (medium risk): Except when assisted by man, the species does not colonize remote places. Natural dispersal rarely exceeds more than 1km per year. The species can however become locally invasive because of a strong reproduction potential.
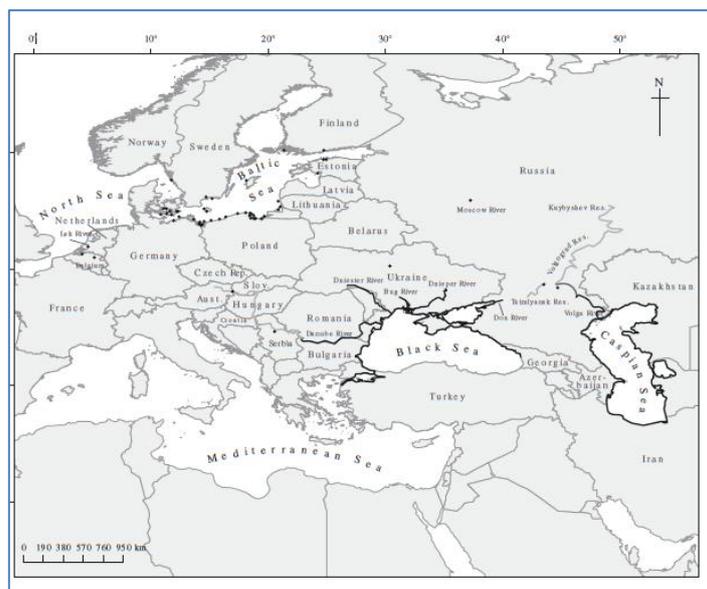

Figure 2: Distribution of *Neogobius melanostomus* (from Kornis et al. 2012)

2. Colonization of high conservation value habitats
(Kornis et al. 2012) and literature therein described that it had invaded Ontario Lake tributaries and now threatens seven endangered species. *M. melanostomus* is able to live in many different habitats and it prefers rocky habitats but is also found in fine gravel and sandy substances in which they may burrow.

<u>Assessment 3</u> (high risk): Non-native species often colonize high conservation value habitats, these are all biotopes where endangered species can be found. Most of the sites of a given habitat are likely to be readily colonized by the NIS when source population is present in the vicinity and poses therefore a potential threat for red-listed species.

3. Alteration of ecosystem functions and/or impact on native species
It frequently exerts strong predatory and competitive effects on native fish species and invertebrates (Kornis et al. 2012). In some areas native populations of mottled sculpin (*Cottus bairdi*) and logperch (*Percina caprodes*) decreased coincidently with an increase in *N. melanostomus*. It often plays an important role in the food web of invaded ecosystems since it can become the dominant fish species in nearshore benthic habitats and cause changes in the fish and benthic species compositions (Kornis et al. 2012). It also preys on zooplankton (Kornis et al. 2012).

<u>Assessment 3</u> (high risk): The development of the non-native species often causes local servere (>80%) population declines and the reduction of local species richness. On a regional scale, it can be considered as a factor precipitating (rare) species decline. Those non-native species form long-standing populations and their impacts on native biodiversity are considered as almost non-reversible. Therefore the impact on ecosystem processes and structures is strong and difficult to reverse e.g. food web disruption (*Crassostrea gigas*) or habitat destruction (*Eriocheir sinensis*).

4. Effects on human health: no effects on human health are known.
<u>Assessment 1</u> (low risk)

5. Effects on natural resources (e.g. fisheries)
N. melanostomus feeds on eggs of fish and also on fry e.g. from lake trout eggs (Chotkowski and Marsden 1999 cited in issg database), lake surgeon (Nichols et al. 2003 cited in issg database) and smallmoth bass (Steinhard et al. 2004 cited in issg database). Therefore, it influences the populations of commercial fish but no serious loss is known.

<u>Assessment 2</u> (medium risk): Data from invasion history suggest that the species has only slight negative impact on natural resources and is only restricted to single locations.

6. Effects on property (e.g. cooling systems): no effects on property are known.
<u>Assessment 1</u> (low risk)

For the assessment whether this species is proposed as a target species, see below Chapter 2.4.

Rhithropanopeus harrisii

<u>Preconditions:</u>
a.) *R. harrisii* is dispersed by ballast water or sediments (Perry 2014 an citation in it). It is found in most international European ports therefore it is assumed that it has been transferred by shipping, either as larvae in ballast water or as hull fouling (Jensen 2010b). Gollasch et al. (2002) also found other decapod species as adults, larvae or juveniles in the ballast water tanks in the water or sediment, e.g. *Eriocheir sinensis*, Panopeus sp. or *Portunus pelagicus*. Further this species is introduced by transfer with oysters in USA. The long planktonic larval period makes it possible for the species to be also dispersed by currents, despite the fact, that in some areas (e.g. Polish Waters) the natural dispersal by currents is low (Hegele-Drywa und Normant 2014). The dispersal by currents is assumed for the Finish and Estonian populations (Fowler et al. 2013) and the spread from California to Oregon occurred via currents during the larval stage (Petersen 2002 cited in Perry 2014).
b.) It is not found in all its ecological potential areas (Fowler et al. 2013).

Harmonized criteria:
1. Dispersion potential or invasiveness
The current distribution of *Rhithropanopeus harrisii* is shown in Figure 3. It has a high fecundity, a long planktonic larval period a wide tolerance range of several environmental factors that likely facilitated its invasion success (Williams 1984 in Fowler et al. 2013). In Finland it spreads very fast: it was found in the port of Naantali near Turku for the first time in 2009 and only two years later (2010-2012) it was detected in an area around Naantali within a radius of 30 km at 82 locations (Fowler et al. 2013). In other regions it spreads not very fast, e.g. in Poland. There, it forms stable populations in the Vistula and Dead Vistula River, but no crabs were found in the Gulf of Gdansk, with which both reservoirs are connected (pers.comm. M.Normant). Therefore it seems that the species dispersion potential is very high, however, it only forms stable populations if the preferred habitat is available.
Assessment 3 (high risk): The species is highly fecund, can easily disperse through active of passive means over distances > 1km/year and initiate new populations.

Figure 3: Distribution of *Rhithropanopeus harrisii* (blue lines at the coasts) (redrawn from Daisie 2012b), the black square marks the finding near Turku and Naantali

2. Colonization of high conservation value habitats
R. harrisii can be found in estuaries and quasi-freshwater lakes with salinities as low as 0,4 psu and is therefore tolerant to a wide range of salinities (0-30 psu in the Baltic Sea (Fowler et al. 2013)) so it is capable of invading a variety of aquatic habitats (Petersen 2006 cited in Global Invasive Species Database 2008, Fowler et al. 2013), but it needs structures such as shells, stones, algae, where it shelters itself ((Fowler et al. 2013; Hegele-Drywa und Normant 2014). So there is a great probability that this species also colonize high conservation value habitats.
Assessment 3 (high risk): Non-native species often colonize high conservation value habitats; these are all biotopes where endangered species can be found. Most of the sites of a given habitat are likely to be readily colonized by the NIS when source population is present in the vicinity and poses therefore a potential threat for red-listed species.

3. Alteration of ecosystem functions and/or impact on native species
No study has yet quantified the impacts of *R. harrisii* but anecdotal reports in the scientific literature indicate that it can alter the food webs and compete with and potentially displace native crabs, crayfish, as well as benthophagous fishes (reviewed in Roche and Trochin 2007 cited in Global Invasive Species Database 2008). In Polish waters, where there are no native crabs, it probably has impacted the original food web structure (Jensen 2010b) or it occurs simply as a new element of the trophic chain and it fills the gap, because in many communities there were no such larger omnivore species (Normant, pers.comm).
It is a carrier of strains of the white spot baculovirus. These viruses are extremely virulent and cause disease in penaeid shrimps and the blue crabs in their native region (Perry 2014 and citation in it). It

can also carry the parasitic barnacle *Loxothylacus panopaei*, which impacts native population along the east coast of North America and the Gulf of Mexico (Hines et al. 1997 cited in Fowler et al. 2013) but this parasite was not found in the Finnish (Fowler et al. 2013) and Polish (Normant, pers.comm.) population of *R. harrisii*. Since there is no negative evidence on native species from European regions where crabs were introduced the impacts on native species are assessed as low.

Assessment 1 (low risk): Data from invasion history suggest that the negative impact on native species and/or ecosystem functions is negligible.

4. Effects on human health: no effects on human health are known.

Assessment 1 (low risk)

5. Effects on natural resources (e.g. fisheries)

In the Caspian Sea, where it has reached high densities the crab causes economic loss to fisherman by spoiling fish in gill nets (Zaitsev and Öztürk 2001 cited in Global Invasive Species Database 2008).

Assessment 2 (medium risk): Data from invasion history suggest that the species has only slight negative impact on natural resources and is only restricted to single locations.

6. Effects on property (e.g. cooling systems)

In Texas, the crab has caused fouling problems in PVC intake to lakeshore homes and clogs the cooling system of a nuclear power plant (Keith 2006 cited in Perry 2014). Also in the Caspian Sea, where it has reached high densities the crab is responsible for fouling water intake pipes (Zaitsev and Öztürk 2001 cited in Global Invasive Species Database 2008).

Assessment 2 (medium risk): Data from invasion history suggest that the species has only slight negative impact on property and this is only restricted to single locations.

For the assessment whether this species is proposed as a target species, see below Chapter 2.4.

Table 3: Compilation of the assessment scores of the NIS, which were assessed on the basis of the preconditions and harmonized criteria. The precondition 2) for *M. manhattensis* is in brackets, since the information about salinity preference is contradictory and it could be that this species inhabits all its potential areas in the Baltic Sea.

			B. ligerica	*M. manhattensis*	*M. leucophaeata*	*N. melanostomus*	*R. harrisii*
Precon-dition	a) Vector Ballast water or sediment (primarily or secondarily)		yes	yes	yes	yes	yes
	b) Occurrence **NOT** in all its potential possible areas		yes	(yes)	yes	yes	yes
Criteria							
1	Spread	Dispersal	2	3	2	2	3
2		Colonization	2	2	2	3	3
3	Impact on	Nat.species & Ecosystem	2	1	2	3	1
4		Hum. health	1	1	1	1	1
5		Nat.resource	1	2	1	2	2
6		Properties	1	2	3	1	2

2.4 Scoring of the assessments of the five tested NIS

It has to be discussed whether or how the assessment scores (Table 3) can be used for selecting TS after their assessments.

A summing up of the scores should not be done. The total score is not useful, which can be shown in the examples of *M. manhattensis* and *M. leucophaeata* (Table 3). *M. manhattensis* has the same score (11) when compared to *M. leucophaeata* (11), but only for *M. leucophaeata* high negative impact (on properties) is known. The high score for *M. manhattensis* resulted from a high dispersal score but

since this species mostly colonizes artificial substrates, it has to be assessed as more harmless than *M. leucophaeata*. For that reason the total score gives no useful information with respect to the assessment whether a species should be classified as a TS.

High fertility of species and high tolerance to varying ecological conditions makes a species to become a successful invader. This causes, in high probability, that it will spread very fast in its new environment and if the colonization is not only restricted to artificial habitats (as for e.g. *M. manhattensis)* it should also be assessed as a TS, even if up to this moment no impact is known. That means that expected impacts should be included in the assessment, but this must be done consistently. This will even out the fact that well established species often get "worse" results in the assessments, because more is known about their impacts (Nyegaard Hvid, pers.comm).

Recommendation

Since a summing up seems not to be useful, it is recommended that if a species is assessed with a '3' (high risk) in one out of the six criteria it has to be selected as a TS if the two preconditions are fulfilled.

Consequently
- *B. ligerica* is not proposed as a TS,
- *M. manhattensis*, it is unclear whether it already lives in all its potential areas in the Baltic Sea, since it needs higher salinities (>16psu) and is therefore only able to live in the most western part of the Baltic Sea. But this species has to be included in the TS list, until further knowledge is available.
- *M. leucophaeata* is proposed as a TS, since it is able to live in the whole Baltic Sea and it can have high impact on properties, as a serious fouling organism in cooling water systems of e.g. power plants,
- *N. melanostomus* is proposed as a TS, since it is a very successful invader and has serious impact on native species,
- *R. harrisii* is proposed as a TS, since it is able to live in the whole Baltic Sea and is a very successful invader. Because of its high potential to spread and to establish it is very likely that it will pose threat to the native community, despite the fact that up to now no serious impacts are known in European waters.

3. Discussion

The idea of this study was to develop a procedure, which can be used to define TS for RA in respect to the A4-exemption. The proposed pragmatic procedure should be seen as a starting point/baseline for further discussions. The end of this process should be an internationally accepted procedure for TS selection to achieve an internationally agreed TS list, which can be used for purposes of A-4 exemptions.

Also many other approaches defined standardized ways for the classification of the invasiveness of the NIS to ensure consistency when determining expected impacts on specific ecological endpoints (e.g. Molnar et al. 2008, Therriault et al. 2013). But these approaches mainly focus on the assessment of the threat of invasive species to marine biodiversity and the specific requirements for the BWMC A-4 exemption were not taken into account. Therefore, a specific procedure had to be developed. The proposed procedure is based on existing concepts (e.g. ISEIA Guideline 2009) and was adapted to the special requirements in respect to the BWMC Guideline G7.

TS are necessary for running the risk assessment model (Ballast Water Decision Support Tool (HELCOM 2013)) according to the BWMC G7, and also other RA Tools are based on TS (David et al. 2013). Therefore, an internationally accepted TS list is essential. Since the proposed factors for selecting TS according to the BWMC G7 are not exactly defined, previously proposed harmonized criteria (HELCOM 2013) were tested and revised.

The problem is that for most of the marine species, information on adverse impacts is extremely poor (e.g. Ojaveer et al. 2014, Ojaveer and Kotta 2015) and if no evidence for impacts is known, that is not to say, that the species could not cause any impact. Therefore, the assessment should be made very carefully and the precautionary principle should be taken into account. If a species cannot be assessed due to missing information, it should be assessed as a TS, until further information is available. This is

one reason, why the TS list has to be a living list, which has to be updated regularly. NIS Databases such as AquaNis (AquaNIS 2013) are very useful sources of information on species and introduction events. The assessment of the species should be made by experts, since for many species the exact identification is very difficult, e.g. for same NIS amphipods (Ojaveer and Kotta 2015). If experts/groups are assessing the species, it is very important that there is a common understanding of the method, e.g. DK used it in a pathway analysis, where the experts score different species groups, otherwise it will be difficult to compare across groups at a later stage (Nyegaard Hvid, pers.comm).

Further, it is problematic to predict how a NIS will behave in its new environment because it is possible that a species, which is harmless in its native area will become invasive in its new environment or it is only locally harmful but not in all regions. An example is *Rhithropanopeus harrisii,* which has been recorded in Europe a very long time ago without any negative impacts. The only known adverse impacts recorded from regions outside Europe (Normant, pers.comm.). Nevertheless, up to now there is no other way to assess the harmfulness of NIS, other than by compiling information from all areas in the world. Each NIS will have more or less effects on the native communities.

The target species lists of OSPAR and HELCOM are to be regarded as living lists under continuous updating by HELCOM and OSPAR BDC, which means that other species can be included or species can be deleted, if further knowledge is available.

Two special types of TS should be included:
- Known, unwanted species that are known to have already generated serious problems for the environment, economy, human health, property or resources somewhere in the world, that have evidence of prior introduction and have a relationship with ballast water as a vector.
- Species which have been comprehensively scientifically investigated for their risk potential but which have not yet caused harm.

3.1 Harmonized Criteria

After the tests and discussions of the first version of the harmonized criteria (HELCOM 2013; BALSAM Interims Report, November 2014) some revisions were proposed as the outcome of this study:

A species can only be selected as a TS if it fulfils two preconditions: a) it must have evidence to prior introduction and relationship with ballast water or sediment and b.) it should not occur in all its ecological potential areas of the Baltic Sea. Only if both preconditions are fulfilled could the species be useful for the RA according to the G7 Guideline and should be further assessed with the revised harmonized criteria (Table 2).

Consequently, the previous 8th criterion 'Ballast water' (HELCOM 2013) was removed from the harmonized criteria list, since this criterion is now a precondition. Further, the two previous criteria (3 and 4) (HELCOM 2013) 'Impact on native species' and 'Alteration of ecosystem functions' are merged to one criterion, since mostly it is not possible to distinguish between these two criteria because, e.g. if a native species is impacted by a NIS, also some ecosystem functions will probably be altered.

The two main general questions (preconditions) which should be considered before a species is considered for inclusion in the target species list using the assessment criteria are:

a.) Is the species is primarily or secondarily introduced with ballast water or sediment?
This means, that only if a species has the potential to be transported via ballast water or sediment it should be taken into account. Species which were e.g. introduced primarily by stocking (e.g. Oysters) but have the potential to be spread secondarily by ballast water or sediment have to be included. All other species are irrelevant in respect to the BWMC G7.

b.) Is the species present in part of the region but not the entire region?
This means, that only if a species is NOT found in all its ecologically potential locations, it will be useful as a TS in respect to the BWMC G7. Information on ecological requirements (e.g. tolerances of salinity and temperature should be taken into account). Species which already live in all their ecologically potential areas are irrelevant in respect to the BWMC G7. Therefore, the found NIS within the port surveys could be invasive (harmful NIS) but could perhaps not be

useful for the RA, if they already occur in the whole Baltic Sea, e.g. *Amphibalanus improvises* or *Dreissena polymorpha*.

Only if both preconditions are fulfilled is the species a potential TS in respect to the BWMC G7 and should be further assessed on the basis of the harmonized criteria. As an outcome of this report six criteria are proposed (Table 2). These criteria can be divided into two categories

I. 'spread' of the NIS after introduction (criteria 1 and 2)

II. 'impacts' of the NIS on native species and ecosystem, human health, resources and properties (criteria 3-6).

I. Spread after introduction

An introduced species causes harm to the introduced region if it has the ability to colonize further (remote) habitats very fast due to high fertility in addition a high competitive potential, especially if habitats with high conservation values are invaded. Therefore, in this category the dispersion potential or invasiveness and the colonization of high conservation value habitat is assessed. Species with a fast spread and high fertility are harmful, since the probability is high that it will dominate the native communities after initial introduction.

It should be discussed whether it makes sense to assess the colonization of high conservation areas (criterion 2) separately since especially species with pelagic larvae will not distinguish between conservation or non-conservation areas and marker buoys or other man-made structures can be used by settling larvae, thus acting as stepping-stones (Jensen, pers.comm).

II. Impacts

A NIS causes harm to the introduced region if it has adverse impacts on native species, ecosystem functions, human health, natural resources and/or on properties. Therefore, in this category these four criteria have to be assessed:

3. Alteration of ecosystem functions and impacts on native species,
4. Effects on human health
5. Effects on natural resources (e.g. fisheries)
6. Effects on property (e.g. cooling systems)

Adverse impacts on habitat and reef forming species or special bioturbation species have to be assessed within criterion 3'.

There exist also other approaches for assessing the invasiveness (e.g. Molnar 2008, Therriault et al. 2013). The assessments criteria are very similar in all approaches (probability of survival, arrival, impacts to the environment) but don't fulfil the specific requirements for the RA in respect to the BWMC G7 and therefore, had to be adapted. The proposed assessment criteria and procedure are based on the Belgium ISEIA procedure (ISEIA Guidelines 2009) and further criteria, which were named in the G7 were included.

3.2 Discussion on the scoring of the proposed criteria

Summing up the single scores and ranking TS on the basis of their impacts scores is **NOT** useful, since mostly the information on the impacts is often insufficient. Further, if a species is very harmful e.g. on property is should be selected as a TS, even when no impacts on the other criteria (alteration of ecosystem functions and impact on native species, human health, natural resources) are known. Therefore a NIS has to be assessed as a TS if it is assessed as high risk species in one out of the four criteria in the category 'impact'. Also, if a species is highly fertile causing a high probability, that it will spread very fast in its new environment and not only to artificial habitats (like e.g. *M. manhattensis)* this species should also be assessed as a TS, even if up to this moment no impact is known.

The proposed harmonized criteria are useful for the assessment, but the main problem is the missing information concerning behaviour and ecology of some NIS (e.g. Ojaveer and Kotta 2015), and sometimes contradictory information exits e.g. as shown for the salinity tolerances of *M. manhattensis.*

Within the BALSAM port surveys five NIS were found, which were proposed as a TS as a result of the ALIEN 2 project (HELCOM 2013). These five species were assessed on the basis of the revised

harmonized criteria and after checking their current occurrences in the Baltic Sea. The assessment results are:

One species (*B. ligerica*), was removed from the TS list since it is not assessed as high risk species. For *M. manhattensis* the assessment is uncertain, since it is not exactly known if it inhabits already all its potential locations in the Baltic Sea, information from the literature to its salinity tolerances are contradictory and the taxonomy is not clear. But according to the precautionary principle this species has to be included in the TS list.

Due to known adverse impacts and high invasion potential from outside Europe *N. melanostomus* and *M. leucophaeata* and *R. harrisii* were assessed as a TS for the RA according to the BWMC (G7). *R. harrisii* is also mentioned on the Swedish Alert List (Främmande Arter 2013) and is considered as very invasive (e.g. NOBANIS, DAISIE (Database DAISIE 2012)). *M. leucophaeata* is also mentioned on the Danish Alert List (Jensen 2013). *N. melanostomus* is mentioned as one out of the 100 worst invasive species on the DAISIE species list (Database DAISIE 2012).

4. Description of the procedure for the Target Species Selection

- TS are necessary for the RA according to the G7 Guideline.
- It is important that the criteria for defining target species are harmonized between countries and accepted by all of them.
- The target species lists of OSPAR and HELCOM are to be regarded as living lists under continuous updating by HELCOM and OSPAR BDC, which means that other species can be included or species can be deleted, if further knowledge is available.
- **It should be noted**, that I made the assessments on the basis of information which is available in literature but if the assessment method will be used in practise the assessments should be done by taxonomic experts. If experts/groups are assessing the species, it is very important that there is a common understanding of the method, e.g. DK used it in a pathway analysis, where the experts scores different species groups, otherwise it will be difficult to compare across groups at a later stage (Nyegaard Hvid, pers.comm).

Proposed Target Species Selection for the Baltic Sea

Those NIS should be assessed as a TS which are known to cause high adverse impact on native species or ecosystem, human health, natural resources or properties or which are highly fertile so that the possibility is high, that the NIS will invade further habitats very fast and dominates the native communities.

The Target Species Selection Procedure should be effected as described below:

If both of the two preconditions

a.) evidence to prior introduction and relationship with ballast water or sediment and

b.) the species should not occur in all its ecological potential areas of the Baltic Sea are fulfilled, further assessment should be made on the basis of harmonized criteria (see below).

The **criteria,** which have to be assessed, are

        1. Dispersal
        2. Colonization
        3. Alteration of ecosystem functions and impacts on native species,
        4. Effects on human health
        5. Effects on natural resources (e.g. fisheries)
        6. Effects on property (e.g. cooling systems)

For the exact definitions of the proposed harmonized criteria see (Table 2)

Scoring:

If one out of the six harmonized criteria is assessed as high risk, the species should be selected as a TS. The problem is, that for many marine species information on impacts are missing. Species that could not be assessed due to missing information should be assumed for the time being as high risk species in the sense of the precautionary principle. Since the TS list should be a living list, the lists will be revised regularly and further knowledge will be considered.

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5. References

AquaNIS, Editorial Board (2013): Information system on Aquatic Non-Indigenous and Cryptogenic Species. World Wide Web electronic publication. Version 2.36+. Online verfügbar unter www.corpi.ku.lt/databases/aquanis, zuletzt geprüft am 16.03.2015.

Carlton J.T., Hodder J. (1995): Biogeography and dispersal of coastal marine organisms: experimental studies on a replica of a 16th-century sailing vessel. Marine Biology 121: 721–730, http://dx.doi.org/10.1007/BF00349308

David, M.; Gollasch, S.; Leppäkoski, E. (2013), Risk assessment for exemptions from ballast water management – The Baltic Sea case study, Marine Pollution Bulletin 75: 205-217.

DAISIE (2012a): European Invasive Alien Species Gateway. Online verfügbar unter http://www.europe-aliens.org, zuletzt aktualisiert am 29.12.2012.

DAISIE (2012b): European Invasive Alien Species Gateway. Rhithropanopeus harrisii. Online verfügbar unter http://www.europe-aliens.org/speciesFactsheet.do?speciesId=50542# . Accessed 3.3.2015

Dziubińska, A. (2011): Mytilopsis leucophaeata, an alien dreissenid bivalve discovered in the Gulf of Gdańsk (southern Baltic Sea). In: *Oceanologia* 53 (2), S. 651–655. Online verfügbar unter doi:10.5697/oc.53-2.651.

Florin, A.-B.; Mo, K.; Svensson, F.; Schagerström, E.; Kautsky, L.; Bergström, L. (2013): First records of Conrad's false mussel, Mytilopsis leucophaeata in the southern Bothnian Sea, Sweden, near a nuclear power plant. In: *BIR* 4 (2), S. 303–309. Online verfügbar unter http://pub.epsilon.slu.se/11248/1/Florin_et_al_140702.pdf, zuletzt geprüft am 12.03.2015.

Fowler, Amy; Forsström, Tiia; Numers, Mikael von; Vesakoski, Outi (2013): The North American mud crab Rhithropanopeus harrisii (Gould, 1841) in newly colonized Northern Baltic Sea: distribution and ecology. In: *AI* 8 (1), S. 89–96. DOI: 10.3391/ai.2013.8.1.10.

Främmande arter (2008): Boccardia redeki. Factsheet. Online verfügbar unter http://www.frammandearter.se/5arter/pdf/Boccardia_redeki.pdf.

Främmande arter (2013): Swedish Alien List. Online verfügbar unter http://www.frammandearter.se/, zuletzt geprüft am 14.03.2015.

Global Invasive Species Database (2008): Rhithropanopeus harrisii. Online verfügbar unter http://www.issg.org/database/species/ecology.asp?si=1217&fr=1&sts=sss&lang=EN, zuletzt geprüft am 10.09.2014.

Gollasch, Stephan; MacDonald, Elspeth; Belson, Sara; Botnen, Helge; Christensen, Jens T.; Hamer, John P. et al. (2002): Life in Ballast Tanks. In: E. Leppäkoski, Gollasch S. und Olenin S. (Hg.): Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Dordrecht: Kluwer, S. 217–231. Online verfügbar unter http://www.corpi.ku.lt/nemo/aqua_app_gollasch.pdf, zuletzt geprüft am 18.01.2012.

Hegele-Drywa, Joanna; Normant, Monika (2014): Non-native crab Rhithropanopeus harrisii (Gould, 1984) – a new component of the benthic communities in the Gulf of Gdańsk (southern Baltic Sea)**This research was funded by the Polish National Science Centre, grant No. 3016/B/PO1/2011/40. In: *Oceanologia* 56 (1), S. 125–139. DOI: 10.5697/oc.56-1.125.

HELCOM (2010): HELCOM LIST OF NON-INDIGENOUS AND CRYPTOGENIC SPECIES IN THE BALTIC SEA (VERSION 2). HELCOM HABITAT 12/2010. Online verfügbar unter http://www.helcom.fi/stc/files/shipping/Version2_HELCOM%20lists%20of%20non-indigenous,%20cryptogenic%20and%20harmful%20native%20species%20and%20HELCOM%20target%20species.pdf, zuletzt geprüft am 25.01.2013.

HELCOM (2013): HELCOM ALIENS 2- Non-native species port survey protocols, target species selection and risk assessment tools for the Baltic Sea. Online verfügbar unter http://www.helcom.fi/Lists/Publications/Non-native%20species%20survey%20protocols,%20target%20species%20selection%20and%20risk%20assessment%20tools%20for%20the%20Baltic%20Sea%20HELCOM%20ALIENS%202.pdf, zuletzt geprüft am 06.10.2013.

Hiscock, K. (2008): Molgula manhattensis. Sea grapes. Marine Life Information Network: Biology and Sensitivity KeyInformation Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Online verfügbar unter http://www.marlin.ac.uk/reproduction.php?speciesID=3823.

ISEIA Guidelines (2009): Guidelines for the environmental impact assessment and list classification of non -native organisms in Belgium; Version 2.6; http://ias.biodiversity.be/documents/ISEIA_protocol.pdf, accessed 19.2.2015.

issg database (2006): Neogobius melanostomus http://www.issg.org/database/species/ecology.asp?si=657&fr=1&sts=sss&lang=EN

Jensen, K. R. (2010a): NOBANIS - Invasive Alien Species Fact Sheet - Molgula manhattensis. Online verfügbar unter http://www.nobanis.org/files/factsheets/Molgula%20manhattensis.pdf, zuletzt geprüft am 25.08.2014.

Jensen, K. R. (2010b): NOBANIS - Marine invasive species in Nordic waters - Fact Sheet - Rhithropanopeus harrisii. From: Identification key to marine invasive species in Nordic waters – NOBANIS www.nobanis.org,. Online verfügbar unter http://www.nobanis.org/files/factsheets/Rhithropanopeus%20harrisii.pdf, zuletzt geprüft am 09.09.2014.

Jensen, K. R. (2013): Selection of target species for risk assessment of Danish ports in connection with the International Convention for the Control and Management of Ship'Ballast Water and Sediments. Report for the Danish Nature Agency, S. 25 and 3 Annexes.

Kornis, M. S.; Mercado-Silva, N.; Vander Zanden, M J (2012): Twenty years of invasion: a review of round goby Neogobius melanostomus biology, spread and ecological implications. In: *J. Fish Biol.* 80 (2), S. 235–285. DOI: 10.1111/j.1095-8649.2011.03157.x.

Lackschewitz, Dagmar; Reise, Karsten; Buschbaum, Christian (2009): Schnellerfassung von Neobiota in Deutschen Küstengewässern und Erstellung von Artenlisten nicht-heimischer Organismen. Hg. v. Alfred-Wegener-Institut für Polar- und Meeresforschung im Auftrag des Landesamtes für Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein.

Leppäkoski, E.; Olenin, Sergej (2000): Non-native species and rates of spread: lessons from the brackish Baltic Sea, S. 151–163. Online verfügbar unter http://www.reabic.net/publ/Leppakoski_Olenin_2000.pdf, zuletzt geprüft am 17.09.2014.

Molnar, J.L.; Gamboa, R.L.; Revenga, C.; Spalding, M.D. (2008): Assessing the global threat of invasive species to marine biodiversity; Frot.Ecol.Environ 6(9): 485-492.

National Park Service, U.S. Department of Interior: Molgula manhattensis. Online verfügbar unter http://www.nature.nps.gov/water/marineinvasives/assets/PDFs/Molgula_manhattensis.pdf, zuletzt geprüft am 04.09.2014.

NOBANIS. Online verfügbar unter http://www.nobanis.org/, zuletzt geprüft am 18.03.2015.

NSBWO (2010): North Sea Ballast Water Opportunity Project, http://www.northseaballast.eu/northseaballast/ , accessed 18.3.2015

Ojaveer,H.; Galil,B.S.; Michin, D.; Olenin, S.; Amorim, A.; Canning-Clode, J.; Chainho, P.; Copp. G.H.; Gollasch, S.; Jelmert, A.; Lehtiniemi, M.; McKenzie, C.; Mikus, J.; Miossec, L.; Occhipinti-Ambrogi, A.; Pecarevic, M.; Pederson, J.; Quilez-Badia, G.; Wijsman, J.W.M. Zenetos, A. (2014) Ten recommendations for advancing the assessment and management of non-indigenous species in marine ecosystems, Marine Policy 44: 160-165

Ojaveer, H.; Kotta, J. (2015): Ecosystem impacts of the widespread non-indigenous species in the Baltic Sea: literature survey evidences major limitations in knowledge; Hydrobiologia 750:171-185

Paavola, Marjo; Olenin, Sergej; Leppäkoski, Erkki (2005): Are invasive species most successful in habitats of low native species richness across European brackish water seas? In: *Estuarine, Coastal and Shelf Science* 64, S. 738–750. DOI: 10.1016/j.ecss.2005.03.021.

Perry, H. (2014): Rhithropanopeus harrisii. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Online verfügbar unter http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=197, zuletzt aktualisiert am 14.09.2011, zuletzt geprüft am 09.09.2014.

Pleus, Allen; LeClair, L.; Schultz, J.; Lambert, G. (2008): 2007-09 Tunicate Management Plan. Washington State Department of Fish and Wildlife. Aquatic Invasive Species Unit. In coordination with the Tunicate Response Advisory Committee. February. Online verfügbar unter http://wdfw.wa.gov/publications/00806/wdfw00806.pdf, zuletzt geprüft am 05.09.2014.

Therriault, T.W.; Weise, A.M.; Higginis, S.N.; You Y.; Duhaime, J. (2013): Risk assessment for three Dreissenid mussels (*Dreissena polymorpha, Dreissena rostriformis bugensis* and *Mytilopsis leucophaeata)* in Canadian freshwater ecosystems; in Canadian Freshwater Ecosystems. DFO Can.Sci.Advis.Sec.Res, Doc. 2012/174 v+88p.

Verween, A.; Vincx, M.; Degraer, S. (2006): Growth patterns of Mytilopsis leucophaeata, an invasive biofouling bivalve in Europe. In: *Biofouling* 22 (4), S. 221–231. DOI: 10.1080/08927010600816401.

Verween, A.; Vincx, M.; Degraer, S. (2010): 3. Mytilopsis leucophaeata: The brackish water equivalent of Dreissena polymorpha? A review, zuletzt geprüft am 25.08.2014.