ICES WGBOSV REPORT 2017

SCICOM Steering Group on Ecosystem Pressures and Impacts

ICES CM 2017/SSGEPI:10

Ref. SCICOM

Interim Report of the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV)

15–17 March 2017

Woods Hole, USA



ICES International Council for the Exploration of the Sea

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2017. Interim Report of the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV), 15–17 March 2017, Woods Hole, USA. ICES CM 2017/SSGEPI:10. 86 pp. https://doi.org/10.17895/ices.pub.8570

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Executive summary

The ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) met at the NOAA Northeast Fisheries Science Center in Woods Hole, USA, on 15–17 March 2017, including a joint meeting on 15 March with the Working Group on Introductions and Transfers of Marine Organisms (WGITMO). The meeting was hosted by Judy Pederson (USA) and chaired by Sarah Bailey (Canada). The meeting was attended by 21 scientists in person, 3 by web-conference, and 2 by correspondence, representing 10 countries; 5 additional scientists representing 3 additional countries attended on the joint meeting day. The objective of the meeting was to discuss and address the six terms of reference (ToRs) in order to co-ordinate and advance research activities that reduce the risk of transporting non-native species via shipping activities.

This interim report provides a brief summary of progress achieved on all ToRs and the related workplan, with National Reports and Abstracts for all presentations appended as annexes. The approach taken at the meeting was for each country to provide an update on the status of shipping vector research in the form of a National Report, facilitating a thorough review of national activities to identify potential collaborations, advance research and address knowledge gaps (ToR a). Subsequently, individual ToRs were progressed through contributed presentations and group discussion. WGBOSV considered two ToRs jointly with WGITMO, examining biofouling as vector for the introduction and transfer of aquatic organisms on small boats and large ships (ToR e) and examining the effect of climate change on the establishment of aquatic species in the Arctic (ToR d).

During year 2, WGBOSV members submitted numerous manuscripts about methods for collection and analysis of ballast water samples to a special issue in the Journal of Sea Research, and developed a submission to the International Maritime Organization concerning the type of scientific data that should be collected during the experience-building phase after entry-into-force of the ballast water convention. Two additional scientific review papers were initiated and progressed intersessionally. One new recommendation came out of the meeting: to formalize the role of the International Maritime Organization (IMO) with the WGBOSV and to formalize the cooperation between ICES, IMO and Intergovernmental Oceanographic Commission (IOC) through a submission from ICES Secretariat to IMO Secretariat. As last year's recommendation to initiate discussion/coordination with other Arctic organisations (e.g. PAME, CAFF) with a view to jointly address non-native species issues in the Arctic has not yet been responded to, it has been restated in this report.

1 Administrative details

Working Group name

Working Group on Ballast and Other Ship Vectors (WGBOSV)

Year of Appointment within current cycle

2016

Reporting year within current cycle (1, 2 or 3)

2

Chair(s)

Sarah Bailey, Canada

Meeting venue

Woods Hole, USA

Meeting dates

15–17 March 2017

2 Terms of Reference a) – z)

a) Conduct strategic planning (identify and develop collaborative activities, advance and standardize methods, etc.) to advance research and address knowledge gaps through review of national activities and to respond to new requests for advice;

b) Evaluate methods for collection and analysis of ballast water samples to inform national and/or international procedures for compliance testing of ballast water management systems;

c) Evaluate methods for, and outcomes of, type approval and operational testing of ballast water management systems to inform national and/or international procedures for type approval of such systems;

d) Investigate and evaluate climate change impacts on the establishment and spread of ship-mediated nonindigenous species, particularly with respect to the Arctic;

e) Investigate and evaluate methods/technologies to assess risks of, to minimize extent of, and to respond to ship biofouling to inform national and/or international policies or guidelines;

f) Evaluate the current role/importance of shipping in relation to other invasion vectors/pathways globally.

3 Summary of Work plan

Year 1	Working on all ToRs, but with special focus on ToRs a, c, and d.
Year 2	Working on all ToRs, but with special focus on ToRs b, e, and f.
Year 3	Report on all ToRs

4 List of Outcomes and Achievements of the WG in this delivery period

- A review of national activities was conducted to identify potential collaborations, advance research and address knowledge gaps.
- Multiple manuscripts about methods for collection and analysis of ballast water samples were contributed to a special issue on advances in ballast water management in the Journal of Sea Research.
- A submission was contributed to the International Maritime Organization concerning the type of scientific data that should be collected during the experience-building phase after entry-into-force of the ballast water convention.
- Information about changes to type approval test procedures for ballast water management systems, and corresponding impacts, was reviewed and considered.
- A scientific paper reviewing the status and risks of introduced species in the Arctic was initiated (jointly with WGITMO).
- Information about approaches for ship biofouling assessment and management were reviewed and considered (jointly with WGITMO).
- A scientific paper reviewing temporal trends in the introduction of nonindigenous species globally was initiated.

5 Progress report on ToRs and work plan

ToR a) To date, National Reports on ballast and other shipping research have been submitted by 12 countries, with most reports updated in year 2. Each report summarizes the status of shipping research in each country, as well as planned research for 2016-2018 and identifies research needs and gaps. Further, the reports highlight upcoming meetings of interest, recent publications and products and contact information for project leads. These were used as the basis to identify and develop collaborative activities within the Group. In addition, in year 2, presentations were contributed to inform Group members about ballast water sampling activities in the Orkney Islands; plans for a modular port-based ballast water treatment system in the Netherlands; progresses in metabarcoding of ballast water samples in the U.S.; and evidence for rapid adaptation of marine species. The Group discussed concerns about the risk associated with requirements to sample ballast water during discharge versus a more conservative approach allowing sample collection from ballast tanks prior to discharge. The Group determined that multiple members were conducting research about ballast water treatment efficacy and suggested that a broad overview summarizing the state of ballast water management in the ap-

proach to the entry-into-force of the convention would be of value to the scientific and management communities. One WG member offered to design a table for the collection of information to support such a review.

ToR b) Following very successful collaboration and communication amongst WGBOSV members in recent years, a proposal was made to develop a special issue in the Journal of Sea Research on advances in ballast water management, with special focus on methods for collection and analysis of ballast water samples. Multiple WGBOSV members co-authored and submitted manuscripts to the special issue in the last year with the special issue being so successful as to split into two issues of at least 10 publications each. In addition, the ToR Lead worked with a subset of WGBOSV members to make a submission to the International Maritime Organization (IMO) concerning the type of scientific data that should be collected during the experience-building phase after entry-into-force of the ballast water convention. Further, in year 2, three presentations provided the Group with the latest updates on methods and tools for the collection and analysis of ballast water samples. During the meeting, the Group discussed the benefits of developing a standardized and coordinated approach to ballast water sampling and analysis as a number of agencies and scientists will be monitoring ballast water in the next 2-3 years. A small subset of group members agreed to share and harmonize methods with a view to submit information to the IMO about standardized methods that could be used globally during the experience-building phase of the Convention.

ToR c) In year 2, three presentations were contributed to inform the Group about changes to the IMO Guidelines for approval of ballast water management systems (G8), and the impact of these changes on testing outcomes (in terms of thoroughness and information gained) and test facilities and vendors (in terms of time and cost). An attempt to organize a joint theme session between WGBOSV and GloBal TestNet during a 2017 conference on aquatic invasive species was unsuccessful due to travel and resource limitations faced by participants in both Groups. The Groups have exchanged information remotely through the exchange of meeting reports. As WGBOSV has a formal role at the IMO while GloBal TestNet has the expertise concerning type approval test methods, the Group discussed making an offer to formally pass information between the two Groups, should there be value in doing so. Finally, the Group discussed the value of a project to collect information about water quality at multiple global ports which could be used to identify ballast water treatment challenge conditions that may be encountered by operational ships and to support environmental-matching risk assessments. Several offers were made to assist the collection of data.

ToR d) In year 1, jointly with WGITMO, WGBOSV developed questions that could direct the development of demonstration advice on "risk management of nonindigenous species associated with shipping in the Arctic", in response to a direct request received from ICES Bureau. After that time, however, ICES Bureau decided not to proceed with the development of such advice. As a result, in year 2, a subset of WGBOSV/WGITMO members began to develop a review paper for publication in a scientific journal, building on the efforts of year 1, and bringing in results of a separate project undertaken to assess changes in Arctic shipping traffic (which were presented during the meeting). The goal of the review paper is to compile a comprehensive list of introduced species in the Arctic, to evaluate the risk associated with current and future vectors of introduction, and to identify knowledge/data gaps, to serve as guidance for future research and management efforts

related to NIS in the Arctic. The project Leader made a presentation on the joint meeting day to share progress to date, having compiled a list of introduction records based on literature review in consultation with regional experts. In addition the project Leader reviewed existing definitions of the marine Arctic and discussed the implications of adopting the different definitions in terms of invasion risk. The Groups discussed the need to be careful with the use of invasion terminology and recommended including definitions of important terms in the paper.

ToR e) Five presentations were contributed under this ToR on the joint day, examining risks associated with rafting of species across the Pacific Ocean on tsunami debris and biofouling on commercial ships. One presentation provided information about biofouling meetings recently held in the United States with international experts to identify and discuss approaches used to quantity and manage biofouling on ships. The Groups discussed the importance of replicate sampling and analysis of data using rarefaction curves to distinguish if new reports of introduced species are confounded by sampling effort. The Groups discussed the need to learn from years of experience in setting regulations and inspections procedures for ballast water when embarking on similar activities related to biofouling, with a view towards setting more practical procedures in place. The Groups recalled the open request for information related to biofouling management by the IMO, suggesting that outputs of the biofouling meetings held in the United States could serve as a basis for a future contribution.

ToR f) The ToR Lead worked intersessionally to request data contributions for a scientific publication under this ToR. A presentation was made to share progress to date, including a summary of the number of contributors to date, the geographic coverage of the data and preliminary temporal trends in the data. The Groups discussed gaps in the data coverage and made suggestions of additional researchers to approach. In particular, it was noted that collaboration with PICES experts may improve global data coverage. The Group discussed the preliminary trends in the data, noting that confounding factors such as search effort and taxonomic biases should be explored further. The Group suggested that taxa with problematic taxonomy (i.e. phytoplankton) should be excluded from the analysis for standardization purposes. It was noted that analyses of vector importance are going to be confounded by multi-vector species and uncertainty, and that standardization of methods to assign vectors across contributors will be very important. On behalf of all contributors, the ToR Lead agreed to consider all points raised above during the further development of the paper.

Other Business: During the course of the meeting, the Group also discussed the uncertain status of WGBOSV in terms of formal association with its umbrella groups. In particular, the Group noted that the IMO Secretariat has requested the ICES Secretariat to submit a proposal to formalize the role of the IMO with WGBOSV and to formalize the cooperation with ICES and IOC. As formal association would benefit the Group in terms of recognition of its expertise and to match the activities of the Group with the needs of other international bodies, the Group recommended that ICES Secretariat submit a proposal to IMO as requested.

After a presentation on PICES activities concerning introductions of aquatic species, the Group discussed benefits of working more closely with relevant PICES experts. It was noted that an upcoming meeting on marine and freshwater invasive species, to be held

20–23 May 2018 in Beijing, China, could serve as a platform for interaction and collaboration between ICES and PICES aquatic invasion experts.

6 Revisions to the work plan and justification

WGBOSV was unable to conduct a joint Theme Session at a scientific conference with other scientific organizations involved in type approval and operational testing of ballast water management systems (ToR c) due to difficulties coordinating schedules, travel and funding for this truly global set of experts; however, information was exchanged with the GloBal TestNet through the exchange of reports and correspondence between Group Chairs. Continued exchange of information via correspondence is expected to continue during years 2 and 3.

7 Next meeting

Next year, WGBOSV proposes to meet in Caniçal (Madeira Island), Portugal, 5–7 March 2018, with João Canning-Clode (Marine and Environmental Sciences Centre) as host. A full-day joint meeting with WGITMO on 7 March 2018 is also proposed.

Annex 1: List of participants

Name	Address	Email
Agnese Marchini	Universita degli Studi di Pavia Dipartimento di Ecologia del Territorio Via S. Epifanio 14, I-27100 Pavia, ITALY	agnese.marchini@unipv.it
Allegra Cangelosi (Remote Participation)	Northeast-Midwest Institute 50 F St. NW, Suite 950 Washington DC 20001, UNITED STATES	acangelo@nemw.org
Amelia Curd	Ifremer - Centre de Bretagne Z.I. de la pointe du Diable CS 10070, 29280 Plouzané, FRANCE	amelia.curd@ifremer.fr
Anders Jelmert	Institute of Marine Research Flødevigen Marine Research Station 4817 His, NORWAY	anders.jelmert@imr.no
Carolyn Tepolt	Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543- 1050, UNITED STATES	ctepolt@whoi.edu
Cato ten Hallers- Tjabbes	CaTO Marine Ecosystems Oosterweg 1, 9995 VJ Kantens, NETHERLANDS	cato@catomarine.eu
Christopher Brown (Remote Participation)	California State Lands Commission, 100 Howe Ave., Suite 100S, Sacramento, CA, 95825, UNITED STATES	Chris.Brown@slc.ca.gov
Cynthia McKenzie	Fisheries and Oceans Canada, Northwest Atlantic Fisheries Center, P.O. Box 5667, St John 's, NL, A1C 5X1, CANADA	cynthia.mckenzie@dfo-mpo.gc.ca
Farrah Chan	Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA	farrah.chan@dfo-mpo.gc.ca
Francis Kerckhof	Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models (MUMM) 3de en 23ste Linieregimentsplein B-8400 Oostende, BELGIUM	fkerckhof@naturalsciences.be
Gordon H. Copp	Centre for Environment, Fisheries and Aquaculture Science Pakefield Road Lowestoft, NR33 0HT UNITED KINGDOM	gordon.copp@cefas.co.uk
Greg Ruiz	Smithsonian Environmental Research Center, 647 Contees Wharf Road Edgewater, MD, 21037-0028, UNITED STATES	ruizg@si.edu
Henn Ojaveer (By Correspondence)	Estonian Marine Institute University of Tartu 2a Lootsi, EE-80012 Parnu, ESTONIA	henn.ojaveer@ut.ee
James Carlton	Williams College - Mystic Seaport P. O. Box 6000, 75 Greenmanville Avenue Mystic, Connecticut 06355 USA	james.t.carton@williams.edu
Jenni Kakkonen	Marine Services, Orkney Islands Council Harbour Authority Building Scapa, Orkney, KW15 1SD UNITED KINGDOM	jenni.kakkonen@orkney.gov.uk

João Canning-Clode	MARE – Marine and Environmental Sciences Centre, Marine Biology Station of Funchal, Cais do Carvão 9000-107 Funchal / Madeira Island PORTUGAL	canning-clodej@si.edu
John Darling	National Exposure Research Laboratory U.S. Environmental Protection Agency Research Triangle Park NC 27711 UNITED STATES	darling.john@epa.gov
Judy Pederson	MIT Sea Grant College Program E38-300 Cambridge MA 02139, UNITED STATES	jpederso@mit.edu
Katja Broeg	Bundesamt fuer Seeschifffahrt und Hydrographie (BSH), Federal Maritime and Hydrographic Agency, Bernhard-Nocht-Str. 78 20359 Hamburg, GERMANY	katja.broeg@bsh.de
Kimberly Howland	Fisheries and Oceans Canada, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6, CANADA	kimberly.howland@dfo-mpo.gc.ca
Lisa Drake	U.S. Naval Research Laboratory PO Box 9036, Key West FL 33040 UNITED STATES	lisa.drake@nrl.navy.mil
Lyndsay Brown	Marine Scotland - Science Marine Laboratory, PO Box 101 375 Victoria Road, Aberdeen, AB11 9DB UNITED KINGDOM	lyndsay.brown@scotland.gsi.gov.uk
Maiju Lehtiniemi (By Correspondence)	Finnish Environment Institute (SYKE) P.O. Box 140, Mechelininkatu 34a 00251 Helsinki, FINLAND	maiju.lehtiniemi@ymparisto.fi
Nathalie Simard	Fisheries and Oceans Canada Maurice Lamontagne Institute 850 Route de la mer, P.O. Box 1000 Mont-Joli (Québec), G5H 3Z4, CANADA	nathalie.simard@dfo-mpo.gc.ca
Rahmat Naddafi	Institute of Coastal Research Swedish University of Agricultural Sciences, SWEDEN	rahmat.naddafi@slu.se
Sarah Bailey (Chair)	Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA	sarah.bailey@dfo-mpo.gc.ca
Stephan Gollasch	GoConsult Grosse Brunnenstr. 61 22763 Hamburg, GERMANY	sgollasch@gmx.net
Stephanie Delacroix (Remote Participation)	Norwegian Institute For Water Research Gaustadalléen 21 NO-0349 Oslo, NORWAY	stephanie.delacroix@niva.no
Thomas Landry	Fisheries and Oceans Canada Gulf Fisheries Centre, P.O. Box 5030 Moncton, NB, E1C 9B6, CANADA	thomas.landry@dfo-mpo.gc.ca
Thomas Therriault (representing PICES)	Fisheries and Oceans Canada Pacific Biological Station 3190 Hammond Bay Road Nanaimo, BC, V9T 6N7, CANADA	thomas.therriault@dfo-mpo.gc.ca

Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
1. Initiate discussion/coordination with other Arctic organisations (e.g. PAME, CAFF) with a view to jointly address non-native species issues in the Arctic.	SCICOM (2016)
2. Submit a proposal to formalize the role of the International Maritime Organization (IMO) with the WGBOSV and to formalize the cooperation between ICES, IMO and Intergovernmental Oceanographic Commission (IOC).	ICES Secretariat (2017)

Annex 3: Agenda

WEDNESDAY 15TH MARCH JOINT MEETING WITH WGITMO		
08.30	Set Up Computers	.30
08:45	Welcoming remarks: **Sarah Bailey, Cynthia McKenzie** (Co-Chairs), **Judy Pederson** (Host)	.5
	Introduction of Participants	.10
	A few words about NEFSC – Deputy Director, **Dr. Susan Gardner**	.15
	Review WGBOSV/WGITMO Joint Day Agenda	.5
	Update on relevant PICES activities – **Tom Therriault**	.10
	Questions	
09.30	**WGBOSV ToR e):** Investigate and evaluate methods/technologies to assess risks of, to minimize extent of, and to respond to vessel biofouling to inform national and/or international policies or guidelines [**WGITMO ToR c)** Investigate biofouling as a vector for the introduction and transfer of aquatic organisms on vessels and artificial hard structures, their pressure and impact on the ecosystem with a comparison of prevention or selective mitigation measures.] ***ToR Lead: Stephan Gollasch***	
	Review ToR objectives and deliverables	.10
	Presentation: Transoceanic rafting of marine biofouling communities — implications for marine debris as a vector for non-indigenous species – **Jim Carlton**	.20
	Questions	.10
	Presentation: U.S. Biofouling Workshop – **Lisa Drake**	.20
	Questions	.10
10.45	**Morning break**	.15
	Presentation: Title to Be Determined – **Greg Ruiz**	.20
	Questions	.10
	Presentation: Biofouling Risk in the Canadian Arctic – **Farrah Chan**	.20
	Questions	.10
	Discussion, Gap Analysis and Strategic Planning under ToR e) [WGITMO ToR c)]	.30

12.30	**Lunch break**	.60
1:30	**WGBOSV ToR d):** Investigate and evaluate climate change impacts on the establishment and spread of ship-mediated nonindigenous species, particularly with respect to the Arctic [**WGITMO ToR b):** Evaluate the impact climate change may have on the introduction and spread of non-indigenous marine organisms, incl. in Arctic environments. ***ToR Lead: Anders Jelmert***	
	Review ToR objectives and deliverables	.10
	Presentation: Results of Canadian Arctic domestic shipping project – **Kim Howland**	.20
	Questions	.10
	Progress Update: Review Paper on AIS risks to the Arctic	
	Part 1 – **Farrah Chan**	.20
	Part 2 – **Stephan Gollasch**	.20
15.00	**Afternoon break**	.15
	Group Discussion to Further Progress the Arctic Review Paper	.45
	Discussion, Gap Analysis and Strategic Planning under ToR d) [WGITMO ToR b)]	.30
	Location of next meeting	.15
	Discuss any Joint Issues Outstanding / Close of WGITMO	.15
17.00	**End of Joint Meeting Day**	

THURSDAY 16TH MARCH

08.30	Set up Computers	.30
09.00	Review WGBSOV Agenda	.10
09.10	**ToR a):** Conduct strategic planning (identify and develop collaborative activities, advance and standardize methods, etc.) to advance research and address knowledge gaps through review of national activities and to respond to new requests for advice. ***ToR lead: Sarah Bailey***	
	Review ToR objectives and deliverables	.10
	Review of National Activities (2016-2018)	
	• Belgium	.10

	• Canada	.10
	• France	.10
	• Germany	.10
	• Italy	.10
	• Netherlands	.10
	• Norway	.10
	• United Kingdom	.10
	• United States	.10
	• Additional Reports by Correspondence	
10.30	**Morning break**	.15
	Presentation: Ballast Water Management: Policy to Sampling – the Orkney Experience – **Jenni Kakkonen**	.20
	Questions	.10
	Presentation: Ports Contingency Planning – **Cato ten Hallers**	.20
	Questions	.10
12.00	**Lunch break**	.60
	Presentation: Metabarcoding of Ballast Water Samples – **John Darling**	.20
	Questions	.10
	Presentation: Rapid Adaptation in Marine Species – **Carolyn Tepolt**	.20
	Questions	.10
	Discussion, Gap Analysis and Strategic Planning under ToR a)	.30
14:30	**ToR b):** Evaluate methods for collection and analysis of ballast water samples to inform national and/or international procedures for compliance testing of ballast water management systems. ***ToR Lead: Lisa Drake***	
	Review ToR objectives and deliverables	.10
	Recap activities on sampling and analysis at IMO – **Lisa Drake**	.15
15.00	**Afternoon break**	**.15**
	Presentation: Ballast Water Sampling Equipment – **Chris Brown** (by webex)	.20
	Questions	.10
	Presentation: How accurate are pulse amplitude modulated (PAM) instruments in calculating an algal cell concentration of Ballast Water Samples? – **Stephan Gollasch** (on behalf of Matej David)	.20
	Questions	.10
	Presentation: Optimizing methods to collect a representative sample for organisms greater than 50 um minimum dimension – **Sarah Bailey**	.20
	Questions	.10
	Discussion, Gap Analysis and Strategic Planning under ToR b)	.30

17.30	**End Day 2**	

FRIDAY 17TH MARCH

08.30	Set Up Computers	.30
09.00	**ToR c):** Evaluate methods for, and outcomes of, type approval and operational testing of ballast water management systems to inform national and/or international procedures for type approval of such systems. ***ToR Lead: Stephanie Delacroix***	
	Review ToR objectives and deliverables	.10
	Update on Special Session @ ICAIS, October 22-26, 2017, Fort Lauderdale, Florida	.10
	Presentation: Impacts of new IMO G8 Guidelines and update on acceptance of MPN method – **Stephanie Delacroix** (by webconference)	.20
	Questions	.10
	Presentation: Global Harbour Characterization – **Allegra Cangelosi**	.20
	Questions	.10
10.30	**Morning break**	.15
	Presentation: Challenge water size-class ramifications for freshwater performance evaluations – **Allegra Cangelosi**	.20
	Questions	.10
	Discussion, Gap Analysis and Strategic Planning under ToR c)	.30
12.00	**Lunch break**	.60
13.00	**ToR f):** Evaluate the current role/importance of shipping in relation to other invasion vectors/pathways globally. ***ToR Lead: Sarah Bailey***	
	Review ToR objectives and deliverables	.10
	Progress Update: Review Paper on Global AIS pathways – **Sarah Bailey**	.20
	Group Discussion to Further Progress the Review Paper	.60
14:30	**Afternoon break**	.15
	Discussion, Gap Analysis and Strategic Planning under ToR f)	.30
	Discuss any Issues Outstanding or Any Other Business	.15
15.30	**Close of WGBOSV 2107 Meeting**	

Annex 4: National Reports

Belgium

Report Prepared By:

Francis Kerckhof, Royal Belgian Institute of Natural Sciences:

fkerckhof@naturalsciences.be

There is currently no work on ballast water or biofouling issues on vessels in Belgium. Belgium has on March 7the 2016 – just before the meeting of the SGBSOV - at last ratified the Ballast Water Management Convention. The Flanders Marine Institute (VLIZ) has issued a preliminary analysis of the distribution and the risk of target species in ports belonging to sailing routes for which companies want to obtain exemption. This study has now been published as a policy informing note 2015_002, and is online available via: http://www.vliz.be/nl/news?p=show&id=4474. None of the shipping routes where eligible for an exemption.

The work studying the fouling on the windmill farms is still ongoing. A range of species has been found, including non-natives and introduced species, especially in the intertidal zone.

Canada (updated 2017)

Report Prepared By:

Sarah Bailey, Fisheries and Oceans Canada: sarah.bailey@dfo-mpo.gc.ca

Kimberly Howland, Fisheries and Oceans Canada: kimberly.howland@dfo-mpo.gc.ca

Cynthia McKenzie, Fisheries and Oceans Canada: cynthia.mckenzie@dfo-mpo.gc.ca

Nathalie Simard, Fisheries and Oceans Canada: nathalie.simard@dfo-mpo.gc.ca

STATUS OF SHIPPING VECTOR RESEARCH

Canada has a long history of research and management concerning shipping vectors, especially regarding ballast water in the Laurentian Great Lakes where activity has been high since the late 1980s. Since the late 2000's there has been a growing interest regarding risks of shipping vectors in the Arctic region due to concerns with increasing shipping activity in response to warming conditions and further development in this region. Fisheries and Oceans Canada and Transport Canada both allocate funds annually to support research and monitoring of aquatic invasive species (including but not exclusively shipping vector activities), which recently has been in the range of $CAD 500-750K, depending on departmental priorities each year. Additional funds from Northern Land Claim groups and other government agencies (Polar Knowledge

Canada and Natural Resources Canada) have provided additional support ($200-300K/year) for research in the Arctic region in recent years. Canada ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, in April 2010. Transport Canada is preparing to fully implement the Convention now that the Convention has been fully ratified and will enter into force on September 8, 2017.

The potential introduction of Asian carps into the Great Lakes from the Mississippi River basin is of high concern. Fisheries and Oceans Canada initiated an Asian Carp Program to prevent the introduction and establishment of four species of Asian carps (Grass, Bighead, Silver and Black carps). This 5-year program began in 2012 with a strong focus on early detection surveillance in the Canadian waters of the Great Lakes (approximately $CAD 875K annually). Additional activities include research to support risk assessments, reduce spread of invasive fishes, and assess potential Asian carp containment options; funds for research in 2016-17 were $CAD 250K.

PLANNED RESEARCH

Planned research will focus on examining risk of shipping vectors to Canadian Arctic ports; developing protocols for collecting and analysing representative samples of ballast water; and evaluating efficacy of ballast water management systems for use in the Canadian environment.

RESEARCH NEEDS

- A baseline data set for Canadian Arctic plankton and benthos by marine ecoregions has been collated, but species records for different taxa should be incorporated into a consistent, standardized database format and ideally published/archived in a way that they can be made publicly available.

RESEARCH GAPS

- DNA barcode reference libraries to catalogue biodiversity of lower trophic level taxa. Such information will provide a basis for the use of new genetic tools for the detection of changes in biodiversity and detection of new species.
- Comprehensive information on species composition and relative abundance of biofouling and ballast-mediated biota on vessels arriving to Arctic ports
- Risk assessment and management strategies for biofouling on vessels arriving to Canadian waters
- Risk assessment for recreational boating as a vector of AIS to Arctic region
- Population genetics studies of cryptogenic species found in port surveys, to better understand origins (native versus introduced)
- Studies confirming efficacy and environmental acceptability of treated ballast water discharged into Canadian ecosystems

MEETINGS

- IMO-GloBallast R&D Forum, Montreal, Canada, 16-18 March, 2016
- 19th International Conference on Aquatic Invasive Species (ICAIS), Winnipeg, Canada, 10-14 April, 2016
- Marine & Freshwater Invasive Species: Ecology, Impact, and Management, Buenos Aires, Argentina, 2-4 May 2016
- Biofouling Workshop: Approaches to Quantifying Biofouling and Considerations of Hull Cleaning. Edgewater, USA. 24-25 August, 2016.
- ICES Annual Science Conference, Riga, Latvia, September 19-23, 2016
- ArcticNet Annual Science Meeting, Winnipeg, Canada, 5-9 Dec, 2016
- ICES-PICES-CIESM special session: Bioinvasion trajectories and impacts in contrasting marine environments. ICES Annual Science Conference, Fort Lauderdale, USA, 18-21 September, 2017
- 20th International Conference on Aquatic Invasive Species (ICAIS), Fort Lauderdale, USA, 22-26 October, 2017
- 3rd International Conference on Marine and Freshwater Invasive Species, Aquatic Ecosystem Health and Management Society, Beijing, China, 20-23 May, 2018
- International Conference on Marine Bioinvasions X , Argentina, 16-18 October, 2018

PROJECT INFORMATION

1. Understanding ballast water as a pathway for introduction of aquatic invasive species (AIS) in the Canadian Arctic (2013-2017)

Kimberly Howland, Fisheries and Oceans Canada: Kimberly.Howland@dfo-mpo.gc.ca
Nathalie Simard, Fisheries and Oceans Canada: Nathalie.Simard@dfo-mpo.gc.ca

The primary objectives of this project are to: 1) Characterize diversity and propagule pressure of zooplankton and phytoplankton in the ballast of ships in Arctic Ports (Churchill and Deception Bay); 2) Evaluate seasonal changes in risks associated with ballast being brought into the Canadian Arctic; 3) Determine effectiveness of current voluntary exchange practices for Arctic domestic ships. The project will provide analyses of species composition and abundance for both domestic and international shipping pathways, seasonal analyses of risks and recommendations regarding current voluntary exchange. Information from this study will improve our abilities to understand and manage ballast-mediated species introductions, help guide voluntary domestic ballast management practices by industry and feed into regulatory decisions by Transport Canada. Ballast samples of ships arriving at ports of Churchill and Deception Bay were collected in 2013-2015. Experimental testing of different exchange locations vs. control (no exchange) was conducted on 3 voyages of the domestic ship MV Arctic in 2015. All sample analyses have been completed and results on zooplankton and dinoflagellates have been incorporated into two master theses (draft theses have been written, primary papers to be submitted for publication in 2017). A paper on microbial community results obtained during voyages has been

published (Johansson *et al.*, 2017).

2. Evaluating ship biofouling as a potential pathway for the introduction and spread of aquatic invasive species (AIS) into the Canadian Arctic (2009-2018)

Farrah Chan, Fisheries and Oceans Canada: Farrah.Chan@dfo-mpo.gc.ca
Sarah Bailey, Fisheries and Oceans Canada: Sarah.Bailey@dfo-mpo.gc.ca

The primary objectives of this project are: (1) To determine whether biofouling organisms on ships can survive voyages from temperate to Arctic ports in Canada. (2) To identify biofouling hotspots for ships operating in an Arctic environment. (3) To characterize biofouling extent and management practices of ships operating in Canadian Arctic waters. (4) To evaluate the importance of ship biofouling as a pathway for the introduction and spread of AIS into the Canadian Arctic. The project will analyse data from hull SCUBA surveys of eight naval ships conducted before, during, and after voyages to the Canadian Arctic in the summers of 2009 to 2012. In addition, we have designed a questionnaire in line with the IMO Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species to collect information about voyage history, hull husbandry practices, and results from recent dry docking or in-water biofouling inspection/cleaning. Surveys were distributed to all ships entering the Canadian Arctic in the summers of 2015 and 2016 via the Canadian Coast Guard. Data from navy SCUBA surveys and questionnaires will be combined with published results of SCUBA surveys on commercial ship hulls to investigate the potential for ships to transport AIS to the Canadian Arctic via biofouling.

3. Study of plankton distribution in ballast tanks in order to collect a representative sample for compliance testing (2015-2017)

Harshana Rajakaruna, Fisheries and Oceans Canada: Harshana.Rajakaruna@dfo-mpo.gc.ca
Sarah Bailey, Fisheries and Oceans Canada: Sarah.Bailey@dfo-mpo.gc.ca

The primary objectives of this project are to determine: (1) if density distributions of plankton inside ballast tanks are heterogeneous and/or stratified, and if so, (2) the comparability of density estimates given by traditional net-haul vs. proposed in-line sampling using different estimation methods. Three extensive sampling trips (independent trials) were conducted in 2015 on a single operating vessel to examine the distribution of plankton in a single ballast tank, using traditional net-hauls and recently developed in-line sampling methods, augmented by stratified sampling through tubing installed at different depths within the tanks. These samples are currently being counted for plankton densities. We will use stochastic models, such as non-homogeneous Poisson, to examine the spatial/temporal structure, heterogeneity, vertical stratification inside tanks, and temporal trends at discharge, of plankton densities. We will use method-comparison techniques to test whether density estimates given by net-haul and in-line sampling, using both traditional and our best-fit stochastic models, differ significantly, and also differ from those given by tube sampling, which exclusively captures the density variation by depth. We will investigate their relative accuracies, and how biases could be corrected analytically using mathematical/statistical models. We will also investigate the relationships between heterogeneity, spatial/temporal trends in densities with respect to environmental variability

and other fixed and random factors using models such as GLMM.

4. Comparison of sampling devices and analytic methods for ballast water compliance monitoring (2015-2017)

Johanna Bradie, Fisheries and Oceans Canada: Johanna.Bradie@dfo-mpo.gc.ca
Sarah Bailey, Fisheries and Oceans Canada: Sarah.Bailey@dfo-mpo.gc.ca

The primary objectives of this project are: (1) to examine whether there are differences in samples collected using traditional net sampling and in-line sampling skids (open and closed configurations), (2) to examine the accuracy and precision of analytic tools and to assess whether quick, indicative methods offer comparable results to standard, time-intensive testing methods (e.g. microscopy) and high-end scientific approaches, and (3) to examine whether there are differences between analytic devices in the detection of UV treatment events. To accomplish these objectives, a voyage was undertaken by 20 international researchers on board the German research vessel, RV Meteor, in June 2015. During this time 28 trials were conducted to evaluate three ballast sampling devices (plankton net and 2 sampling skids) and a number of analytic devices (>200µm: 1 technique, >50µm: 5 techniques, >10µm and <50µm: 10 techniques, bacteria: 6 techniques). Water samples were collected using paired sampling devices and analyzed in parallel by all analytic methods to determine whether results were similar between devices. All results have been analysed and submitted for publication as part of the special issue on Recent Advances in Ballast Water Research in the Journal of Sea Research (e.g., Bradie *et al.* 2017).

5. Development of community-based program for monitoring and early detection of aquatic invasive species in the Canadian Arctic – preparing for increased shipping related to resource development and climate change (2015-2018)

Kim Howland, Fisheries and Oceans Canada: Kim.Howland@dfo-mpo.gc.ca
Nathalie Simard, Fisheries and Oceans Canada: Nathalie.Simard@dfo-mpo.gc.ca

Increased shipping in the Canadian Arctic associated with resource development and climate warming will inevitably result in unwanted species introductions. Preventative measures, such as ballast water exchange and treatment and reduction of vessel fouling, are key components for management of aquatic invasive species (AIS). However, these measures are not 100% effective. Thus, in addition to prevention, management should focus on strategies for monitoring and early detection, especially where AIS have not yet established or population levels are still low, as in the Canadian Arctic. Monitoring improves the likelihood of detecting invasions at early stages when there is a greater chance for successful eradication, containment, or to prepare to adapt to the presence of a new species. Through this project we are developing a foundation for the development of a monitoring and early detection system in the Canadian Arctic. This includes the following elements and is extending past research efforts by DFO and the Canadian Aquatic Invasive Species Network (CAISN): 1) Identification and ranking of key ship-mediated AIS for early detection and monitoring, and geographic locations with highest probability for establishment; 2) Development of genetic early detection methodologies (e.g., environmental or eDNA) for AIS in high risk ports; 3) Establishment of a community based monitoring network/capacity. In 2015 and 2016, collection of port samples (including eDNA samples) and training programs were conducted in the Arctic Ports of Churchill, Iqaluit

and Deception Bay. Lab analysis of these samples is currently ongoing. In 2017, we plan to collect port and ballast samples in Pond/Milne Inlet. Additional lab work and identification/genetic analyses are also planned for the third year of this project.

6. An investigation of the risk posed by marine recreational boating as a vector in the introduction and spread of aquatic invasive species in Canada (2011-2016)

Nathalie Simard, Fisheries and Oceans Canada: Nathalie.simard@dfo-mpo.gc.ca
Cynthia McKenzie, Fisheries and Oceans Canada: Cynthia.mckenzie@dfo-mpo.gc.ca

A national marine recreational boating risk assessment was conducted in 2015 to assess the risk of this vector poses to marine systems on both the east and west coasts in Canada. The risk assessment includes information on the level of infestation of NIS in the different Canadian and international ecoregions, the probability that boat vectors will be fouled with NIS – based on extensive surveys and statistical models, information on boat movements, and environmental similarity of source and receiving ecoregions. This is combined with information on annual boat traffic to estimate the relative risk of NIS due to boating in the different Canadian marine ecoregions. This research document and corresponding scientific advice have been published (Simard *et al.* 2017; DFO 2017).

7. **An investigation of the risk posed by freshwater recreational boating as a vector for the secondary spread of aquatic invasive species in Canada (2013 – 2017)**

Andrew Drake, Fisheries and Oceans Canada: Andrew.drake@dfo-mpo.gc.ca
Sarah Bailey, Fisheries and Oceans Canada: Sarah.bailey@dfo-mpo.gc.ca
Nicholas Mandrak, University of Toronto: Nicholas.mandrak@utoronto.ca

A freshwater recreational boating risk assessment was conducted in 2016 and 2016 to quantify the risk of secondary spread of aquatic invasive species in the Great Lakes basin (including freshwaters of the St. Lawrence River). Using agent-based models and other statistical methods, the risk assessment quantified the probability that recreational boats would facilitate the spread of AIS within and among the Great Lakes basin, and the probability that boater-mediated spread would surpass rates of natural dispersal. The assessment was conducted for functional groups of AIS based on their fouling potential (e.g., organisms with planktonic stages, macrophytes, and biofouling species, such as molluscs). A second document quantified the probability of AIS introduction resulting from overland movements of recreational boats in freshwaters. These research documents and corresponding scientific advice have been published (Drake *et al.* 2017; Drake 2017).

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Croatia

Report Prepared By:

Josip Mikuš, University of Dubrovnik, Croatia, josip.mikus@unidu.hr

Marijana Pećarević, University of Dubrovnik, Croatia, marijana.pecarevic@unidu.hr

STATUS OF SHIPPING VECTOR RESEARCH

Research regarding ballast water as a vector of introduction of non-native species in the Croatian part of the Adriatic Sea started in 1990s. The first such project has been conducted at the University of Dubrovnik in the period 1996–2007 and the work on this issue has been continued till today.

Croatia ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO, 2004) in June 2010. The first national Regulation on Management and Control of the Ballast Water has been enacted by Croatian Parliament in 2007. This Regulation was modified and improved in November 2012 (Official Gazette: NN 128/12). The Regulation enacts the principles and methods in managing and controlling of the ballast water in floating objects during their stay or voyage in Croatian part of the Adriatic Sea.

After several records of the blue crab *Callinectes sapidus* in the eastern Adriatic Sea, speciments were found at the mouth of the river Neretva in November 2009. Till today this species established population in this area competing native *Carcinus aestuarii*. Recently, three specimens of the adult blue crab were caught inside the Nature Park Vransko Lake in May 2013 (Župan *et al.* 2016). This is the first appearance of this species in the Mediterranean freshwater ecosystems thus further monitoring of the blue crab should gain more interest and support.

PLANNED RESEARCH

IPA CBC Adriatic Ballast water management system for Adriatic Sea protection (BALMAS) project, started in November 2013, is reaching its final this year. Project partners agreed to continue this important work within a new joint project after 2016. The new project should build up on the knowledge achieved in BALMAS and continue monitoring and improvement of ballast water management in the Adriatic Sea.

RESEARCH NEEDS

Experience and knowledge of BOSV members in species determination or ballast water management could be welcome and valuable during the project preparation

and implementation.

RESEARCH GAPS

Systematic monitoring of introduced species in Croatian waters is still not established. This should be of high interest for Croatian scientific community as well as for economy in order to find the best practice in detection and control of introduced species (e.g. earlier mentioned Blue crab which continues to spread to new areas after first introduction in Croatia).

MEETINGS

No meetings planned for this period.

PROJECT INFORMATION

1. Ballast water management system for Adriatic Sea protection (BALMAS) (2013-2016)

Lead beneficiary: Institute for Water, Republic of Slovenia;
Final beneficiary: University of Dubrovnik, Marijana Pećarević, marijana.pecarevic@unidu.hr

Ballast water management system for Adriatic Sea protection – BALMAS (http://www.balmas.eu/) project includes partners from all Adriatic countries. The general BALMAS objective is to establish a common cross-border system linking all Adriatic research experts and national authorities to avoid the unwanted risks to the environment and humans from the transfer of HAOP, through the control and management of ships' BW and sediments. Adriatic countries recognised that BW related data (e.g. the presence and invasiveness of HAOP in Adriatic ports, BW uptake and discharge activities, sediment disposal, chemical pollution with BW) and knowledge (e.g. port baselines and monitoring, BW sampling for compliance control, risk assessment, how to deal with non-compliant vessels, early warning system, effectiveness of BWM systems and measures) need to be shared in order to enable implementation of the BWM Convention requirements through a common BWM plan, and provide support to responsible authorities for faster and effective decision making with a decision support system (DSS). The goal of the project is preparation of a common Ballast Water Management (BWM) Plan for the Adriatic Sea area and implementation of the BALMAS BWM decision support system (DSS) including compliance control and enforcement (CME), compliant with the International Convention for the Control and Management of Ship´s Ballast Water and Sediments (BWM Convention) considering local specifics.

Estonia (updated 2017)

Report Prepared By:

Henn Ojaveer. Estonian Marine Institute, University of Tartu. Lootsi 2a, 80012 Pärnu. Estonia

STATUS OF SHIPPING VECTOR RESEARCH

Monitoring, incl. port biological monitoring

The specifically dedicated and governmentally funded national alien species monitoring program, started in 2010, was continued in 2015 and 2016. The alien species monitoring consists of three major sub-components: 1) monitoring of high risk areas of primary invasions; 2) tracking long-term performance of selected most important alien species and 3) evaluation of ecological and socioeconomic impacts caused by alien species. Monitoring of high risk areas of primary invasions – vicinity of ports – has been conducted in Port of Tallinn (since 2010) and Port of Sillamäe (since 2012), both located in the Gulf of Finland. Several stations were sampled in port vicinity and also in more distant localities called also as reference sites. Importantly, all data and annual reports are freely available, though unfortunately written in Estonian only (Anon. 2016).

Port biological monitoring (Muuga Harbour, Port of Tallinn) according to HELCOM protocol was added to the programme in 2014 with sampling being carried out in spring, summer and autumn. The monitoring included recording of key environmental conditions (incl. CTD profiles) and sampling of phytoplankton, zooplankton, benthic infauna, fouling communities and mobile epifauna.The samples taken both from the harbour area as well as adjacent localities confirm that spatio-temporally, the most stable and abundant populations were those of the cirriped *Amphibalanus improvisus* and the polychaete *Marenzelleria neglecta*, however, with substantial reduction in distribution area and abundance of the latter species during a few recent years (Anon. 2016).

Distribution of the round goby

Pan-Baltic modelling results show that the distribution of the round goby Neogobius melanostomus is primarily related to local abiotic hydrological conditions (wave exposure). Furthermore, the probability of round goby occurrence was very high in areas in close proximity to large cargo ports. This links patterns of the round goby distribution in the Baltic Sea to shipping traffic and suggests that human factors together with natural environmental conditions are responsible for the spread of NIS at a regional sea scale. Thus, the models demonstrate clearly that the spatial distribution of the round goby in the Baltic Sea is a function of shipping intensity (distance to port, cargo traffic) and abiotic hydroclimatic environment (wave exposure). Although high frequency of release does not necessarily lead to successful invasions, the round goby seems not to have major environmental constraints in the Baltic Sea (Kotta *et al.* 2016).

Ballast Water Management Convention

As BWMC is expected to enter into force soon, shipping companies will start seeking exemptions for ballast water management in accordance with BWMC Regulation A-4. However,without scientifically robust risk assessment (RA) and consistent rules, the exemptions may introduce a new form of risk within a convention generally designed to reduce risks. To address this, a dedicated one week meeting was arranged in Pärnu (Estonia) with attendance of Sergej Olenin, Dan Minchin and Henn Ojaveer. As a result two documents were preapared:

1) Ojaveer *et al.* 2105. Proposal for IMO Ballast Water Management Convention A-4 Target Species selection criteria, submitted to the submitted to HELCOM Workshop on IMO BWMC target species, criteria and revision process (Tallinn, Estonia; 26 August 2015);

2) Olenin *et al.* 2016. Assessing exemptions under the ballast water management convention: preclude the Trojan horse. Marine Pollution Bulletin http://dx.doi.org/10.1016/j.marpolbul.2015.12.043

These documents describe an adaptive system for granting exemptions, consisting of six major components: target species selection procedure, port-to-port RA, monitoring, information support, administrative decision and review process. The systemis based on key principles defined in the IMO guidelines for RA and is designed to continuously accumulate evolving experience on granting exemptions. The ultimate goal is to contribute to the control of the spread of HAOPs, without placing an unnecessary burden on the shipping industry

Impacts

The range and density of the non-indigenous *G. tigrinus* is still increasing. Within a ten year of establishment the abundance of *G. tigrinus* showed no signs of decline with the invasive species exceeding about fifteen times the abundance values of native gammarids (Reisalu *et al.* 2016). Our recent experimental study demonstrated that the invasive *G. tigrinus* has higher reproductive potential compared to the native species (*Gammarus duebeni*, *Gammarus occanicus*, *Gammarus zaddachi*). Moreover, virtually all adult gammarids exerted a significant predation pressure on juvenile amphipods. Thus, the combined effect of predation on juvenile amphipods and large brood production of *G. tigrinus* could be plausible explanations describing increased abundance of *G. tigrinus* and decrease of local gammarid populations in the north-eastern Baltic Sea but plausibly in similar shallow water habitats in other seas (Jänes *et al.* 2015).

Our long-term data series analysis indicate that the late summer dynamics of the calanoid copepod *E. affinis* were explainable by a combination of positive SST effect and negative effect of *C. pengoi*. While these effects were for the younger stages independent of each other, we found for *E. affinis* adults indications of a control change. The TGAM suggested that SST has a positive effect only under low levels of *C. pengoi* abundances. At higher abundances of *C. pengoi*, reproductive processes governed by SST cannot counteract the predation pressure on *E. affinis*. On an average year, abundances of *C. pengoi* are above the threshold for entire July and August (data not shown). In contrast, abundances of *Acartia* spp. were not related to SST or abundances of *C. pengoi*, at least statistically (Klais *et al.* in prep.).

The Harris mud crab *Rhithropanopeus harrisii* was first found in Estonian waters in 2011. Further investigations in 2012 evidenced that the species has colonised whole Pärnu Bay and already occurring outside the area in the NE Gulf of Riga. There was an interactive effect between the presence of prey and crab population density with prey availability increasing the crab's affinity towards less favored habitats when population densities were low. Increased aggression between crab individuals increased their affinity towards otherwise less occupied habitats. Less favored habitats were typically inhabited by smaller individuals and presence of prey increased occupancy of some habitats for larger crabs. The experiment also demonstrated that the crab may inhabit a large variety of habitats with stronger affinity towards boulder fields covered with the brown macroalga *Fucus vesiculosus*. This implies stronger impact of crab in such habitats in the invaded ecosystem (Nurkse *et al.* 2015). *R. harrisii* significantly modifies meiobenthic communities and has by far the strongest effects on meiobenthos compared to any other environmental varible. The effects of *R. harrisii* varied among different habitats with the crab mostly modifying taxonomic composition and species abundances of meiobenthic communities mostly on unvegetated soft bottom sediments (Lokko *et al.* 2015).

PLANNED RESEARCH

As a direct outcome of the BWMC exemption research, analysis on seasonal port biological sampling carried out in Muuga Harbour (Port of Tallinn) will be undertaken. This will assist in not only defining the meaningful sampling frequency by various methods/organism groups, but also will help to evaluate the certainty of data obtained in those seasonal samplings

RESEARCH NEEDS

- Significance of biofouling as a vector for non-native species introductions
- Reduction of uncertainty in assigning concrete introduction pathway for species introductions
- Challenge scientists to operationally share new information via AquaNIS

MEETINGS

HELCOM Workshop on IMO BWMC target species, criteria and revision process (Tallinn, Estonia; 26 August 2015).

PROJECT INFORMATION

List individual projects of relevance to BOSV that will occur 2016-2018, using the format as below:

1. Project Title: Biodiversity changes – *investigating* causes, consequences and management implications (BONUS BIO-C3)
Contact information: https://www.bio-c3.eu/

BIO-C3 will investigate causes and consequences of changes in biodiversity, effects on ecosystem functioning, food web dynamics, productivity and assesses implications for environmental management and sustainable use of ecosystem goods and services. Planned biodiversity analyses will apply an integrated approach at species,

genotype, population, community and ecosystem levels. Essential Baltic Sea features are low numerical species diversity, many recent immigrants, glacial relicts and simple food webs that nevertheless sustain goods and services of high economic and societal value. BIO-C3 will i) investigate genetic adaptation, eco-physiology, colonisation and role of native versus non-indigenous species, ii) advance understanding of functional links between biodiversity, external pressures and food-web interactions, and iii) improve future projections of trends in biodiversity. Biodiversity is dynamic, responding to various drivers that operate at different temporal and spatial scales. Spatio-temporal biodiversity responses will be analysed and evaluated by hindcasts and projections considering abiotic/biotic /anthropogenic drivers (climate change, eutrophication, species invasion, fisheries) and their interactions. Identified factors and processes will feed into impact assessments, guiding management policies to improve indicators of Good Environmental Status, efficacy and management of Marine Protected Areas and to conceptualise and design management evaluation frameworks.

2. Project Title Round goby in Estonian coastal waters: applied research for developmenting further action plan
Contact: Kristiina Nurkse, Estonian Marine Institute, University of Tartu. Email (kristiina.nurkse@ut.ee)

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Finland (updated 2017)

Report Prepared By:

Maiju Lehtiniemi, Finnish Environment Institute,

maiju.lehtiniemi@ymparisto.fi

STATUS OF SHIPPING VECTOR ACTIVITIES AND RESEARCH

Finland finally ratified the IMO BWMC 8 September 2016 and with this ratification the Convention will enter into force 8 September 2017. A national group to discuss and share knowledge on the implementation of the BWMC in Finland is an important forum and has been working efficiently during the past few years. It is led by the Finnish Traffic and Safety Agency, and the Finnish Environment Institute, Ministry of Environment, Ministry of Traffic and Communication and The Finnish Shipowners' Association as well as representatives from ship owner companies take actively part to the meetings and discussions.

Finland is actively contributing to ballast water and other maritime transport related meetings at IMO, HELCOM and regional and international meetings related to the implementation of the EU MSFD and EU IAS Regulation. Finland has led the NIS indicator (Trends in arrival of new non-indigenous species) update process in HELCOM together with Lithuania, Germany and Sweden. The indicator update was done for the second Baltic Sea holistic status assessment HOLAS II (to be completed during 2017) and shows that there were now new primary introductions in Finnish waters (no new NIS for the Baltic Sea area observed in Finnish waters) during the assessment period (2011-2016) although a few species were new for Finland (e.g. jellyfish *Maeotias marginata*, observed 2012 in the Archipelago Sea).

Ongoing and completed research activities are found in the project descriptions below.

PROJECT INFORMATION

1. A pilot study on granting exemptions for ships under the Ballast Water Management Convention regulation A-4, based on the operability of HELCOM & OSPAR Risk assessment tool and expert judgement (project completed 2016)

Ville-Veikko Intovuori, Finnish Traffic and Safety Agency, ville-veikko.intovuori@trafi.fi
Maiju Lehtiniemi, Finnish Environment Institute: Contact: maiju.lehtiniemi@ymparisto.fi

A small project was completed in 2016 to test the HELCOM/OSPAR tool to grant exemptions from the ballast water treatment. The study tested how well the tool and the target species criteria and list included in the tool works. As test case a few shipping routes were selected between a few ports in the Baltic Sea and in the North Sea. The results were presented and discussed in HELCOM/OSPAR TG Ballast meeting in November 2016 in Brussels.

2. Project BALLAST: Literature review on indicative ballast water analysis methods (project completed in January 2017)

Maiju Lehtiniemi, Finnish Environment Institute: Contact: maiju.lehtiniemi@ymparisto.fi
Okko Outinen, Finnish Environment Institute: Contact: okko.outinen@hotmail.com

The project aimed to make a comprehensive literature review on indicative ballast water analysis methods and to recommend the most suitable methods for Finnish authorities to use in indicative inspections.

3. VISAKE - VIERASLAJIEN VARHAISVAROITUS- JA SEURANTAJÄRJESTELMÄN KEHITYS JA TAHATTOMIEN LEVIÄMISVÄYLIEN HALLINTA
(EU Regulation on Invasive Alien Species: Proposal for listing, prioritization and management of unintentional introduction pathways) (will be completed in March 2017)

Maiju Lehtiniemi, Finnish Environment Institute: Contact: maiju.lehtiniemi@ymparisto.fi

The project aims at analyzing and prioritizing the potential unintentional pathways for EU listed invasive species to Finland and inside Finland and suggesting management for the prioritized pathways to meet the requirements of the EU Regulation 1143/2014 on Invasive Alien Species.

France (updated 2017)

Report Prepared By:

Amelia Curd, Ifremer: Amelia.curd@ifremer.fr

Philippe Goulletquer, Ifremer: Philippe.goulletquer@ifremer.fr

Daniel Masson: Daniel.masson@ifremer.fr (retired)

STATUS OF SHIPPING VECTOR RESEARCH

A European consortium composed of ecologists and economists has examined the costs of putative non-indigenous species (NIS) mitigation measures directed towards fouling on commercial ships, at the European level (Fernandes *et al.* 2016). Their study used data from U.K. and France listing fouling NIS, some of which had been obtained in the course of the Interreg Marinexus project (WP3 – J. Bishop & F. Viard). Despite the limitations due to the scarcity of data that are available, Fernandes *et al.* (2016) suggest that NIS could have a higher impact than native species on fuel consumption. The reasons behind being some properties specific to NIS (life-history traits and resistance to polluants and anti-fouling coating). The costs incurred may thus be viewed as positive investments if they prevent or mitigate the spread of NIS.

Also in the course of the Interreg Marinexus project (WP3 – J. Bishop & F. Viard), surveys on hull ships of leisure crafts were carried out in Brittany. These data are unpublished but had been reported in Deliverable 1 for WP3 (Bishop & Viard, 2014) of the Interreg project. To summarize the results, sessile fauna were looked for on the hulls of 72 leisure boats in Plymouth marinas and 50 leisure boats from three marinas in Brittany (Brest, Aber Wrac'h and Trebeurden). Non-indigenous species were commonplace, with a modal occurrence of 4 non-indigenous species per boat over the two areas, and means of 3.8 and 4.4 NNS per boat in Plymouth and Brittany, respectively. The list of NIS species recorded on these boats is available in the Appendices provided with the Deliverable. In addition, one survey (visual inspection and scraping for further identification in the lab) was made on the hull of one ferry, notably travelling across the English Channel. A total of 73 taxa were recorded with only a few non-indigenous species and all of them already being reported in the Channel.): the algae *Scytosiphondotyi*, the barnacle *Austrominius (= Elminius) modestus,* and possibly the ascidians *Corella eumyota* and *Asterocarpa humilis*. However, apart from *Austrominius modestus*, these findings have yet to be confirmed using barcoding methods.

Other ongoing research is of a more technical nature. A study by Guilbaud *et al.* (2015) evaluated the techno-economic feasibility of using a microfiltration membrane process to remove high concentrations of microalgae from seawater. A recent paper by Tournadre (2015) used altimeter data to detect and monitor ship traffic through a method of analysis of echo waveform. The resulting ship traffic analysis shows a global fourfold increase in ship traffic between 1992 and 2012, with the largest increase being observed in the Indian Ocean and Chinese seas, thus reflecting changes in world trade. An international team of biochemists are researching the properties of

the natural antifouling agent polygodial. This bioactive constituent is particularly effective against macrofouling ascidians and barnacles (Moodie *et al.*, 016).

In anticipation of the entry in force of the Ballast water Convention, new ballast water management plans aboard the research vessels (RV) of the French oceanographic fleet have begun. Although ballast water volumes pumped and released are small, these RVs carry out surveys in many different areas of the globe and as a result and are more likely to take on board and introduce NIS. The majority of the fleet is under the responsibility of the holding GENAVIR:

-"THALASSA": grosstonnage: 2803 UMS
-"POURQUOI PAS?": grosstonnage: 7854 UMS
-"ATALANTE": grosstonnage: 3559 UMS
-"EUROPE": grosstonnage:335 UMS
-"SUROIT": grosstonnage:946 UMS
-smaller vessels: "THALIA"(135 tons);"GWEN DREZ"(106 tons); "HALIOTIS" (6.28 tons); "ANTHEA" (571 tons); "ALIS" (for IRD; 207 tons)

Beginning with the RV "THALASSA », the solution retained is to use fresh water as ballast: the ship has a reverse osmosis desalination plant and a freshwater tank of 190 m3, for 187 m3 ballast water capacity. It is a question of changing the piping during the periodic refit operation of summer 2017, with sealed valves to prohibit saltwater use (except in an emergency). This is compatible with the G8 regulation, providing:

- IMO approval of the management plan
- sampling valves are installed in the piping system for port state controls

The suggestion to register ballast operations in an electronic logbook including GPS positions, for any further control was also made. If this system appears satisfactory at use and to the maritime authorities, the RVs "POURQUOI PAS" and "ATALANTE" will also be fitted with the same system. For the other smaller RVs, different solutions must be provided (i.e. commercially available physical or chemical treatment) bearing in mind that the ballast water capacity of those RVs are small and hence do not justify a costly treatment system.

In accordance with the requirements set out in Regulation B-4 paragraph 2 Ballast Water Exchange of the BWM, the French Ministry of Environment has tasked Ifremer with the designation of ballast water exchange areas between Corsica and mainland France. An analysis of surface currents and primary production will be carried out by June 2017 to designate potential areas of ballast water exchange for those ships unable to conduct BW exchange in accordance with regulation B-4-1[1].
On the 8th of August 2016, a law (loi n°2016-1087) on the "recovery of biodiversity, nature and landscapes" was adopted, which led to a revision of the French Environmental Code. Article 121 of this law clearly states that, should a ship carry out unregulated de-ballasting within waters under French jurisdiction, the captain will be imprisoned for one year and fined 300 000 euros

[1] i.e. at least 200 nautical miles from the nearest land and in water at least 200 metres in depth

RESEARCH NEEDS

Cooperation at an international level is essential and greatly facilitated by the WGBOSV and WGITMO groups. The gateway between scientific bodies and the port state control officers in charge of inspecting the implementation of the BWMC should be improved.

RESEARCH GAPS

- Biofouling studies of marinas, leisure craft and commercial vessels such as ferries
- DNA barcode reference libraries to catalogue biodiversity of lower trophic level taxa.
- Risk assessments of recreational boating as a vector of non-native species

MEETINGS

- 19th International Conference on Aquatic Invasive Species (ICAIS), Winnipeg, Canada, 10-14 April 2016
- Marine and Freshwater Invasive Species, Buenos Aires, Argentina, 2-4 May 2016
- Island Biology 2016, Terceira Island, Azores, 18-22 July 2016
- NEOBIOTA 2016 – 9th International Conference on Biological Invasions, Vianden, Luxembourg, 14-16 September

PROJECT INFORMATION

1. OCEANOMICS (2013 - ongoing)

Colomban de Vargas, Station Biologique de Roscoff: vargas@sb-roscoff.fr

The OCEANOMICS project is building on the success of the Tara Oceans expedition, a public / private initiative that collected samples and eco-morpho-genetic data across 11 organism size fractions covering all planktonic communities - from viruses to animals - over more than 150 sites and 3 depths across the global oceans. OCEANOMICS offers a combination of high throughput sequencing and imaging protocols to extract information from this unique collection on several systemic levels: DNA, RNA and phenotypes. Comparisons of these new results with environmental metadata and new genomes and transcriptomes of strains/ reference planktonic organisms sequenced in the framework of the project will give access to a thorough taxonomic, metabolic, ecosystemic understanding of the structure, dynamics and evolution of plankton biodiversity.

2. EMODNET Atlantic Checkpoint (2015-2018)

Jacques Populus, Ifremer: Jacques.populus@ifremer.fr

The purpose of the EMODnet checkpoints is to audit the value of marine data services to solve particular commercial and policy challenges with the development of the Blue Economy. With an increasing number of public marine data sources available, it is timely both to (a) support users in finding the right data products to solve their particular challenges and (b) examine how existing data services should be improved; including the content they offer and the way the service is delivered. The Atlantic Checkpoint considers eleven challenges of importance to the Blue Economy

in the North East Atlantic, one of which concerns alien species. For each challenge a screening is undertaken to identify the data suitable to meet the challenge and an adequacy report produced on the data in actually solving the challenge. This adequacy report considers both the utility of the available data, but also what data gaps were found to exist. The alien species challenge aims to develop up to ten indicators on the impacts on ecosystems and economy of alien species, via a spatial analysis of multiple data sets. Scientific partners: AZTI (lead), Ifremer, IPMA, CSIC.

3. Spread of *Asterocarpa humilis* on ship hulls

Frédérique Viard, viard@sb-roscoff.fr

As part of an international cooperation between Chile and France, notably supported by the GDRI DEBMA (coord. M. Cock), a collaborative research work was initiated between the Station Biologique of Roscoff and the UCSC in Concepcion (Chile) to study the species colonizing ship hulls and port infrastructure in the Bay of Concepcion. A jointly-supervised Masters student examined the species found on large cargos and vessels anchored in the Bay of Concepcion (Pinochet *et al.* submitted). Among the species found, one cargo displayed the invasive tunicate *Asterocarpa humilis*, already reported in Europe and other regions in Chile. A specimen was also found in a nearby shellfish farm. This finding extends the current distribution range of this species in Chile and is the first evidence that ship hulls can transport this species. It is noteworthy that the cargo on which *A. humilis* was found is travelling all along the Pacific coasts (from British Columbia to Chile), thus in areas where the species has not been reported so far (e.g. BC, Canada). Additional studies of ports and cargos are planned in the future, in the framework of this collaboration.

4. AQUANIS 2.0

Frédérique Viard, viard@sb-roscoff.fr

The project AQUANIS 2.0 (2016-2021), supported by the Fondation TOTAL, aims to develop new tools based on environmental DNA and metabarcoding approaches, two promising tools for non-indigenous species detection and monitoring in marine coastal habitats. This project is focusing on non-indigenous species and their native relatives present in the biofouling communities in artificial habitats (marinas) in Brittany. Besides better knowledge of the fouling communities living in marinas, this project will support surveys of NIS in marinas from Brittany (surveys started in 2010 as part of the Marinexus Program and during the PhD thesis of Sarah Bouchemousse).

5. Marine communities structuring: harbor ecology and invasion biology as comprehension tools

Christophe Lejeusne, clejeusne@sb-roscoff.fr

This ongoing project, supported by the Brittany Region and the Conseil Departemental Finistere, is focusing on biofouling assemblages in marinas. It specifically aims at examining the response of native vs. non-native species to environmental

factors like temperature and pollutants. Using environmental survey and experimental approaches, it aims to understand how abiotic factors are drivers of harbor community assemblages and potentially favor non-native species.

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Germany (updated 2017)

Report Prepared by:

Stephan Gollasch, GoConsult: sgollasch@aol.com

Katja Broeg, Federal Maritime and Hydrographic Agency (BSH): Katja.Broeg@bsh.de

STATUS OF SHIPPING VECTOR ACTIVITIES & RESEARCH

Ballast Water Management Convention (IMO-BWMC)

The entry- into-force requirements for this Convention were met, so that ballast water management requirements will be in force from 8th of September 2017 onwards. Within the coming 5 years, more and more ships will have to comply with the D-2 standard of the BWMC (new ships from the moment of entry into force onwards, ships already built need to comply from their next IOPP survey onwards, which is in maximum 5 years after entry into force of the convention). Within a trial period which will also comprise a so-called "experience building phase", non-compliance with the D-2 will not be pursued.

The German Federal Maritime and Hydrographic Agency (BSH) continues approving ballast water management systems (BWMS).

Completed projects:

During the Interreg IVB e-CME Ballast Water project an online training course for compliance monitoring and enforcement of ballast water management standards was developed. Training courses were successfully held and the training material is available online at the World Maritime University, Malmö, Sweden. For more information see http://elearning.e-cmeballastwater.eu/ or contact Josefin Madjidian, jam@wmu.se.

Notes**:** More and more "warm-water" species were found in the southern German Bight and these were considered as range expansions from the NE Atlantic, which are likely supported by climate change. One example is *Goneplax rhomboides*, a decapod native to the NE Atlantic and Mediterranean Sea, which had until recently rarely been reported from the North Sea, with no evidence of sustainable populations. However, recent surveys documented an increasing abundance of this species in the area since 2000 (Neumann *et al.* 2013) and very recently more than 80 individuals were caught at 50 sampling stations so that the crab is now considered to occur with a self-sustaining population. It seems that low winter temperatures affect the species

survival.
Several formerly introduced species were documented to spread.
New species found in 2016 include

- Sea squirt *Didemnum vexillum*, Sylt Island[2]
- Brown algae *Undaria pinnatifida*, Sylt Island[3]
- Polychaete *Boccardia proboscidea*, Helgoland Island[4]
- Sea squirt *Corella eumyota*, in Jade-Weser-Port, first record for German Bight (Nestler 2017)
- Red alga *Ceramium circinatum* was already found 2015 on an oyster reef near Juist Island and was located again in 2016 (Nesteler 2017)
- Amphipod *Monocorophium uenoi*, first record for German Bight in Port of Bensersiel (Nestler 2017).

In the "Platform for Information Exchange on Neobiota (NEOBIOTA)" (see below) it was noted that the newly opened port in Germany in 2012, i.e. the Jade-Weser-Port, only two years later became known as the area with the highest number of non-indigenous species in Lower Saxony. This may be due to the creation of new (hard-bottom) habitats and species introductions by ballast water and biofouling. In a follow up study this hot spot of NIS was confirmed (Nestler *et al.* 2017). Most non-indigenous species were found at floating pontoons. Stone embankments hosted lower numbers of non-indigenous species.

The German targeted monitoring for non-indigenous species revealed that the different sampling methods and approaches resulted in different numbers of non-indigenous species. With 60 % of all known NIS the rapid assessment surveys (RAS) in ports have the poorest performance. 75 % NIS were found when using the HELCOM/OSPAR Joint Harmonized Procedure (JHP) port sampling protocol. Results of both methods together would result in 85% NIS. Only when including NIS from oyster reefs and other hot-spots, all known NIS are collected (Bock & Lieberum 2016, Buschbaum pers. comm.).
It should be noted that the German sampling activities to target NIS exclude plankton because the taxonomic expertise is lacking.
The choice of extended rapid assessment (e-RAS) at hot spots like harbours, marinas and aquaculture as routine monitoring programme for the new introduction is based on the fact that Germany considers it important to perform monitoring for non-indigenous species frequently (at least once a year). This allows for a higher probability of early detection. Since a yearly survey of all hot spots following the JHP would be too expensive, the rapid assessment has been chosen as a cheaper but still adequate alternative. Comparisons between JHP and rapid assessment demonstrated that the settlement plates offered detection of many non-indigenous species during JHP. Recent studies in Lower Saxony (Nestler *et al.* 2017) demonstrated that considering analyses of settlement plates from all harbour locations, the NIS species-accumulation curve nearly reached saturation. Therefore it had been decided that

[2] https://www.awi.de/forschung/besondere-gruppen/nordseebuero/neobiota-meldestelle.html
[3] https://www.awi.de/forschung/besondere-gruppen/nordseebuero/neobiota-meldestelle.html
[4] https://www.awi.de/forschung/besondere-gruppen/nordseebuero/neobiota-meldestelle.html

RAS is complemented by settlement plates in the routine monitoring for non-indigenous species. The monitoring programme of German North Sea and Baltic coast comprises 17 locations.

The German Federal Ministry of Transport and Digital Infrastructure (BMVI) initiated a coordinated research effort to address early detection methods and management concepts for non-indigenous species introduction and spread by transport vectors. Further tasks are e.g. expanding the knowledge base for future exemptions from ballast water management requirements, identification of species introduction hot spots and introduction vectors as well as an improvement of the German authority network regarding non-indigenous species. Focus will be on the relationship and mechanisms between primary introduction of species by international transport and the secondary spread by inland waterway transportation and leisure boating considering both, ballast water and biofouling. So far, port surveys according to the JHP have been initiated, questionnaires concerning the amount of ballast water used in inland transportation developed and distributed. In addition, marinas and leisure boats will be surveyed. As model region, the Elbe river with the ports of Cuxhaven and Hamburg and its inland and Baltic Sea connections (Kiel harbour and canal) has been chosen.

During the Interreg IVB e-CME Ballast Water project an online training course for compliance monitoring and enforcement of ballast water management standards was developed. Training courses were successfully held and the training material is available online at the World Maritime University, Malmö, Sweden. For more information see http://elearning.e-cmeballastwater.eu/ or contact Josefin Madjidian, jam@wmu.se.

PLANNED RESEARCH

The German Federal State of Schleswig Holstein plans to initiate a study to document the non-indigenous species in the Kiel Canal (NEOBIOTA working group, pers. comm.).

A project proposal addressing various aspects of ballast water and biofouling related issues was submitted to the Interreg Baltic funding scheme. Should it be funded, this project will include all Baltic countries, including the Russian Federation who will participate as associated organization.

Data gathering during the experience building phase of the BWMC

The Roadmap for implementation of the BWM Convention is associated with an experience building phase. This phase will comprise three stages: data gathering, data analysis, and Convention review. Details for the implementation are currently developed within a MEPC correspondence group.

To facilitate a data rich environment (MEPC 70/4/14, paragraph 9), BSH is interested to conduct sampling and analysis of ballast water of ships following to the entry into force of the convention (2017-2019) depending on the availability of funding.

RESEARCH AND COOPERATION NEEDS

National Reports to WGBOSV are seen as essential information to track species introductions. This in particular refers to our neighbouring countries as newly found species there are taken as a warning signal because these may reach our waters in the near future. This highlights the need for international cooperation like contingency plans and common procedures for immediate report of new introductions to the respective stakeholders; e.g., information from National Reports on such new findings are made available to the experts conducting the German coastal monitoring programmes as kind of an early warning measure.

In contrast to ballast water, knowledge about biofouling as vector for species introduction and its management, especially after the ban of TBT as antifouling paint component, is limited. The probability that even after the BWMC comes into force, species introduction by maritime transport will not be stopped is high. In addition, fouling of leisure boats may act as important vector for secondary spread within a region. To address this vector, and to fill knowledge gaps, Germany stimulated regional discussion about a research programme on the development of biofouling management strategies for Baltic Sea maritime traffic and leisure boats at the third workshop of the EU-SBSR "Baltic Leadership Programme" (BLP). These activities may be accompanied by the work of WGBOSV under ToR e. The above mentioned proposed Interreg Baltic project COMPLETE (Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping) will address these issues in the Baltic Sea if it will receive funding.

The **NEOBIOTA platform** (see above) has established a point of contact to register newly found non-indigenous and/or cryptogenic species: https://www.awi.de/forschung/besondere-gruppen/nordseebuero/neobiota-meldestelle.html. This "knowledge center" maintains the most up-to-date list of introduced and cryptogenic species along the German coasts (Lackschewitz *et al.* 2017). The data from this list were also added to AquaNIS (February 2017). The NEOBIOTA platform considers AquaNIS as prime data source for non-indigenous and cryptogenic species.

AquaNIS was developed further and, amongst other things, on the front page is now a list of the most recently updated species introduction events (www.corpi.ku.lt/databases/index.php/aquanis).

During the 12th **Trilateral Governmental Wadden Sea Conference** (Tønder, Denmark, 6 February 2014) it was decided to develop a Strategic Framework for Alien Species for the trilateral Wadden Sea. Currently, a number of different monitoring programmes are in effect in the three collaborating countries, including the Dutch, German and Danish Wadden Sea area. The Working Group on Alien Species (WG-AS) initiated a project to develop a proposal for a common Trilateral Monitoring and Assessment Program for Alien Species (TMAP-AS) in the trilateral Wadden Sea area to identify possible areas for cross-border approaches and collaboration. The Common Wadden Sea Secretariat commissioned Bureau Waardenburg, The Netherlands, to develop such a proposal, which was outlined in van der Have & Lensink (2016).

RESEARCH GAPS

Chinese Mitten Crab

The trigger for the oscillating (massive) abundance increase of the Chinese mitten crab remains unknown. Fishermen reported in 2015 a decline in catchment records. It is interesting to note that *E. sinensis* is a substantial food source of shore birds like gull-billed terns. A recent investigation confirmed that up to 40 % of their prey items are pre-adult Mitten Crabs (Risch *et al.* 2016) whereas native coastal decapods, which occur in abundance (e.g. *Carcinus maenas*), are neglected (Risch pers. comm.). Should the aim of the EU Regulation 1143/2014 on Invasive Alien Species (see below) be successful and *E. sinensis* management measures be effective, the birds may suffer from food shortage as their natural prey items are largely reduced by intensive agricultural efforts in the Elbe area (downstream of Hamburg) (Risch *et al.* 2016). Management measures were also applied during the early mass developments of the crab without success (Panning 1952). However before taking measures, it is to be considered that the management of an alien species of EU-concern may substantially affect native species.

In a similar case Diest *et al.* 2005 reports that another alien species of EU concern, i.e. *Procambarus clarkii*, is a considerable food item for terns in Spain.

Introduction and spread

The role of offshore constructions as hot-spots of non-indigenous species and therefore as pathway for entry and spread remains to be investigated. It is currently evaluated if data which are generated during the approval process of offshore wind-energy farms might be used for these assessments.

Good Environmental Status (GES)

Several concepts to identify GES for the implementation of MSFD Descriptor 2 were discussed at a WSFD Workshop on Non-Indigenous Species (D2) at the Joint Research Centre, Italy in September 2015. It was concluded that this requires further work and needs further support. Ongoing activities will hopefully provide relevant experience and knowledge. It was therefore advised to involve the D2 expert group with the aim to implement MSFD Descriptor 2 in a harmonised and coherent way by addressing, e.g., monitoring, scales and aggregation as well as thresholds and reference points.

Germany currently recommends to base the GES evaluation on a trend indicator (number of new human-mediated species arrivals) and not on abundance and distribution because of the high monitoring effort needed to evaluate the latter.

In a recent documentation (HELCOM 2015) it was shown that the trend in new NIS introductions increased since the beginning of the 1900s, which indicates a sub-GES status in the entire Baltic Sea in the period up to 2012. However, there has been a slight decrease in the number of new NIS introduced species in recent years, but an overall assessment is still missing. The boundary between GES and sub-GES is “no new introductions of NIS per assessment unit through human activities during a six year assessment period”. The German NEOBIOTA group considers using less than one new human-mediated NIS per six years to indicate GES. Considering that at least 5 new species were found in 2016 (see above) a GES cannot be expected for German coastal waters. However, for the first agreed six year period (2011-2016) GES was

documented for parts of the German Baltic coast (Mecklenburg Bay and Arkona Basin) with no new NIS recorded.

EU Regulation 1143/2014 on Invasive Alien Species

This regulation enables provision of lists of "critical species" as species of Union-wide concern, species of regional concern and species of national concern. Species on the Union list will be published in early 2016. In a draft version of this list only one out of 37 species listed was a marine (catadromous) species, i.e. the Chinese mitten crab. All other species are freshwater or terrestrial. We see a possible research gap to in detail identify species selection criteria for these lists. Further, marine species should be considered as entrees on the Union list although these are possibly covered by the IMO BWM Convention, IMO biofouling guidelines and EC instruments on aquaculture. Based on the IAS Regulation each Member State needs to report the presence and distribution of the species on this list also providing options for management and/or eradication. However, some species on the lists are so widely distributed that eradication efforts are meaningless. After consultation with WTO, the commercial trade with living organisms of these species will be prohibited. However, some issues remain, including what will be happening when organisms of these species are imported from non-EU Member States? May these parcels be opened for inspection (conflict with postal privacy)? In cases it was confirmed that these species were sent, can the donor be made known to authorities (for prosecution)? Nehring (2016) published a report documenting the current distribution in Germany of the 37 species of EU-wide concern.

Discharge of treated ballast water

Some BWMS making use of active substances require the neutralization of the ballast water before discharge. However, it is largely unknown if there may be long-term accumulation effect of the neutralizers in use. Further, the treatment of ballast water may change the pH or other water parameters and it is unknown what effect this may have to the recipient environment. These points may especially be valid in enclosed ports with a limited water exchange. As a start, a research project was launched at GEOMAR, Kiel to address the amount of disinfection by-products in treated ballast water upon release (see below).

Helgoland coastal protection

Regarding the Natura 2000[5] management plan for Helgoland island the relevant environmental protection ministry asked for suggestions how to prevent the import of mainland species (e.g., rodents, predators, snails) with coastal protection material (brushwood, stones) transported to the island. This is still an unresolved point of concern (Borcherding pers. comm.).

Non-indigenous species in ports

For exemptions of ballast water management requirements a comprehensive risk assessment needs to be done based on the knowledge of harmful aquatic organisms and pathogens, including non-indigenous and cryptogenic species, occurring in the

[5] Stretching over almost 6 % of the EU's marine territory, this is the largest coordinated network of protected areas in the world.

ports concerned. Noting also that ports are hot spots for ship-mediated species introductions several sampling activities were started to document these species in German ports (e.g. Buschbaum *et al.* 2012, Lackschewitz *et al.* 2014, Henning *et al.* 2015, Nestler *et al.* 2017, see also NEOBIOTA platform above and Buschbaum & Lackschewitz below).

MEETINGS

In order to develop and coordinate German monitoring efforts and other non-indigenous species related aspects, meetings of the national NEOBIOTA expert working group are anticipated, at least twice a year.

Germany is actively contributing to ballast water and other maritime transport related meetings at IMO, HELCOM, and OSPAR, and regional and international meetings related to the implementation of the EU-MSFD.

PROJECT INFORMATION

1. Rapid-assessment of non-native species in German Coastal Waters including further development of the trend indicator

Christian Buschbaum, Alfred Wegener Institute:
Christian.Buschbaum@awi.de
Dagmar Lackschewitz, Alfred Wegener Institute:
Dagmar.Lackschewitz@awi.de
Rolf Karez, Landesamt für Landwirtschaft, Umwelt und ländliche Räume Schleswig-Holstein, Küstengewässer
Rolf.Karez@llur.landsh.de
Alexander Schroeder, NLWKN * Betriebsstelle Brake / Oldenburg
Alexander.Schroeder@NLWKN-OL.Niedersachsen.de
Gregor.Scheiffarth, Nationalparkverwaltung Niedersächsisches Wattenmeer, Wilhelmshaven
Gregor.Scheiffarth@nlpv-wattenmeer.niedersachsen.de

The German alien species monitoring programmes continue with several sampling stations in ports along the Baltic and North Seas. The samplings are conducted annually between August and October with a focus on benthos and to a lesser degree on plankton. Recent monitoring activities in Germany filled geographical gaps in the network of coastal monitoring stations. Results of the rapid assessments indicate that the rate of newly recorded NIS is lower in the Baltic Sea compared to the North Sea.

2. Reliability of ballast water test procedures (ReBaT) Project (finished)

Susanne Heitmüller, Federal Maritime and Hydrographic Agency (BSH):
Susanne.Heitmüller@bsh.de
Katja Broeg, Federal Maritime and Hydrographic Agency (BSH):
Katja.broeg@bsh.de

Several ballast water sampling and sample processing/analytical methods were tested on a voyage of the research vessel Meteor when sailing between Cap Verde and Germany in June 2015. The voyage was attended by 19 scientists from 9 countries. (Ballast) water with low and high organism load was sampled and processed to chal-

lenge the methods used. The result report is in the making. The full report was made available in 2016[6] and manuscripts were submitted to peer review journals. One of them (Bradie *et al.*, 2017) is already published.

3. Naturschutzfachliche Invasivitätsbewertungen für in Deutschland vorkommende gebietsfremde Wirbellose, Pilze und Pflanzen
(Nature protective invasion assessment for in Germany occurring non-indigenous invertebrates, fungi and plants)
Wolfgang Rabitsch, Umweltbundesamt GmbH, Vienna, Austria:
wolfgang.rabitsch@umweltbundesamt.at
The project is ongoing for Bundesamt für Naturschutz (BfN), Bonn, Germany. Fact sheets of aquatic non-indigenous invertebrates and algae in Germany were developed. The project report for the aquatic species is scheduled to be released in 2017 (Rabitsch *et al.* 2017). This project continues with the aim to develop fact sheets for other non-indigenous aquatic and terrestrial species.

4. EU Verordnung zu invasiven Arten: Listungsvorschläge und Priorisierung der Einbringungspfade für invasive Arten von unionsweiter Bedeutung in Deutschland
(EU Regulation on Invasive Alien Species: Proposal for listing and prioritization of introduction pathways)
Stefan Nehring, Bundesamt für Naturschutz (BfN), Bonn, Germany:
Stefan.Nehring@BfN.de
The project aims at refining and adopting the current methodology for the assessment of the invasive potential of species (http://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/skript401.pdf) to meet the requirements of the EU Regulation 1143/2014 on Invasive Alien Species concerning their definition as species of Union-wide concern. In addition, the pathways of species introductions are going to be prioritized.

5. Ballast water management for Adriatic Sea protection (BALMAS)(finished)
Matej David, Dr. Matej David Consult d.o.o.:
Matej.David@siol.net
Stephan Gollasch is involved as external expert in the BALMAS project. The project integrates all necessary activities to enable a long-term, environmentally efficient and financially and maritime transport sustainable implementation of ballast water management measures in the Adriatic Sea. BALMAS established a common cross-border system linking all Adriatic research, experts and national responsible authorities in order to avoid the unwanted risks to the environment and humans from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast waters and sediments. The project ended in 2016 and a comprehensive list of project activity reports is available on the project homepage (www.balmas.eu). Selected BALMAS reports were also made available at the www.researchgate.net account of Stephan Gollasch.

[6] http://www.bsh.de/de/Meeresdaten/Umweltschutz/ReBaT-Projekt/index.jsp

6. Independent Laboratory

Cees van Slooten, Control Union Certifications:
cvslooten@controlunion.com

The Independent Laboratory consortium developed under the umbrella of the Dutch company Control Union was launched to meet the U.S. test requirements for BWMS. The U.S.-recognized consortium includes amongst others NIOZ, IMARES, GoConsult and Dr. Matej David Consult d.o.o. and is currently planning land- and shipboard tests of BWMS. http://controlunion.com/en/news/control-union-accepted-as-independent-lab-by-the-us-coast-guard

7. GloBalTestNet

Allegra Cangelosi, North-East Mid-West Institute
acangelo@nemw.org

A formal group of test organizations involved in certification tests of BWMS was established as the "GloBal TestNet" to facilitate increased standardization and harmonization of test procedures and information exchange. The 2016 meeting of the group overlaps with the BOSV and ITMO meetings. Agenda items include the U.S. and IMO Guidelines G8 test requirements for BWMS versus testing realities. In 2016 Stephan Gollasch was the representative of the European test facilities. Another meeting was held in January 2017 and the minutes were published on the homepage http://www.globaltestnet.org/home.

8. Macro-invasion-ecology – towards understanding the global flows and distribution of alien species

Hanno Seebens, Biodiversity and Climate Research Centre (BiK-F)
hanno.seebens@uni-oldenburg.de

This project in a first step, will combine and analyse the currently most comprehensive databases of native and alien species distributions of various taxonomic groups. This unique data set will allow the establishment of networks of reported alien species flows between countries for each taxonomic group. In a second step, these reported invasion networks will be combined with existing comprehensive databases of invasion pathways and environmental conditions to simulate the global spread of alien species and to identify the relevant mechanisms to reliably predict alien species flows. The data will be inspected for inter-taxonomic variations in network topologies, important source regions, major introduction routes, hot spots of invasions and spatio-temporal variations.

9. BAllastwatertest QUality Assurance (BAQUA)

Dennis Binge, Katja Broeg, Federal Maritime and Hydrographic Agency (BSH):
Dennis.Binge@bsh.de, Katja.Broeg@bsh.de

This project aims at developing BSH quality standards, ringtest facilities and performance for the validation of test facilities and sampling- and analytical methods used in the framework of the type approval of ballast water management systems and compliance monitoring. In January 2017 the development of a prototype for a round robin test facility started in co-operation with the Alfred-Wegener Institute (B. Buck). The completion is expected in July.

10. Helgoland Island sampling activities

Ralph Kuhlenkamp, PHYCOMARIN, Hamburg, Germany
ralph.kuhlenkamp@phycomarin.de

Registration of neobiota during standard long-term monitoring of coastal waters around Helgoland are conducted under the European Water Framework Directive and Marine Strategy Framework Directive implemented by the State Agency for Agriculture, Nature and Rural Areas (LLUR) of Schleswig-Holstein, Germany. Realization through qualitative and quantitative monitoring of the phytobenthos at one intertidal and one subtidal site, and of the macrozoobenthos at three sites: intertidal, on *Laminaria*-rhizoids and in the Tiefe Rinne (near Helgoland) (Kuhlenkamp & Kind, PHYCOMARIN, pers. comm.).

Observation of species attached to floating algae (mainly *Himanthalia elongata*) of foreign origin (France or Great Britain): rare events of massive inputs of species from other European sites through long-distance transport via buoyant and drifting algae (see Kuhlenkamp & Kind 2013).

Sporadic investigation of neobiota in Helgoland: surveys of harbour constructions, buoys and pontoons etc. (Kuhlenkamp & Kind, PHYCOMARIN, pers. comm.).

11. Interreg IVB Project e-CME (finished)

Josefin Madjidian, World Maritime University, Malmö, Sweden
jam@wmu.se

During this project an e-learning course for compliance, monitoring and enforcement of the Ballast Water Management Convention was developed and the e-CME course material is available at:

http://elearning.e-cmeballastwater.eu/

The course is free, but you need to register to open the files. The backbone of the course is narrated presentations and videos showing how to take ballast water samples and how to get them processed.

12. Metabarcoding and eDNA

Several metabarcoding and eDNA projects are underway to evaluate these technologies for the (rapid) identification of (non-indigenous) species.

- *Project GBOL - German Barcode of Life: Inventory and genetic characterization of animals, plants and fungi in Germany*
  The GBOL project aims at capturing the genetic diversity of animals, fungi and plants in Germany. The genetic inventory of these organisms is based on their DNA barcodes. Germany has taken a leading role in an international consortium of natural history museums, zoos, herbaria, research organizations and government institutions to jointly establish the "DNA barcode library of life". Currently there are about 4.6 million DNA Barcodes of around 250,000 described species recorded in the international BOLD database (January 2016).
- *Mass sequencing of environmental samples for the development of future techniques for the identification of diatoms in water quality assessment*
  R. Jahn, BGBM, Freie Universität Berlin - Zentraleinrichtung Botanischer Garten und Botanisches Museum Berlin-Dahlem.
- *PhD Research Training Group "The ecology of molecules" („EcoMol") in the framework of research topics in biodiversity and marine science at the University of Olden-*

burg
Work package 7: Following migration of animals in the North Sea by environmental DNA (eDNA) (Gerlach, Schupp, Dittmar).

- *Identification of Invasive Seaweeds by metabarcoding* (NGS)
  S. Steinhagen, GEOMAR, Kiel.
- *Development of an e-DNA-based method for the detection of crayfish plague Aphanomyces astaci in water samples*
  C. Wittwer, C. Nowak, Senckenberg; M. Thines, Biodiversität und Klima Forschungszentrum (BiK-F).

13. Prevention of Marine Pollution caused by Ship-Sourced Wastes. Ballast Tank Sediment Management

Guido Van Meel, Sweco, Ankara, Turkey
guido@icthc.com

The project was initiated to provide an overall view on ship-sourced waste and sediment from ballast tanks was considered relevant in Turkey. Sediment is widely neglected although it is addressed the IMO BWM Convention. A review of current sediment practices in selected European countries revealed that the amount of sediment received is largely unknown. This information would be relevant to plan for sufficient sediment reception facilities. The sediment and water mixture at the bottom of ballast tanks is usually discharged through so called drain plugs. In other cases, where such drain plugs are unavailable, workers go to the sediment at the bottom of the tanks and collect it by shovel and bucket. In many dockyards this material is just dumped over the side. In other dockyards, the water is extracted (e.g. by gravity) and the remaining sediment is tested for contamination with heavy metals etc. According to its pollution level the sediment is discharged in reception facilities for contaminated waste or used as land-fill.

14. Risks Of ballast water treatment by the global Shipping Industry (ROSI)

Susann Tegtmeier, GEOMAR, Kiel, Germany
stegtmeier@geomar.de

The research project was launched at GEOMAR, Kiel to address the amount of disinfection byproducts in treated ballast water upon release. A new threat to the stratospheric ozone layer may be expected from oceanic halocarbons produced by the oxidative treatment of ship ballast water. Given the anticipated drastic increase of such technologies as a consequence of the upcoming IMO Ballast Water Management Convention entry into force, a risk assessment is needed for the governance of anthropogenic activities in the ocean. During the project we plan on board testing of ballast water to quantify the amount of halocarbons produced by oxidative water treatment. These measurements will constitute the first essential step of a ballast water risk assessment at the interface of environmental research, shipping industry and stakeholders.

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Italy

Report Prepared By:

Erika Magaletti, Italian National Institute for Environmental Protection and Research (ISPRA): erika.magaletti@isprambiente.it

Luca Castriota, ISPRA: luca.castriota@isprambiente.it

Francesca Garaventa, National Research Council (CNR) – Institute of Marine Sciences (ISMAR): francesca.garaventa@ismar.cnr.it

Manuela Falautano, ISPRA: manuela.falautano@isprambiente.it

Teresa Maggio, ISPRA: teresa.maggio@isprambiente.it

STATUS OF SHIPPING VECTOR RESEARCH

Research on ballast water is relatively recent in Italy. The first port baselines surveys were funded by the Italian Ministry of the Environment and conducted in 2006 by ISPRA in the

ports of Trieste (NE Italy) and Milazzo (Sicily). After that, no systematic research on the ballast water issue has been carried out until 2013, when the EU IPA Adriatic Strategic Project 'BALMAS' (Ballast Water Management System for Adriatic Sea Protection; www.balmas.eu, budget 7,2 million euros) was started.

The project BALMAS is still on-going and is expected to end in September 2016. A documentary on the project activities, made by ISPRA, can be viewed at https://www.youtube.com/watch?v=B4_D2myKJHc

Activities such as Port Baseline surveys, ballast water sampling and analysis, development and test of an early warning system, data acquisition on ballast water operations and shipping patterns, have been carried out in 12 Adriatic Ports. In Italy, the Adriatic ports that have been investigated are Trieste, Venezia, Ancona and Bari. Non-indigenous species have been detected and scientific publications are in preparation. For example, the diatom *Didismosphenia geminata* was detected in the port of Venice. This species produces nuisance growths in freshwater rivers and streams of the northern hemisphere and is considered an invasive species in Australia, Argentina, New Zealand, and Chile. *D. geminata* threatens aquatic habitats, biodiversity and recreational opportunities, but does not pose risks to human health. The Pacific oyster *Crassostrea gigas* was found in the ports of Trieste, Venice and Ancona. The European Alien Species Information Network (EASIN) classifies *C. gigas* as alien species, with high impact on the environment mostly due to reduction of biodiversity. The species is included in the list of the 100 worst invasive species according to the Delivering Alien Invasive Species Inventories for Europe (DAISIE). Also, the Asian egg-carrying copepod *Pseudodiaptomus marinus* was found in the ports of Trieste and Venice. In 2007 and 2009, it was firstly detected in the Adriatic Sea, near Rimini and Trieste Monfalcone, but was not considered to be an established species. BALMAS findings suggest that this species is now established in the Adriatic Sea. European Alien Species Information Network (EASIN) classifies *P. marinus* as alien species. Its environmental impact is unknown.
Additional activities, not related to BALMAS, include scientific and technical support to Italian manufacturers of Ballast Water Treatment System for the achievement of the IMO Basic and Final Approval.

PLANNED RESEARCH

Project proposals to the EU on the ballast water issue are in preparation, in collaboration with Slovenia, Croatia and Greece. In 2015, national monitoring activities for the implementation of the EU Marine Strategy Framework Directive, Descriptor 2 (non-indigenous species), have started. Specifically, an assessment of abundance and taxonomic composition of plankton species in the main ports is being carried out by the Regional Environmental Agencies and is funded by the Italian Ministry of the Environment.

RESEARCH NEEDS

- Defining a transnational observatory for an effective alert system on new introductions of non- indigenous species and for their secondary diffusion, in particular invasive ones, between contiguous countries, also considering small ports and touristic moorings.
- Implementing studies focusing at the identification of vectors for alien species, particularly dealing with biofouling.
- Improving impact studies of non-indigenous species on native species, communities and ecosystems.

- Implementing DNA barcode libraries for rapid species identification through environmental DNA techniques.

RESEARCH GAPS

- DNA barcode libraries are not complete and therefore are not always available for rapid species identification
- Insufficient knowledge of response measures for containment of invasive species spread and mitigation of impacts
- Lack of sampling/monitoring, risk assessment and management strategies for biofouling on vessels arriving to Italian waters
- Insufficient knowledge of biofouling from the different vectors such as marine litter
- High level taxonomists and experts in marine invasions required at the national level – need for establishment of a National Focal Point for HAOP (Harmful Aquatic Organisms and Pathogens).

MEETINGS

- Training on identification of alien species from Mediterranean fouling, from 19 to 24 September 2016 at Lecce, Salento University: "Identification of hard bottom introduced invertebrate species in the Mediterranean basin and their ecological relevance: influence on fouling successional pattern" info at www.medalien.com.
- Conference "Alieni tra noi" 7 October 2016, Sala Riviera of the Congress Center of the Genova Exhibition in occasion of the 51th Boat Show of Genova. By Assonautica Provinciale of Genova, with the cooperation of the Marine Protected Area of Portofino
- 30 August-2 September 2016, University of the Studies of Milano Bicocca. 1st Unified National Congress SITE - UZI – SIB (Società Italiana di Ecologia, Unione Zoologica Italiana, Società Italiana di Biogeografia) "Biodiversity: concepts, new tools and future challenges"
- EuroMarine workshop: Management of bioinvasions in the Mediterranean Sea - the way forward. Ischia (Naples, Italy) 4-5 May 2016 Villa Dohrn-Benthic Ecology Center Hotel "Villa Maria"

PROJECT INFORMATION

1. BALMAS (Ballast Water Management for Adriatic Sea Protection)

Erika Magaletti, ISPRA: erika.magaletti@isprambiente.it
Mauro Marini, ISMAR-CNR: m.marini@ismar.cnr.it

The general BALMAS objective is to establish a common cross-border system linking all Adriatic research experts and national authorities to avoid the unwanted risks to the environment and humans from the transfer of HAOP, through the control and management of ships' BW and sediments. Adriatic countries recognised that BW related data (e.g. the presence and invasiveness of HAOP in Adriatic ports, BW uptake and discharge activities, sediment disposal, chemical pollution with BW) and knowledge (e.g. port baselines and monitoring, BW sampling for compliance control, risk assessment, how to deal with non-compliant vessels, early warning system, effectiveness of BWM systems and measures) need to be shared in order to enable implementation of the BWM Convention requirements through a common BWM plan, and provide support to responsible authorities for faster and effective decision making with a

decision support system (DSS). The goal of the project is preparation of a common Ballast Water Management (BWM) Plan for the Adriatic Sea area and implementation of the BALMAS BWM decision support system (DSS) including compliance control and enforcement (CME), compliant with the International Convention for the Control and Management of Ship´s Ballast Water and Sediments (BWM Convention) considering local specifics.

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Netherlands (updated 2017)

Report Prepared By:

C.C. ten Hallers-Tjabbes (CaTO) email: cato@catomarine.eu

C. van Slooten (CUC) email: cvslooten@controlunion.com

F.Fuhr, M.Veldhuis, E. Brutel (MEA-nl) email: f.fuhr@mea-nl.com; m.veldhuis@mea-nl.com

S. Smolders (MinEZ, NVWA) email: a.a.j.smolders@nvwa.nl

A. Gittenberger (GimMaRIS) email: gittenberger@yahoo.com

K.Kaag (Imares) email: Klaas.Kaag@wur.nl

STATUS OF SHIPPING VECTOR RESEARCH

The three facilities involved in testing of ballast water management systems in the Netherlands: MEA-nl (Marine Eco Analytics), Wageningen Marine Research (WMR, formerly IMARES) and Control Union Water B.V. (CUW, formerly NIOZ), which profiles were explained in the NL national reports of 2014 and 2015, continued on with testing activities and related research, each of them with a somewhat different focus.

Several projects inventorying invasive species and species distribution were performed by GiMaRIS.

ACTIVITIES IN BALLAST WATER TESTING

CUC

In 2015 Control Union Certifications B.V. and five ballast water treatment test companies, NIOZ, IMARES, GoConsult, DavidConsult and TNO formed a consortium to offer testing services to BWMS manufacturers for IMO and USCG Type Approval testing and related pilot testing. On April 29th 2015, the consortium was accepted as Independent Laboratory by the US Coast Guard for the Type Approval testing of BWMS according to the regulations as stipulated in 46 CFR 162.060.

Control Union Certifications B.V., having its registered office at Meeuwenlaan 4-6, 8011 BZ, Zwolle, the Netherlands, is a global network of inspection/certification operations and dedicated laboratories. Its speciality is independent worldwide certification, cargo surveying and superintendence.

Control Union Certifications B.V. has, together with various subcontractors within its consortium (NIOZ, IMARES), carried out and planned R&D testing for a range of BWMS manufacturers. This work was performed and planned in the context of acquiring BWMS certification in accordance with IMO and USCG requirements.

In 2016 IMARES adopted a new name: 'Wageningen Marine Research (WMR)'.

NIOZ and Control Union joined forces by incorporating a spin-out company to perform testing of ballast water management systems: Control Union Water B.V. (CUW).

All the ballast water related test activities that are performed at NIOZ are now conducted by CUW. Dr. Peperzak remains the test facility director at CUW.
Control Union Certifications B.V. (CUC) has continued to expand its consortium of partners and has been joined by the Northeast Midwest Institute's Great Ships Initiative (GSI) for Shipboard testing services and the American Bureau of Shipping (ABS) to offer services in support of the readiness evaluation of ballast water management systems as required by 46 CFR 162.060 and IMO G8 Guidelines.
CUC has, in 2016, coordinated and completed a number of projects together with various subcontractors within its consortium (WMR, GoConsult, DavidConsult, CUW, and GSI).
CUC, WMR, Goconsult and DavidConsult have prepared the Basic Approval Application of the MICROFADE II ballast water treatment system. The application has been submitted by the Netherlands and assessed at the 34th GESAMP-BWWG meeting (MEPC 71/4/3).
CUC and CUW coordinated and conducted multiple land-based test cycles in the context of Type Approval testing.
CUC and GSI coordinated and conducted multiple shipboard test cycles in the context of Type Approval testing.

WMR
WMR has focused its investigations on the need for natural and D-2 compliant BW test water for year-round testing. Plankton is been cultivated in their aquaculture tanks under a growth-stimulating regime. By such approach WMR also hopes to curb the adverse effect of excessive zooplankton grazing on phytoplankton, to the detriment of the numbers of phytoplankton cells.
WMR has also performed an inventory of potentially invasive species in the ports of Groningen Seaports and adjacent Wadden Sea areas; the study would serve as background information for the ports contingency project at Groningen Seaports.

MEA-nl
After in former years having successfully completed testing of BWM systems that since have been certified by different administrations, MEA-nl has continued to test ballast water management systems for certification. The test reports have since been delivered to the relevant authorities; the national administrations have notified MEPC of the certification of the systems, including making the test reports available to IMO. Notification of one, recently tested system, the ports-contingency BWM system (See below under NSBWO) is expected to be submitted to MEPC 71.
MEA-nl has continued to investigate the many questions that have been emerging in the wake of testing ballast water management systems. To enhance and share our scientific potential on ballast water and hull fouling issues, MEA-nl has started a close co-operation with Plymouth Marine Laboratory (PML).

Update on studies initiated and reported as such in the National report-NL of 2015 (MEA-nl)
The MEA-nl study on sediment analysis of short-sea shipping arrivals in Groningen Seaports has been integrated in a report on verification testing for certification. The system has been certified; the certifying national administration will inform MEPC 71

accordingly.
A similar situation holds for the MEA support studies for the development of emerging technologies for dredging companies and port reception facilities. The investigations at MEA have successfully been finalised, with the completion of the land-based and shipboard tests
The case for contingency case has been presented in several forums
For the support studies for evolving technologies using potable water, has the MEA involvement in sediment studies successfully been completed and reported accordingly.
The MEA-nl study to quantify organisms in residual water and sediment of ballast tanks after discharge is part of an ongoing study to establish trends.
The adequacy of BWM systems based on electrolytic chlorination to perform at low salinities (>0.5. PSU) has been recorded by MEA-nl during testing for verification.
MEA's involvement in the testing has been completed successfully and the report has been delivered to the relevant authority.
MEA-nl's study to improve analytical methods for phytoplankton is still on-going, as are the studies for the development of a standard sampling tool and the comparative study of different staining methods. First results have been published.
MEA looked further into DOC/POC content in natural waters and the effect of adding such material to the testing water, based on literature data and own findings. The study showed that additions of organic material have more negative side effects than benefits to the testing.
MEA-nl will continue with the present ongoing studies and is supervising a study on characteristics of same-risk areas, relevant selection criteria and evaluation framework.

REGIONAL DEVELOPMENTS IN BALLAST-WATER RELATED POLICY AND SCIENCE

The now terminated project North Sea Ballast Water Opportunity **(NSBWO**, Interreg IV B, 2009-2014) has resulted in several spin-off initiatives, such as the contingency ballast water treatment unit for ships with non-compliant ballast water entering port. The unit has been tested by MEA-nl at land-based and has completed ship-board testing. The testing documentation has been delivered to the Netherlands Administration and has been processed accordingly.
Other spin-off initiatives of NSBWO are an ongoing informal exchange of information, developments and ideas between former project partners from administrations, ship-owner organisations and ports representatives, during events such as IMO meetings and conferences, co-ordinated by C.C. ten Hallers-Tjabbes.

New Records of ship-mediated species

Ocenebra inornata is wide-spread in Oosterschelde and lake Grevelingen.
***Urosalpinx cinerea* has not been found during the survey**

RECENT PUBLICATIONS AND PRODUCTS

Fuhr F, Veldhuis M., Brutel de la Riviere, E. van der Star I. (2015). Challenges and solutions from certification testing and their implications for the practical implementation of ballast water management; Ind. J. of Geo-Marine Sciences, Vol43 No11,

Gittenberger, A. (2016). Alien species of the Wadden Sea database. Issued by Office of risk assessment and research, the Netherlands Food and Consumer Product Safety Authority.

Gittenberger (2016). Uitheemse soorten gevonden in diverse inventarisaties bij schelpdieren in de Oosterschelde en de Grevelingen. Issued by Office of risk assessment and research, the Netherlands Food and Consumer Product Safety Authority.

Gittenberger, A., Rensing, M., Schrieken, N. & H. Stegenga (in press). Species survey of the Sloehaven. i.o.v. Office for risk assessment and research, the Netherlands Food and Consumer Product Safety Authority.

Pérez, J.M. Jofre, M., Martínez, M., Yáñez, v. Catalan, M.A., Parker, A., Veldhuis, M. and Pruneri. V. (2017). CMOS based image cytometry for detection of phytoplankton in ballast water. Biomedical Optics Express 1240, Vol. 8 (2)

MEPC 68-INF.19 - Information on the type approval of the ERMA FIRST BWTS ballast water management system (Greece)

MEPC 68-INF.27 - Information on the type approval of the Coldharbour GLDTM Ballast Water Management System (United Kingdom)

MEPC 69-INF.15 - Information on the type approval of the Van Oord Ballast Water Management System (Netherlands)

Application for Basic Approval of the MICROFADE II Ballast Water Management System. Submitted by the Netherlands. MEPC 71/4

Van der Meer, M. de Boer, K. Liebich, V. ten Hallers, C. Veldhuis, M. Ree, C., 2017. Ballast Water Risk Indication for the North Sea, Coastal Management, 2016, 44 (6): 1–22

Norway

Report Prepared By:

Anders Jelmert, Institute of Marine Research, anders.jelmert@imr.no

Stephanie Delacroix, Norwegian Institute of Water Research. Stephanie.delacroix@niva.no

Norway has ratified the BWC, and has implemented mandatory ballast water management (D1-Standard (Exchange) since 2010. Currently the relevant authorities is preparing for the BWC coming into force.

STATUS OF SHIPPING VECTOR RESEARCH

Harbour surveys in Narvik (N68.43, E17.41) have not been repeated (last survey 2014, may contribute to a baseline for future research).
Harbour survey at Melkøya (N70.69, E23.62) was not made in 2015, but is due in 2016 (or will eventually be made in 2017).
No sampling of ballast water or hull fouling in 2015.

PLANNED RESEARCH

Harbour surveys and BW + HF in sub-arctic/high boreal harbours will be made if funded

RESEARCH NEEDS

Exchange of check-lists, exchange of primers / sequences for relevant organism groups and target species

RESEARCH GAPS

Need for more efficacy testing for BWT techniques at low temperatures. Collection and eventually supplement existing species baseline for a) arctic proper, b) sub-arctic/ high boreal (The zones from which species transported into the arctic have the least range of adaption change to establish).

Need for information on robustness/sensitivity of dominant zooplankton and phytoplankton species from seawater/freshwater/brackishwater in different temperature zones for different physical and chemical water disinfection treatments

MEETINGS

Arctic Frontiers, 2016: http://www.arcticfrontiers.com/downloads/arctic-frontiers-2016
Arctic Frontiers 2017: http://www.arcticfrontiers.com/
Nor-shipping 2017: http://messe.no/en/nor-shipping/
IMO Ballast water conference, www.ballast2016.com

PROJECT INFORMATION

No planned project is currently funded for 2016-2018

2015: USCG approval of NIVA's ballast water testing facility; 2 years of experience with testing methods differences between IMO and USCG protocols regarding temperature, salinity, TSS, DOC, sampling and analysis methods.
2016: Several ongoing projects at NIVA for land-based and shipboard testing of ballast water treatment systems according to both IMO and USCG requirements
2014-2017: Study on 10-50um organisms enumeration methods in UV treated ballast water
2015-2018: Study on water quality of discharged fish transport/ballast waters from wellboats

RECENT PUBLICATIONS AND PRODUCTS

Ware, C., Berge, J., Jelmert, A., Olsen, S. M., Pellissier, L., Wisz, M., Kriticos, D., Semenov, G., Kwaśniewski, S., Alsos, I. G. (2015), Biological introduction risks from shipping in a warming Arctic. *Journal of Applied Ecology*. doi: 10.1111/1365-2664.12566 Volume 53, Issue 2, pages 340–349, April 2016

United Kingdom (updated 2017)

Report Prepared By:

Lyndsay Brown, Marine Scotland Lyndsay.brown@gov.scot

With contributions from:

Elizabeth Cook, Scottish Association for Marine Science

Gordon Copp, Cefas
Jenni Kakkonen, Orkney Islands Council
Leanne Page, Maritime and Coastguard Agency
Paul Stebbing, Cefas

STATUS OF SHIPPING VECTOR RESEARCH

The BWM Convention enters into force on 8th September 2017. The UK continues to support the aims of the Convention and is currently producing the legislation required for the UK to meet the Convention obligations. Once this legislation is in place the UK will be able to accede to the Convention.

Orkney Islands Council continues to implement the Ballast Water Management Policy for Scapa Flow.
In order to maintain pristine environmental status in Scapa Flow the Orkney Islands Harbour Authority has developed an all-encompassing Ballast Water Management Policy that allows for this whilst exceeding international standards. As part of the Ballast Water Management Policy an annual non-natives species monitoring programme was implemented. The 2017 surveys will start in June 2017.

PLANNED RESEARCH

The Orkney Islands Council continues to implement the Ballast Water Management Policy for Scapa Flow. The accompanying monitoring programme will continue annually with 2017 surveys starting in June 2017.

Marine Scotland is planning on undertaking a survey of a marina on the west coast of Scotland and surrounding areas, similar to one carried out in 2010 by Scottish Association for Marine Science in response to the first observation of the invasive sea squirt *Didemnum vexillum*. The area will be surveyed by RIB and all floating and manmade structures will be inspected, including underwater video footage of vessel hulls.

RESEARCH GAPS

A stronger evidence base is still needed to underpin future exemption decisions – it is still unclear how exemptions will be granted or what evidence will support the exemptions. The Marine Industries Liaison Group (MILG) planned to promote these issues.

MEETINGS

- Canadian Conference for Fisheries Research (St John's, Newfoundland, Canada; 8–10 January 2016) (www1.uwindsor.ca/glier/ccffr/past-programsabstracts).

- 27th USDA Interagency Research Forum on Invasive Species (Annapolis, Maryland, USA; 12–14 January 2016).
- Mississippi River Basin Panel on Aquatic Nuisance Species Meeting (Gulfport, Mississippi, USA; 13–14 January 2016)
- 9th International Conference on Marine Bioinvasions (Sydney, Australia; 19–21 January 2016)
- ICAIS 2016 – 19th International Conference on Aquatic Invasive Species (Winnipeg, Manitoba, Canada; 10–14 April 2016)
- 13th GB Stakeholder Forum on Non-Native Species (York, England, 8 July 2016).
- Freshwater Invasives (FINS-II) – Networking for Strategy (University of Zagreb, Croatia; 11–14 July 2016)
- International Society of Limnology (SIL) – Alien species ecological impacts: from genomics to macroecology (Turin, Italy; 31 July – 5 August 2016)
- Sharing Good Practice: Marine Biosecurity Workshop (Dunstaffnage Marine Laboratory, Oban, UK; 31 August 2016).
- Neobiota 2016 – 9th European Conference on Biological Invasions: "Biological Invasions: interactions with environmental change" (Vianden, Luxembourg; 14–16 September 2016).

PROJECT INFORMATION

1. Ballast Water Management Policy for Scapa Flow, Orkney

Jenni Kakkonen, Orkney Islands Council: Contact Email jenni.kakkonen@orkney.gov.uk

Orkney Islands Council continues to implement the Ballast Water Management Policy for Scapa Flow (adopted in December 2013 by Orkney Islands Council).
http://www.orkneyharbours.com/pdfs/bwm/Ballast%20Water%20Management%20Policy%20for%20Scapa%20Flow%2010%20December%202013.pdf
A total of ten non-native species have been recorded so far during the 2016 monitoring season (identification of samples will be completed by 31 March 2016). Of the ten species identified, all have been previously recorded in Orkney. The monitoring programme will continue annually with 2017 surveys starting in June 2017.

During 2016 ballast water samples were collected and analysed from 22 vessels visiting Scapa Flow, Orkney. The sampling was carried out in accordance with the Orkney Islands Council Ballast Water Management Policy for Scapa Flow. Methods used were developed using the guidance given by IMO (IMO, 2009). The results from the sampling events are Commercial In Confidence.

Reference:

International Maritime Organisation. (2009). *Ballast Water Management Convention and the Guidelines for its implementation*. IMO. 234 pp.

2. Marine Pathways Group

Paul Stebbing, Cefas: Contact Email paul.stebbing@cefas.co.uk

The Marine Pathways Project, which aimed to reduce the risk associated with pathways by which marine invasive non-native species may be introduced into the British Isles, finished in 2015, with the outcomes presented in Tidbury *et al.* (2016). Cefas continues to coordinate the Marine Pathways Group, which is a follow on from the Marine Pathways Project. Since 2015 the Marine Pathways group has taken on a more advisory role, aiding in the development of OSPAR and UK assessments and indicators. The group now functions as an expert group providing technical support and guidance to HBDSEG, while maintaining an overview of and co-ordinating current work in relation to marine INNS. The group aids communication and collaboration between experts in the field of INNS across different organisations and countries. It also offers a platform by which stakeholders can input into INNS work. The Marine pathways group has been involved in a number of key pieces of work on INNS. These include completion of INNS assessments for OPSAR and UK in accordance with the Marine Strategy Framework Directive (MSFD), biosecurity training and awareness raising and responses to introduction events. In November 2016 the group met in London to discuss the MSFD, specifically its requirements and processes and the progress made by the UK towards achieving targets. During the meeting, gaps were identified and potential work programmes to bridge these were identified.

3. NNS Monitoring and Surveillance Programme

Paul Stebbing, Cefas: Contact Email paul.stebbing@cefas.co.uk

Cefas has finalised priority marine NNS monitoring and surveillance lists. These include high priority species currently present and those that are considered likely to arrive in the near future. These lists are not currently available. As of April 2016 species on either the monitoring or surveillance lists have been included in regular marine biodiversity monitoring programmes. This is part of the continued development of NNS marine monitoring, with further developments being made in 2017.

4. Response to a *Didemnum vexillum* outbreak at a west coast sealoch.

Lyndsay Brown, Marine Scotland: Contact Email Lyndsay.brown@gov.scot

The Scottish Working Group on Marine Invasive Species has been coordinating the response to an outbreak of *Didemnum vexillum* at an oyster farm on a west coast sealoch. This has comprised of various farm and shore-based surveys, dive surveys to inspect the protected serpulid reef and also a RIB survey of floating structures within the loch. Vessel hulls were inspected by underwater video footage for signs of *Didemnum* fouling in addition to moorings, pontoons, jetties, marker buoys and bridge stanchions.

5. Molecular Identification of Marine Invasive Species (MIMIS)

Paul Stebbing, Cefas: Contact Email paul.stebbing@cefas.co.uk
Gordon Copp, Cefas: Contact Email gordon.copp@cefas.co.uk

Research and development of molecular tools continues at Cefas for the detection of non-native species, in particular the use of environmental DNA (e-DNA) and substratum scrapes. The eDNA approach (Davison *et al.* 2016) has been applied to assess to efficacy of an attempt to eradicate topmouth gudgeon (*Pseudorasbora parva*) from an angling pond in southeastern England (Davison *et al.* 2017). Using a robust sampling protocol, eDNA

analysis of water samples from the pond revealed that topmouth gudgeon was still present, and subsequent intensive trapping at the detection locations revealed a small number of specimens. Marine work has focused on the detection of target species relevant to the MSFD and WFD, and methods have been field validated. The marine-based DNA analysis of substratum scraps is continuing, and the work on inland still waters will be expanded in April 2016 to include the detection of non-native freshwater and diadromous fishes in running waters. For further information on the detection of marine species, contact Paul Stebbing (paul.stebbing@cefas.co.uk) and for freshwater and diadromous fishes contact Gordon H. Copp (gordon.copp@cefas.co.uk).

6. PhD studentship at the Scottish Association for Marine Science

Liz Cook, Scottish Association for Marine Science: Contact Email Elizabeth.Cottier-Cook@sams.ac.uk

A new PhD studentship is underway at the Scottish Association for Marine Science. The project will investigate the probability of offshore floating wind turbines and associated vessels acting as vectors for the transfer of marine invasive non-native species. This is in conjunction with Statoil, Environmental Research Institute in Thurso and University of St. Andrews.

RECENT PUBLICATIONS AND PRODUCTS

Baptie, M.C., Foster, R.J. & Cook, K.B. (2016). First record of the copepod *Eurytemora herdmani* in the Firth of Forth, Scotland. *Marine Biodiversity* 46, 819 – 825.

Copp, G.H., Russell, I.C., Peeler, E.J., Gherardi, F., Tricarico, E., MacLeod, A., Cowx, I.G., Nunn, A.D., Occhipinti Ambrogi, A., Savini, D., Mumford, J.D. & Britton, J.R. (2016a). European Non-native Species in Aquaculture Risk Analysis Scheme – a summary of assessment protocols and decision making tools for use of alien species in aquaculture. *Fisheries Management & Ecology* 23, 1–11.

Copp, G.H., Godard, M.J., Russell, I.C., Peeler, E.J., Gherardi, F., Tricarico, E., Moissec, L. Goulletquer, P., Almeida, D., Britton, J.R., Vilizzi, L., Mumford, J.D., Williams, C., Reading, A., Rees, E.M.A. & Merino, R. (2016b). A preliminary evaluation of the European Non-native Species in Aquaculture Risk Assessment Scheme applied to species listed on Annex IV of the EU Alien Species Regulation. *Fisheries Management & Ecology* 23, 12–20.

Copp, G.H., Vilizzi, L., Tidbury, H., Stebbing, P.D., Tarkan, A.S., Moissec, L. & Goulletquer, P.H. (2016c) Development of a generic decision-support tool for identifying potentially invasive aquatic taxa: AS-ISK. . *Management of Biological Invasions* 7, 343–350.

Davison, P.I., Créach, V., Liang, W-J., Andreou, D., Britton, J.R. & Copp, G.H. (2016). Laboratory and field validation of a simple method for detecting four species of non-native freshwater fish using eDNA. *Journal of Fish Biology* 89, 1782–1793.

Davison, P.I., Copp, G.H., Créach, V., Vilizzi, L. & Britton, J.R. 2017. Application of environmental DNA analysis to inform invasive fish eradication operations. *Naturwissenschaften* (in press)

Glamuzina, B., Tutman, P., Nikolić, V., Vidović, Z., Pavličević J., Vilizzi, L. & Copp, G.H. & Simonović, P. (early view) Comparison of taxon-specific and taxon-generic risk screening tools for identifying potentially invasive non-native fishes in the River Neretva catchment (Bosnia & Herzegovina and Croatia). *River Research and Applications* (doi: 10.1002/rra.3124)

Tarkan, A.S., Vilizzi, L., Top, N., Ekmekçi. F.G., Stebbing, P.D. & Copp, G.H. (2017). Identification of potentially invasive freshwater fishes, including translocated species, in Turkey using the Aquatic Species Invasiveness Screening Kit (AS-ISK). *International Review of Hydrobiology* (in press)

Tidbury, H., Taylor, N., Copp, G.H., Garnacho, E. & Stebbing, P.D. (2016). Predicting and mapping the risk of introduction of marine non-indigenous species into Great Britain and Ireland. Biological Invasions 18, 3277–3292.

Shelmerdine, R.L., Mouat, B. & Shucksmith, R.J. (2017). The most northerly record of feral Pacific oyster *Crassostrea gigas* (Thunberg, 1793) in the British Isles BioInvasions Records 6 (1): 57–60.

United States (updated 2017)

Report Prepared By:

Submitted by: Lisa Drake, U.S. Naval Research Laboratory (NRL), lisa.drake@nrl.navy.mil

Contributors: Allegra Cangelosi, Great Ships Initiative, acangelo@nemw.org

Fred Dobbs, Old Dominion University, fdobbs@odu.edu

Judith Pederson, MIT Sea Grant, jpederso@mit.edu

Mario Tamburri, Maritime Environmental Resource Center (MERC), University of Maryland (UMD), tamburri@umces.edu

Greg Ruiz, Smithsonian Environmental Research Center (SERC), ruizg@si.edu

STATUS OF SHIPPING VECTOR RESEARCH

Ballast Water and Hull Fouling Research

In 2015, research on ballast water as a *vector* of aquatic nuisance species (ANS) focused on the transport of organisms in the Arctic, while research on *biofouling* focused in 2015 and 2016 on evaluating methods for surveying vessels ships' and quantifying available surfaces for the transfer of organisms. Work in 2015 and 2016 on the *treatment of ballast water* proceeded in several areas: investigations of discharge toxicity associated with the neutralization of chlorine-treated ballast water, the appropriate collection of ballast water samples, the efficacy of combining open ocean exchange with ballast water treatment, and testing of ballast water management systems (BWMS) for U.S. type approval (TA). For example, at the Maritime Environmental Resource Center (MERC), two land-based TA tests were conducted aboard the MERC Mobile Test Platform, and two sets of shipboard tests were initiated in 2015. In 2016, research on microbial ballast water communities was conducted, with papers published using molecular approaches to identify diversity of bacteria and protists. Papers were also drafted or published on the management of ballast water and propagule delivery. *Compliance testing of BWMS* was addressed by conducting validation testing of commercially available fluorometry-based tools and convening a workshop to explore the practicability and

applicability of using adenosine triphosphate (ATP)-based compliance tools to determine the number of living organisms in discharged ballast water. Further, the suitability of using one size class of organisms to assess ships' compliance with the discharge standard was investigated. Regarding *ANS risk assessment*, a study continues to characterize the risk-release relationship of invasive species in the Great Lakes using meso-scale experiments and field surveys. *Economic assessments* were conducted during 2015 to collect and analyse information regarding the economics aspects of ballast water and hull fouling regulations and related technology markets. Finally, one new non-native species was reported in the U.S. In 2015, the polychaete *Branchiomma coheni*, which has been found in Tampa Bay Florida for several years.

Ballast Water Management Efforts

Ballast water management reporting and recordkeeping was amended and finalized and effective February 22, 2016. The U.S. "Coast Guard will require vessels with ballast tanks operating exclusively on voyages between ports or places within a single Captain of the Port Zone to submit an annual report of their ballast water management practices. This rule also simplifies and streamlines the ballast water report form. Finally, this rule will allow most vessels to submit ballast water reports after arrival at a port or place of destination, instead of requiring submission of such reports prior to arrival. This rule will reduce the administrative burden on the regulated population, while still providing the Coast Guard with the information necessary to analyze and understand ballast water management practices." (https://www.federalregister.gov/articles/2015/11/24/2015-29848/ballast-water-management-reporting-and-recordkeeping).

The Coast Guard Marine Safety Center (MSC) denied four requests to approve a culture-based viability assay for organisms in the ≥10 μm and <50 μm size range as equivalent to the required test method (in the Environmental Technology Verification [ETV] Program Protocol). That the decision, which was appealed, was denied. A task group of the ETV Technical Panel continued to review and refine a test plan to validate the use of the Most Probable Number (MPN) technique to enumerate organisms.

The USCG is aware of multiple BWMS that are undergoing TA testing at independent laboratories (ILs), and with the Maritime Administration (MARAD), the USCG organized a series of teleconference for ILs to discuss the challenges of testing BWMS (CAPT Scott Kelly, BWM Summit, Long Beach CA, 10-11 February 2016). As of 14 March 2017, three BWMS had been type approved by the USCG—two employ ultraviolet radiation [UV] and one uses electrodialysis to produce an oxidant—all also include a filtration step.

Recent or Anticipated Introductions (see the U.S. National report for the ICES Working Group on Introductions and Transfers of Marine Organisms for more detail)

Branchiomma coheni is a sabellid tubeworm that was described from the Pacific coast of Panama, near the mouth of the Panama Canal, and was reported in Florida

last year. This worm occurs in rocky tide pools, marinas and docks, cultured oysters, and locks at the Pacific end of Panama Canal; its range extends north to the Gulf of California. In 2012 and 2014, it was found on fouling plates at one marina in Tampa, Florida. This worm was likely transported through the Panama Canal in ballast water or biofouling. Several species of sabellid and serpulid worms have been transported through the canal, between the two oceans, in both directions (Keppel *et al.* 2015).

The clinging jellyfish, *Gonionemus vertens* has been present since 1894, but it is now causing severe stings associated with the Pacific species and may be a new introduction. Genetic studies of two amphipod species, *Orchestia gammarellus* and *Corophium volutator* have been shown to be non-native in the Northwest Atlantic. Several recently introduced species (*Colpomenia peregrina* (moving south), *Palaemon macrodactylus*, *P. elegans*, and *Dasysiphonia japonica*) are expanding ranges; one the barnacle *Chthamalus fragilis* appears to be moving northward probably with increased temperatures.

The forthcoming book by Mathieson and Dawes will be a useful species list of seaweeds in the Northwest Atlantic. Here, 25 algal species found from Downeast Maine (Bay of Fundy) to Maryland are identified, and many species have not been previously reported although they have been present for many years.

Mathieson, AC and Dawes CJ (in press) Seaweeds of the Northwest Atlantic; Botany / Environmental Studies, 000 pp., 00 illus., $00.00 paper, ISBN 978-1-62534-000-0, $90.00 hardcover, ISBN 978-1-62534-000-0. This book is expected to be published soon and can be found at www.umass.edu/umpress.

PLANNED RESEARCH

Investigations into the applicability and practicability of ballast water compliance tools will proceed, as will research to quantify the risk-release relationship, the efficacy of combining open ocean exchange with ballast water treatment, and hull fouling. Testing of BWMS for TA will continue at the three U.S. test facilities: MERC, the Great Ships Initiative (GSI), and the Golden Bear Facility (GBF).

RESEARCH NEEDS

All of the above research topics will be strengthened by ongoing dialogue between U.S. researchers and ICES researchers conducting work along these lines.

RESEARCH GAPS

Climate change is not explicitly addressed in the above topics (although ANS research in the Arctic Ocean was spurred by climate-induced changes in the extent and duration of Arctic sea ice). Other groups at ICES are working in this area, and it will be useful to exchange of ideas. No research is being conducted on the colonization of artificial, submerged surfaces, such as wind turbines, and it would be useful to remain informed about that work through ICES.

MEETINGS

- The 10th International Conference on Marine Bioinvasions will be held October 16-18, 2018, in Puerto Madryn, Argentina.
- Mary Carman, the organizer of the International Invasive Sea Squirt Conference, announced the release of the final version of the special IISSC-V issue of MBI: http://www.reabic.net/journals/mbi/2016/Issue1.aspx.

PROJECT INFORMATION

1. Hull Fouling Cleaning Workshop

Mario Tamburri, MERC: tamburri@umces.edu
Lisa Drake, NRL: lisa.drake@nrl.navy.mil

A workshop will be convened to explore quantitative methods for determining efficacy of: (a) in-water fouling removal approaches (hull and niche areas), (b) capture of material released from vessel surfaces (particularly copper), and (c) effects of fouling removal approaches on vessel coating. It occurred in August 2016, and the report is being issued.

2. Meeting to Explore Novel Techniques to Assess Biofouling

Lisa Drake, NRL: lisa.drake@nrl.navy.mil

A meeting was convened in June 2016 to discuss novel and emerging technologies that can be used to quantify biofouling—specifically, large fouling organisms, such as barnacles and mussels—on the wetted surfaces of ships. Technical experts familiar with technologies designed for or adaptable to this purpose were invited to foster a discussion of the challenges and opportunities of the various technologies. The report is available (First *et al.* 2016).

3. Efficacy of Open Ocean Exchange with Ballast Water Treatment

Lisa Drake, NRL: lisa.drake@nrl.navy.mil

A study is underway to examine the effectiveness of combining open ocean exchange with ballast water treatment to reduce the transport and delivery of potentially invasive species. Two shipboard trials have been completed to compare the number of living organisms in ballast water that has undergone exchange and treatment vs. ballast water treatment alone. An assessment of the practicability of conducting exchange plus treatment was completed (First and Drake, in review), and a literature review summarizing the biological efficacy of exchange was published (Molina and Drake 2016).

4. Compliance Tools

Lisa Drake, NRL: lisa.drake@nrl.navy.mil
Mario Tamburri, MERC: tamburri@umces.edu
Allegra Cangelosi, GSI: acangelo@nemw.org

In 2015, the verification testing two variable fluorescent fluorometers was completed, and four more were evaluated in 2016. All laboratory trials were completed at one site, and al field trials were completed at three sites. The report of the project is in final review. The effort to examine use of ATP kits for ballast water compliance monitoring will continue.

5. Characterizing the Risk-Release Relationship for Aquatic Invasive Species in the Great Lakes

Allegra Cangelosi, GSI: acangelo@nemw.org

The overarching objective of the Risk-Release project is to define and implement experimental methods for parallel (1) mesocosm and (2) field survey approaches to characterizing the risk-release relationship for aquatic invasive species establishment in the Great Lakes. The mesocosm experiments assess cause and effect of establishment probability vs. inoculation densities. The objective of the field survey experimental approach is to determine the real-world relationship of propagule discharge concentrations and establishment of a second sentinel invader (the bloody-red mysid, *Hemimysis*) in specified harbors.

6. Economic Assessments

Mario Tamburri, MERC: tamburri@umces.edu

The assessments conducted during 2015 regarding the economics aspects of ballast water and hull fouling regulations and related technology markets resulted in several draft papers. They were not released last year because the U.S. EPA and IMO initiated reviews of ballast water treatment systems that could require modifying the analyses.

7. Revision of the International Organization for Standardization (ISO) standard for ballast water sample collection (11711-1, Discharge Sampling Port)

Lisa Drake, NRL: lisa.drake@nrl.navy.mil

The current version of the ISO standard describing the discharge sampling port for ballast water is being revised. Specifically, changes will address (1) removing the probe (i.e., allowing for non-permanent installations), (2) standardizing port dimensions, and (3) accommodating various probe geometries. It is anticipated that this work will be concluded by the fall of 2017.

RECENT PUBLICATIONS AND PRODUCTS

Ashton GV, Davidson IC, Geller J, Ruiz GM (2016) Disentangling the biogeography of ship biofouling: barnacles in the Northeast Pacific. Global Ecology & Biogeography 25:739-750

Carney K, Minton M, Holzer K, Miller AW, McCann L, Ruiz G (2017) Evaluating the combined effects of management and trade dynamics on transfers of marine organisms by ships' ballast water. PLoS ONE (in press)

Cohen AN, Dobbs FC, Chapman PM. Revisiting the basis for US ballast water regulations. Mar Pollut Bull, submitted

Davidson IC, C Scianni, C Hewitt, R Everett, E Holm, GM Ruiz, and MN Tamburri. Differential strategies for ship biofouling assessments and management: examining the gaps between vessel performance and biosecurity. Biofouling, 32:411-428

Davidson IC, Minton M, Carney KJ, Miller AW, Ruiz GM (2017) Pioneering patterns of ballast water treatment in the emerging era of marine vector management. Marine Policy 78: 158-162

Drake LA, Moser CS, Wier TP, Grant JF (2015) Ballast Water Sample Ports, Sample Probes, and Sample Collection Devices: Recommendations for Standardization. Letter report

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Annex 5: Presentation Abstracts

ToR a)

Ballast Water Management: Policy to Sampling – the Orkney Experience

Jenni Kakkonen

During 2010 the Orkney Harbour Authority concluded that a ballast water policy that had been introduced during the 1980's was out of date and not commercially viable. The publication of the International Maritime Organization (IMO) Convention for the Control and Management of Ships' Ballast Water and Sediments Convention in 2004 and publication of several European (EU) Directives in the 1990's meant that at some stage the Harbour Authority would have to revise the Policy for Scapa Flow. The meshing of IMO and EU requirements into one Policy was to prove to be a long and difficult process and after three years, in December 2013, the policy was approved by the Orkney Islands Council.

The approved Policy contains requirements for all vessels wishing to discharge ballast water into Scapa Flow to exchange or exchange and treat in designated areas, and for ballast water samples to be collected, before permission to discharge is given by the Harbour Authority.

The majority of the ballast water samples are taken directly from the ballast water tanks using the guidance contained within the IMO 2004 Convention. Samples for salinity, bacteria, phyto- and zooplankton are collected and analysed. The phyto- and zooplankton samples are enumerated for viable / non-viable organisms and all organisms are identified to the lowest taxonomic level possible to identify any non-native species in the ballast water.

In conclusion, with three years of practical experience and having spent the previous three years setting an IMO / EU compliant Policy the following may be drawn out of experience thus far:

- Sampling methods need to be adapted almost at case by case basis
- Sampling equipment needs to be versatile and the sampling team need to understand how to use and adapt methods
- Salinity checks on-board vessels are a good quick method to give guidance if ballast water exchange has been carried out
- Access to vessels at anchor, an issue both for sampling team and equipment
- On-shore support for sampling team at departure and especially at arrival vital to ensure that the samples have been collected correctly
- So far there have been no problems from the vessels' crews whilst carrying out checks and taking samples.

The Policy, monitoring, reporting and vessel sampling processes will always be classed as "work in progress" as research, methods and instrumentation are developed.

Ports contingency planning and solutions

Cato ten Hallers, on behalf of Geert Jan Reinders, Groningen Seaports

Ballast water management (BWM) on ships is regulated by IMO in the BWM Convention (EiF September 2017).

If ports, although not obliged by IMO, would act on BWM they do so under their own steam, as an innovative platform, in response to the environmental challenges posed by ballast water and by recognizing a potential business case to serve the shipping industry.

Ports can play a primary role in solving possible problems, which ships might meet when their ballast water is not fit for discharge according to the conditions of the BWMC by offering a solution to render the BW discharge harmless .

Groningen Seaports (GSP) has taken up the challenge since 2010 and since 2012 has joined hands with Damen Shipyards to offer a ports-based BWM solution by hosting the BW treatment system developed by Damen. GSP so responded to the impetus to act on behalf of a port was roused in the early years of the North Sea Ballast Water Opportunity (NSBWO) project (EU-Interreg), where pro-active port partners met. The Damen BWTS is now certified by the Netherlands administration. Groningen Seaports also acts from a specific responsibility in relation to its location bordering the UNESCO World Heritage Site, the International Wadden Sea.

In the initiative the port has to offer facilities and solutions to meet the environmental challenges associated with the interface between shipping and the marine and coastal environment coming together in ports, such as:

- Offering additional berthing for ships having BWM problems
- Impact on a port by a ship calling that is unable to discharge
- Competitive differences between ports that offer a BWM solution and those that do not
- Co-operation with waste handling facilities
- Seek early warning on ships with non-compliant BW

Non-compliant BW can arise due to:

  - ships not having a BWM system on board,
  - a BWM system that did not function to meet the IMO regulation for discharge
  - an emergency that interfered with proper operating a BWM system

To ensure that specific challenges were met an overall project together with other relevant actors (a waste management facility, a research facility, a policy adviser) an overall project has been performed, with important/fundamental (f)actors:

- The situation of GSP at the Wadden Sea
- The presence of sufficient participants to allow for a complete trajectory to develop the ports contingency solution, build it by Damen Shipyards, make it fit for use in Groningen Seaports as a pilot, and complete a full-scale test series for certification at MEA-nl.

The complete-chain solution allows for offering solutions to the identified challenges, as will be explained the presentation.

Biodiversity entering United States ports via ballast water discharge: An analysis using high throughput sequencing

John Darling, Yungou Gong, Yuping Zhang, John Martinson, Sara Okum, Erik Pilgrim, Katrina Lohan, Greg Ruiz

Ballast water has long been one of the most active vectors for introduction of non-indigenous aquatic species, particularly in coastal environments. Despite the establishment of regulatory frameworks and management practices aimed at mitigating the risks of invasion posed by ballast water, continued translocation of coastal biodiversity remains a substantial management challenge. Here we apply high throughput sequencing (HTS) to characterize the biodiversity being conveyed via ballast water discharge into three heavily trafficked US ports in the Chesapeake Bay, Texas, and Alaska. Using standard bioinformatics approaches based on sequence data derived from the nuclear 18S ribosomal RNA locus, we describe the delivery of biodiversity into these ports and the factors that determine the rate at which that diversity accumulates, considering variables such as number of ships, the number of ecologically distinct source regions, and the application of management practices during transit. We also investigate the degree to which this HTS data can be used to draw inferences regarding the sources of ballast water-borne diversity or the effectiveness of management, especially mid-ocean ballast exchange. In addition, in order to explore the utility of HTS for early detection and prioritization of management practices, we utilize existing lists of marine invasive species to examine ballast samples for the presence of species that are known to be or have potential to become invasive in recipient port environments. Our findings suggest that HTS data derived from the 18S locus can be utilized to investigate broad patterns of biodiversity associated with ballast water transport, but that low resolution may limit species-level taxonomic assignments and ultimately require additional loci for more detailed investigations. This research provides additional evidence that HTS is emerging as an important tool for understanding invasion risks associated with ballast water discharge, and for assessing the effectiveness of management approaches designed to mitigate those risks.

Rapid Adaptation and Marine Invasion

Carolyn Tepolt

As global climate change accelerates, invasive species are predicted to benefit due to their ability to survive and thrive in novel environments. There is a growing body of evidence, both physiological and genetic, suggesting that adaptation may play an important role in the establishment and spread of marine species introductions. Local adaptation in the native range over long time scales can lead to differences between populations that influence their ability to colonize a new environment, with certain source populations "pre-adapted" to succeed in certain recipient environments. After becoming established in a new environment, marine invaders may be able to adapt on a time scale of decades to centuries to better persist and spread in their introduced range. The European green crab (*Carcinus maenas*) provides an ideal case study for exploring the role of adaptation in facilitating marine invasion across a range of time scales. Physiological and genetic evidence point to local adaptation to temperature in the species' native range. This native divergence may have facilitated invasion: the initial introduction, from a south-central

European source, appeared to be limited in its northward expansion. After the later introduction of crabs from a genetically distinct northern European source, the species rapidly expanded north to Newfoundland, where it is a serious fisheries pest. Genomic work underscored the difference between northern and southern populations, both in the native and invasive range, and identified several genes which are likely under ongoing selection to temperature in the species' invasive range. Overall, emerging research into marine adaptation suggests three potential implications for invasion management: 1) within-species variation may influence invasion potential, 2) species may be able to adapt post-invasion to facilitate their survival and spread, and 3) multiple introductions from genetically distinct sources may increase the fitness or resilience of existing invasive populations.

ToR b)

California's Proposed Ballast Water Discharge Compliance Assessment Protocols

Christopher Brown

This talk presented information on California's proposed ballast water discharge performance standards compliance assessment protocols and a comparison of three ballast water sample rapid assessment tools.

The Marine Invasive Species Program currently assesses compliance through vessel inspections and quarterly GIS-based analysis of ballast water management locations. As ballast water management rules shift from open-ocean exchange to numerical based discharge standards, the tools used by California's Marine Invasive Species Program to assess compliance will need to evolve. In 2020, California is scheduled to begin implementing ballast water discharge performance standards, and Marine Invasive Species Program staff members will need ballast water discharge collection and analysis protocols to assess compliance with each organism size class of these discharge standards. Emerging technologies, such as hand-held rapid assessment tools, are crucial for protecting state waters from ballast water mediated introduction of invasive species.

The Marine Invasive Species Program is planning to collect and analyze samples from more vessels that are using an installed ballast water management system to treat ballast water prior to discharge. The results from these trials, and feedback on the proposed compliance assessment protocols, will guide the Marine Invasive Species Program as we move toward the implementation of performance standards. The protocols are available for review and comment as part of an informal comment period.

PAM vs. Microscope for indicative CME

Matej David, **Stephan Gollasch**

The tests were done on 10 vessels with untreated ballast water in the Port of Koper, Slovenia. It was documented that the viable phytoplankton concentration is different as per the sounding pipe sampling location top, middle and bottom (TMB). The cell concentra-

tions were revealed by using CMFDA as a vital stain and an epifluorescence microscope as well as by using the Turner Ballast Check (BC) pulse-amplitude modulated (PAM) fluorometry.

The cell counts ranged from 47/ml to 1/ml. The highest counts were made by BC, the lowest by the microscope, and in most cases BC showed a higher concentration than the microscope counts. In six measurements the difference was higher than 10 cells (D-2 standard). The biggest difference was when BC measurement was 47.3 ind/mL and the microscope count was 13.5 ind/mL (difference 33.8 ind/mL).

The lowest cell concentration was found in the top samples. >95% of tests had higher phytoplankton at the bottom. In ca. 45 % of tests the number of phytoplankton cells at the bottom was double compared to top and in 25% the number at the bottom was even three times higher.

Two cases were observed where the mean TMP measured cell count showed non-compliance, but measurement in one location alone would have been resulted in compliance. Further, we observed more cases where microscope counts resulted in compliance and BC in non-compliance. Possibly BC overestimates the phytoplankton content? In case when port State control efforts to verify compliance of ballast water management standards consider sampling via sounding pipes, we recommend that samples are taken from at least in two different locations in the sounding pipes.

Optimizing methods to collect a representative sample for organisms greater than 50 µm in minimum dimension

Sarah Bailey and Harshana Rajakaruna

Zooplankton populations are spatially heterogeneous in nature and inside ship ballast tanks. Sampling methods should take heterogeneity into account, particularly when estimating quantitative variables such as abundance or concentration. It is particularly important to generate unbiased estimates of zooplankton concentration in ballast water when assessing compliance with new international ballast water discharge standards. We measured spatial heterogeneity of zooplankton within ballast water using three sampling methods. In-tank pump samples were collected at fixed depths within the vertical part of the ballast tank (side tank). Vertical net-haul samples were collected from the upper portion of the tank as a depth-integrated and historically-relevant method. In-line, time-integrated samples were collected during ballast discharge by an isokinetic sample probe, likely representing the double bottom part of the ballast tank. The bias and precision associated with each sampling method was evaluated in reference to the estimated average abundance of the entire ballast tank, which was modelled from the data collected by all methods. Sample representativeness, as compared to the tank average, varied depending on the depth or tank volume discharged. In-line discharge samples provided the least biased and most precise estimate of average tank abundance (having lowest mean squared error) when collected during the time frame of 20-60% of the tank volume being discharged. Results were consistent across five trips despite differences in ballast water source, season, and age.

ToR c)

Impacts of new IMO G8 Guidelines and update on acceptance of MPN method

Stephanie Delacroix

With the Ballast Water Convention ratification in September last year, IMO has also adopted in November 2016 some amendments of the G8 guidelines. The G8 guidelines describe the requirements for the testing protocol for Type Approval of Ballast Water Management System (BWMS). When comparing with the testing requirements of the US. EPA's ETV protocol, most of the changes in G8 were improving significantly the harmonization of the testing requirements with ETV, which is a very good thing. The very few new requirements in G8, which are not specifically addressed to in the ETV protocol, are regarding the documentation of the temperature effect and the minimum retention time on the BWMS treatment efficacy. As it is difficult to apply less than 24h of retention time for practical reason during land-based testing, IMO might adopt the same philosophy than USCG, but not sure yet. This means that a BWMS which complies with discharge requirements within 24h of retention time, no limitations on the retention time will apply on the Type approval certificate of the BWMS. In parallel to this harmonization effect of testing guidelines, there is a significant harmonization effort going on in between the different test facilities (TF) included within one and same Independent Laboratory (IL); as DNV-GL from Norway. However, a similar harmonization process is missing between the ILs and USCG. One of the most important discussions initiated by DNV-GL within the 4 TFs is aiming in to determining the minimum oxidant demand of the challenge water to comply with the IMO and USCG requirement of testing the BWMS with challenging but not rare test water. Hence, the addition of aromatic DOC additives into the challenge water to comply with the minimum DOC required by IMO (USCG has a huge impact on the consumption of the oxidants injected in the ballast water by the BWMS. Some other similar discussions are also going on within the Global TestNet which regroups most of the TFs in Asia, USA and Europe.

Ballast Water Management System Challenge Conditions in Global Harbors:

Toward a Shared Access Database of Global BWMS Challenge Conditions to Inform BWMS Design, Testing and Use

Allegra Cangelosi

The Great Ships Initiative research team, in significant collaboration with an Advisory Committee of other global BWMS test facility representatives and research partners, compiled a set of readily available port/harbor BWMS challenge condition information. Data sets were analyzed to determine whether adequate information already existed or whether there was a need for creation of a purpose-designed, semi-restricted-access living database comprising real world port/harbor conditions of direct relevancy to BWMS performance.

Target Harbors were identified based on global connectivity to ports/harbors worldwide (i.e., as sources of ballast water uptake and/or recipients of ballast discharge); high tonnage/container volume; risk/susceptibility to aquatic species invasions (AIS); and geo-

graphic/geophysical distribution. Overall, 195 ports/harbors were selected for inclusion in the target list from a total of 52 countries.

Data sets no older than 2009, and relevant to as many of these ports/harbors as possible, were collected through literature review and solicitation of Advisory Committee leads and data sets. Data sets were rated in terms of age of data, applicability to BWMS challenge assessment, and extent of descriptive information regarding methods, and data quality. Data sets were also classified in terms of biogeographic region and port use characteristics.

The most prevalent water quality and biological parameters subject to measurements across the potentially useable data sets, and water quality and biological parameter data ranges across the potentially useable data sets were determined.

Results showed on only 49 data sets representing only 47 target global ports/harbors were available at the time of study**.** Of these, only 42 of the 49 available data sets (40 global harbors) contained any data considered "potentially useable" solely based data age (collected in 2000 or later). Of the 40 ports/harbors with available data sets, temperature, TSS, salinity represented the dominant parameters. Based on this analysis, it was determined that existing robust data are not available to adequately describe even broad primary BWMS challenge conditions in nature globally and of relevance to BWMS performance.

The study recommends tapping new BWMS Certification test intake water data, especially from ship tests, rather than using existing harbor monitoring data, as a ready and increasingly robust source of information with direct relevance to the BWMS challenge condition assessment need. An organization such as the GloBal TestNet (www.globaltestnet.org) would be well positioned to construct and host a quasi-open access data base of this data moving forward. Specifically, BWMS testing entities could collaboratively parlay their high quality, highly relevant, and up to date intake water data from global BWMS Ship and Land Certification Test intake assessments into a shared data base. As more shipboard testing occurs, this data set will continue to expand its spatial and temporal coverage.

The result could be an "On-Line Map-Based BWMS Challenge Conditions Database". The living database of relevant port/harbor challenge conditions globally should be Web-hosted, map-based framework, i.e. geospatial in nature, and quasi open access with manipulation capabilities limited to credentialed users. Users could access, sort and download data based on any individual or compound data parameter(s), including finite or relative locations, season, and time of day. For Test Facilities, the undertaking would afford capacity to conduct initial investigations into the challenge adequacy of test water in a prospective shipboard test location prior to any travel. For Regulators, Vendors and Ship-Operators, it would afford an increasingly accurate physical/chemical/biological database with which to target performance expectations and testing conditions. Finally, as global harbor conditions evolve over time, the shared information will help detect and characterize local and/or global trends over time, generally, and in particular places.

The Problem with Protist Size Class Limitations in Biological Efficacy Testing for Certification of Ballast Water Management Systems in Fresh Water

Allegra Cangelosi, Euan Reavie

The USCG/IMO regulatory bounds for protists (cells ≥ 10 to < 50 μm in minimum visible dimension) are too narrowly drawn to capture adequate abundances and diversity of organisms in the Great Lakes and other freshwater estuaries in the intended taxonomic category. This flaw in the regulations could greatly diminish the value of Type Approval testing as a means of identifying Ballast Water Management Systems (BWMSs) that would be effective in real-world operation to and from freshwater systems. Meanwhile, the size class concept is also too arbitrarily constructed to deliver assessment standardization of tests across trials, much less facilities and ship locations. The ICES BWWG should advise IMO on the need for, and ways to, redefine the protist category for purposes of BWMS Type Approval testing to increase Type Approval testing predictiveness of BWMS performance, and test standardization, in the wide range of relevant aquatic ecosystems, including pure fresh water.

USCG/IMO requirements dictate certain biological challenge conditions be present for a BWMS Certification test to be considered valid. Specifically, there are minimum intake and control discharge densities of live organisms in regulatory size classes associated with organism "minimum dimension". For the protist size class, i.e., cells ≥ 10 to < 50 μm in minimum dimension, IMO/USCG require 1,000 live cells/mL on intake, and 100 live cells/mL in control discharge. The Intake density requirement serves the practical purpose of assuring adequate biological loads to physically challenge the BWMS; the control discharge requirement, on the other hand, tests whether survival is sufficient to rule out that hold time alone could cause discharge to meet the standard.

The regulatory size classes roughly conform to major taxonomic groupings which require distinct analytical approaches. Organism densities and viability in the ≥ 10 to < 50 μm in minimum dimension (i.e. protist) size class are assessed using fluorescent microscopy and vital stains. Constituent cells commonly occur in densities of hundreds to tens of thousands of individuals per mL. The size class upper bound was intended to exclude most zooplankton, which are far sparser—occurring in thousands to millions per cubic meter—and best measured with light microscopy. The lower bound of the protist size class excludes ultra-numerous bacteria and picoplankton, the viability of which are analyzed by an alternate set of analytical methods involving culturing on growth media.

However, as productive and authentic a source water system the Duluth-Superior Harbor (DSH) is, the Great Ships Initiative (GSI) must significantly manipulate intake water for to meet USCG/IMO regulatory challenge conditions in the protist size class. GSI is a U.S. Coast Guard (USCG)-Certified Test Facility for supporting land- and ship-based evaluations of BWMSs. GSI's Land-Based Test Facility conducts BWMS evaluations in DSH, a freshwater estuary and the busiest shipping port in the Great Lakes port range. At the GSI facility (and throughout the Great Lakes), the lower bound of the size class is too high. That is, the proportion of protist cells, whether part of a larger colony or free-living, which exceed 10 μm in minimum dimension is relatively low in the Great Lakes. Having a minimum size of 5 um for this criterion would more realistically represent these protists (Litchman, *et al.*, 2009). The trend toward low abundances of protists with

cells above the lower bound of the size class is also evident in at least some freshwater systems outside the Great Lakes (Muylaert, *et al.*, 2000) .

As a result of these problems, USCG-Certified land based test facilities using natural fresh water must spike or concentrate organisms, a process that is expensive, time consuming, prone to failure and creates unnatural conditions. Meanwhile, there is no scientific benefit to so narrowly construing the protist size class. On the contrary, the size class boundaries are arbitrarily applied due to incompatibility between standardized minimum dimension determination and random organism positioning during microscopic evaluation (hence the qualifier minimum visible dimension). Further, the size class does not correlate to algal particle size, if this type of standardization was the hope, due to the colonial nature of the most abundant freshwater protist species; any impact on BWMS performance of minor differences in cell dimension would likely be obscured by colony size effects. Further, there is no taxonomic or physiological relevance of the size class boundaries, if standardizing tests relative to particular taxa were of interest, because the larger cells in the assemblage are often simply a sparser subset of large and small clones, a problem that is especially relevant to the diatom algae. Finally, there is no advantage to limiting the protist taxonomic spread subject to certification test assessment, since more diversity of organisms in the land-based test will better reveal any BWMS weaknesses (or strengths) than an assessment involving only a limited number of taxa subject to analysis. This presentation described the regulatory artifact, and, recognizing the difficulty of altering regulatory requirements, proposed that scientific discussion commence through ICES in the next year to define more predictive alternative approaches to allow scientifically sound improvement of the regulation at the next process opportunity.

Litchman, E., Klausmeier, C. A., & Yoshiyama, K. (2009). Contrasting size evolution in marine and freshwater diatoms. Proceedings of the National Academy of Sciences, 106(8), 2665-2670.

ToR d)

Evaluating risks associated with ballast water release by domestic vessels transiting to Canadian Arctic waters

Kimberly Howland, Nathalie Simard, Sarah Bailey, Frédéric Laget, Pascal Tremblay, André Rochon, Gesche Winker

Although regulations exist for international ships, domestic vessels navigating between Canadian ports are currently exempt from ballast water management regulations. Currently, much of the domestic ballast released in the Arctic is brought in by ice-class vessels capable of travelling throughout much of the year. These vessels frequently conduct voluntary exchange in northern Canadian coastal waters to reduce the risk of non-indigenous species (NIS) introductions; however there are questions regarding the effectiveness of exchange and how this varies by season. To address these questions, a 3-year study aimed at better understanding risks associated with the currently non-regulated domestic shipping pathway was recently initiated with the MV Arctic, a domestic vessel that regularly transits (from June-February) between Quebec City/Montreal and Deception Bay, Quebec (Nunavik). Objectives were to: 1) evaluate seasonal variation in plankton abundance and diversity within ballast to assess seasonal changes in risk for introduction of NIS through ballast release; 2) experimentally evaluate efficacy of voluntary exchange by comparing plankton communities before and after ballast exchange in

control tanks (unexchanged water) as well as from tanks exchanged at two different locations. There was a strong effect of season on both propagule pressure and species composition with plankton abundance being highest in in ballast water pumped into tanks or exchanged in July and August. Plankton abundance and diversity did not differ statistically among exchange sites in different areas of the Gulf of St. Lawrence; however there was a large difference in both abundance and species composition in exchanged versus control (unexchanged) tank immediately after exchange and upon arrival in the destination port of Deception Bay. Exchange resulted in the replacement of freshwater plankton with marine species and resulted in much higher propagule pressure of both native and NIS of plankton relative to unexchanged control tanks. Locations currently used for exchange are in areas of upwelling with high summer productivity and thus may increase potential for uptake and transfer on marine NIS with potential to survive in the marine destination port of Deception Bay. Future studies should examine the potential for use of other exchange sites that may have lower productivity and fewer NIS such as off the Labrador Shelf. Information from this study can improve our abilities to understand and manage ballast-mediated species introductions, help guide voluntary ballast management practices by industry and feed into regulatory decisions by Transport Canada.

The Arctic Shipping Route: a New Species Introduction Corridor

Stephan Gollasch, Dan Minchin, Matej David, Anders Jelmert and Jon Albretsen

Several non-indigenous species (NIS) have been spread between northern oceans mainly from stocking and aquaculture activities. This has enabled some NW Pacific species, and their associates, to successfully colonise North Atlantic waters; and some will have passed the other way. Few NIS are known to have spread between these regions with shipping, either because of the persistent high latitude surface ice-barrier or intolerance of the warm water or tropical seas. As Arctic ice recedes a corridor is expected to enable a seasonal passage of vessels through and to this region. Both incremental poleward expansions of NIS can be expected as well as long distance transmissions. We present scenarios where NIS might become spread by different shipping related pathways to and through Arctic seas arising from sea-ice depletion. For example, a shipping route from Rotterdam to Yokohama currently is 11,200 nm, but only 6.500 nm on the northern route with savings in distance to exceed 40%. Between San Francisco and Rotterdam the northern route would be ca. 2,000 nm (ca. 25 %) shorter. Considering also the canal fees, fuel, and other costs, Arctic routes could cut the cost of a single voyage by a large container ship from ca. $17.5 million to $14.0 million.

We expect that the NE Atlantic is more susceptible to North Pacific NIS as the eastern side of continents (e.g. Asia) have more extreme environments which provides NIS originating there with an advantage when arriving in less extreme environments (e.g. Europe). Further, Europe will receive more shipping from Asia via the Russian polar route compared to the US East Coast because of the larger shipping route shortcut from Asia to Europe via Russia rather than from the Pacific to the Atlantic via polar Canada.

Shipping will not be the only responsible mode for the arrival of NIS in Arctic Seas. Climate warming is set to further human activities at progressively higher latitudes to involve varied forms of transport, exploitation, aquaculture, ranching and recreational

activities. There will be direct movements of NIS by ships between temperate regions of either northern oceans via the shorter routes in addition to a slower creeping natural spread to form a cold-water route which will not have existed for over four million years.

There are three principal invasion patterns likely to take place, i.e., by a gradual range expansion (natural range expansions, fishery discards), by progressive steps from one locality to another (local transport, modules associated with mineral and oil exploration and natural range expansion) or passage by ships between the more temperate regions of the two northern oceans though, and to, Arctic seas.

ToR e)

Biofouling Opening Presentation

Stephan Gollasch

The dominating species introduction vectors may be different in different regions, but the key vectors world-wide are ballast water, biofouling and species imports for aquaculture. Examples were ballast water was seen as more prominent compared to biofouling exist for Germany (Gollasch 1996), ICES member countries (Minchin *et al.* 2005) and Europe (Gollasch 2006). In contrast, biofouling was seen more important than ballast water in San Francisco Bay (Cohen & Carlton 1995), New Zealand (Cranfield *et al.*, 1998), GloBallast data (Gollasch 2000), Port Phillip Bay (Hewitt *et al.* 2004), Hawaii (Carlton & Eldridge 2009, Loope 2011), North Sea (Gollasch *et al.* 2009) and California (Williams *et al.* 2013). However, the some of the most "critical" species arrive in ballast water (HAB, human pathogens, *Dreissena*, *Mnemiopsis*)! Fouling species also have strong impacts (e.g. *Teredo*, *Balanus*, *Dreissena*, *Didemnum*, *Undaria*, *Crassostrea*, *Cordylophora, Ficopomatus, Hemigrapsus*).

IMO adopted the 2011 Guidelines for the control and management of ships´ biofouling to minimizing the transfer of invasive aquatic species. This instrument and other recommendations address biofouling management plans and record books and choosing the anti-fouling system. It was further suggested that dry-docking support blocks should be varied at each docking, or ensure that areas under these blocks are anti-fouling painted at least at alternate dry-dockings. It was further noted that bow, stern and other thrusters are prone to coating damage and that rudder hinges and stabilizer fin apertures should be routinely maintained at dry-dockings. Lastly, in-water inspections and cleaning should be considered with a risk assessment approach not that NIS are released by these activities. In 2012 IMO released the Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft, which refers to in-water cleaning, trailered craft, coating checks etc. In June 2013 Australia and New Zealand have released new anti-fouling and in-water cleaning guidelines developed in consultation with industry stakeholders.

The last comprehensive biofouling study on larger commercial vessels conducted in Europe seems to be the Germany study (Gollasch 1996). More recent European studies include Ashton *et al.* 2006 (Scottish recreational vessels), McCollin & Brown 2014 (Scottish drydocks with vessels <5,000 DWT or GT (<100 m length, regional)). The studies docu-

mented that not only sessile organisms were found, but also mobile species. In the German study in maximum 107 barnacles and 64 mussels were found in 100 cm² heavily fouled vessel surface. This was calculated to be 12.2 kg wet weight per m². The highest diversity was 23 different species in a sample. The most heavily fouled vessel had a fouling which in parts was 30 cm thick, developed by tube forming polychaetes. The most commonly found species was *Balanus improvisus.* Three other species are highlighted here as interesting cases. Firstly, *Diadumene lineata.* It is a well-known cryptogenic species, which colonized Atlantic and Pacific coasts of North America and NW Europe, Baltic as well as Mediterranean Seas. The first European record was documented in the UK in 1899. During the period 1920-24 it was also found in Germany (North Sea) in one location, but became extinct. Our finding of this species in the 1990s indicates that it may become re-introduced. The second example is *Hemigrapsus penicillatus.* It was first recorded in Europe 1994 in France, but we found it on a vessel already in 1993 with 2 males and 4 females on 30 cm² scraped vessel surface. Possibly the vessel we sampled introduced this species to Europe. Thirdly, we found a species new to science! This was named after the „habitat" where it was found as *Cryptostylochus hullensis* (flat worm). This account was not easy to publish as „type locality" was a vessel! It is listed in WoRMS and the co-author of this paper was Faubel, who is a flatworm expert and he described the Genus in 1983.

It may be interesting to note that the first time ever a ship was send away because of the biofouling situation. The Indonesian bulk carrier *DL Marigold* has been ordered to leave the Port of Tauranga, New Zealand waters after its hull was judged to be threat to biosecurity (10 March 2017). Ministry of Primary Industries (MPI) divers discovered dense fouling (barnacles, tube worms). The ship was given 24 hours to depart the port. Steve Gilbert, border clearance director at the MPI, said "The longer the vessel stayed in New Zealand, the greater chance there was for unwanted marine species to spawn or break away from the ship. So we had to act quickly". The vessel is not allowed to return until it is clean. New rules require all international vessels to arrive in New Zealand with a clean hull from May 2018 (http://www.marinelink.com/news/ordered-zealand-dirty422900).

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Marine Debris as a Vector for Invasive Marine Species: Transoceanic Dispersal of Coastal Marine Organisms by Japanese Tsunami Marine Debris

James Carlton, John Chapman, Jonathan Geller, Jessica Miller, Gregory Ruiz

The arrival onto the shores of North American and Hawaii of a vast flotilla of materials (ranging from large docks to medium-sized vessels to small baskets and buoys) generated from the shores of Japan on 11 March 2011 by the Great East Japan Earthquake and Tsunami offered an opportunity to study ocean-scale dispersal of potentially invasive species on marine debris. Hundreds of objects, landing from Alaska to California and in the Hawaiian Archipelago, have been sampled between 2012 and 2017 with 100s of living Japanese species. A Special Issue of Aquatic Invasions and other papers are in preparation documenting the scale of this phenomenon, and its implications for the current and future roles of the increasing amount of marine debris as a dispersal vector.

U.S. Biofouling Meetings

Lisa Drake

In August 2016, experts on biofouling from Australia, Canada, New Zealand (NZ), and the United States (US) met at the Smithsonian Environmental Research Center (SERC) in Edgewater, MD. A series of several meetings was held to establish a quadrilateral part-

nership in marine biosecurity research among the four countries. The purpose of the partnership is not only to seek greater alignment of research but also collaboration in areas of common interest.

One of the events in the series was a two-day meeting organized by the Maritime Environmental Resource Center (MERC). Part one was convened to consider approaches to characterize and quantify biofouling. Part two was convened to identify and discuss existing approaches used for in-water cleaning of vessels, as well as a means to quantify the efficacy of cleaning. This presentation summarizes the presentations, discussions, and conclusions from these two days. The main lessons learned were:

- Across administrations and regions, similar gaps and challenges exist—no standardized procedure for testing the efficacy of cleaning technologies exists, nor does a procedure for assessing ships' compliance with biofouling standards.
    - The group agreed universal standard procedures would be ideal, and existing procedures and lessons learned can inform the development of such practices.
- All administrations use paperwork as a first gate to know if biofouling management has occurred.
    - There is a need to standardize a method to determine if biofouling management procedures were used appropriately.
- There should be a focus on an approach to assess and remove fouling in niche areas.
    - The relationship of the extent of fouling between niche areas and the flat hull surfaces should be investigated.
- A means to distinguish between living and dead organisms is needed.
- This group should continue to meet annually in person and investigate links to other organizations (e.g., ICES WGBOSV or the Institute of Marine Engineering, Science and Technology [IMarEST]).
- There is a need to create a central data repository for current regulations, protocols, and reports.

Biofouling Risk in the Canadian Arctic

Farrah Chan

Many aquatic species colonize external surfaces of ship hulls (i.e. biofouling) and can dislodge and/or reproduce at later ports. While ship biofouling is recognized as a major transport vector of aquatic nonindigenous species (NIS) globally, its magnitude in the marine Arctic is little studied and poorly understood. Arctic sea ice may scape hulls, negatively impacting biofouling organisms; conversely, scraping or abrasion may release organisms into the water, thus increasing invasion risk. Therefore, we surveyed the hulls of eight naval and 13 commercial ships to characterize biofouling assemblages (alga and invertebrate taxa) delivered to Canadian Arctic ports in the summers of 2009 to 2012. We also used a questionnaire to obtain data on ships' operation profiles and hull maintenance practices, variables that may be related to biofouling, for the broader population of all ships entering Canada's Arctic during the summers of 2015 and 2016. Using these data, we (i) determined the composition and survivorship of biofouling assemblages

delivered to the Canadian Arctic via biofouling; (ii) identified factors that influence biofouling extent on ships, and (iii) incorporated results from dive surveys with questionnaire findings to evaluate the potential for ships to transport NIS to the Canadian Arctic via biofouling. Our study addresses the knowledge/data gaps on the biology of biofouling organisms on ships operating in Arctic waters and provides insights into ship biofouling risk in an Arctic environment.

ToR f)

Yachts in Mediterranean

Amelia Curd

Luxury mega-yachts are often equipped with large, tropical coral reef aquaria. In the Mediterranean and Caribbean, during high tourism seasons these vessels can reach high densities in certain marinas or MPAs (Guidetti, Magnani & Navone, 2016). Little information is readily available on the water-exchange and renewal procedures of these custom-built aquaria. However, their existence was flagged at the WGBOSV meeting as these luxury mega-yachts potentially represent an understudied vector which transports tropical species in great comfort over large distances. In the eastern Mediterranean in particular, where climate change is making it possible for aquaria -kept Indo-Pacific species to survive after being released (Zenetos, Apostopoulos & Crocetta, 2016), awareness-raising in certain hotspots would be beneficial. The University of Nice Sophia-Antipolis (Patrice Francour) is currently working with the Monaco Marine Reserve to draft an information leaflet for luxury yacht skippers, which will be shared via the Monaco Yacht Club.

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