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Report of the Working Group on Ballast and Other Ship Vectors (WGBOSV)

5–7 March 2018

Madeira, Portugal



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Executive summary

The ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) held three annual meetings in 2016-2018 in order to conduct scientific activities that will reduce the risk of transporting non-native species via shipping activities. During this period, 60 scientists participated in WGBOSV meetings, including four graduate students/post-doctoral fellows, representing 18 ICES and four IOC countries.

This final report provides a brief summary of progress achieved during the 2018 meeting, and summarizes the work achieved against all terms of reference (ToRs) for the period 2016–2018. WGBOSV considered two ToRs jointly with the Working Group on Introductions and Transfers of Marine Organisms (WGITMO): examining biofouling as vector for the introduction and transfer of aquatic organisms on small boats and large ships; and examining the effect of climate change on the establishment of aquatic species in the Arctic. In 2018, the Groups addressed a request for information on ship-mediated introductions of harmful algal bloom species in the Arctic from the Working Group on Harmful Algae Bloom Dynamics (WGHABD), and produced an ICES VIEWPOINT on “Evaluating and mitigating introduction of marine non-native species via vessel fouling”.

During 2016–2018, WGBOSV initiated a special issue on Recent Advances in Ballast Water Research in the Journal of Sea Research (volume 133, 2018), with 15 articles contributed by WGBOSV members. The Group also collected data for >1500 primary introduction events in aquatic systems, between 1965–2015, across 12 geographic regions globally to assess temporal trends in the introduction of non-native species, determining that pathways of introduction have changed in relative importance over time and across regions. In addition, the Group reviewed the status of introduced marine species in the Arctic, finding that shipping has been the primary pathway for introductions there, and that a lack of baseline taxonomic data hinders the identification and management of new non-native species. These two review papers are expected to be finalized shortly and submitted for publication in peer-reviewed scientific journals.

WGBOSV reinvigorated and strengthened its partnership with the International Maritime Organization (IMO), increasing co-operation on ballast water and biofouling activities. WGBOSV contributed two documents, Standard Operating Procedures for the collection of treated ballast water samples and a proposal to standardize the collection of scientific data, in support of IMO activities. WGBOSV welcomed representatives of the IMO and PICES (North Pacific Marine Science Organization) to its meetings in an effort to improve communication and increase collaboration between the groups. WGBOSV identified a need to evaluate the efficacy of new ballast water management systems, to conduct additional research concerning species introductions in the Arctic under climate change, and to improve management of ship biofouling in order to prevent future introductions. The Group therefore recommended that the WGBOSV be extended for another three years and proposed new/revised ToRs, accordingly. Finally, the Group noted the high number of participants at recent meetings and discussed the need to set a limit on participants to ensure that ToRs can be advanced effectively. It was also recognized that a large group is more difficult to accommodate in terms of physical meeting space and technological support.

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)

3

Chair(s)

Sarah Bailey, Canada

Meeting venue and dates

14–16 March 2016, Olbia, Italy

15–17 March 2017, Woods Hole, USA

5–7 March 2018, Caniçal (Madeira), Portugal

2 Terms of Reference

- 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 Summary of Achievements of the WG during 3-year term

- A special issue on Recent Advances in Ballast Water Research was produced in the Journal of Sea Research (volume 133, 2018), with 15 articles contributed by WGBOSV members including 3 which expressly acknowledge benefits of ICES WGBOSV participation (<https://www.sciencedirect.com/journal/journal-of-sea-research/vol/133>)
- Data for >1500 primary introduction events in aquatic systems, during 1965-2015, was collected and analysed for 12 geographic regions globally to assess temporal trends in the introduction of nonindigenous species; a scientific paper is expected to be submitted before end of 2018
- Document PPR 5/5/2 (*Guidance for research studies that will collect scientific data during the experience-building phase*) was submitted to the International Maritime Organization (Sub-Committee on Pollution Prevention and Response), outlining Standard Operating Procedures for the collection of treated ballast water samples for use by scientific researchers globally
- Document MEPC 70/4/18 (*Comments on the collection of scientific data during the experience-building phase*) was submitted to the International Maritime Organization (Marine Environment Protection Committee), containing a proposal to standardize the collection of scientific data, the results of any biological analysis of treated water, and the circumstances of any failures to achieve the standards of regulation D-2 during the experience-building phase associated with the implementation of the Ballast Water Management Convention
- Jointly with WGITMO, produced an ICES VIEWPOINT on *Evaluating and mitigating introduction of marine non-native species via vessel fouling*
- Jointly with WGITMO, have supported and advanced AquaNIS, the online information system on aquatic non-indigenous species with contributions of national data on new findings (biological introduction events) in aquatic systems, and participation on the core development team responsible for maintenance and long-term reliability of AquaNIS data (<http://www.corpi.ku.lt/databases/index.php/aquanis>)
- Jointly with WGITMO, a scientific paper reviewing the status and risks of introduced species in the Arctic was initiated, and is expected to be submitted before end of 2018
- Jointly with WGITMO, responded to a request from WGHABD concerning the role of shipping as a vector for the introduction of harmful algal bloom organisms in the Arctic, by conducting a review and presenting the information to the WGHABD annual meeting

- Contributed presentation: McKenzie, C.H. 2018. Harmful Algae Networking with ICES Working Groups on Introduction and Transfer of Marine Organisms and Ballast Water and Other Ship Vectors. 18th International Conference on Harmful Algae. October 12-16, 2018 Nantes, France.

5 Final report on ToRs, workplan and Science Implementation Plan

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

National reports were contributed each year, with 2018 reports attached in Annex 6 and earlier reports attached to interim annual reports. Each report provides a detailed description of shipping vector research activities undertaken during 2016-2018, identifies research needs and gaps, and highlights relevant meetings/conferences and recent publications/products of interest. The national reports were used as the basis to identify and develop collaborative activities within the Group. In year 3, presentations were contributed to inform Group members about northward expanding non-indigenous species in Europe; recent ballast water research activities in Spain; biological sampling of ports in Estonia; a literature review of indicative analysis methods for ballast water samples; the project COMPLETE; an upcoming assessment of ship in-water cleaning activities; and an evaluation of ballast water and biofouling management common denominators and differences (Abstracts in Annex 7). The Group discussed the continued need to support and contribute data to AquaNIS, the online information system on aquatic non-indigenous species (<http://www.corpi.ku.lt/databases/index.php/aquanis>). The Group also discussed potential benefits of increasing communication with the Intergovernmental Oceanographic Commission (IOC) of UNESCO as an outreach outlet.

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

Considerable progress was made on this ToR with many participants conducting research nationally to develop and/or evaluate methods for collection and analysis of ballast water samples. This work is very important as the shipping industry enters the Experience Building Phase of the Ballast Water Management Convention, during which many ships will install new Ballast Water Management Systems (BWMS). With this change in ballast water management practices, there is an urgent need for scientific research to understand how well the BWMS are working to reduce the risk of species introductions. There is also a need for scientific guidance about the tools and methods enforcement personnel should use in order to monitor requirements of the Convention. Presentations sharing new knowledge on these topics were contributed annually, with 2018 presentation abstracts in Annex 7. In addition to the special issue in the Journal of Sea Research mentioned above, the Group produced and submitted two documents for consideration by the International Maritime Organization (IMO) concerning the type of scientific data that should be collected during the Experience-Building Phase, and, Standard Operating Procedures for the collection of treated ballast water samples for use by scientific researchers globally. These two contributions provide guidance that will help to

standardize scientific research related to BWMS which is being collected globally, facilitating future merging of data for more robust analyses. The Group suggested that there will be a continued need for science input during the Experience Building Phase and agreed to coordinate closely with the IMO Secretariat to ensure that WGBOSV can continue to make relevant scientific contributions to the IMO.

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

In year 3, two presentations were contributed to inform the Group about operational testing of BWMS in Canada and challenge water conditions encountered during more than 100 test voyages (see Annex 7). Over the three years of this ToR, the Group discovered that there was need to continue to improve standardization across BWMS type approval facilities. Although only a few WGBOSV members have expertise related to these specific activities, it was recognized that the Group could facilitate improvements by helping to collect data about environmental conditions and biological communities of aquatic ecosystems around the world that may serve as source locations for ballast water. The Group discussed the importance of conducting standardized scientific research examining the efficacy of BWMS during the next few years under the Experience Building Phase, in order to confirm that the risk of marine introductions is being further reduced by the use of BWMS. In addition, the Group discussed a potential project to collect data on the current status and experience with implementation of requirements and utilization of BWMS globally. The Group recognized the value of collecting such data now, and in 5-10 years, to investigate changes resulting from the implementation of the Ballast Water Management Convention and to identify any issues that may not be addressed well.

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

In response to the request from WGHABD concerning the role of shipping as a vector for the introduction of harmful algae bloom (HAB) organisms in the Arctic, work was conducted intersessionally, jointly with WGITMO and external experts, to conduct a review on the current status and knowledge of HABs in the Arctic. The review revealed that there was little data on HABs in the Arctic, with most available data collected from waters near Greenland or in the Canadian Arctic. Approximately 25% of the species reviewed to date are potentially harmful, but many are considered rare or occur only occasionally in the Arctic. Significant progress was also achieved on the compilation of a comprehensive list of introduced species in the Arctic, with the aim to evaluate the risk associated with current and future vectors of introduction, to identify knowledge/data gaps, and to serve as guidance for future research and management efforts related to NIS in the Arctic. A scientific review paper has been drafted and is expected to be submitted for publication in a peer-reviewed scientific journal in 2018. The Group discussed the need to continue to identify and monitor activities of the Arctic Council under the ARIAS strategy, with a view to providing advice or scientific information in the near future. Due to the rapidly changing climate and exponential growth of human activities in the Arctic,

the Group identified a need to continue to assess risks of species introductions and mitigation strategies.

ToR 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

Considerable progress was made on this ToR over the three years, with presentations during the annual meetings and intersessional work culminating in the development of an ICES VIEWPOINT on “Evaluating and mitigating introduction of marine non-native species via vessel fouling”. The viewpoint summarizes the current state of knowledge about the risk of biofouling as a pathway for introduction of non-native marine species, and recommends that active management be undertaken to reduce biofouling of commercial and recreational vessels as an urgent priority. During the 2018 meeting, the Groups discussed potential areas of collaboration with the IMO GloFouling project, with a view to providing advice or scientific information to IMO in the near future. It was noted that the IMO is expected to conduct a review of the 2011 Biofouling Guidelines, and that WGBOSV is well placed to make future contributions to IMO to support the review. The Group finally determined that additional research is needed to develop and improve biofouling management guidelines and practices, and that it would be valuable to coordinate and communicate relevant activities through the WGBOSV.

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

Considerable progress was made on this ToR intersessionally, with the collection of data for >1500 primary introduction events in aquatic systems for 12 geographic regions globally during the timeframe 1965–2015. Analyses to assess temporal trends in the introduction of non-indigenous species have begun, and a scientific paper is expected to be submitted in 2018 to a peer-reviewed scientific journal. Preliminary results suggest that the relative importance of different pathways of introduction (e.g. shipping, aquaculture, canals) has changed through time, and differs across geographic regions.

6 Cooperation

- WGBOSV met jointly with WGITMO for one full day during each annual meeting 2016-2018 to address issues of joint interest, increasing the breadth of expertise available to progress ToRs.
- WGBOSV responded to a request from WGHABD concerning the role of shipping as a vector for the introduction of harmful algal bloom organisms in the Arctic – a review was conducted and results were communicated through a presentation at WGHABD annual meeting.
- WGBOSV renewed collaboration and better communication with the Intergovernmental Oceanographic Commission of UNESCO and the International Maritime Organization. Both IOC and IMO confirmed interest to remain as umbrella organizations of WGBOSV, providing opportunity for IOC experts and IMO Secretariat to participate in annual WGBOSV meetings, to receive information about products of WGBOSV activities (annual reports, publications,

etc.) and to receive scientific input from WGBOSV on issues within their expertise. This renewed collaboration will broaden the impact of WGBOSV activities outside the ICES organization.

- WGBOSV developed formal partnership with the GEF-UNDP-IMO GloFouling Partnerships Project, with ICES signing on as a strategic project partner – GloFouling aims to reduce ship-mediated aquatic introductions by building capacity for better biofouling management. This partnership will allow WGBOSV to identify future research needs related to biofouling management, and will increase impact outside the ICES organization.
- WGBOSV connected with the Global TestNet organization (a consortium of BWMS testing organizations working together to standardize test procedures) to identify potential areas of coordination and collaboration. This cooperation resulted in the identification of new research needs related to BWMS, and expanded the network of experts available to contribute to WGBOSV ToRs.
- WGBOSV welcomed a PICES representative to annual meetings with a view to develop better communication and collaboration between ICES and PICES groups working on non-indigenous species issues, facilitating a more global view in WGBOSV activities and impact.
- WGBOSV welcomed relevant experts from non-ICES countries – including Croatia, Greece, Israel and Italy – allowing WGBOSV to undertake more global view when conducting topical reviews and collaborative activities. It was noted that participation by these countries enhanced connections between IOC and CIESM (the Mediterranean Science Commission)
- WGBOSV connected with Arctic Council (U.S. representative) to identify potential areas of coordination and collaboration – it was determined that WGBOSV activities are in line with priorities under the Arctic Invasive Alien Species (ARIAS) Strategy and Action Plan, and that additional cooperation and communication is needed to ensure Arctic Council benefits from existing scientific expertise.

7 Summary of the Working Group self-evaluation and conclusions

A copy of the full Working Group self-evaluation is included as Annex 4 of this report.

WGBOSV has worked on ICES SSGEPI Science Plan Priorities 1, 10, 12, 13, 20, 25, 27 and 31. This includes the development of an inventory of introduced aquatic non-native species in 12 regions globally, including a baseline assessment for the Arctic. WGBOSV conducted research on the efficacy of Ballast Water Management Systems and developed standardized procedures for the collection of scientific data related to efficacy assessments.

WGBOSV had high level of achievement with the organization of a special issue on Recent Advances in Ballast Water Research (Journal of Sea Research, volume 133, 2018), two written contributions to the International Maritime Organization, collation of a large dataset on global biological invasions, and two scientific papers in preparation with expected submission date in 2018. In addition, WGBOSV responded to a request for infor-

mation from WGHABD and drafted an ICES VIEWPOINT on “Evaluating and mitigating introduction of marine non-native species via vessel fouling”.

WGBOSV renewed collaboration and better communication with the Intergovernmental Oceanographic Commission of UNESCO and the International Maritime Organization (partner umbrella organizations of WGBOSV) and developed formal partnership with the GEF-UNDP-IMO GloFouling Partnerships Project. WGBOSV also reached out to Global Test Net organization, PICES and the Arctic Council.

WGBOSV experienced difficulties due to very high participation at recent meetings, both in-person, and with multiple requests for remote participation by web-ex. When the number of in-person participants is greater than 30, it becomes difficult for the host organization to provide facilities such as adequate space and internet bandwidth. In addition, with conference-style seating, productive discussion is reduced, which can impact the ability to deliver on Terms of Reference. Requests for web-ex participation are demanding on the host (to provide adequate sound equipment) and technological difficulties at either end of the connection result in delays in the Agenda and additional stress for the meeting Chair/host

WGBOSV recommends a continuation of the WG with modified draft ToRs proposed in Annex 3. With the entry-into-force of the Ballast Water Management Convention and its related Experience-Building Phase, and the upcoming review of the 2011 Biofouling Guidelines, there will be an ongoing need for scientific input into international policies developed at the International Maritime Organization. In addition, biological introductions vectored by biofouling, and in particular introductions to the Arctic, are pressing environmental issues requiring additional research and policy priority.

Annex 1: List of participants

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Annex 2: Recommendations

| RECOMMENDATION | ADRESSED TO |
|--|----------------|
| 1. To approve a new term for the WGBOSV to work on three-year ToRs (Annex 3), with Lisa Drake (USA) as new Chair, and IOC and IMO as partner umbrella organizations. | SCICOM |
| 2. WGBOSV to meet jointly with WGITMO for one full day, annually, to progress ToRs of joint interest. | WGBOSV, WGITMO |

Annex 3: WGBOSV drat terms of reference 2019–2021

The ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBSOV), chaired by Lisa Drake, United States, will work on ToRs and generate deliverables as listed in the Table below.

| | MEETING DATES | VENUE | REPORTING DETAILS | COMMENTS (CHANGE IN CHAIR, ETC.) |
|-----------|---------------|--------------------------|------------------------|----------------------------------|
| Year 2019 | 6-8 March | Weymouth, United Kingdom | Interim report by DATE | |
| Year 2020 | March | TBD | Interim report by DATE | |
| Year 2021 | March | TBD | Final report by DATE | |

ToR descriptors

| TO R | DESCRIPTION | BACKGROUND | SCIENCE PLAN TOPICS ADDRESSED | DURATION | EXPECTED DELIVERABLES |
|------|--|--|-------------------------------|----------|---|
| a | Conduct strategic planning (identify and develop collaborative activities, advance and standardize methods, etc.) to advance research and address knowledge gaps by reviewing national activities and responding to new requests for advice. | ICES strategic plan Goal 2: understand the relationship between human activities (e.g., shipping) and marine ecosystems to estimate pressures and impacts and develop science-based sustainable pathways; and Goal 3: Evaluate and advise on options for the sustainable use and protection of marine ecosystems. Potential advice requests from agencies such as OSPAR. | 2, 3, 4, 5 | 3 years | Report to ICES. Respond to advice requests, as applicable. |
| b | Evaluate test conditions, methods for collection of ballast water, or analysis of samples to inform national and/or international procedures for type approval and compliance testing of ballast water management systems. | The Convention for the Control and Management of Ships' Ballast Water and Sediments, (2004) (BWMC) aims to minimize the transfer of harmful aquatic organisms with the ballast water from ships. It is imperative that the BWMC is implemented in a scientifically valid and standardized way | 3, 5 | 3 years | Input on the general applicability or otherwise of such conditions or methods to IMO or national regulators through meeting participation, correspondence group and/or technical paper or peer-reviewed manuscript. |

| | | | | | |
|---|--|--|------------|---------|---|
| | | globally. There are science and advisory requirements related to validated methods and procedures. | | | |
| c | Investigate and evaluate climate change impacts on the establishment and spread of ship-mediated nonindigenous species, particularly with respect to the Arctic. | This work will be carried out jointly with WGITMO. Contributes to SICCM and ICES high-priority action area 'Arctic research'. | 2, 3, 4 | 3 years | Cooperation with WGITMO by providing input at joint meetings and feedback on research results. |
| d | 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. | This work will be carried out jointly with WGITMO. Ships' biofouling is, with ballast water, a primary bioinvasion vector. As management of invasion vectors is the only effective way to reduce risks of new invasions, addressing biofouling issues is of high priority in bioinvasions management. | 2, 3, 4, 5 | 3 years | Strengthen ties to the IMO GloFouling Partnerships through meeting participation and increased discussion of research aims; report to ICES. |
| e | Evaluate the development of DNA- and RNA-based molecular tools for surveillance and monitoring of ship-borne invasive species. | Considering the complexity of the taxonomic groups to which invasive species belong, the decline in taxonomic expertise, the need for robust monitoring efforts, and the need for reliable and accurate methods to assess compliance to regulations (e.g. BWM), RNA- and DNA-based molecular tools have been proposed as complementary approaches to traditional methods. Although some challenges remain, these methods warrant close scrutiny. | 2, 3, 4, 5 | 3 years | Input on the general applicability or otherwise of such methods to IMO or national regulators through meeting participation, correspondence group and/or technical paper or peer-reviewed manuscript. |

Summary of the Work Plan

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

Supporting information

| | |
|--|--|
| Priority | The work of the Group forms the scientific basis for essential advice related to the movement of invasive aquatic organisms and pathogens via ballast water and other shipping vectors. As a joint working group, it also follows and supports related work within the IMO and IOC. |
| Resource requirements | The research programmes which provide the main input to this group are already underway, with resources provided by national governments and scientific funding agencies. The additional resources required to undertake activities in the framework of this group are negligible. |
| Participants | The Group is normally attended by some 25-35 members and guests, but has more than 65 members in total. |
| Secretariat facilities | None. |
| Financial | No financial implications. |
| Linkages to ACOM and groups under ACOM | The group will serve as primary respondent to incoming advice requests on various issues related to ship-mediated introductions. |
| Linkages to other committees or groups | There is a very close working relationship with WGITMO. Potential or occasional linkage with WGBIODIV, WGHABD, WGIMT, WGPME and WGZE. |
| Linkages to other organizations | International Oceanographic Commission (IOC), International Maritime Organization (IMO), North Pacific Marine Science Organization (PICES). In addition, the outcomes are relevant to other national and international organizations involved in the development of regulatory policies. |

Annex 4: WGBSOV self-evaluation

- 1) Working Group on Ballast and Other Ship Vectors (WGBOSV)
- 2) Year of appointment: 2016
- 3) Chair: Sarah Bailey, Canada
- 4) Venues, dates and numbers of in-person+remote participants :

| | | |
|------------------|-------------------|-------------------|
| 14–16 March 2016 | Olbia, Italy | 35+9 participants |
| 15–17 March 2017 | Woods Hole, USA | 26+5 participants |
| 5–7 March 2018 | Canical, Portugal | 41+6 participants |

WG self-evaluation

5) If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.

#1: Assess the physical, chemical and biological state of regional seas and investigate the predominant climatic, hydrological and biological features and processes that characterise regional ecosystems

WGBOSV reviewed the status of introduced aquatic species in 12 regions globally and investigated the vectors presumed responsible for their introductions.

#10: Develop historic baseline of population and community structure and production to be used as a basis for population and system level reference points

WGBOSV developed a list of aquatic non-native species in the Arctic, to be used as a baseline/reference for future risk assessments and monitoring plans.

#12: Develop approaches to mitigate impacts from these [anthropogenic] activities, particularly reduction of non-target mortalities and enhancement/restoration of habitat and assess the effects of these mitigations on marine populations

WGBOSV members conducted research on the efficacy of Ballast Water Management Systems to confirm reduction in introduction risks/impacts, with some members supporting developmental (type approval) testing.

#13: Develop indicators of pressure on populations and ecosystems from human activities such as eutrophication, contaminants and litter release, introduction of alien species and generation of underwater noise

WGBOSV developed an inventory of the number of introduced aquatic species across 12 global regions.

#20: Provide priorities and specifications for data collection frameworks supporting Integrated Ecosystem Assessments (IEAs)

WGBOSV made contributions to the International Maritime Organization concerning standardized methods for the collection of data surrounding Ballast efficacy – this standardized global data will eventually be used to support risk assessment and revision (if required) of the Ballast Water Management Convention.

#25: Identify monitoring requirements for science and advisory needs in collaboration with data product users, including a description of variable and data products, spatial and temporal resolution needs, and the desired quality of data and estimates

WGBOSV developed a list of required variables for monitoring of BWMS efficacy under the Experience Building Phase of the international Ballast Water Management Convention.

#27. Identify knowledge and methodological monitoring gaps and develop strategies to fill these gaps

WGBSOV identified knowledge gaps related to management of ballast water and bio-fouling as vectors of introduction of aquatic non-native species. Collaborative discussions and projects have led to improved tools and procedures for scientific monitoring.

#31: Ensure the development of best practice through establishment of guidelines and quality standards for (a) surveys and other sampling and data collection systems; (b) external peer reviews of data collection programmes and (c) training and capacity building opportunities for monitoring activities

WGBSOV developed Standard Operating Procedures for the collection of treated ballast water samples for use during the Experience Building Phase of the international Ballast Water Management Convention.

6) In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc. *

- A special issue on Recent Advances in Ballast Water Research was produced in the Journal of Sea Research (volume 133, 2018), with 15 articles contributed by WGBOSV members including 3 which expressly acknowledge benefits of WGBOSV participation (<https://www.sciencedirect.com/journal/journal-of-sea-research/vol/133>)
- Data for >1500 primary introduction events in aquatic systems, during 1965-2015, was collected and analysed for 12 geographic regions globally to assess temporal trends in the introduction of nonindigenous species; a scientific paper is expected to be submitted before end of 2018
- Document PPR 5/5/2 (*Guidance for research studies that will collect scientific data during the experience-building phase*) submitted to the International Maritime Organization
- Document MEPC 70/4/18 (*Comments on the collection of scientific data during the experience-building phase*) submitted to the International Maritime Organization
- Supported and advanced AquaNIS, the online information system on aquatic non-indigenous species (<http://www.corpi.ku.lt/databases/index.php/aquanis>)
- A scientific paper reviewing the status and risks of introduced species in the Arctic was initiated, and is expected to be submitted before end of 2018
- Responded to a request from WGHABD
- Contributed presentation: McKenzie, C.H. 2018. Harmful Algae Networking with ICES Working Groups on Introduction and Transfer of Marine Organisms and Ballast Water and Other Ship Vectors. 18th International Conference on Harmful Algae. October 12-16, 2018 Nantes, France.
- Co-produced ICES VIEWPOINT (with WGITMO) on *Evaluating and mitigating introduction of marine non-native species via vessel fouling*

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

In 2015, WGBOSV responded to the request from OSPAR to review the OSPAR JAMP Eutrophication Guidelines on Phytoplankton Species Composition (through WGITMO).

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

- Renewed collaboration and better communication with the Intergovernmental Oceanographic Commission of UNESCO and the International Maritime Organization.
- Developed formal partnership with the GEF-UNDP-IMO GloFouling Partnerships Project, with ICES signing on as a strategic project partner
- Connected with the Global TestNet organization (a consortium of BWMS testing organizations working together to standardize test procedures)
- Welcomed a PICES representative to annual meetings
- Welcomed relevant experts from non-ICES countries – including Croatia, Greece, Israel and Italy – participation by these countries enhanced connections with IOC and CIESM (the Mediterranean Science Commission)
- Connected with Arctic Council (U.S. representative)

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

WGBOSV has experienced difficulties due to very high participation at recent meetings, both in-person, and with multiple requests for remote participation by web-ex. When the number of in-person participants is greater than 30, it becomes difficult for the host organization to provide facilities such as adequate space and internet bandwidth. In addition, with conference-style seating, productive discussion is reduced, which can impact the ability to deliver on Terms of Reference. Requests for web-ex participation are demanding on the host (to provide adequate sound equipment) and technological difficulties at either end of the connection result in delays in the Agenda and additional stress for the meeting Chair/host.

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

Yes. WGBOSV does recommend a continuation of the WG with modified ToRs proposed in Annex 3. With the entry-into-force of the Ballast Water Management Convention and its related Experience-Building Phase, and the upcoming review of the 2011 Biofouling Guidelines, there will be an ongoing need for scientific input into international policies developed at the International Maritime Organization. In addition, biological introductions vectored by biofouling, and in particular introductions to the

Arctic, are pressing environmental issues requiring additional research and policy priority.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

Not applicable.

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

Additional expertise on DNA- and RNA-based molecular tools could improve the ability of WGBOSV to fulfil new ToR e) *Evaluate the development of DNA- and RNA-based molecular tools for surveillance and monitoring of ship-borne invasive species*

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

Knowledge about biological introductions in the Arctic.

Annex 5: Agenda

ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors MEETING AGENDA 5-7 March 2018

Venue: Quinta do Lorde Hotel Resort
Sítio da Piedade
9200-044 Caniçal – Madeira, Portugal

MONDAY 5TH MARCH

| | | |
|-------|---|-----|
| 08.30 | Set Up Computers | .30 |
| 09.00 | Welcoming remarks: Sarah Bailey (Chair), João Canning-Clode (Host) | .10 |
| | Introduction of Participants | .10 |
| | Review WGBOSV Agenda | .5 |
| | Election of New Chairperson (2019-2021) | .5 |
| 09.30 | 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. <i>ToR lead: Sarah Bailey</i> | |
| | Review ToR objectives and deliverables | .5 |
| | Review of National Activities (2016-2018) | |
| | • Belgium | .5 |
| | • Canada | .5 |
| | • Croatia | .5 |
| | • Estonia | .5 |
| | • Germany | .5 |
| | • Latvia | .5 |
| | • Lithuania | .5 |
| | • Netherlands | .5 |
| 10.30 | Morning break | .20 |
| | • Norway | .5 |
| | • Poland | .5 |
| | • Portugal | .5 |
| | • Sweden | .5 |
| | • United Kingdom | .5 |
| | • United States | .5 |

- Additional Reports by Correspondence

| | | |
|--------------|--|------------|
| | Presentation: Some northward expanding non-indigenous species in Europe – Dan Minchin | .5 |
| | Presentation: Recent ballast water research activities in Spain – Anaïs Rey | .5 |
| | Presentation: Update on national port biological sampling – Henn Ojaveer | .20 |
| | Questions | .10 |
| 12.30 | Lunch break | .60 |
| 13:30 | Presentation: Literature Review of Indicative Analysis Methods – Okko Outinen (remote participation) | .20 |
| | Questions | .10 |
| | Presentation: Project COMPLETE – Sergej Olenin | .20 |
| | Questions | .10 |
| | Presentation: Assessment of ship in-water cleaning technologies – Mario Tamburri | .20 |
| | Questions | .10 |
| 15.00 | Afternoon break | .20 |
| | Presentation: Evaluation of ballast management and biofouling management, common denominators and differences – Cato ten Hallers | .20 |
| | Questions | .10 |
| | Discussion and Reporting under ToR a); Planning ToRs/Deliverables (2019-2021) | .30 |
| 15.50 | 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 |
| | Summary of current status and discussion at IMO regarding ballast water management – Teo Karayannis | .20 |
| | Questions | .10 |
| | Recap of activities on sampling and analysis (SOPs) at IMO – Lisa Drake | .10 |

| | | |
|-------------------------------------|--|-----|
| 17.15 | End of Day 1 | |
| TUESDAY 6TH MARCH | | |
| 08.30 | Set up Computers | .30 |
| 09.00 | ToR b) continues... | |
| | Presentation: Overview of the NRL sampling device – Lisa Drake | .20 |
| | Questions | .10 |
| | Presentation: ATP analysis method - SGS | .20 |
| | Questions | .10 |
| | Discussion and Reporting under ToR b); Planning ToRs/Deliverables (2019-2021) | .30 |
| 10.30 | Morning break | .20 |
| | 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 <i>ToR Lead: TBD</i> | |
| | Review ToR objectives and deliverables | .10 |
| | Presentation: Early Results of “Experience Building Phase” BWMS testing in Canada - Sarah Bailey | .20 |
| | Questions | .10 |
| | Presentation: Testing Ballast Water Management Systems – Challenge Water Conditions During more than 100 Test Voyages – Stephan Gollasch (and Matej David) | .20 |
| | Questions | .10 |
| | Presentation: Ballast water Sampling Assessment – Greg Ruiz | .20 |
| | Questions | .10 |
| 12.30 | Lunch break (Tour?) | .60 |
| 13.30 | Discussion and Reporting under ToR c); Planning ToRs/Deliverables (2019-2021) | .30 |
| | ToR f): Evaluate the current role/importance of shipping in relation to | |

| | | |
|---|--|------------|
| other invasion vectors/pathways globally <i>ToR Lead: Sarah Bailey</i> | | |
| | Review ToR objectives and deliverables | .10 |
| | Presentation: Recent trends in ballast water risk - Jenni Kakkonen | .20 |
| | Questions/Discussion | .10 |
| | Presentation: Early Results of Global Vector Analysis - Sarah Bailey | .20 |
| | Questions/Discussion | .10 |
| 15.00 | Afternoon break | .20 |
| | Discussion and Reporting under ToR f) | .30 |
| 16.30 | Planning WGBOSV ToRs and Deliverables (2019-2021) | .30 |
| 17.00 | End Day 2 | |
| WEDNESDAY 7TH MARCH JOINT MEETING WITH WGITMO | | |
| 08.30 | Set Up Computers | .30 |
| 09.00 | Welcoming remarks: Sarah Bailey, Cynthia McKenzie (Co-Chairs), João Canning-Clode (Host) | .15 |
| | Welcoming remarks from the Office of the Secretary of the Environ- ment | .15 |
| | Introduction of Participants | .10 |
| | Review WGBOSV/WGITMO Joint Day Agenda | .5 |
| 09.45 | WGBOSV ToR e): Investigate and evaluate methods/technologies to assess risks of, to minimize extent of, and to respond to vessel biofoul- ing to inform national and/or international policies or guidelines [WGITMO ToR c) Investigate biofouling as a vector for the introduc- tion and transfer of aquatic organisms on vessels and artificial hard structures, their pressure and impact on the ecosystem with a compari- son of prevention or selective mitigation measures.] <i>ToR Lead: TBD</i> | |
| | Review ToR objectives and deliverables | .10 |
| | Presentation: IMO GloFouling Activities – Teo Karayannis (+ Antoine Blonce and John Alonso by remote participation) | .20 |
| | Questions | .10 |

| | | |
|--------------|--|------------|
| 10.30 | Morning break | .20 |
| | Presentation: Overview of biofouling work in U.S. – Lisa Drake | .20 |
| | Questions | .10 |
| | Presentation: ICES Biofouling Viewpoint – Cynthia/Bella | .20 |
| | Questions | .10 |
| | Discussion and Reporting under ToR e) [WGITMO ToR c)]; Planning BOSV ToRs/Deliverables (2019-2021) | .30 |
| 12.30 | Lunch break | .60 |
| 13:30 | 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: TBD | |
| | Review ToR objectives and deliverables | .10 |
| | Request from WGHABD concerning the role of shipping as a vector for the introduction of HAB organisms in the Arctic | .5 |
| | Presentation: Current knowledge on HABs in the Arctic – Kim Howland & Christine Michel (remote participation) | .20 |
| | Questions | .10 |
| | Presentation: Early Results of Review Paper on AIS risks to the Arctic – Farrah Chan (remote participation) | .20 |
| | Questions | .10 |
| | Discussion – Response to WGHABD | .15 |
| 15.00 | Afternoon break | .20 |
| | Discussion and Reporting under ToR d) [WGITMO ToR b)]; Planning BSOV ToRs/Deliverables (2019-2021) | .30 |
| | <ul style="list-style-type: none"> consider feedback from ICES regarding ability to propose joint activities with other Arctic organizations | |
| | Resolution of Any Outstanding Issues | .15 |
| | Any Other Business | |
| | <ul style="list-style-type: none"> Update on relevant PICES Activities – Tom Therriault | .15 |
| | <ul style="list-style-type: none"> Baltic NIS monitoring strategy – Henn/Sergej/Maiju | .15 |

- Location of next meeting – **Stephan Gollasch** .10

Close of WGBSOV 2018 .10

| | |
|--------------|---------------------------------|
| 17.00 | End of Joint Meeting Day |
|--------------|---------------------------------|

Annex 6: 2018 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 ratified the Ballast Water Management Convention on March 7 the 2016. Work studying the biofouling on windmill farms is ongoing. A range of species has been found, including non-natives and introduced species, especially in the intertidal zone. When possible, the fouling community on RV Belgica is sampled.

Canada

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 for shipping vector activities), which recently has been in the range of \$CAD 500-750K, depending on departmental priorities each year. 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, and is now making efforts to fully implement the Convention.

Canada's new Ocean Protection Plan includes policies, funding and activities to address the issue of derelict vessels which have been found to be a source of pollution and of biofouling including Non-Indigenous Species (NIS). Transport Canada's program applies to larger commercial vessels and Fisheries and Oceans Canada (DFO) Small Craft Harbour (SCH) program applies to smaller fishing and recreational vessels. The goal is to remove these vessels as part of Canada's commitment to protecting the ocean environment.

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). The program received \$17.5M (2012-2017), with a strong focus on outreach/education, early detection surveillance and response in the Canadian waters of the Great Lakes. The program was continued in March 2017 with up to \$20M over 5 years (2017-2022). Additional activities include research to support risk assessments, reduce spread of invasive fishes, and assess potential Asian carp containment options.

PLANNED RESEARCH

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

RESEARCH NEEDS

- Research is needed to develop better management practices for biofouling, such as remotely-operated devices for risk assessment and cleaning with particle retention.
- 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 and provide a basis for the use of new genetic tools for the detection of changes in biodiversity and detection of new species.
- 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-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, 20-24 September, 2017

dale, USA, 22-26 October, 2017

- 3rd International Conference on Marine and Freshwater Invasive Species, Aquatic Ecosystem Health and Management Society, Beijing, China, 27-29 August, 2018
- International Conference on Marine Bioinvasions X, Puerto Madryn, Patagonia, 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 (theses have been published, primary papers to be submitted for publication in 2018). 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 (2015-2018)

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 characterize biofouling extent and management practices of ships operating in Canadian Arctic waters; (2) To evaluate the importance of ship biofouling as a pathway for the introduction and spread of AIS into the Canadian Arctic. Using a questionnaire that follows the IMO Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species, this project will 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 will be cross-referenced with global positioning information to determine the longer history of

vessel activity in order to conduct a risk assessment.

3. Study of plankton distribution in ballast tanks in order to collect a representative sample for compliance testing (2015-2018)

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. Preliminary findings and recommendations were published in 2018 (Rajakaruna *et al.* 2018).

4. Comparison of sampling devices and analytic methods for ballast water compliance monitoring (2015-2018)

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. Results were published in the special issue on Recent Advances in Ballast Water Research in the Journal of Sea Research (Bradie *et al.* 2018).

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, man-

agement 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 2015-2017, collection of port samples (including eDNA samples) and training programs were conducted in the Arctic Ports of Churchill, Iqaluit, Deception Bay and Pond/Milne Inlet. Lab analysis of these samples and identification/genetic analyses are currently ongoing. Results on zooplankton and dinoflagellates have been incorporated into two master theses (ongoing work).

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)

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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). A primary paper on an assessment of recreational boating as a vector for marine non indigenous species on the Atlantic Coast of Canada has been submitted.

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)

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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).

8. In-transit survival and post-arrival performance of hull fouling aquatic invasive species (2017-2019)

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Ships may act as vectors of introduction for aquatic invasive species (AIS) through hull fouling. However, there is limited understanding of the survival of fouling species following short-term in-transit changes in environmental conditions. Normally, last port-of-call (LPoC) information is used to assess the relative risk of introduction of AIS. However, species present in hull fouling communities may be very different from those in the LPoC given that organisms may have accumulated over time through voyages to multiple destinations subjected to a variety of environmental conditions. Further, it is typically assumed that individuals from populations of a given hull fouling species across a range of latitudes have similar probabilities for survival in novel receiving environments, although studies of other organisms show that physiological performance and capacity for adaptation may vary substantially depending on population of origin. This study used a two-step approach for studying the environmental tolerances for survival and post-arrival performance of fouling organisms. The first will evaluate AIS survival and recovery following exposure to short-term changes in salinity and temperature simulating pathways with transitions between marine and freshwater and back to marine environments, or vice-versa. The second will evaluate the performance and acclimation capacity of fouling AIS populations from different latitudes to the full range of expected temperatures in Canadian waters (temperate-polar). The results of this project will provide a better understanding on fouling vectors and the response of species to changes in environmental conditions. This can contribute to the development of more complete and realistic hull fouling risk assessments.

9. Control of the invasive vase tunicate, *Ciona intestinalis*, on the Burin Peninsula, NL to prevent the spread through vessel vectors (2015-2018)

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Marguerite Farrell-Drake Harbour Authority, Burin, NL Canada

A three year project to remove and control the vase tunicate (*Ciona intestinalis*) in Little Bay, Burin Peninsula has been completed. The project was funded by DFO SPERA (Strategic Program for Ecosystem-based Research Advice) and the Provincial Department of Fisheries and Aquaculture with additional support from DFO Oceans, Memorial University and NAIA. The purpose of the project was to remove and control vase tunicate in the areas (Little Bay, Marystown) where early detection made removal feasible. Eradication in an open marine environment is not possible, but control of this invasive tunicate species appears to be very effective. Although harbours in Little Bay and Marystown have been mitigated and controlled in the area, the harbour in Burin which was not part of the mitigation project continues to be invaded by the vase tunicate. It is particularly important to control the spread from this active fishing harbour before it is spread to other areas. Currently, Burin is the only non-controlled area for this invasive tunicate in NL. In order to prevent the introduction or spread from this source harbour, the vectors (movement through boating) and source populations required a rapid response while the temperature is low and the invading species are not reproductive. These vectors include stationary infrastructure, floating infrastructure, vessels and gear. This project provided trials to treat (remove from the water or clean) the floating docks and vessels (which were also treated with antifouling paint... These control actions are allowed and recommended within the *Aquatic Invasive Regulations* for the *Canadian Fisheries Act*.

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Estonia

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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, 2016 and 2017. 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. 2018).

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. 2018).

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 prepared:

- 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 system is 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 oceanicus*, *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.* 2017). We have also investigated the feeding of the dominant small pelagic fish – herring *Clupea harengus membras* and three-spined stickleback *Gasterosteus aculeatus* – in the Gulf of Riga (Baltic Sea) in the summers of 1999–2014. From the total of 9,652 stomachs, 26 different prey items were identified. Most frequent of these were the cladoceran *Bosmina* spp. (present in 50% of all nonempty stomachs), followed by the copepod *E. affinis* (36.7%) and the non-native large predatory cladoceran *C. pengoi* (21.0%). Judging from the relative proportion and frequency of occurrence, *Bosmina* spp. and *E. affinis* were the most consumed prey items; in the diets of three-spined stickleback and large herring, *C. pengoi* also contributed substantially (17% and 27%, respectively; Ojaveer *et al.* 2017).

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 variable. The effects of *R. harrisii* varied among different habitats with the crab mostly modifying taxonomic com-

position and species abundances of meiobenthic communities mostly on unvegetated soft bottom sediments (Lokko *et al.* 2015). Laboratory experimental evidence of separate and interactive effects of *N. melanostomus* and *R. harrisii* on benthic invertebrate communities in a shallow coastal ecosystem of the Gulf of Riga demonstrated that round goby and mud crab exerted a significant predation pressure on different benthic invertebrate species and the effects of the studied predators were largely independent (Nurkse *et al.* 2017)

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).

BONUS symposium on Science delivery for sustainable use of the Baltic Sea living resources (Tallinn, Estonia, 17-19 October 2017)

PROJECT INFORMATION

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 developing further action plan (project funded under Estonian Environmental Investments Centre)

Contact: Kristiina Nurkse, Estonian Marine Institute, University of Tartu. Email (kristiina.nurkse@ut.ee)

2. Project Title Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping (INTERREG COMPLETE)

Contact: Henn Ojaveer, Estonian Marine Institute, University of Tartu. Email (henn.ojaveer@ut.ee)

The major involvement of shipping in uncontrolled introduction of invasive species, i.e. potential harmful aquatic organisms and pathogens (HAOP) remains an unresolved problem, which may have consequences on environment, economies and human health. To address this problem, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWMC 2004) and, more recently, the Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (2011). At the regional level, the HELCOM Baltic Sea Action Plan (2007) has set the ecological objective 'No introductions of alien species from ships'.

The management of both ballast water and biofouling of ships is a complex task. The BWMC will enter into force at the 8th of September 2017 and numerous decisions will have to be taken by port state administration and ship owners while implementing the convention. The HELCOM and OSPAR Commissions agreed in 2013 on a joint harmonised procedure (JHP) for BWMC A-4 exemptions to the requirement to treat ballast water based on the IMO Guidelines G7 (2007). The JHP, which aims to ensure a regionally efficient and transparent implementation of the Convention, should be further improved and operationalized regionally. The implementation of the IMO Biofouling Guidelines will help to achieve a 'win-win' solution, where the absence of biofouling reduces the risk of potential HAOP introductions, at the same time preventing chemical pollution by antifouling paints and increasing the ships' performance due to decreased fuel consumption and emissions.

COMPLETE is tackling several gaps and proposing operational frameworks and actual tools: measures on how to take into account rights and obligations of involved stakeholders; developing effective risk assessment procedures for ballast water management exemptions; ensuring active regional cooperation and information exchange of HAOP findings; proposing the integrated regional non-indigenous species (NIS) monitoring system and surveillance for compliance control with ballast water man-

agement standards. The target groups are national ministries and agencies of transport and environment; ship owners and their associations; Baltic Sea ports and coastal municipalities; shipyards; marinas and boating associations; HELCOM and its contracting parties. The associated project partners represent the key target groups benefiting from the project outputs.

COMPLETE is addressing one of the key challenges of the BSR with the ultimate goal to develop operational frameworks and provide user-oriented tools to make shipping more environmentally friendly and, whenever possible, without placing an unnecessary burden on the shipping industry.

RECENT PUBLICATIONS AND PRODUCTS

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Finland

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STATUS OF SHIPPING VECTOR ACTIVITIES AND RESEARCH

Finland finally ratified the IMO BWMC 8 September 2016 and with this ratification the Convention entered 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 in regional and international meetings related to the implementation of the EU MSFD and EU IAS Regulation. Finland is active in the joint HELCOM-OSPAR Task Group on Ballast Water Management Convention Exemptions (HELCOM/OSPAR TG BALLAST) where countries around Baltic Sea and North East Atlantic work to develop a common framework on the specific issues of exemptions for the BWMC, for the Baltic Sea (managed by HELCOM) and for the North East Atlantic (OSPAR) region. The Task Group started in 2013 and its eight meeting was held in Helsinki in November 2017 (www.helcom.fi/Helcom-at-work/groups/maritime/tg-ballast). 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 during 2017 and shows that there were no 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 and *Sinelobus vanhaareni* 2016).

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

PROJECT INFORMATION

1. Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping, COMPLETE (2017-2020).

Miina Karjalainen, Kotka Maritime Research Association

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

The project is led by Kotka Maritime Research Association, Finland and funded by INTERREG Baltic Sea Region Programme. There are 12 project partners from seven Baltic Sea countries. Finland is represented by five partner institutes (Kotka Maritime Research Association, Finnish Environment Institute, University of Helsinki: Dept of Environmental Sciences, Keep Archipelago Tidy and Kymenlaakso University of Applied Sciences). Project is tackling several knowledge gaps: the need to take into account rights and obligations of involved stakeholders; approaches for NIS monitoring

and surveillance for EU Marine Strategy Framework Directive (MSFD) and Ballast Water Management Convention (BWMC); risk assessment based exemptions from ballast water management requirements; legal aspects; regional cooperation and information exchange. Project results will provide comprehensive knowledge for decision making to understand the different antifouling practices in maritime and leisure traffic. Based on this knowledge, recommendations will be compiled which enable the development of harmonized biofouling management strategies for the entire Baltic Sea region. The project aims at developing a roadmap for a harmonized approach by involving all relevant stakeholders already during its development. This strategy will also benefit global approaches (e.g. IMO Marine Environment Protection Committee, MEPC) to address non-indigenous species introduction by biofouling and preventing chemical pollution by antifouling paints at the same time. SYKE is leading the work package 2 in the project where the aim is to develop and test new methods for NIS monitoring that could be taken into routine use in the Baltic Sea countries.

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

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

Okko Outinen, Finnish Environment Institute: okko.outinen@ymparisto.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) (completed in March 2017)

Maiju Lehtiniemi, Finnish Environment Institute: 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.

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

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

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

PUBLICATIONS:

- Bucklin A, Lindeque PK, Rodriguez-Ezpeleta N, Albaina A, Lehtiniemi M. 2016. Metabarcoding of marine zooplankton: prospects, progress and pitfalls. *J Plankton Res.* 1–8. doi:10.1093/plankt/fbw023
- Lehtiniemi M, Copp GH, Normant-Saremba M, Ojaveer H 2016: Alien species: EU list should add potential invasives. *NATURE Correspondence* 533(7603):231
- Ojaveer H., Olenin S., Narščius A., Florin A.-B., Ezhova E., Gollasch S., Jensen K.R., Lehtiniemi M., Minchin D., Normant-Saremba M., Stråke S., 2017. Dynamics of biological invasions and pathways over time: case study of a temperate coastal sea. *Biological Invasions* 19 (3), 799-813.
- Olenin Sergej, Narščius Aleksas, Gollasch Stephan, Lehtiniemi Maiju, Marchini Agnese, Minchin Dan, Srébalienė Greta 2016: New Arrivals: An Indicator for Non-indigenous Species Introductions at Different Geographical Scales. *Frontiers in Marine Science* 3: 208
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- Outinen O, Lehtiniemi M 2017. Literature Review for the Indicative Ballast Water Analysis Methods. *Trafi Research Reports* 10/2017
https://www.trafi.fi/filebank/a/1514987384/9af431e971eeade2559e583f748e9ee6/28957-Trafi_10_2017_Literature_Review_for_the_Indicative_Ballast_Water_Analysis_Methods.pdf

France

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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 UK 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 (biological traits such as growth rate, their prevalence and resistance to pollutants 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 as yet 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 NIS per boat in Plymouth and Brittany, respectively. The list of NIS spe-

cies 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 *Scytosiphondotyia*, 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.

Under the umbrella and initiative of the Western Australia government, an international initiative coordinated by Joana P. Dias made it possible to acquire vouchers and associated COI barcodes for 75 introduced marine species specimens (representative of all but four of the species listed in the “Western Australian Prevention List for Introduced Marine Pests”). This includes species that are native in France (e.g. the annelid *Sabella spallanzanii*) as well as species introduced in Europe, and France (e.g. the mollusk *Crepidula fornicata*, the ascidian *Didemnum vexillum* etc.; See Table S1 in Dias *et al.* (2017)). Other species are listed and indicated for monitoring because they are known to survive in ballast waters and fouling of vessels during transoceanic trips. European, including French researchers, were involved in this work. The reference collection supports the fast and reliable taxonomic and molecular identification of the 75 species, and is also useful in supporting the development of a variety of DNA-based detection strategies such as real-time PCR and metabarcoding of complex environmental samples (e.g. biofouling communities). This work paves the way for similar actions in Europe, for instance in light of the implementation of the Marine Strategy Framework Directive surveillance programme.

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.*, 2016).

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”: gross tonnage: 2803 UMS
- “Pourquoi Pas?”: gross tonnage: 7854 UMS
- “Atalante”: gross tonnage: 3559 UMS

Beginning with the RV "Thalassa», the solution retained was to retrofit the vessel with a Bio-Sea® 90 FX modular system, which combines a mechanical filtration with UV disinfection. This installation was approved by the French maritime affairs in September 2017. The BIO-SEA products have also been accepted by USCG (United States Coast Guard) as an AMS (Alternate Management System). The USCG type approval is currently in its administrative process as all BIO-SEA B range tests have been successfully passed. The final approval is expected in the first quarter of 2018.

Electronic logbooks for registering ballast operations for all three research vessels have also been developed and approved by the French maritime authorities. A feasibility study for retrofitting the RVs "Pourquoi pas?" and "Atalante" with a ballast water treatment system is scheduled for 2018.

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 was carried out in June 2017 to designate potential areas of ballast water exchange for those ships unable to conduct BW exchange in accordance with regulation B-4-1¹.

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.

During the summer of 2017, a flyer was handed out to owners of mega-yachts in the area of Monaco Principality and in neighbouring marinas of the French Riviera, as a result of collaboration between the ECOMERS laboratory of University of Nice Sophia-Antipolis and the Monegasque Association for the Protection of Nature (AMPN). The key message is a plea to not release any plants or animals from aquariums at sea, and to request yacht owners/managers who have on-board aquariums to make sure the water is properly treated (i.e. by ozonation, filtering or UV).

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

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

- DNA barcode reference libraries to catalogue biodiversity already reported at a worldwide level, including taxa of lower trophic level.
- Risk assessments of recreational boating as a vector of non-native species

MEETINGS

The French National Agency for Biodiversity (AFB) organized a workshop dedicated to environmental DNA: [a revolution for the management of aquatic biodiversity?](#) (Paris, 18/10/2017). Although most of the workshop dealt with freshwater and terrestrial environments where considerable progress had been made in the past years, one talk dedicated to marine NIS was provided F. Viard based on two review papers (Viard *et al.* 2016 and Darling *et al.* (2017)) to highlight the high potential (and challenges) of such tools for monitoring marine NIS, notably in light of the MSFD.

The [18th International Conference on Harmful Algae](#) will be held in Nantes from the 21-26th October 2018 in Nantes, France.

PROJECT INFORMATION

1. EMODNET Atlantic Checkpoint (2015-2018)

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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. This challenge handles the ability to identify & source alien species information in the sea basin, assesses whether the current available marine datasets are readily available and appropriate to the use case, as well as flagging up gaps in the current EU data collection framework. Scientific partners: AZTI (lead), Ifremer, IPMA, CSIC.

2. 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.* 2017). Among the species found, one cargo displayed the invasive tunicate *Asterocarpa humilis*, already reported in Europe and other regions in Chile. This report is supported by morphology and evidenced by molecular barcoding (using reference data developed earlier, Bishop *et al.* (2013)). A specimen was also found in a nearby shellfish farm, and further specimens in other aquaculture

seashell longlines and on harbor pilings. These findings extend the current distribution range of this species in Chile to a new marine ecoregion and are the first evidence that ship hulls can transport this species.

It is noteworthy that the cargo on which *A. humilis* was found has a shipping route 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.

3. AQUANIS2.0 (2016-2021)

Frédérique Viard, viard@sb-roscoff.fr

The AQUANIS 2.0 project, supported by the Fondation TOTAL, aims at developing 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, see 2016 WGITMO report).

4. Marine communities structuring: harbour ecology and invasion biology as comprehension tools (2017-)

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This ongoing project, supported by the Brittany Region and the Conseil Départemental Finistère, is focusing on biofouling assemblages in marinas. It specifically aims at examining the response of native vs. non-native species to environmental factors such as temperature and pollutants. Using environmental survey and experimental approaches, it aims to understand how abiotic factors are drivers of harbour community assemblages and potentially favor non-native species.

5. Atlantic Blue Port Services (@BLUEPORTS) - Interreg Atlantic Area (2017-2020)

Fabienne Vallée, fabienne.vallee@brest.port.fr

The cooperation project “@BLUEPORTS”, was selected by the Interreg Atlantic program in May 2017. It aims to rally the maritime community to jointly design attractive port based reception/treatment services for polluted water, starting with oil and ballast water. The ultimate goal is to create awareness and motivation to stop discharging at sea and, using the Atlantic Area as a support platform, to test enhanced solutions via pilot sites. For ballast water, the mobile port based treatment unit developed by [Damen Green](#) will move from port to port to be tested with port reception facility (PRF) operators, users and policy makers. It is a new service which could drastically reduce the economic and operational impact of the BWMC. The project, which is led by the Brittany Chamber of Commerce and Industry (CCI Bretagne), gathers 28 partners and associated partners across the Atlantic Area: PRF operators, public authorities/agencies, companies, universities, clusters and professional networks.

RECENT PUBLICATIONS AND PRODUCTS

- Darling, J.A., Galil, B.S., Carvalho, G.R., Rius, M., Viard, F., Piraino, S., 2017. Recommendations for developing and applying genetic tools to assess and manage biological invasions in marine ecosystems. *Marine Policy* 85, 54–64.
<https://doi.org/10.1016/j.marpol.2017.08.014>
- Dias, J., 2017. Establishment of a taxonomic and molecular reference collection to support the identification of species regulated by the Western Australian Prevention List for Introduced Marine Pests. *Management of Biological Invasions* 8, 215–225.
<https://doi.org/10.3391/mbi.2017.8.2.09>
- Fernandes J. A., Santos L., Vance T., Fileman T., Smith D., Bishop J., Viard F., Queirós A.M., Merino G., Buisman E. and Austen, M., 2016. Costs and benefits to European shipping of ballast-water and hull-fouling treatment: impacts of native and non-indigenous species. *Marine Policy*. Available on-line as an Early-View. 10.1016/j.marpol.2015.11.015
- Moodie, L.W.K., Trepos, R., Cervin, G., Larsen, L., Larsen, D.S., Pavia, H., Hellio, C., Cahill, P., Svenson, J., 2017. Probing the Structure–Activity Relationship of the Natural Antifouling Agent Polygodial against both Micro- and Macrofoulers by Semisynthetic Modification. *Journal of Natural Products* doi:10.1021/acs.jnatprod.6b01056
- Pinochet, J., Leclerc, J.-C., Brante, A., Daguin-Thiébaud, C., Díaz, C., Tellier, F., Viard, F., 2017. Presence of the tunicate *Asterocarpa humilis* on ship hulls and aquaculture facilities in the coast of the Biobío Region, south central Chile. *PeerJ* 5, e3672.
<https://doi.org/10.7717/peerj.3672>
- Viard, F., David, P., Darling, J.A., 2016. Marine invasions enter the genomic era: three lessons from the past, and the way forward. *Current Zoology* 62, 629–642.
<https://doi.org/10.1093/cz/zow053>

Germany

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SPECIES

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 Island²
- Brown algae *Undaria pinnatifida*, Sylt Island³
- Polychaet *Boccardia proboscidea*, Helgoland Island⁴
- 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 (Nestler 2017)
- Amphipod *Monocorophium uenoi*, first record for German Bight in Port of Bensen (Nestler 2017).
- Bivalve *Ruditapes philippinarum*, first living individuals in November 2016 at Langeneß (North Sea), later near the North Sea islands Föhr and Sylt (both 2017). This was recorded at BeachExplorer, a citizen science instrument, but the records were confirmed by Rainer Borchert (Schutzstation Wattenmeer e.V., Hafenstrasse 3, 25813 Husum, Germany).

New species found in 2017

- Two new arrivals were recorded for Germany in 2017 but they could not be added to AquaNIS yet as they were not identified to species level. One is in the Polychaeta Genus, *Laonome* (Lackschewitz pers. comm.). It was found 2016 in the Kiel Canal and 2017 in the Brunsbüttel locks (North Sea side of the canal) and in the port of Hamburg (Anja Schanz, pers. comm.). We noted Dutch records of *Laonome calida* in 2009 and in Belgium 2014, but it has to be certified yet if this German records are the identical species. Other records including Latvia (2012), Estonia (2014) and Sweden (2014) were reported as *Laonome* sp. The second species is a small, round shaped, dark colonial ascidian tunicate found in Büsum (North Sea). The taxonomic analysis is currently on going.
- *Styela clava*, known to occur along the German North Sea shores since 1997, was found at two stations during GEOMAR NIS rapid assessment monitoring in the Port of Kiel in 2017. The salinity is lower than anticipated for their occurrence. The taxonomy was confirmed by Thomas Stach. This is the first record from the German Baltic coast. The closest known occurrence is in Denmark in the Limfjord, but the species was not recorded in the Danish Baltic Sea (Kattegat).

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 is in force since 8th of September 2017. 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). From 2024 all ballast water on BWMC relevant vessels needs to meet the D-2 standard. 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 wa-

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>

ter management systems (BWMS).

Monitoring

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 (NIS) 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 NIS were found at floating pontons. Stone embankments hosted lower numbers of NIS.

The German targeted NIS monitoring revealed that the different sampling methods and approaches resulted in different numbers of NIS. 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 NIS monitoring 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 NIS during JHP. Recent studies in Lower Saxony (Nestler *et al.* 2017) demonstrated that, considering analyses of settlement plates from all harbour locations, the NIS - accumulation curve nearly reached saturation. Therefore it had been decided that RAS is complemented by settlement plates in the routine NIS monitoring. The NIS monitoring programme of the German North Sea and Baltic coast includes 17 locations.

BMVI Network of experts

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 NIS. 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 conducted in Hamburg and Kiel in 2017, questionnaires concerning the amount of ballast water used in inland transportation developed and distributed, leisure boats were sampled for biofouling in combination with questionnaires on antifouling used, biofouling management, routes and journeys of the respective boat. In addition, the marinas were sampled. As model region, the Elbe river with the ports of Cuxhaven and Hamburg and its inland and Baltic Sea connections (Kiel harbour and canal) and marinas in this area have

been chosen. Results will be presented at the next ICES meeting in Hamburg 2019.

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 <https://www.wmu.se/project/e-cme> or contact Josefin Madjidian, jam@wmu.se.

The BSH project BAQUA (Ballastwater Test Quality Assurance), the development of a prototype of a round robin test facility to compare sampling and analysis of various test facilities or methods, has been finalised in September 2017. The prototype is currently tested for its suitability before the full scale unit is constructed.

ONGOING PROJECTS

The German Federal State of Schleswig Holstein initiated a study to document NIS 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 and was successful to be funded. The project name is "Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping" (COMPLETE). This project will include all Baltic countries, including the Russian Federation who will participate as associated organization. COMPLETE is tackling several gaps in ballast water and biofouling knowledge and will result in the development of operational frameworks and actual tools, e.g., measures on how to take into account rights and obligations of involved stakeholders; developing effective risk assessment procedures for ballast water management exemptions; ensuring active regional cooperation and information exchange of harmful aquatic organisms and pathogens (HAOP) findings; proposing an integrated regional NIS monitoring system and surveillance for compliance control with ballast water management standards. The target groups are national ministries and agencies of transport and environment; ship owners and their associations; Baltic Sea ports and coastal municipalities; shipyards; marinas and boating associations; as well as HELCOM and its contracting parties. In summary, COMPLETE is addressing one of the key challenges of the Baltic Sea Region with the ultimate goal to develop operational frameworks and provide user-oriented tools to make shipping more environmentally friendly and, whenever possible, without placing an unnecessary burden on the shipping industry.

PLANNED RESEARCH

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 (EBP). This phase will comprise three stages: data gathering, data analysis, and Convention review. EBP is currently ongoing and first project findings are communicated to IMO. To facilitate the EBP (MEPC 70/4/14, paragraph 9), BSH plans 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 and in the context of slow steaming and prolonged docking times, 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. The above mentioned proposed Interreg Baltic project COMPLETE will address these issues in the Baltic Sea. These activities may be accompanied by the work of WGBOSV under ToR e.

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 2018). 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).

HELCOM Holistic assessment (HOLAS)

(<http://www.helcom.fi/Lists/Publications/State%20of%20the%20Baltic%20Sea%20-%20First%20version%202017.pdf>) and **OSPAR Intermediate assessment (IA)** (<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/>) have been performed in 2017/2018 in line with the reporting period of the EU Marine Strategy Framework Directive (MSFD). The indicator concerning Descriptor 2 on NIS is in both regional assessments the so-called trend indicator for new arrivals of NIS. Germany delivered data from running NIS monitoring for the assessments which slightly differ between HELCOM and OSPAR. In the future, the harmonisation of the assessments and indicators should be reached. This has already been mentioned by OSPAR within the COBAM-NIS expert group. In addition, a closer collaboration with the HELCOM/OSPAR TG Ballast is intended.

HELCOM/OSPAR TG Ballast continues its work on the amendment of the Joint Harmonised Procedure for the Contracting Parties of HELCOM and OSPAR on the granting of exemptions under International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation A-4, which has been adopted as OSPAR Agreement 2013-09 and by HELCOM Ministerial Meeting Copenhagen 3 October 2013. This work is done in close cooperation with the above mentioned COMPLETE project.

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 collaborat-

ing 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). Based on this report and a workshop on this subject conducted in 2017, the **Alien Species Management and Action Plan (MAPAS)** has been finalised in January 2018 and sent for presentation at the Leeuwarden (NL) conference in May 2018.

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 effect 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. At BSH, a database is developed which will comprise information on all non-indigenous species detected in German marine waters, including species detected on offshore constructions.

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 in-

roduced 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 NEOTIOTA group considers to use less than one new human-mediated NIS in the Baltic and less than two new human-mediated NIS in the North Sea per six years to indicate GES. Considering that at least 5 new species were found in 2016 only (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

Regulation (EU) 1143/2014 on invasive alien species (the IAS Regulation) entered into force on 1 January 2015, fulfilling Action 16 of Target 5 of the EU 2020 Biodiversity Strategy. It provides for a set of measures to be taken across the EU in relation to invasive alien species included on a list of Invasive Alien Species of Union concern. The first Union list entered into force on 3 August 2016 (no marine species, but see below). The first update of the Union list entered into force on 2 August 2017 with 12 additional species (no marine species).

At the EU IAS committee meeting at 5th December 2017, many members requested a pause before the list of IAS of Union concern is further updated, in order to allow you to focus on the implementation of the Regulation for the species that are already listed. The Commission services reflected on this request and decided to proceed as follows:

- The Scientific Forum on IAS will continue its work towards delivering its opinion on the risk assessments submitted in 2017, and any other risk assessments submitted in 2018 by the deadline of 10 February 2018.
- All risk assessments for which the Scientific Forum delivers a positive opinion will be brought to the IAS Committee for consideration together (both 2017 and 2018 submissions) in the context of a possible update of the Union list in 2019. Therefore, there will be no updating of the list in 2018.
- During 2018, the Commission and the Member States will focus on strengthening the implementation of the Regulation for those species that are already listed and work with economic actors to help prepare for potential listing of more species.

The update originally planned for 2019 includes one marine species, *Plotosus lineatus* (striped eel catfish). It is known to occur in the Red Sea, East Africa to Samoa, north to southern Japan, southern Korea, the Ogasawara Islands, south to Australia and Lord Howe Island. Palau and Yap in Micronesia. It sometimes enters freshwaters of East Africa (Lake Malawi) and Madagascar (www.fishbase.de, assessed 14 FEB 2018). No publicly available records of this species were found in AquaNIS.

On the list is so far only one marine (catadromous) species, i.e. the Chinese mitten crab. All other species are freshwater or terrestrial. 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. Three distinct types of measures are envisaged, which follow an internationally agreed hierarchical approach to combatting IAS:

- **Prevention:** a number of robust measures aimed at preventing IAS of Union concern from entering the EU, either intentionally or unintentionally.
- **Early detection and rapid eradication:** Member States must put in place a surveillance system to detect the presence of IAS of Union concern as early as possible and take rapid eradication measures to prevent them from establishing.
- **Management:** some IAS of Union concern are already well-established in certain Member

States and concerted management action is needed so that they do not spread any further and to minimize the harm they cause.

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 of the first list.

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 conducted at GEOMAR, Kiel to address the amount of disinfection byproducts in treated ballast water upon release (see below).

Helgoland coastal protection

Regarding the Natura 2000⁵ 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 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.

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

PROJECT INFORMATION

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

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The German alien species monitoring programmes continue with several sampling stations (Figure 1) 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.

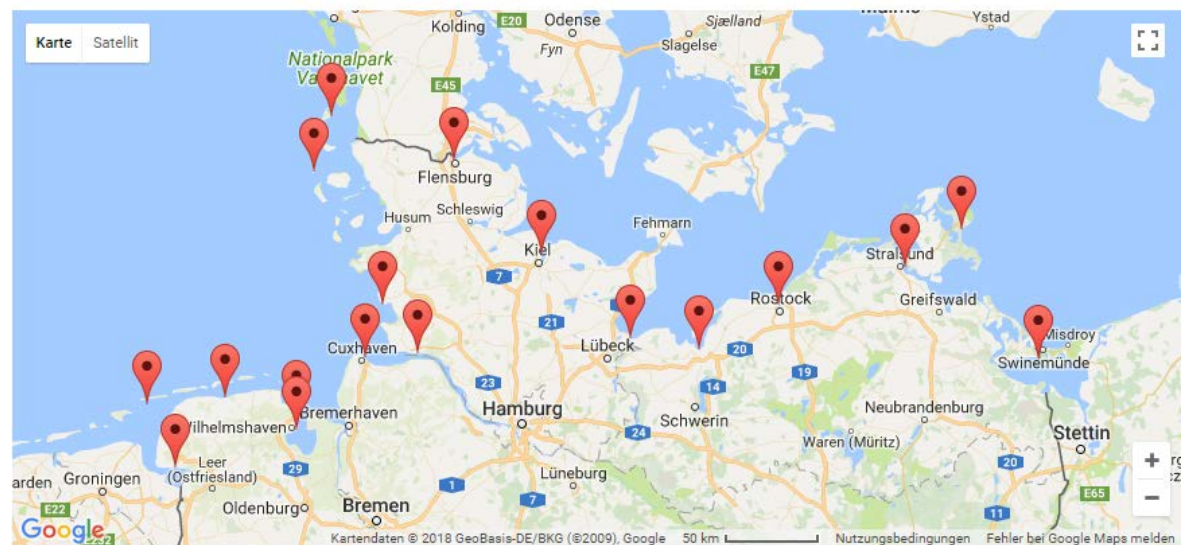


Figure 1 German stations involved in regular and/or rapid NIS assessments.

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

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Katja Broeg, Federal Maritime and Hydrographic Agency (BSH):

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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 challenge the methods used. The result report is in the making. The full report was made available in 2016⁶ and manuscripts were submitted to peer review journals and were published in 2017 as Special Issue of the Journal of Sea Research. Further, the overall results were published separately (Bradie *et al.*, 2017).

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)

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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: Leistungsvorschläge 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) (finished)

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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)

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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. Stephan Gollasch was involved as external expert in the BALMAS project. 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 accounts of Stephan Gollasch and Matej David.

⁶ <http://www.bsh.de/de/Meeresdaten/Umweltschutz/ReBaT-Projekt/index.jsp>

6. Independent Laboratory

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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 Control Union Water (CUW with laboratories at NIOZ), Wageningen University and Research (WUR – formerly known as IMARES), GoConsult and Dr. Matej David Consult d.o.o. and is offering land- and shipboard and other tests of BWMS. <https://industrialinspections.controlunion.com/en/our-services/ballast-water-systems>.

7. GlobalTestNet

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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. 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. Meetings are held approximately annually, with the most recent one in February 2018. The minutes of the meetings were published on the homepage <http://www.globaltestnet.org/home>.

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

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This project in a first step, combined and analysed the currently most comprehensive databases of native and alien species distributions of various taxonomic groups. This unique data set allowed the establishment of networks of reported alien species flows between countries for each taxonomic group. In a second step, these reported invasion networks were 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 were 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) (finished)

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Whithin this project, a prototype of a ringtest facility has been developed as basis for a full scale unit 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 the prototype was constructed in co-operation with the Alfred-Wegener Institute (B. Buck). Currently, it is tested before the full scale unit will be built.

10. Helgoland Island sampling activities

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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)

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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 Oldenburg*

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

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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)

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The research project was launched at GEOMAR, Kiel to address the amount of disinfection by-products 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 use of such technologies as a consequence of the 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 on board testing of ballast water was planned 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. Due to logistical difficulties less samples of active substance treated ballast water than planned could be taken and analysed.

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Lithuania

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STATUS OF SHIPPING VECTOR ACTIVITIES AND RESEARCH

Lithuania did not yet (March 2018) ratified the International Maritime Organization's International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC) although Lithuanian authorities are currently working on the ratification of BWMC and the Lithuanian Maritime Safety Organization strongly suggest ship owners to fulfill the requirements of the BWMC (LMSA, 2016-12-08, No 6(116)S-1488). From 2014-05-01 all ships entering the Lithuanian ports are obliged to change ballast waters in accordance with the BWMC D1, this rule is not applied to the ships operating only within the Baltic Sea. Since 2013-11-01 all ships under the Lithuanian jurisdiction must have a ballast water management log-book and BWM plan according to the Order of the Ministry of Transportation (Nr. 3-577/D1-841/V-1038).

PROJECT INFORMATION

Project AAA-BV (2015-03-16 - 2016-04-30)

funded by the Environmental Protection Agency (EEA grants programme) was aimed to prepare national documents needed for ratification of the BWMC. The project objectives were: to analyze national, foreign (especially from the Baltic Sea region) and international legislative acts related to the ballast water management; to develop the rules for ships calling to LT waters in relation to BWMC.; to identify LT institutions involved in ballast water management control and define their responsibilities and principles of interaction; to assess the risk of NIS introductions to LT waters with ship ballast water; to perform Port Baseline Biological Survey (PBBS); make recommendations for HAOPs monitoring. An adaptive system for granting exemptions (BWMC Regulation A-4) was developed, consisting of six major components: target species selection procedure, port-to-port RA, monitoring, information support, administrative decision and review process (Olenin *et al.* 2016).

Project BALMAN (2015-01-02 - 2017-12-31)

"Development of the ships' ballast water management system to reduce biological invasions" a joint Lithuania-Latvia-Taiwan cooperation fund project. This project was aimed at to foster the development of the ships' ballast water management system aimed at prevention of biological invasions in three countries involved by getting the synergetic effect from interdisciplinary expertise in ballast water management and bioinvasion research, involving researchers from Taiwan, Latvia and Lithuania. The Work was organized in 4 work packages, each involving different specialists, from ecologists and biologists to sociologists, mechanical engineers and information technology specialists: WP1 Environmental and socio-economic pressures associated with ship ballast water mediated biological invasions; WP2. Port sampling protocols and rapid assessment surveys; WP3. Stakeholder's perception towards ballast water management and evaluation of technical parameters of ballast water treatment systems and WP4. Information system aimed at synthesis and dissemination of the project results. The project resulted in publication of nine peer-reviewed papers in journals indexed in ISI WoS system, for example: two papers were published on the results of the biological survey performed by the Lith-

uanian and Taiwanese teams in the port of Kaohsiung, the largest port of Taiwan, and one of the largest ports of the world (Minchin *et al.* 2016a,b); three papers were published based on the data about non-indigenous species movements by ballast water and other vectors (Olenin *et al.* 2016; Olenin *et al.* 2017; Ojaveer *et al.* 2016).

Project COMPETE (10/2017 – 09/2020)

“Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping” was initiated by the Institute of Marine Research, Klaipėda University (IMR_KU) together with the Kotka Maritime Research Association, Finland. The main objective of the project is to minimize introduction of harmful aquatic organisms and pathogens (HAOPs) by shipping through the development of a consistent and adaptive management system for the Baltic Sea region. The overall goals are: 1) Harmonized implementation of the Ballast Water Management Convention; 2) Proposal (roadmap) for a regional biofouling management strategy; and 3) Consistent regional monitoring of non-indigenous species. In the project IMR_KU is responsible for the following activities: A2.1 Selecting innovative tools for detection of target harmful aquatic organisms and pathogens (e-DNA and other methods); A3.3. Delivering the regionally harmonized fully operational early warning system; A5.1. Information system on non-indigenous species and harmful aquatic organisms and pathogens (AquaNIS).

AquaNIS (2014-ongoing)

Information system on aquatic non-indigenous and cryptogenic species

<www.aquanis.ku.lt> Contains data on NIS and CS biological and other traits (including association with shipping vectors and availability of molecular data), salinity and temperature tolerance limits, introduction events in countries and country-regions in European regional seas, Northwest Pacific Ocean, New Zealand and Canadian Arctic. The system is maintained at a server of IMR_KU.

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Netherlands

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STATUS OF SHIPPING VECTOR RESEARCH

SUMMARY

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.

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, IMO has been notified of the certification of the InvaSave (MEPC 71/INF.4). 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. A recently published paper by van der Meer *et al.*, showed that in the North Sea, an area formerly considered to be homogenous patterns, as the present current pattern results in a natural barrier for organisms to move from East to West.

ACTIVITIES IN BALLAST WATER TESTING

MEA-nl (Marine EcoAnalytics)

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) has been 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).

A ballast water treatment system (BWTS) tested for certification at MEA-nl has been accepted by the U.S. Coast Guard (2017). A BWTS developed for small ships and making use of potable water has been certified by the NL administration, based on type-approval testing at MEA-nl (2017). The contingency BWT unit for ships entering port with non-compliant ballast water tested in 2016 by MEA-nl has been certified by the Netherlands administration and was launched in Groningen Seaports in 2017. Apart from that MEA-nl has conducted several filter-performance tests. Besides testing of BWTS, MEA-nl is exploring several other promising trajectories, has a monitoring programme for ambient water and conducts a validation programme for inverted microscopy for organisms 10-50 micron.

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 has informed 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, the MEA involvement in sediment studies has 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 ongoing, 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, while the test results were not affected by differences in DOC levels.

- 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.

Wageningen Marine Research (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 conducted an inventory of potentially invasive marine species and risks for introduction of NIS in the ports of Groningen Seaports and adjacent Wadden Sea areas; the study intended to serve as background information for the ports contingency project at Groningen Seaports. The project used classical taxonomy as well as molecular techniques (Slijkerman *et al.* 2017, WUR report C045/17).

CUC - CUW

The in 2015 established consortium of Control Union Certifications B.V. (CUC) and the Dutch ballast water treatment test companies, former NIOZ, now Control Union Water (CUW), former IMARES, now Wageningen Marine Research (WMR) and TNO together with the non-NL companies GoConsult and DavidConsult, offers testing services for BWMS manufacturers for IMO and USCG Type Approval testing. The consortium has been accepted as Independent Laboratory by the US Coast Guard according to the regulations in 46 CFR 162.060. Control Union Certifications B.V., a global network of inspection/certification, specialises in independent worldwide certification, cargo surveying and superintendence. The consortium, carried out and planned R&D testing for a range of BWMS manufacturers, in the context of acquiring BWMS certification in accordance with IMO and USCG requirements.

WMR by its name change underpins the institutes relationship with Wageningen University. CUW resulted from an alliance between the BWMS test facility formerly located at NIOZ and CUC to perform ballast-water related test activities.

The consortium has since been joined by the Northeast Midwest Institute's Great Ships Initiative (GSI) for Shipboard testing and the American Bureau of Shipping (ABS) for services in support of the readiness evaluation of ballast water management systems as required by 46 CFR 162.060 and the IMO G8 Guidelines.

In 2016 CUC conducted several projects together with subcontractors within its consortium (WMR, GoConsult, DavidConsult, CUW, GSI).

- CUC, WMR, Goconsult and DavidConsult have prepared the Basic Approval Application of the MICROFADE II ballast water treatment system has been submitted by the Netherlands and has been assessed GESAMP-BWWG (MEPC 71/4/3).
- CUC and CUW conducted multiple land-based test cycles in the context of Type Approval testing.
- CUC and GSI conducted multiple shipboard test cycles in the context of Type Approval testing.

In 2018 CUC conducts ballast water treatment system type approval testing for US Coast

Guard and IMO G8 type approval and G9 final approval.

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

PLANNED RESEARCH

MEA-nl will continue to perform comparative studies of different analytical methods in view of verification testing,

Other planned research by MEA-nl:

- Investigating the relationship between ballast-water performance testing and levels of organic matter in the ambient water.
- Investigating the relationship between bioregions and the US Coast Guard requirements.
- Validation of the analytical methods PAM Fluorimetry and Flow Cytometry for use in testing BWTS performance.

CUC will continue to coordinate and execute multiple testing projects in the context of US Coast Guard Type Approval, IMO G8 Type Approval and IMO G9 Final Approval.

RESEARCH NEEDS

- Comparative studies on emerging monitoring methods for Port-State compliance, which are based on standard scientific methods, could be stimulated through co-operation within the framework of BOSV
- Statistical clarity on the margins for required numbers of organisms per unit volume, such as 10/...ml.
- Investigations that can unveil the validity of criteria for challenge water. [demonstrate the validity].
- Examining the role of national law on the possibility to perform WET tests as required by IMO and the USCG. As an example: In the Netherlands performing WET tests on live animals (as required) have to be conducted according to the national Law on Animal Experiments (1984?), which entails that such tests have to be outsourced to a laboratory abroad.

RESEARCH GAPS

- Consequences of the low priority given to the experience-building phase as proposed by IMO
- The role of the absence of ship-owner data performance of certified BWTS once installed and operated on board.
- the role of assumptions that are not based on a sound base of knowledge in the requirements for BWTS testing on the true validity of such testing and on the pressure to achieve.
- Any potential difference in robustness between BWTS performance tests that are making use of natural ambient water only and those that use water augmented by standard test organisms (STO)s.
- The role of organic matter in the test water and ecotoxic effects of BWT, more specifically on the formation of relevant chemicals (toxic by- and end products)

MEETINGS

- Rapid assessment of Port Sloehaven in the Westernschelde;
- Development of monitoring programme specific for alien species in the Wadden Sea;
- 18th International Congress on Marine Corrosion and Fouling (ICMCF) Toulon, June 19-24 2016
- 19th International Congress on Marine Corrosion and Fouling (ICMCF), Melbourne, Florida, June 25-29 2018.

PROJECT INFORMATION

Soorteninventarisatie oesterputten en oesterpercelen, 2015 (Project Species inventory oyster pits and plots, 2015)

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

In the summer of 2015 a species survey was conducted focusing on all sublittoral oyster culture beds in the Netherlands and a series of inland water basins, which are used to keep local and imported shellfish alive just before they are sold to the market. On the oysters and in these water basins a relatively high number (in comparison to numbers known from mussel beds) of non-native species was found.

Inventarisatie van de tarrastortplaatsen in de Oosterschelde, 2015 (Project Species inventory of disposal sites for shellfish tarra in the Oosterschelde, 2015)

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To study the potential risk of invasive species spread related to broken shells, algae and other material that is disposed in the Oosterschelde by the shellfish industry, a species inventory was conducted in December 2014 and January 2015 at three locations that were designated by the Dutch ministry these disposals. In comparison to other sites in the Oosterschelde a relatively high number of non-native species was recorded at these sites

Construction of trilateral database including all non-native species recorded in the Wadden Sea, 2016

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, in 2016 a database was constructed including all non-native species that were ever recorded in the trilateral database, including e.g. date of first sighting in the Netherlands, Germany and Denmark, transport vectors, etc. (Gittenberger, 2016).

Construction of list of non-native species recorded in the Dutch Delta during non-native species focused, shellfish production related, surveys, 2016.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, in 2016, to assess which non-native species may be transported by shellfish transports or other shellfish production related activities, a list was constructed of non-native species recorded on [1] commercial oyster and mussel plots, [2] on dumping grounds and [3] in the oyster-ponds in the Dutch Delta region.

The risk was assessed for the route port of Hull - port of Rotterdam, questioning whether an exemption to the ballast water convention could be granted for this route based on OSPAR/HELCOM guidelines, 2016-2017.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned in 2016 by the shipping industry, based on surveys done in the ports of Hull and Rotterdam following the OSPAR-HELCOM guidelines, it is being assessed whether an exemption to the ballast water convention could be granted. This process is ongoing in 2017.

Non-native species survey of the port of Vlissingen (Sloehaven), 2016a.

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Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, in 2016, a port survey was conducted of the port of Vlissingen (Sloehaven) according to the OSPAR/HELCOM port survey protocol.

Non-indigenous species presence and distribution in intertidal hard substrate environments of the Western Scheldt, 2016

EcoAuthor / Sander Wijnhoven / sander.wijnhoven@ecoauthor.net

Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, in 2016, transect survey throughout the Western Scheldt. 2-seas regions project.

Fouling monitoring in the Westerschelde, 2016-2017.

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Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, from 2016 to 2017 five locations in the Westerschelde are monitored with SETL (settlement) plates on a three-monthly basis to assess the presence and spread of non-native fouling species in the ports and harbours of the Westerschelde along a salinity gradient varying from marine to brackish waters.

Trilateral Monitoring and Assessment Programme for Alien Species Wadden Sea, 2016

Bureau Waardenburg / Tom van der Have/ t.m.van.der.have@buwa.nl

Commissioned by the Common Wadden Sea Secretariat in 2016, proposal for harmonised monitoring program

Monitoring the port of Den Helder, a port of the Royal Dutch Navy, 2016-2018.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, since 2016, for two years, the biodiversity in the port of Den Helder is monitored with SETL (settlement) plates on a three-monthly basis with a focus on the presence and spread of non-native fouling species in the ports. In addition the fouling (with a focus on non-native fouling species) on at least three navy vessels per year is assessed directly after these vessels are taken out of the water in a dry dock for maintenance.

Biofouling as a transport vector of non-native marine species in the Dutch Delta, along the North Sea coast and in the Wadden Sea, 2016.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned in 2016 by the shipping industry, based on surveys done in the ports of Hull and Rotterdam following the OSPAR-HELCOM guidelines, it is being assessed whether an exemption to the ballast water convention could be granted for this route. This process is ongoing in 2017.

Non-native species survey of the port of Vlissingen (Sloehaven), 2016b-2017.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

Commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority, in 2016-2017, an assessment was made of the risk of biofouling in the Netherlands, with a focus on pleasure crafts. The study was based on existing risk assessments, total species inventories, students' projects, citizen science-based studies and the continuous monitoring project SETL that focuses on non-native species in pleasure craft harbours. It is stated that harbours are well-known as places where non-natives are primarily introduced into NW Europe. In addition it is concluded that hull fouling at this moment, is probably the main transport vector with which non-native marine species get introduced into the Netherlands and subsequently transported along the Dutch coast.

Biofouling as a transport vector of non-naïve marine species in the Dutch Delta, along the North Sea Coastthe North Sea coast and in the Wadden Sea.

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

An assessment was made of the risk of biofouling in the Netherlands, with a focus on pleasure crafts. The study was based on existing risk assessments, total species inventories, students' projects, citizen science-based studies and the continuous monitoring project SETL that focuses since 2006 on recording non-native species in pleasure craft harbours. In total more non-native species were found in harbours than on dikes, shellfish beds, reefs, and in soft sediments in the Dutch Delta, along the North Sea coast and in the Wadden Sea.

Report: Gittenberger, A., Wesdorp, K.H. & M. Rensing, 2017. Biofouling as a transport vector of non-native marine species in the Dutch Delta, along the North Sea coast and in the Wadden Sea. GiMaRIS rapport 2017_03: 48 pp. issued by Office for Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority.

Transport vectors of non-native species in the Dutch North Sea

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A total list of species that have been recorded over the years in monitoring programs in the Dutch part of the North Sea was constructed in 2016, commissioned by the Dutch ministry of economical affairs (Bos *et al.*, 2016). This includes 77 species that are non-native to the Netherlands. They have been introduced by either their natural distribution capacities from neighbouring countries, or by anthropogenic vectors linked to e.g. shipping and fishery activities. Of these species 66 find their origin outside NW Europe. The study focused on assessing the most likely vectors of transport. In recent years hull fouling was concluded to be the most import vector of import for alien species in Europe and within the Netherlands.

Report: Gittenberger, A. & M. Rensing, 2017. Transport vectors of non-native species in the Dutch North Sea. GiMaRIS rapport 2017_04: 7 pp. issued by Ministry of Economic Affairs (of the Netherlands), Department of Nature & Biodiversity.

Monitoring non-native species in the port of Vlissingen in 2016 conform the joint HELCOM/OSPAR port survey protocol

GiMaRIS / Arjan Gittenberger / Gittenberger@gimaris.com

In 2017 a report was finalised on the results of the 2016 non-native species survey w in the Sloehaven, Vlissingen, The Netherlands, following the HELCOM/OSPAR port survey protocol, which is part of the "Joint harmonised procedure for the contracting parties of HELCOM and OSPAR on the granting of exemptions under the international convention for the control and management of ship's ballast water and sediments, regulation A-4" (HELCOM/OSPAR, 2013). In total 336 samples were taken from 149 different sampling locations in four research areas within Sloehaven region in spring and late summer. In these samples a total of 220 species were identified to the species level of which 30 were non-native.

Report: Gittenberger, A., Rensing, M, Schrieken, N & H. Stegenga, 2017. Monitoring non-native species in the port of Vlissingen in 2016 conform the joint HELCOM/OSPAR port survey protocol. GiMaRIS report 2017_05: 49 pp. issued by Ministry of Economic Affairs (of the Netherlands), Department of Nature & Biodiversity.

Risk Assessment of the bryozoan *Biflustra grandicella*

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A risk assessment was done for the corn-flak coral *Biflustra grandicella*, which was recorded in Europe for the first time in the winter months of 2016-2017 in The Netherlands. The risk assessment was commissioned by the Office for Risk Assessment and Research of the Netherlands Food and Consumer Product Safety Authority and based on the Harmonia+ methodology.

Report: Gittenberger, A. & M. Rensing, 2017. Risk Assessment of the bryozoan *Biflustra grandicella*. GiMaRIS report 2017_42: 17 pp. issued by Ministry of Economic Affairs (of the Netherlands), Department of Nature & Biodiversity.

Overview alien species monitoring in the Western Scheldt

Ecoauthor, GiMaRIS & eCoast

In 2017 a report was finalised with an overview of the monitoring efforts and the presence of alien species among macrofauna, macro-algae and plankton that have been recorded in the Western Scheldt. The basis of this study is the (ongoing) monitoring and inventory work of the companies GiMaRIS, eCOAST and Ecoauthor with a focus on alien species in the estuary supplemented with alien species recordings in long-term monitoring programmes within the frame of MWTL. For each of the alien species the first year of observation and their current distribution in the Western Scheldt is presented on the basis of different monitoring techniques. The number of recordings with different techniques at different sites, identify best habitats and sites (potential hotspots) for observation of different types of alien species. Most important vectors of primary introduction appear to be shiphull fouling and ballast water although the natural dispersal of alien species from sources in the vicinity is important as well.

Report: Wijnhoven, S., Gittenberger, A., Faasse, M., Schellekens, T. (2017). Overview alien

species monitoring in the Western Scheldt: Current status of monitoring efforts and presence of alien species among macrofauna and algae. Ecoauthor Report Series 2017 - 01, Heinkenszand, the Netherlands.

Non-indigenous species and risks from ballast water in Eemshaven and Delfzijl

Wageningen Environmental Research & GiMaRIS

In 2017 a report was finalised with the results of a baseline study in the port of Eemshaven and the port of Delfzijl, managed by the port authority Groningen Seaports (GSP), in order to describe the present species community, both indigenous and non-indigenous. The monitoring approach was adapted from available HELCOM/OSPAR protocols and comprised sampling in various relevant habitats (sediments, water and hard substrates, including pontoons, pillars, quays and SETL plates). In a selection of samples, species were detected using DNA metabarcoding (resulting in eDNA profile) techniques. In the harbour of Eemshaven a total of 262 species were found and in Delfzijl 202 species. In both harbours together, 332 unique species were identified, of which 47 are known non-indigenous species.

RECENT PUBLICATIONS AND PRODUCTS

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- 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.
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- 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 69/INF.15 - Information on the type approval of the Van Oord Ballast Water Management System (Netherlands)
- MEPC 71/4. - Application for Basic Approval of the MICROFADE II Ballast Water Management System. (Netherlands)
- MEPC 71/4/13. Contingency planning for ballast water management, port solution (Netherlands)
- MEPC 71/4/14. Analytical methods for determining viability of organisms in the 10 to 50 µm size class. (Netherlands)
- MEPC 71/INF.4. Information on the type approval of the Damen InvaSave 300 ballast water management system (Netherlands)
- MEPC 71/INF.32. Notes on the same-risk area concept based on the conditions in the North Sea (IUCN)
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- Report: D.M.E. Slijkerman, S.T. Glorius, A. Gittenberger, B.E. van der Weide, O.G. Bos, M. Rensing, G.A. de Groot, 2017. Monitoring Groningen Sea Ports, Non-indigenous species and risks from ballast water in Eemshaven and Delfzijl. Wageningen, Wageningen

Marine Research (University & Research centre), Wageningen Marine Research report C045/17 A. 81 pp.

Norway

Report Prepared By:

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Summary

The IMO Ballast Water convention has entered into force, and the Norwegian authorities has

amended laws and regulations accordingly.

The return of foreign deployed oil service vessels for anchorage has demonstrated the importance of oil service vessels as potential vectors. An inventory of a newly arrived vessel in 2016/2017 revealed numerous NIS from attached to hull/ "moon pool"

a. *IMO Ballast water convention entered into force September 2017*

<https://www.sdir.no/aktuelt/nyheter/ballastvannkonvensjonen-i-kraft-fra-september-2017/>

b. *Revision of regulation for ballast water exchange in Norwegian waters*

<https://www.sdir.no/aktuelt/nyheter/ballastvannkonvensjonen-i-kraft-fra-september-2017/>

STATUS OF SHIPPING VECTOR RESEARCH

Since 26th of January 2017, NIVA can provide US Coast Guard testing to the English Class Society Lloyd's Register as approved subcontracted test facility, in addition to the Norwegian Class Society DNV-GLS

in accordance with 46 CFR 162.060-26 (Land based testing) and 46 CFR 162.060-28 (Shipboard testing). Contact: Stephanie Delacroix, NIVA. Stephanie.delacroix@niva.no

As a part of a NIS citizen science program for divers, several Rapid Coastal Survey exercises were made in marinas in Western Norway during 2016 and 2017. Divers had the opportunity to visit a newly arrived ROV vessel arrived from anchorage in the Mexican Gulf. In the "moon pool", a large hollow structure for lowering ROVs and diver's bells, numerous species (more than 40 different taxa) from several systematic groups: molluscs, crustaceans, fish, and bryozoans were found. At a revisit to the vessel some 6 months later, no live specimens were found, neither on the vessel, nor in the surrounding area. The results are under preparation for a paper. Contact: Vivian Husa, IMR, Vivian.husa@hi.no. The studied area was close to the city Haugesund N 59.307, E 5.356.

PLANNED RESEARCH

During 2018, similar RCS exercises will be made in an oil service vessel anchorage area further north, close to the city Ålesund N 62.401, E 6.130.

Norway has recently launched a new ice-classed research vessel. Studies on both hull fouling in Arctic and Antarctic waters, and ballast water treatment system performance and low water temperatures are being planned.

RESEARCH NEEDS

Exchange of check-lists, exchange of primers / sequences for relevant organism groups and target species. Development/validation of eDNA methods for NIS.

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/brackish water 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

Visits and revisits to oil service vessel anchorage sites. Contact: Vivian Husa, IMR. Vivian.husa@hi.no

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

Rinde, E (ed) Utvikling av metodikk for overvåking av fremmede marine arter: (Development of methods for the monitoring of alien marine species). In Norwegian W/English summary. NIVA rapport L.NR. 7131-2017

<http://www.miljodirektoratet.no/Documents/publikasjoner/M723/M723.pdf>

Poland

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STATUS OF SHIPPING VECTOR RESEARCH

Ratification of the International Maritime Organization's International Convention for the Control and Management of Ships' Ballast Water and Sediments (the BWMC) was suspended in the second half of 2017, after the inter-ministerial as well as public consultations had been completed. The reason was the need to advance works on the amendment of the Act on the Prevention of Pollution from Ships (and some other national Acts), which has to be adjusted to BWMC requirements. The completion of works is expected in the middle of 2018, then Poland will ratify BWMC.

In 2016 Ministry of Maritime Economy and Inland Navigation obliged authorities of four Polish sea ports (Szczecin, Świnoujście, Gdynia and Gdańsk) to carry out the non-indigenous species (NIS) survey, based on Joint Harmonised Procedure for the Contracting Parties of HELCOM and OSPAR. Information on NIS representing different ecological formations (plankton, benthic infauna and epifauna, fouling organism) as well as environmental factors within the port area could be used for granting of exemptions under BWMC, Regulation A-4. Unfortunately, due to the delays in the preparation of national guidelines, as well as numerous methodological doubts submitted by potential contractors, port survey has not been performed in 2017. It is very likely that it will start in spring 2018.

Poland is the second country after Germany with the largest number of non-indigenous species in the Baltic coastal waters (Ojaveer et al., 2017). Shipping is an essential vector of all introductions. It is very likely, that the last two NIS recorded in Poland, an American amphipod *Melita nitida* (Normant-Saremba et al., 2017) and tanaidacean *Sinelobus vanhaareni* (AquaNIS, 2015) were introduced on hulls of recreational craft or commercial vessels. Both species have no larval stage in their life cycle and have appeared for the first time in the Port of Gdynia. Both species were found due to the studies of fouling communities in the Port of Gdynia as well as mobile epifauna with the aid of artificial habitat collectors filled with oyster shells (hard bottom). For this reason, it is necessary to take action not only to manage the introduction of NIS in ballast tanks, but also on ships' hulls (biofouling). It requires implementation of both international and regional regulatory requirements. Poland, together with partners from other six Baltic Sea states has been involved in the project COMPLETE, which started in October 2017 and is addressing in the broad context both major vectors of harmful aquatic organisms and pathogens, ballast water and biofouling. It is therefore expected that in the next three years gaps concerning biofouling issues in Poland will be filled as well as the challenges related to BWMC implementation will be met.

PLANNED RESEARCH

- In 2018 it is planned to assess an overall biofouling potential of commercial ships and leisure boats. It is also aimed to prepare a map of risk areas which

are prone to be colonised by NIS. National biofouling regulations, cleaning procedures and facilities will be collected to create interactive map of hull cleaning services. Planned research will be also focused on benefits of biofouling management on ship speed, fuel consumption and emissions. The meetings with national stakeholders will be organized to get and share between all associated organisations experience and knowledge on biofouling management which in the near future will enable policy makers to implement harmonized biofouling management strategies for the entire Baltic Sea region.

- Biological monitoring of Polish ports according to Joint Harmonised Procedure for the Contracting Parties of HELCOM and OSPAR will be performed from Spring to Autumn 2018.

RESEARCH NEEDS

- Studies showing significance of biofouling as the vector of introduction and spread of NIS.

MEETINGS

- Harbours Review Spotlight - Ballast Water Management Seminar, EU Transport Week, March 2017.
- National Marine Environment Protection Committee (MEPC) section at the Centre for IMO Affairs meeting, April and October 2017.

PROJECT INFORMATION

1. Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping, COMPLETE (2017-2020).

Monika Normant-Saremba, University of Gdansk: monika.normant@ug.edu.pl

Joanna Hegele-Drywa, University of Gdansk: joanna.hegele-drywa@ug.edu.pl

This project is led by Kotka Maritime Research Association, Finland and co-funded by INTERREG Baltic Sea Region Programme. There are 12 project partners from 7 Baltic Sea states. Poland is represented in the project by the University of Gdańsk. As many as 23 associated organizations from 8 Baltic Sea states representing marine sector and project target groups are also involved. Project is tackling several gaps: the need to take into account rights and obligations of involved stakeholders; approaches for NIS monitoring and surveillance for EU Marine Strategy Framework Directive (MSFD) and Ballast Water Management Convention (BWMC); risk assessment based exemptions from ballast water management requirements; legal aspects; regional cooperation and information exchange. The technical aspects of that complex problem include yet limited knowledge on antifouling practices and procedures (and resulting level of biofouling); the lack of common cleaning procedures and facilities, their cost-efficiency analysis; quantities of biofouling waste and its handling procedures; the role of leisure boats and their trailers in primary introductions and secondary spread of non-indigenous species (NIS). Project results will provide comprehensive knowledge for decision making to understand the different antifouling practices in maritime and leisure traffic. Based on this

knowledge, recommendations will be compiled which enable the development of harmonized biofouling management strategies for the entire Baltic Sea region. The project aims at developing a politically and strategically promising roadmap for a harmonized approach by involving all relevant stakeholders already during its development. This strategy will also benefit global approaches (e.g. IMO Marine Environment Protection Committee, MEPC) to address non-indigenous species introduction by biofouling and preventing chemical pollution by antifouling paints at the same time.

RECENT PUBLICATIONS AND PRODUCTS

- Brzana R., Janas U., Borecka A., 2017. New records of Conrad's false mussel *Mytilopsis leucophaeata* (Conrad, 1831) in the Vistula Delta. *Oceanological and Hydrobiological Studies* 46 (2), 231-236.
- Dobrzycka-Krahel A., Skóra M., Raczyński M., Szaniawska A., 2017. The signal crayfish *Pacifastacus leniusculus* - distribution and invasion in the southern Baltic coastal river. *Polish Journal of Ecology* 65(2), 445-452.
- Normant-Saremba M., 2017. Why does ballast water pose a danger to eco-systems? *Harbours Review (Voices)* 2 (14), 13.
- Normant-Saremba M., Marszewska L., Kerckhof F., 2017. First record of the North-American amphipod *Melita nitida* Smith, 1873 in Polish coastal waters. *Oceanological and Hydrobiological Studies* 46 (1), 108-115.
- Ojaveer H., Olenin S., Narščius A., Florin A.-B., Ezhova E., Gollasch S., Jensen K.R., Lehtiniemi M., Minchin D., Normant-Saremba M., Stråke S., 2017. Dynamics of biological invasions and pathways over time: case study of a temperate coastal sea. *Biological Invasions* 19 (3), 799-813.
- Szaniawska A., Dobrzycka-Krahel A., Jaszczolot J., 2017. Spiny-cheek crayfish *Orconectes limosus* (Rafinesque, 1817) on its way to the open coastal waters of the Baltic Sea. *Oceanological and Hydrobiological Studies* 46 (4), 451-463.
- Woźniczka A., Wawrzyniak-Wydrowska B., Radziejewska T., Skrzypacz A., 2016. The quagga mussel (*Dreissena rostriformis bugensis* Andrusov, 1897) – another Ponto-Caspian dreissenid bivalve in the southern Baltic catchment: the first record from the Szczecin Lagoon. *Oceanologia* 58 (2), 154-159.

Portugal

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This report was compiled with contributions from Inês Trigo (DGPM-Directorate General for Maritime Policy, Portugal), Rodrigo Fernandes (Bentley Systems), João Canning-Clode (Madeira research unit of MARE) and Paula Chainho (MARE, Faculdade de Ciências da Universidade de Lisboa).

LEGISLATION

Portugal has on the 31st of July 2017 officially approved for accession the Ballast Water Management Convention through the Decree-law nº23/2017 (Diário da República 1^a Série, nº 146, 31 Julho 2017). Following the entry into force of the Convention in 8 Sep-

tember 2017, Portugal deposited at IMO on 19 October 2017, the official document of approval of the Ballast Water Management Convention. In agreement with article 18, number 3, of the Convention, the Convention entered into force in Portugal on January 19, 2018.

In October 5-6, 2017, at the “Our Ocean” meeting in Malta, Portugal expressed the will to have a leadership role in ocean environmental protection and committed to develop new regulations by 2020 addressing the introduction of marine non-indigenous species to ensure the effective implementation of the Ballast Water Convention.

STATUS OF SHIPPING VECTOR RESEARCH

Several research projects on non-indigenous species have included risk assessment studies of fouling organisms in recreational marinas. These studies have allowed the continuous update of non-indigenous species (NIS) lists for continental Portugal and the Azores and Madeira archipelagos and the identification of fouling as the potential vector of introduction. In 2017, thirteen new NIS were added to the list, most of them with hull fouling as the major potential vector. In one case (Ctenophora *Mnemiopsis leidyi* A. Agassiz, 1865), the potential vector is considered to be ballast water. The complete species list with the associated references may be found in the annual national report for Portugal of ICES WGITMO 2017.

The start-up company, BIOMIMETX SA, founded in 2013, is developing research on biomimetic anti-fouling solutions to prevent marine biofouling. The company has isolated and characterized bacteria with natural biocide properties and expects to have a marketable product soon.

Regarding Ballast Water, two projects are currently being developed. One addresses the management and treatment of ballast water in port environments (Atlantic Area INTERREG project, @BlueportServices) and the other investigates the impact of human activities and climate change in marine communities in the Macaronesia region (INTERREG MAC 2014-2020 project: “Seguimiento, control y mitigación de proliferaciones de organismos marinos asociadas a perturbaciones humanas y cambio climático en la Región Macaronésica (MIMAR)”). The latter will include ballast water sampling in ports in the different archipelagos.

PLANNED RESEARCH

2018 – 2020 MONISPOR – Monitoring marine non-indigenous species in Portugal. Project to be submitted to the Blue Fund (“Fundo Azul”), National Funding Program a financial mechanism established by the Government of Portugal to promote the protection and monitoring of the marine environment, among other priority investment areas.

Planned research will focus on the development of a national wide monitoring program for non-indigenous species, particularly those with invasion potential. Recreational marinas and ports will be the target sites. Standardized protocols will be developed to be used at a national level. This work will support risk assessment of recreational boating as introduction vectors of non-indigenous species. As result of this work a national database for non-indigenous marine species will be produced, including relevant information for species identification, distribution maps, photographic records among other items.

RESEARCH NEEDS

There is the need to establish links between the scientific community, port authorities and state control institutions in charge of inspecting the implementation of the Ballast Water Management Convention. Port authorities and government institutions still have little awareness on the importance of maritime transport as a source of NIS.

It would be helpful to have a national focal point to foster research on ballast water and biofouling as a source of NIS and on the economic impact of these introductions. This would contribute to support decision making and implementation of management strategies.

RESEARCH GAPS

In Portugal research on risk assessment, prevention, management strategies and ballast water treatment is still at its infancy.

MEETINGS

March 2017, 1st Meeting on non-indigenous aquatic species in the Tagus river basin. Organized by MARE (Chainho, P., P. Anastácio & F. Ribeiro), Alcochete, Portugal.

September 2017, kick-off meeting of the Interreg Atlantic project @BlueportServices, Lisbon, Portugal.

PROJECT INFORMATION

1. @BlueportServices: Interreg Atlantic project, coordinated by CCI Brest (France), to promote ballast water treatment services in Port facilities in the Atlantic Arc, with three full partners from Portugal, namely, Bentley Systems (former Action Modulers)(national project coordinator), Eco-Oil, and the Administration of Madeira Ports (Portos da Madeira) (1, 2). Several other Portuguese institutions participate as associate partners, namely DGPM-Directorate General for Maritime Policy, DGRM-Directorate General for Maritime Resources, Fórum Oceano and port authorities from Lisboa, Setúbal, Açores, Leixões and Sines. The project objectives are related to the management and treatment of ballast water in port environments including development and testing of port based reception/treatment services. The project expects to actively contribute to the implementation of the Ballast Water Management Convention. The kick-off meeting took place in Lisbon, in September 2017.

Bentley Systems role in the project can be summarized as follows:

1. Coordinating Portuguese partners, improving communication between Project coordination, Portuguese ports, Administrations, companies and other national stakeholders.
2. Working on the Solution (treatment): Booking website for reserving ballast water treatment in Atlantic ports.
3. Working on the Problem Management: Tools for Managing environmental risk of ballast-borne marine invasive species.
4. Online On-demand (and on-the-fly) simulation of spreading / dispersion of polluted discharges at sea.
5. Average (pre-calculated) and dynamic (on-demand) ballast water risk index based on: (i) Ballast water sources / vessel information; (ii) Environmental conditions, currents, dispersion (combining climatology, remote sensing and forecast models); (iii) Location of

marine protected areas; (iv) Index inspired on existing strategies in REMPEC (Mediterranean), HELCOM (Baltic) and North Sea.

6. Ballast water uptake warning system: Concept based in BWM convention (Regulation C-2): (i) Notify mariners of areas under their jurisdiction where ships should not uptake Ballast Water due to known conditions (poor tidal flushing; high turbidity; near sewage outfalls; Identified HAB's in the surrounding areas); (ii) Propose alternative areas for uptake.

2. INTERREG MAC 2014-2020 project: "Seguimiento, control y mitigación de proliferaciones de organismos marinos asociadas a perturbaciones humanas y cambio climático en la Región Macaronésica (MIMAR)" with partners from Madeira (Madeira research unit of MARE – Marine and Environmental Sciences Centre, and University of Madeira), Canary Islands and Cape Verde. The project will include ballast water sampling in these locations in the coming years.

References

- (1) Jornal da Economia do Mar, <http://www.jornaldaeconomiadomar.com/blueports-discutido-portugal/>
- (2) Jornal da Economia do Mar, <http://www.jornaldaeconomiadomar.com/18111-2/>

Sweden

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STATUS OF SHIPPING VECTOR RESEARCH

Sweden is active in the joint HELCOM-OSPAR Task Group on Ballast Water Management Convention Exemptions (HELCOM/OSPAR TG BALLAST) where countries around Baltic Sea and North East Atlantic work to develop a common framework on the specific issues of exemptions for the Ballast Water Management Convention (2004), both for the Baltic Sea (managed by HELCOM) and for the North East Atlantic (OSPAR) region. The Task Group started in 2013 and has regular meetings where the eight meeting was held in Helsinki November 2017 (www.helcom.fi/Helcom-at-work/groups/maritime/tg-ballast). In Sweden it is the Transport Agency that grant exemptions from Ballast water management after advice from Swedish Agency for Marine and Water Management and Swedish Meteorological and Hydrological Institute. Within TG BALLAST a regional procedure for the exemption work, Joint harmonised procedure (JHP) has been developed. The JHP covers both the administrative processes for exemptions as well as the monitoring and risk assessments required when two countries are seeking exemption for a ship on fixed route between two ports.

The port monitoring protocols developed under HELCOM-OSPAR Joint Harmonised Procedure has been used in Swedish ports Gothenburg and Brofjorden (Lysekil). In Brofjorden also a study regarding taxonomical analytical methods has been conducted, where traditional taxonomy (microscopy) was compared with genetic taxonomy (DNA-analyses and meta-barcoding).

Ship hull as vector for spread of biofouling and alien species has recently got attention in Sweden. In the Swedish mitigation program with work required under EU-framework to reach Good Environmental Status in the Marine Environment there is a task with aim to develop guidance for authorities and actors regarding hull cleaning and management of both chemical (hazardous substances from antifouling paint) and biological (invasive species) pollution. A project with aim to gather global data and information regarding the work with hull cleaning recommendations and regulations to use as background material in coming development of Swedish recommendations for hull cleaning was carried out in 2016-2017 (financed by Swedish Agency for Marine and water Management). Further a literature study of recreational boats as vector for spread of alien species compared to commercial ships was conducted in 2016-2017 (financed by Swedish Agency for Marine and Water Management)

The project “Changing antifouling practises for leisure boats in the Baltic Sea” CHANGE financed by BONUS with aim to reduce antifouling toxins in the Baltic Sea ended in 2017 and have produced reports on alternative antifouling measures and recommendations for sustainable antifouling practises. The project “Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping” COMPLETE started in October 2017 and Sweden is working in the project together with six other Baltic Sea states.

Two biofouling species have been reported in the period, the serpulid tubeworm *Ficopomatus engimaticus* from Limhamn Marina, Malmö, Southern Sweden (from several panels with antifouling paint tested within the CHANGE project, autumn 2016) (pers comm. Fredrik Lindgren) and the barnacle *Austrominius modestus* from Öckerö marina, Gothenburg, West coast of Sweden, autumn 2017 (single example from antifouling paint project panel, Chalmers University of Technology, Lena Granhag)

PLANNED RESEARCH

During 2017–2018 the Swedish Agency for Marine and Water management will test and evaluate port monitoring through extended Rapid Assessment Survey (eRAS), for 2 ports and 2 marinas in the Baltic Sea and North Sea. eRAS has been developed by Germany for EU Marine Strategy Framework Directive.

Within the project COMPLETE Sweden and Chalmers University will investigate effect of hull cleaning on hard and soft biofouling from various paint types.

RESEARCH NEEDS

Collaborations considering hull cleaning recommendations in the Baltic Sea (HELCOM) and North Sea (OSPAR) area are wanted/needed from Swedish perspective. The responsible instances for areas where hull cleaning is performed is in the need of common guidance and standards, which also is requested by hull cleaning companies for permissions and development. The hull cleaning operators are moving between different areas/regions.

RESEARCH GAPS

The impact of hull cleaning on different groups of biofouling organisms needs to be in-

investigated with high resolution to resolve if cleaning will remove and/or destroy the organisms. Effect of cleaning on both different types of young stages (spores and larvae) and on adult stages with different fragility (soft and hard shell species) are needed to predict the further spreading capacities.

Studies of capturing of the biological and chemical waste during hull cleaning using different methods and leakage rates of toxins (for example Cu, Zn) from antifouling paints that are being cleaned are needed for future hull cleaning recommendations.

MEETINGS

Biofouling and hull cleaning workshop in Gothenburg 4-5 April 2017, organized by Chalmers and Lighthouse for environmental agencies, hull cleaning and shipping companies, ports and academia. About 40 participants from Sweden, Finland, Norway, Denmark and New Zealand) helped in the work to gather and identify need of background material in the development of future hull cleaning guidelines.

PROJECT INFORMATION

Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping” COMPLETE

Lena Granhag, Chalmers University of Technology. lena.granhag@chalmers.se

The COMPLETE-project is funded by the EU-Baltic Sea Region (BSR) running from 2017-2020. The project is coordinated by Finland, Kotka Maritime Research Association with 12 partners and Sweden is represented by Chalmers University of Technology. The project aim is to minimize the introduction and spread of harmful aquatic organisms and pathogens by shipping through management strategies and tools for the Baltic Sea Region, by addressing both major vectors Ballast Water and Biofouling.

Changing antifouling practises for leisure boats in the Baltic Sea” CHANGE

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The CHANGE project financed by BONUS with overall aim to reduce antifouling toxins in the Baltic Sea ended in 2017. Within the project reports on alternative antifouling measures and recommendations for sustainable antifouling practises for leisure boating in the Baltic Sea has been produced. Project website: changeantifouling.com

Increased energy efficiency through reduced biofouling

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The project running from 2015-2018 is funded by Swedish Energy Agency and has conducted calculations of biofouling costs in terms of fuel consumption and the and possible cost reduction that can be achieved with hull cleaning. It also targets optimization of force and frequency in the cleaning events.

Measures towards reduced Antifouling paint impact in the Baltic Sea from commercial shipping

Project running 2018-2019 funded by BalticSea2020 with aim to reduce Antifouling paint impact in the Baltic Sea from commercial shipping, through mapping of ship traffic, paint use and new data on leakage rates of toxins from paints in different salinities.

RECENT PUBLICATIONS AND PRODUCTS

Larsson AI, Granhag L and Jonsson P (2016) Instantaneous flow structures and opportunities for larval settlement: barnacles swim to settle. PlosONE 11:e0158957

Oliveria D and Granhag L (2016) Matching forces applied in underwater hull cleaning with adhesion strength of marine organisms. Journal of Marine Science and Engineering 4:66

Wrange *et al.* (2016) The story of a hitch-hiker: population genetic patterns in the invasive barnacle *Balanus (Amphibalanus) improvisus* Darwin 1854. PlosONE 11:e0147082

Lagerström M, Lindgren JF, Holmqvist A, Dahlström M, and Ytreberg E (2018) In situ release rates of Cu and Zn from commercial antifouling paints at different salinities. Marine Pollution Bulletin

United Kingdom

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STATUS OF SHIPPING VECTOR RESEARCH

The UK has not yet ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. The legislative process that will allow the UK's accession to the Convention is currently underway. It is the intention of the UK to complete this process within a timeframe that will allow the amendments to the Convention, which are due to enter into force in April 2019, to be incorporated in to the completed legislative package. The UK continues to play an active role in discussions regarding the Convention at the IMO and is actively engaged with industry to encourage compliance with the Conventions requirements.

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 2018 surveys will start in June 2018.

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 2018 surveys starting in June 2018.

Cefas has contributed to the work being undertaken to develop pathway action plans under the Alien Species Regulation, including those for the recreational boating and angling pathways. Cefas also continues to lead on the monitoring programme for Descriptor 2 of the MSFD. Further developments to this are planned for 2018.

Marine Scotland continue to survey and monitor two aquaculture sites, two marinas and a sealoch on the west coast of Scotland in response to established populations of carpet sea squirt, *Didemnum vexillum*.

Natural Resources Wales is undertaking baseline surveys of dredge disposal sites around Wales for marine NNS to advise its marine licensing team and dredge disposal companies on the risks of spreading INNS. Biosecurity management measures have been produced in relation to dredging activities and will be implemented through the Marine Licensing process.

Work on the disinfection berth in Holyhead Marina in north Wales is on-going. Prof. Stuart Jenkins and Dr Ronan Roach are continuing to trial the berth for recreational vessels at Holyhead Marina. They are also undertaking further stakeholder surveys to understand the level of appetite for biosecurity measures at Holyhead.

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 (Montréal, Canada; 6–8 January 2017) (www.uwindsor.ca/glier/ccffr/).
- CEDA 2017 – Central Dredging Association, CEDA Dredging Days Conference (Rotterdam, The Netherlands; 9–10 May 2017) (https://dredging.org/news/news/ceda-dredging-days-2017---programme-announced/detail_news=0048_000327_000000).
- North American Invasive Species Forum (Savannah, Georgia, USA; 9–11 May 2017) (www.invasivespecies2017.org/).
- SEFS-10 – Symposium for European Freshwater Sciences (Olomouc, Czech Republic; 2–7 July 2017) (www.sefs10.cz/how-register).
- Island Invasives 2017 – Scaling up to Meet the Challenge (University of Dundee, UK; 10–14 July 2017) (www.islandinvasives2017.com/).
- Island Invasives Conference – Scaling Up to Meet the Challenge (Dundee, Scotland; 10–14 July 2017) (www.islandinvasives2017.com/).
- BES Symposium 2017: The Macroecology of Alien Species: Patterns, Drivers and Consequences of Global Biotic Exchange (Durham University; 24–26 July 2017).

(www.britishecologicalsociety.org/events/bes-symposium-2017-macroecology-alien-species-patterns-drivers-consequences-global-biotic-exchange/)

- EUROMAL 2017 – 8th European Congress of Malacological Societies (Krakow, Poland; 10–14 September 2017) (www.euromal.pl/)
- II. Workshop on Invasive Species – Global meeting on invasion ecology (Bodrum, Turkey; 27–29 September 2017) (<https://istilaciturlerclistayi.ecovasion.org/workshop-announcement/>)
- ICES-PICES-CIESM session 2017: Bioinvasion trajectories and impacts in contrasting marine environments (Fort Lauderdale, Florida, USA; 18–21 September 2017) (<http://ices.dk/news-and-events/asc/ASC2017/Pages/Theme-session-B.aspx>)
- ICAIS 2017 – 20th International Conference on Aquatic Invasive Species (Fort Lauderdale, Florida, USA; 22–26 October 2017) (www.icaais.org/)
- ICBI 2017 – 3rd International Congress on Biological Invasions (Hangzhou, China; 19 November 2017) (www.icbi2017.org/dct/page/70066)

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).
<https://www.orkneyharbours.com/port-authority/services/ballast-water-management>

During 2017 ballast water samples were collected and analysed from 19 vessels wishing to discharge ballast water in Scapa Flow, Orkney. The ballast water sampling was carried out in accordance with the Orkney Islands Council Ballast Water Management Policy for Scapa Flow; salinity was measured on-board, every sample was tested for bacteria and for plankton abundance and plankton identification was carried out to species level to determine presence of any non-native species. All methods used were developed using the guidance given by IMO (IMO, 2009). The vessel specific 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 Group, chaired by Dr. Paul Stebbing, comprising experts from all relevant government organisations across the UK, has continued to provide technical support and guidance on INNS to HBDSEG, discuss and coordinate work on INNS and disseminate information to stakeholders where appropriate. In addition to regular meetings via teleconference, the annual Marine Pathways Group face to face meeting was held at Defra in London on the 17th and 18th January 2018. Key points discussed at this meeting, included the review and update of the MSFD target species list, refinement of the UK marine INNS monitoring programme to include high risk areas of introduction, the de-

velopment of new action plans for species such as the Carpet Sea Squirt (*Didemnum vexillum*) and methods and approaches for the assessment of NNS risk management.

3. NNS Monitoring and Surveillance Programme

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

The MSFD NNS priority lists, and species ID guides, whose development was led by Cefas, are now published and can be accessed via the GBNNSS website: <http://www.nonnativespecies.org/index.cfm?pageid=597>

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, and further developments will be made during 2018 to address gaps identified within the programme. During 2017 Cefas received a full suite of results from all monitoring programmes involved. Further work has been completed on the UK integrated assessments for D2 under the MSFD. This involved comparing assessment results to characteristics and targets laid out in Marine Strategy Part 1. Cefas has also contributed to the work being undertaken to develop pathway action plans under the Alien Species Regulation, including those for the recreational boating and angling pathways.

4. Molecular Identification of Marine Invasive Species (MIMIS)

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Cefas has undertaken molecular analysis of a number of water samples from the Thanet MPA for the presence of *Didemnum vexillum*. While this work is not yet completed, initial outputs highlight the presence of *Didemnum vexillum* in some of the samples.

Cefas has also received funding for further development of primer sets for priority INNS. Primer set development and validation against a range of native species and positive controls is currently being undertaken. In combination with scrape sample collection methods previously developed by Cefas, these primer sets will be used for monitoring of high risk locations for INNS.

5. Strategic Science for Invasive Non-Native Species (SSINNS)

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

In April 2017, a new three year research project started at Marine Scotland Science to develop novel DNA-based monitoring techniques such as single species-detection of INNS by species specific real time PCR or multispecies-detection by metabarcoding. Sampling protocols utilising water, scrape and settlement panel samples are also being developed. Single species detection techniques will contribute to Descriptor 2 of the MSFD and offer an alternative or additional approach to rapid surveys of INNS introduction in Scotland. The feasibility of the metabarcoding approach to identify the impact of INNS on native communities will be assessed. This project also aims to improve our understanding of INNS pathways and vectors. In collaboration with the Scottish Environment Protection Agency (SEPA) a hot spot analysis will be carried out in order to identify high risk areas suitable for routine INNS surveillance.

6. Joint PhD Studentship between Marine Scotland and Aberdeen University

Iveta Matejusova, Marine Scotland: Contact Email Iveta.Matejusova@gov.scot

A PhD studentship started in October 2017 in collaboration between MSS and the University of Aberdeen. This project will contribute to investigate of use of eDNA for monitoring marine invasive species and biodiversity in deep sea areas.

RECENT PUBLICATIONS AND PRODUCTS

- Ashelby, C.W., Sewell, J., Rostron, J., Shrubsole, R., Child, T. & Clark, P.F. 2017. Evidence for the invasion and successful establishment of *Hemigrapsus takanoi* Asakura & Watanabe, 2005 (Decapoda, Varunidae) in Great Britain. *Crustaceana* 90, 695–708.
- Copp, G.H. 2017. GB Non-native Species Rapid Risk Assessment (NRRRA) of: *Oncorhynchus gorbuscha* (Walbaum) (pink or humpback salmon). Cefas, Lowestoft, 19 p. (available at: www.cefas.co.uk/nns/)
- Jeffries, D.L., Copp, G.H., Lawson-Handley, L.J., Sayer, C.D. & Hänfling, B. 2017. Genetic evidence challenges the native status of a threatened freshwater fish (*Carassius carassius*) in England. *Ecology & Evolution* 7, 2871–2882.
- Li, S. Chen, J., Wang, X. & Copp, G.H. 2017. Invasiveness screening of non-native fishes for the middle reach of the Yarlung Zangbo River, Tibetan Plateau, China. *River Research and Applications* 33, 1439–1444.
- Loxton, J., Wood, C.A., Bishop, J.D.D., Porter, J.S., Jones, M.S. & Nall, C.R. 2017. Distribution of the invasive bryozoan *Schizoporella japonica* in Great Britain and Ireland and a review of its European distribution. *Biological Invasions* 19, 2225–2235.
- Piria, M., Copp, G.H., Dick, J.T.A., Duplić, A., Groom, Q., Jelić, D., Lucy, F.E., Roy, H.E., Sarat, E., Simonović, P., Tomljanović, T., Tricarico, E., Weinlander, M., Adámek, Z., Bedolfe, S., Coughlan, N.E., Davis, E., Dobrzycka-Kraheil, A., Grgić, Z., Kirankaya, Ş.G., Ekmekçi, F.G., Lajtner, J., Lukas, J., Koutsikos, N., Mennen, G.J., Mitić, B., Pastorino, P., Ruokonen, T.J., Skóra, M.E., Smith, E.R.C., Šprem, N., Tarkan, A.S., Treer, T., Vardakas, L., Vehanen, T., Vilizzi, L., Zanella, D. & Caffrey, J.M. 2017. Tackling invasive alien species in Europe II: threats and opportunities until 2020. *Management of Biological Invasions* 3, 273–286.
- Roy, H.E., Rabitsch, W., Scalera, R., Stewart, A., Gallardo, B., Genovesi, P., Essl, F., Adriaens, T., Booy, O., Branquart, E., Brunel, S., Copp, G.H., Dean, H., D'hondt, B., Josefsson, M., Kenis, M., Kettunen, M., Linnamagi, M., Lucy, F., Martinou, A., Moore, N., Nieto, A., Pergl, J., Peyton, J., Schindler, S., Solarz, W., Stebbing, P.D., Trichkova, T., Vanderhoeven, S., Van Valkenburg, J. & Zenetos, A. 2017. Developing a framework of minimum standards for the risk assessment of alien species. *Journal of Applied Ecology* (doi: 10.1111/1365-2664.13025).

United States

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STATUS OF SHIPPING VECTOR RESEARCH

Ballast Water and Ship Biofouling 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, 2016, 2017 on evaluating methods for surveying and quantifying vessels' available surfaces for the transfer of organisms.

Ballast Water Research and Verification Testing

Work in 2015-2017 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 2017, the MERC facility and the U.S.-based Independent Laboratory (IL), NSF International, announced they would no longer conduct BWMS TA after the currently contracted testing is concluded.

The Golden Bear Facility (GBF) completed land-based and shipboard testing for successfully type approved ballast water treatment system in 2017. In early 2018, GBF completed land-based and shipboard TA testing of a BWMS and will begin testing another system in Spring 2018. 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.

In 2015-2017, the Great Ships Initiative (GSI; until May 2017) and then the Great Waters Research Collaborative (GWRC; the team formerly known as GSI, commencing in June 2017) completed USCG Shipboard Certification testing of two BWMS and one land-based

BWMS (the report is being finalized). In addition, the team undertook 18 sampling events to characterize the assemblage composition and density of potential ANS in U.S. ships and Canadian Lakers (ships that trade solely within the Great Lakes and connecting channels) that ply the Great Lakes/St. Lawrence Seaway System and carry ballast water from the lower lakes to Lake Superior. GWRC is currently building a multi-user, cooperative database for the Global TestNet (GTN) members, researchers, regulators, BWMS designers, and environmental advocates to (1) collectively compile real-world challenge conditions relevant to BWMS operations in harbours globally, and (2) develop an International Organization for Standardization (ISO) standard to test BWMS filters.

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. The GBF continues to work with The Glosten Associates and the California State Lands Commission's Marine Invasive Species Program to develop a mobile compliance sampling tool.

Ship Biofouling Research

Research was conducted to develop (and employ) a means to quantify the potential transfer of ANS via ships' biofouling. To that end, the total wetted surface area (WSA) of commercial ships in the global fleet, as well as the WSA of ships arriving to the United States, was determined. The surface area of ship's "niche areas" (e.g., seachests, rudders, bow thrusters, etc.) was also determined for the global fleet. In 2018, a project to quantify the efficacy of in-water cleaning and capture (IWCC) of ship-cleaning technologies was begun.

Other ANS Research Efforts

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.

One new non-native species was reported in the U.S.; in 2015, the polychaete *Branchiomma coheni* was documented as established; it had been found in Tampa Bay, Florida several years earlier.

Ballast Water Management Efforts

U.S. Coast Guard

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 analyse 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 $\geq 10 \mu\text{m}$ and $< 50 \mu\text{m}$ size range as equivalent to the required test method (in the Environmental Technology Verification [ETV] Program Protocol). The decisions were appealed, and appeals were 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. A validation test of a proposed MPN method will take place in the Spring of 2018.

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 1 March 2018, six BWMS have been type approved by the USCG—two employ ultraviolet radiation [UV], three produce oxidants by electrochlorination, and one uses chlorine dioxide—all also include a filtration step.

<https://homeport.uscg.mil/Lists/Content/DispForm.aspx?ID=311&ContentTypeId=0x010077A263807AAFE54DBF09C291D3EAA816008BFEC11A80BC564EB4241068A94ACD2E>

U.S. Environmental Protection Agency

The U.S. EPA continues to develop the next version of the Vessel General Permit (VGP), with a draft permit expected by June 2018 and a final version issued before the current permit expires on December 18, 2018. The key considerations informing the next permit are found in the 2015 court ruling regarding the 2013 VGP. The ruling determined the EPA was “arbitrary and capricious” with respect to establishing ballast water management requirements, and it included the following findings:

- EPA should not have adhered to the U.S./IMO ballast water discharge standard without a better explanation, as the court concluded there *are* shipboard technologies capable of surpassing the U.S./IMO standard.
- EPA prevented the EPA Science Advisory Board from assessing the feasibility of onshore treatment approaches.
- EPA’s exemption of pre-2009 Lakers from the numeric ballast water treatment standards was arbitrary and capricious, because a “lack of a supply” of BWMS does not render them unavailable and, as discussed above, EPA had erred in not giving greater consideration to the availability of onshore treatment approaches.

- EPA's VGP was too vague to "ensure compliance" with water quality standards, stating that the narrative standard is (1) insufficient to give a shipowner guidance as to what is expected, and (2) allows for water quality exceedances in limited instances for which the permittee does not have to address until after identification of such exceedances
- EPA erred in not including monitoring to assess compliance with the water quality standards.

As the permit is readied, the Vessel Incidental Discharges Act (VIDA), which has been proposed in the U.S. Congress for years, is again a topic of interest. Senator Roger Wicker (R-Miss) is working to include the act—which removes EPA's responsibility for regulating ballast water—into the omnibus spending bill. As has been the case in years past, there is opposition to the bill, and its future is uncertain.

The EPA is funding a number of studies that address ANS in the Great Lakes:

- A coastal/inland waters study to examine the vessel-related vectors that possibly aid in the transfer of ANS to the Great Lakes from commercial vessels (ballast water transfer and hull fouling), as well as recreational vessels. Ideally, empirical data would exist for both propagule pressure and habitat suitability, but little, if any, have been generated for the relevant vectors and habitats. Therefore, a modelling approach was employed where proxy data were available, including a quantitative analysis of the environmental similarity among ports and a qualitative analysis for selected ANS identified as potentially posing a risk to the Great Lakes. Through a literature review, a qualitative approach was used for the hull fouling of commercial vessels and for recreational vessels.
- A study to examine the vessel-related vectors that possibly aid in the inter-lake transfer of ANS within the Great Lakes from commercial vessels (ballast water transfer and hull fouling), commercial fishing vessels, and recreational vessels. Again, little empirical data were available. A modelling approach was used when proxy data were available to simulate the relative risk of inter-lake transfer of ANS via ballast water discharged by commercial vessels. This work included a semi-quantitative analysis of the environmental similarity among ports and selected ANS identified as potentially posing a risk to the Great Lakes. Through a literature review and by contacting experts in the field, a qualitative approach for other vectors (hull fouling of commercial vessels, commercial fishing vessels, and recreational vessels) was applied.
- A viral haemorrhagic septicaemia (VHS) study to investigate options to prevent the spread of VHS within the Great Lakes via ballast water. A literature review was conducted to identify regions in the Great Lakes infected by the virus, potential new techniques to detect ballast water contaminated by VHS, the susceptibility of the virus to various types of treatment (e.g., chlorination, UV disinfection), and the practicality of treating or otherwise mitigating ballast water in Lakes.
- A study to examine the effect of increased surface water temperatures in the Great Lakes on the expected survival of ANS that have (1) not yet become established in the Lakes and (2) have been previously determined to be unlikely to

survive introduction based on current environmental conditions (e.g., temperature). The approach will be to calculate the current environmental distance (using temperature and salinity) between the top 25 global and Great Lakes port pairs (using data from the National Ballast Water Information Clearinghouse [NBIC]). Next, the distances will be recalculated using the predicted surface temperatures, where available. The approach will also be applied to specific ANS.

- A technical development document on ballast water that EPA to supplement the rationale for the next VGP. The document takes a broad look at the range of ballast water management and monitoring alternatives.

Hull Fouling Management Efforts

California

The state's biofouling management regulations ("Biofouling Management Regulations to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports") went into effect in October 2017, and coverage under them is dependent on each vessel's drydocking schedule.

http://www.slc.ca.gov/Programs/MISP/4_8_GuidanceDoc.pdf

- Applies to vessels ≥ 300 GT that can or do carry ballast water
- Coverage is dependent on each vessel's drydocking schedule
 - New vessels: upon delivery on or after 01 JAN 2018
 - Existing vessels: first regularly scheduled out-of-water maintenance on or after 01 JAN 2018
- Intended to align with the International Maritime Organization's (IMO) 2011 Guidelines for the Control and Management of Ship's Biofouling to Minimize the Transfer of Invasive Aquatic Species
- Vessels must submit a Marine Invasive Species Program Annual Vessel Reporting Form ≥ 24 h in advance of first arrival each calendar year

Washington State

Washington State commissioned a six-year strategic plan for biofouling Management, which is based on programs in New Zealand, Australia, and California.

https://wdfw.wa.gov/ais/ballast/reports/mcclary_et_al_2017_wa_6-year_biofouling_strategic_plan.pdf

Western Region

The Western Regional Panel on Aquatic Nuisance Species will undertake a series of actions outlined in a white paper.

<https://www.fws.gov/answest/coastal%20group/Final%20CC%20Biofouling%20White%20Paper%2011Apr17.pdf>

It discusses actions that the Coastal Committee will be undertaking in 2018 that will be regional in scope:

- A region-wide, in-water cleaning model framework (essentially creating a con-

sistent set of biological requirements for in-water cleaning systems to become permitted)

- A set of regional best management practices (documents/brochures for biofouling management of recreational boats, commercial fishing boats, and mobile marine infrastructure (e.g., mobile drilling rigs, dredge vessels).

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. 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 *Dasyatisphonia japonica*) are expanding ranges; one the barnacle *Chthamalus fragilis* appears to be moving northward probably with increased temperatures.

The 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 (2017) Seaweeds of the Northwest Atlantic; Botany / Environmental Studies, 816 pp., 115 illus., \$105.00 paper, ISBN 978-1-62534-000-0, \$90.00 hardcover, ISBN 978-1-62534-000-0.

<https://www.umass.edu/umpress/title/seaweeds-northwest-atlantic>

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 one U.S. test 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 20th International Conference on Aquatic Invasive species was held October 22-26, 2017 in Fort Lauderdale, Florida, USA. <http://www.icaais.org/html/previous20.html>
- The 10th International Conference on Marine Bioinvasions will be held October 16-18, 2018 in Puerto Madryn, Argentina. <http://www.marinebioinvasions.info/>
- 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. In-Water Cleaning and Capture (IWCC) Project

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Greg Ruiz, SERC: ruizg@si.edu

A core team and a Technical Advisory Committee (TAC) were established; they will refine a protocol to determine the cleaning technologies' efficacy and their ability to capture heavy metals. A request for proposals to participate in hull-cleaning demonstrations (which will be held in Spring and Summer 2018 in Baltimore, MD and Alameda, CA, respectively) was circulated. From the applications received, five technologies will participate in the 2018 demonstrations.

2. Hull Fouling Cleaning Workshop

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A workshop was 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 (Drake *et al.* 2017).

3. Meeting to Explore Novel Techniques to Assess Biofouling

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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).

4. Efficacy of Open Ocean Exchange with Ballast Water Treatment

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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 2017), and a literature review summarizing the biological efficacy of exchange was published (Molina and Drake 2016).

5. Compliance Tools

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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 all field trials were completed at three sites. The report of the project has been published, the individual vendor reports are available on the ACT website (<http://www.act-us.info/>), and a manuscript summarizing the results has been submitted (First *et al.*). The effort to examine use of ATP kits for ballast water compliance monitoring will continue.

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

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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.

7. 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.

8. Revision of the International Organization for Standardization (ISO) standard for ballast water sample collection (11711-1, Ballast water discharge Sampling Port; 11711-2, Ballast water sample collection and handling)

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

The current version of the ISO standard describing the discharge sampling port for ballast water (11711-1) is being revised. Specifically, changes to Part 1 will address (1) re-

moving the probe (i.e., allowing for non-permanent installations), (2) standardizing port dimensions, and (3) accommodating various probe geometries. The standard is being circulated as a draft international standard, with a deadline for comments on March 12, 2018 and an anticipated publication date in June 2018.

A proposal for a new work item to develop Part 2 was circulated, and comments were received in January 2018. They will be considered at the next meeting of ISO Working Group 12 (Aquatic Nuisance Species) in May 2018.

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Annex 7: 2018 Presentation Abstracts

ToR a)

Some northward expanding non-indigenous species in Europe

Dan Minchin

The circum-Antarctic ascidian, the orange-tipped tunicate *Corella eumyota*, was first recorded in Brittany, France in 2002 (Lambert (2004) *JMBA* 84:239-241). Since then it has spread to the Atlantic coast of the Iberian Peninsula and to Britain in 2004 and Ireland in 2005. It has rapidly spread about the coast of Ireland extensively fouling some leisure craft at marina berths. It has been found stranded ashore on debris in a remote area on the west coast of Ireland. Despite its short larval duration it has had an ability to spread rapidly. Its current most northerly distribution is the north of Scotland and in Orkney (Nall *et al.*, (2015) *Aquat. Inv.* 10(1): 107-121). *Corella eumyota* is capable of cross- and self-fertilisation and can form dominant 'carpets'. In Ireland those found on boat hulls had extended and unretractable orange siphons, whilst those on the lower shore and immediately sub-tidally had shorter siphons, without any orange colouration and lay fixed on their right side. This tunicate may be expected to extend its range further northwards along Atlantic coastal waters to Shetland, Iceland and Norway and may enter the Barents Sea. In time it may be spread to the New England States of North America and Atlantic coasts of Canada.

The phaeophyte *Undaria pinnatifida* may also extend its range northwards and may be expected to appear on the Atlantic coast of Scotland and its western and northern Isles. It is currently expanding its range and abundance in Northern Ireland.

Recent ballast water research activities in Spain

Anaïs Rey

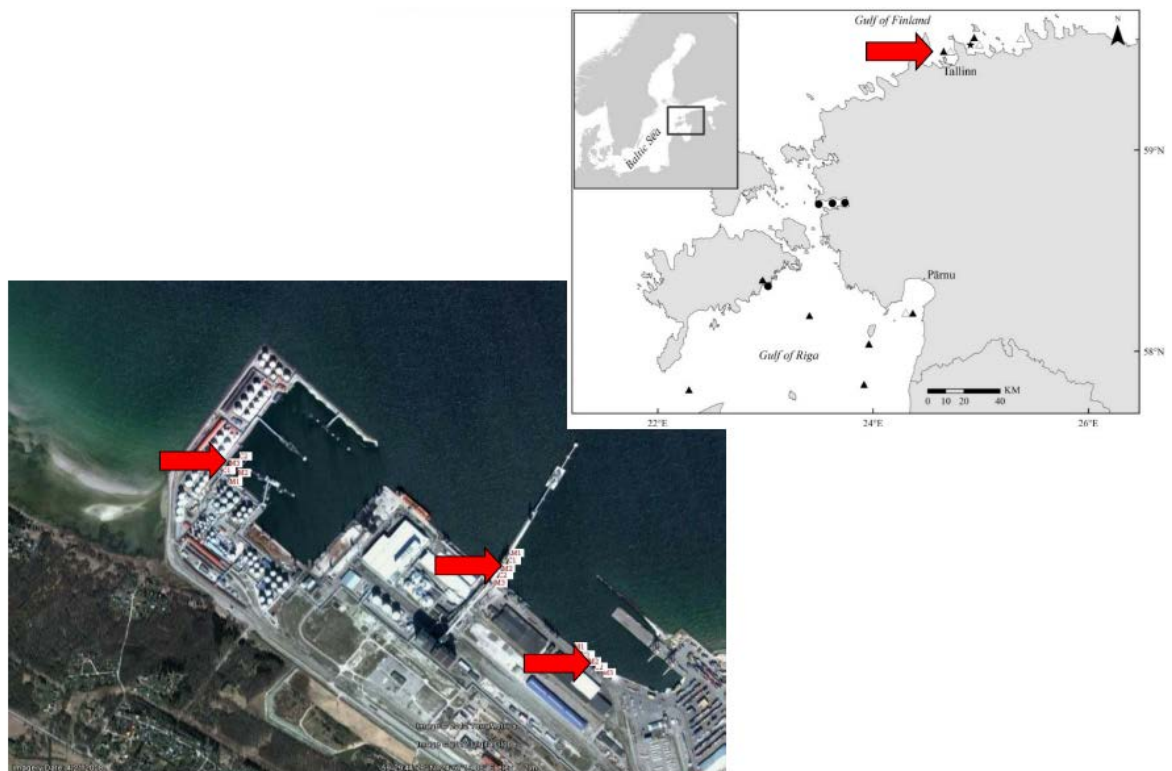
Highlights of some Spanish recent ballast water activities for the three years 2016 to 2018 were summarized. The ballast water activities were divided in three parts: i) Scientific publications and projects, ii) Collaboration between scientists and maritime stakeholders and iii) Scientific outreach. Among the scientific activities, the outcomes of two Ph.D. thesis have been presented, one conducted by Javier Moreno (Cadiz University) on the evaluation and development of technologies for marine water disinfection with a focus on ballast water treatment and the other one, ongoing, by Anaïs Rey (AZTI) on applying DNA metabarcoding to detect Non-Indigenous Species introduced with ballast water. Among collaboration between scientists and stakeholders, the port baseline survey campaign in Las Palmas port undertaken by Julio de La Cueva from the Port State Control following the Helcom/Ospar joint procedure for ballast water exemptions has been highlighted. This campaign will continue also in ten Spanish major ports starting in 2018. To finish, the European Union project ResponSEable has been presented as one important Spanish contribution in ballast water research outreach led by Dr Maria C. Uyarra and Dr Angel Borja from AZTI for public awareness (flyers and YouTube video on ballast water-mediated biological invasions) but also maritime sector to educate about sustainable shipping via Environmental Awareness Courses approved by IMO.

Update on national port biological sampling Henn Ojaveer

Port biological monitoring (Muuga Harbour, Port of Tallinn) was added to the national monitoring programme of coastal marine waters in 2014, and is being performed since then. The work follows joint HELCOM/OSPAR Guidelines on the granting of exemptions under the International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation A-4 HELCOM. The sampling frequency is three times per year (spring, summer and autumn) and includes:

1. recording of key environmental conditions (incl. CTD profiles): water temperature, connectivity, transparency, Chl a and oxygen concentration
2. sampling of phytoplankton, zooplankton, benthic infauna, fouling communities and mobile epifauna.

While plankton and benthic infaunal sampling and sample analysis uses 'traditional' HELCOM methods also applied in the Baltic Sea biological monitoring, specific methodology is applied for sampling of fouling communities. These are settling plates and scraping equipment to sample four types of solid material – natural stone, cement, rubber, metal. Also, specific traps are used in sampling mobile epifauna: fish and crab traps, which will put into water for 48 hours (3 replicates in each terminal).



Port biological sampling locations in Muuga harbour (Port of Tallinn, Estonia). From left to right: small craft terminal, grain terminal and cargo terminal.

Literature Review of Indicative Analysis Methods

Okko Outinen and Maiju Lehtiniemi

The International Convention for the Control and Management of Ships' Ballast Water and Sediments entered into force in September 2017. The general obligations of the Ballast Water Management Convention include control measures that the Parties to the Convention are required to take to ensure that the ships entering their ports are in compliance with the Convention. In Finland, Finnish Transport Safety Agency (TraFi) is the authority responsible for port state control inspections of ships. The inspection is primarily conducted as a documentary check; however, the authority may always carry out ballast water sampling to verify that the ship is in compliance with the Convention. The sampling consists of an indicative analysis and a detailed analysis. Indicative analysis refers to indicative sampling of the ballast water pumped out of a vessel. If the ship fails to meet the standard, a detailed analysis must be performed in a laboratory. Based on the laboratory results, it is decided whether further measures will be taken. The purpose of this study commissioned by TraFi was to find an indicative analysis method for the use of TraFi's port state control inspectors. The Finnish Environment Institute (SYKE) conducted the study for TraFi. The study was based on an intensive literature review (125 references) and compared 18 different methods studied earlier. Based on the study the recommended methods to be used in inspections are PAM (Pulse amplitude-modulation fluorometry) and ATP (Adenosine triphosphate). The most important assessment criteria were the reliability and user-friendliness of the method, the time required for obtaining the results as well as the procurement and operating costs of the method.

Project COMPLETE

Sergej Olenin

Summary

The project COMPLETE (Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping) is an INTERREG Baltic Sea Region (BSR). The project supports the BSR programme priority 3. 'Sustainable Transport' in its specific objective 3.4 'Environmentally friendly shipping'. The main objective of the project is to minimize introduction of harmful aquatic organisms and pathogens (HAOPs) by shipping through the development of a consistent and adaptive management system for the Baltic Sea region. The overall goals are: 1) Harmonized implementation of the Ballast Water Management Convention; 2) Proposal (roadmap) for a regional biofouling management strategy; and 3) Consistent regional monitoring of non-indigenous species. There are 12 full partners in the project, including nine research institutes and universities (Finland, Estonia, Latvia, Lithuania, Poland and Sweden), a Federal agency (Germany), an NGO (Finland) and an intergovernmental environmental organization (HELCOM). The Lead Partner is the Kotka Maritime Research Association, Finland. Eight people representing full project partners are members of the ICES/IOC/IMO WG BOSV and/or ICES WGITMO. The associated project partners include 22 organizations, representing nine Baltic Sea riparian countries, including environmental ministries and agencies, transport agencies, ship owner associations, port authorities and maritime academies. The project duration is 36 months (10/2017 – 09/2020) and total budget 3,2

million euros. More information on project tasks and deliverables may be found at www.balticcomplete.com (to be opened 06/2018).

Project details

COMPLETE aims at developing a consistent and adaptive management system proposal for the Baltic Sea region, addressing two major vectors of harmful aquatic organisms and pathogens introductions by shipping: ballast water and ship hulls. It is highly relevant to the Priority 'Sustainable Transport' and directly addresses a management objective "No introductions of alien species from ships" of the HELCOM Baltic Sea Action Plan. Project partners have expertise and know-how in innovative solutions for shipping, risk assessment and management systems, surveillance and monitoring. Participation of HELCOM as a partner ensures involvement of relevant institutions from HELCOM countries, contributing to harmonized implementation of exemptions under Ballast Water Management Convention (BWMC) and elaboration of the BSR biofouling management strategy proposal.

The management of both ballast water and biofouling of ships is a complex task. COMPLETE is tackling several gaps: the need to take into account rights and obligations of involved stakeholders; approaches for non-indigenous species (NIS) monitoring and surveillance for Marine Strategy Framework Directive (MSFD) and BWMC; risk assessment based exemptions from ballast water management requirements; legal aspects; regional cooperation and information exchange. The technical aspects of that complex problem include yet limited knowledge on antifouling practices and procedures (and resulting level of biofouling); the lack of common cleaning procedures and facilities, their cost-efficiency analysis; quantities of biofouling waste and its handling procedures; the role of leisure boats and their trailers in primary introductions and secondary spread of NIS.

The main target groups are: shipping industry (getting advice on best practices to ensure safe, efficient and environmentally friendly transport, e.g. resulting in saving fuel); shipyards (by promoting the use of new technologies for hull cleaning services); marinas and boating associations (by providing knowledge on best practices and environmentally friendly small boat management); national competent ministries of transport and environment (by fulfilling the EU Regulation No 1143/2014, reaching Good Environmental Status (GES) of the MSFD Descriptors 2 and 8, harmonized implementation of the IMO BWMC and Biofouling Guidelines); Baltic Sea ports and coastal municipalities (by increasing competitive equality, exchange knowledge and experience); power plant and other large industrial establishments using cooling waters from the sea (by advise on mitigation of species introductions at "warm water islands").

The project includes 6 interrelated work packages (Fig. 1)

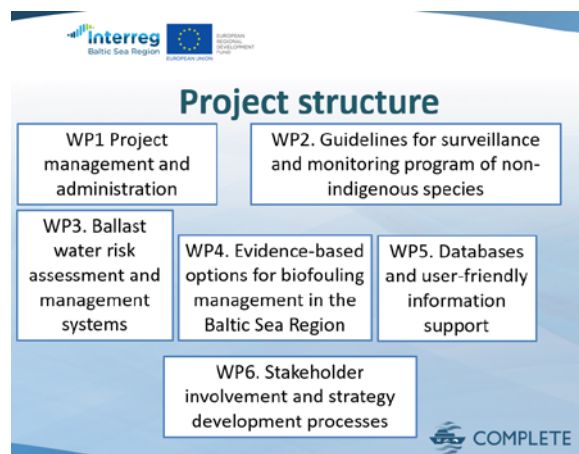


Fig. 1. Work package structure of the INTERREG Baltic Sea Region project COMPLETE (Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping).

The overall aim of WP 2 is to develop a system to permanently monitor the effectiveness of ballast water and hull biofouling management measures and to evaluate the progress towards the ecological objective ‘*No introductions of alien species from ships*’. WP3 is aimed to develop a fully operational and regionally harmonised structure for the ships’ ballast water management in the BSR. WP4 aims for collecting and assessing legal and national regulation aspects, and current knowledge and practices for direct use by target groups. WP5 is aimed at developing information products, which will be maintained after the end of the project. These products will be used for collecting, summarizing and assessing data on harmful aquatic organisms and pathogens (AquaNIS), and for decision-making on choosing optimal antifouling system and cleaning options. WP5 will use data gathered in WP2, WP3 and WP4, providing information support for development of roadmap for biofouling management (WP6). WP6 is oriented on active communication and involvement all project target groups with aim to develop a proposal of a roadmap for harmonized biofouling management for Baltic Sea Region.

Assessment of ship in-water cleaning technologies

Mario Tamburri, L.A. Drake, G.M. Ruiz, C. Scianni, I. Davidson, M.R. First, J.C. Kuo, C. Junemann

Ship biofouling presents notable problems for the maritime industry by increasing drag and concomitant fuel consumption and exhaust emissions, as well as facilitating coating breakdown and subsequent vessel corrosion. Ship biofouling is also a notable vector for the global-scale transfer and introduction of non-native aquatic species, which can have enormous ecological and economic impacts on coastal environments. A number of in-water cleaning and capture (IWCC) systems have been developed in recent years, focused mostly on hull husbandry. To facilitate further innovations that address these critical maritime and environmental issues, and to help transition IWCC technologies into widespread operation, a collaboration of third-party testing programs, researchers, and agencies has established a ship in-water biofouling cleaning and grooming evaluation initiative. The goal of this program is to independently quantify system efficacy and reliability in removing fouling organisms—and capturing debris and potential contami-

nants—from complex vessel structures. Currently, seven companies have applied to take part in a series of IWCC evaluations in 2018-19 with the specific goals of (1) refining and standardizing methods and procedures for testing IWCC technologies, and (2) providing rigorous, independent data on the performance of in-water cleaning systems that can be used to apply for permitted, commercial use in ports around the world. This presentation will discuss the initiative's structure and function, summarize results to date, and describe future efforts in this area.

Evaluating ballast water management and biofouling management, Common denominators and distinct differences and Fouling Removal Chain

Cato C. ten Hallers-Tjabbes

Ballast water management (BWM) and biofouling management (BFM) are both regulated by IMO, albeit it at a different level of protection. We discuss the role of the regulatory regime on emerging innovation by opening new windows and perspectives to the market. Innovation in its turn may support the development of regulations and assist in implementation. A good example is the antifouling Convention when the paint industry decided to branch off from the TBT industry to be able to develop their innovative potential. The BWM Convention has boosted innovation in BWM and in testing and certification trajectories, although the reverse loop to policy development was lagging. The voluntary biofouling guidelines have generated less pressure for innovation. The BWMC is geared for prevention, BFM regulation is partly preventive (antifouling technologies), partly responsive (removal of external biofouling). The latter requires proven technologies and testing of adequate efficacy and environmental acceptability. Such testing has much in common with testing of BWMS. Number and status of remaining organisms demonstrate efficacy, type and level of remaining relevant chemicals indicate the level of environmental acceptability. Apart from the difference in organisms (pelagic in BW, benthic settlers in BF) their role in the practice of shipping differs.

Consequences of preventive policies for BF is cost-effective while for BW they entail additional costs. The resistance from a major part of the shipping sector rendered innovative industries far less able to act as a stimulus to policies.

While BWM that happens in the port of origin is regulated to bear no risk for the environment, removal of biofouling leaves biological matter from an external source and potentially biocidal and other chemical waste. Such waste needs handling according to article 5 of the AFS Convention (Waste materials from application or removal of an Annex I Anti-Fouling System should be collected, handled, treated and disposed of in a safe and environmentally sound manner).

To prevent AFS contamination on all levels we developed a 'waste-removal chain' (Safe removal of AFS paint, Safe waste collection, Safe waste handling, Waste treatment, Safe waste disposal). Apart from the ongoing development of AF technologies that aim to be both perfectly preventive and perfectly aligned with shipping practice, and in the absence of adequate evaluation of AF removal technologies we propose to consider a moratorium on non-validated under-water hull cleaning technologies and propose a trajectory for evaluating such technologies.

ToR b)**Latest developments at IMO regarding the BWM Convention****Theofanis Karayannis**

The *International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (BWM Convention) aims to minimize the transfer of invasive aquatic species through ships' ballast water and sediments and entered into force on 8 September 2017. Recent meetings of various IMO bodies, primarily the Marine Environment Protection Committee (MEPC) and the Sub-Committee on Pollution Prevention and Response (PPR), but also other bodies, have generated a remarkable amount of important outcomes necessary for the effective and uniform implementation of the BWM Convention upon its entry into force. Further developments are also expected at forthcoming meetings, including amendments to the BWM Convention in addition to the continued development of various guidelines.

Recap of activities on sampling and analysis (SOPs) at IMO**Lisa Drake**

To the fifth meeting of the International Maritime Organization's (IMO) Pollution, Prevention and Response (PPR) subcommittee, the ICES WGBOSV submitted guidance for research groups that will collect data during the Experience-Building Phase (EBP). The guidance included a description of sampling equipment recommended for use as research is conducted during the EBP. It also included detailed standard operating procedures (SOPs) for use by scientists for collecting samples, splitting samples, filtering water for rinsing nets, and cleaning equipment. Finally, a form to determine the appropriately sized sample port was included. At PPR 5, the information was put into abeyance to be considered at the 72nd meeting of the Marine Environment Protection Committee (MEPC 72, April 2018).

Overview of the NRL sampling device**Lisa Drake, C.S. Moser, T.P. Wier, S.C. Riley, S.H. Robbins-Wamsley, V. Molina, J.F. Grant, M.R. First.**

As international regulations governing the discharge of living organisms in ships' ballast water enter into force, port state authorities will require a device for compliance inspectors to potentially use onboard ships to conduct compliance testing. Importantly, the device must be easy to transport aboard the ship, quick to connect to the main ballast water pipe, and reliable in collecting a representative sample of ballast water flowing through the pipe. To that end, a pocket-sized Compliance Sampling Device (CSD) was designed, fabricated, and validated. The CSD incorporates a fixed-orifice flow meter and a valve for controlling flow. Experiments were conducted to evaluate the accuracy of flow measurements, and stability of the CSD. To determine whether the restricted flow causes loss or damage to the organisms, concentrations and photochemical yield measurements of samples from the CSD were compared to controls, or samples of water freely flowing through an unobstructed. No significant differences in concentrations or photochemical yield measurements were observed between samples from the CSD or the control. Results from these experiments showed that the device would be acceptable for use in compliance sampling aboard ships.

Middle East Ballast Water Compliance Monitoring

Peter Paul Stehouwer, Vladimiro Bonamin

In August 2017, new ballast water regulations for ballast water compliance monitoring in one Middle East country. All ballast water discharges from ships arriving in ports on both the Red Sea shore and the Arabian Gulf shore must be sampled according to the requirements of this regulation. Samples were to be taken directly from the ballast tanks, two randomly selected ballast tanks per ship must be analyzed. Samples were analyzed for compliance with regulation D-2 of the ballast water management convention using indicative analysis methods. This procedure applies regardless of the type of ballast water management the ship is using.

Ships must arrange the sampling themselves through their port agents. These port agents select one of the available companies to execute the sampling and analysis. SGS was one of four companies selected to perform this compliance monitoring.

SGS opted to use the B-QUA ATP compliance test kit by AquaTools. This kit detects the amount of Adenosin TriPhosphate (ATP), the universal energy carrier found in all living organisms, in the water sample. Based on the amount of ATP a compliance indication is provided. The method also has an uncertainty range, based on the inherent difficulty of converting a bulk parameter to specific organism concentrations. Given the sampling requirements, only the ≥ 10 -<50 organisms and bacteria could be analyzed. The sample volume was too small for analysis of the ≥ 50 fraction.

From August to January, SGS tested a total of 36 discharge events. On 32 of these, the ship used exchange; on three events, the ship had used its treatment system; and during one event no exchange or treatment had been used. The three treatment systems were two of the electrochlorination type and one of the UV-irradiation type. For the ≥ 10 -<50 organism fraction one ship was found to be non-compliant on one of its samples, this ship had used exchange. For the bacteria analysis 12 ships were found to be non-compliant on one or more samples, 11 using exchange and one using no treatment or exchange.

ToR c)

Presentation: Early Results of “Experience Building Phase” BWMS testing in Canada - Sarah Bailey, Oscar Casas-Monroy

Canada began research in support of the IMO’s Experience Building Phase in 2017. The objectives of the research are to begin trialing multiple indicative sampling and analysis methods to determine feasibility under a compliance-type scenario, and to gain information about invasion risk levels associated with new Ballast Water Management Systems (BWMS). A scientific team was deployed on monthly rotations on Canada’s Pacific and Atlantic coasts, and in the Laurentian Great Lakes. The team visited ships which had BWMS installed and in use, during ballast discharge operations. Time-averaged samples of treated ballast water were collected during normal ballast discharge operations from the discharge line in the ship’s engine room, in accordance with recommendations for isokinetic sample collection, with the aim to collect representative samples. Samples were analyzed within six hours of collection using both detailed and indicative analysis meth-

ods. Multiple ballast water samples had impressive results (near-zero values of organisms), although multiple exceedances of the D-2 standard were also observed. It appears that exceedances are more likely to occur for the larger than 50 µm size class. Multiple explanations for exceedances are possible, including incorrect installation, operation or maintenance of BWMS, as well as failure of the BWMS equipment. Given the small sample size (9 complete tests) and the fact that ship crews are at a very early stage of the learning curve for BWMS, additional research is needed to fully understand the level of risk (or probability of exceedances) associated with the use of BWMS.

Testing Ballast Water Management Systems – Challenge Water Conditions During more than 100 Test Voyages

Stephan Gollasch, Matej David

Ballast water management systems (BWMS) are rigorously tested in land-based and shipboard settings according to requirements outlined in the Guidelines G8 of the International Maritime Organization (IMO). Noting doubts that the water conditions to challenge BWMS as stated in G8 may not be challenging enough to represent all port water conditions world-wide, this guideline was revised at IMO in 2016 to make G8 better fit for purpose. We have conducted more than 100 performance test voyages of BWMS during the last 13 years and this contribution summarizes the intake water conditions we observed during these tests. The data presented include the abiotic water conditions (i.e., temperature, salinity, TSS and POC) and the counts of living organisms in the two size classes addressed by the Ballast Water Performance Standard (Regulation D-2) of the IMO Ballast Water Management Convention. We further compare our findings with the test requirements set by the U.S. Coast Guard and outlined in the ETV Protocol 2010. Our data will show how close the shipboard challenge water requirements are to what we observed in nature. Further, based on our findings, recommendations for possible further G8 improvements will be given. These recommendations will refer to the challenge water conditions in land-based performance tests of BWMS, which was kept unchanged during the recent G8 revision. One of our recommendations is to increase the TSS content in the test water to provide for a stronger challenge that BWMS meet the D-2 standard.

ToR f)

Recent trends in ballast water risk

Jenni Kakkonen

The Ballast Water Management Policy for Scapa Flow was approved by the Orkney Islands Council in December 2013. The approved Policy contains requirements for all vessels over 400gt wishing to discharge ballast water into Scapa Flow to exchange or exchange and treat (if an approved treatment system is fitted) before permission is given by the Harbour Authority to enter Scapa Flow. Part of the Harbour Authority's assessment of all vessels on arrival is the collection of ballast water samples for salinity, bacteria and plankton analysis.

Data from 44 ballast water sampling events were examined which resulted in 45 taxa of interest, 22 non-native plankton taxa and 23 toxic producing taxa. Preliminary analysis of the non-native plankton data provided no trends when analysed against three factors,

last port of call, exchange area or month when the ballast exchange was carried out. Port of Rotterdam was the most frequent 'last port of call' and was used for detailed investigation. The non-native plankton species recorded in the ballast water samples were compared with those recorded in the AquaNIS database for Port of Rotterdam and with the results from the Port of Rotterdam non-native species surveys carried out in 2014 (Gittenberger *et al.*, 2014). The following conclusions were drawn: *Odontella sinensis* was the only species which is common with the ballast water samples, AquaNIS database and Port of Rotterdam surveys and the AquaNIS and Port of Rotterdam surveys report 5 out of 6 same species. Questions to be explored further are, where the 6 additional non-native species present in the ballast water samples would have originated, are they from the previous ports prior the vessels visit to Rotterdam, are they from the exchange area or are the records for Port of Rotterdam out of date. Final comparison of the non-native plankton data was carried out with the Scapa Flow Marine Non-Native Species Monitoring programme results, 4 non-native species have been recorded in Scapa Flow, three of which have been recorded in the ballast water samples (*Ceratium trichoceros*, *Corethron criophilum* and *Karenia mikimotoi*). None of these have persisted in the environment and none have been recorded since 2015. The preliminary analysis did not highlight any trends or patterns of presence of NNS vs exchange area, last port of call or seasonality, further analysis is required as well as the inclusion of HAB species. So far there is no indication that discharging exchanged (or exchanged and treated) ballast water to Scapa Flow has resulted in new introductions to Orkney.

ToR e)

GEF-UNDP-IMO GloFouling Partnerships Project Concept

Antoine Blonce, John Alonso (presented by **Teo Karayannis**)

The GloFouling Partnerships project – a collaboration between the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the International Maritime Organization (IMO) – will address the transfer of invasive aquatic species through biofouling on ships' underwater hull and structures. The new project will build capacity in developing countries, developing and harmonizing best practices and focusing on the implementation of the IMO *Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species* (Biofouling Guidelines), with a view to minimize the impacts of marine biofouling.

Overview of biofouling work in U.S.

Lisa Drake

Hull fouling management efforts continue in the United States, notably with California's biofouling management regulations ("Biofouling Management Regulations to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports") entering into effect in October 2017. In other state and regional efforts, Washington State commissioned a six-year strategic plan for biofouling Management, which is based on programs in New Zealand, Australia, and California. Finally, the Western Regional Panel on Aquatic Nuisance Species will undertake a series of actions outlined in a white paper. Regarding recent research developments, in early 2018, a project to quantify the efficacy of in-water cleaning and capture (IWCC) of ship-cleaning technologies was begun.

ICES Biofouling Viewpoint

Composed by **Bella Galil and Cynthia McKenzie**, with contributions from Sarah Bailey, Marnie Campbell, Ian Davidson, Lisa Drake, Chad Hewitt, Anna Occhipinti-Ambrogi, and Richard Piola.

Evaluating and mitigating introduction of non-native species via vessel fouling

The recent robust increase in the merchant fleet and recreational boating has transformed vessels into a significant “vectors of change” in marine ecosystems. Vessel biofouling affects the environment as well as the economics of vessel management. Biofouled vessels support ecological communities characterized by great abundances of opportunistic and non-native species. If established in new regions, these vessel-transported species can affect the native species, community structure, and, ultimately, ecosystem functions. Biofouling compromises the operational effectiveness of vessels, their effective range and maneuverability, and even safety procedures when these rely on seawater uptake systems. Further, biofouling can accelerate corrosion, and it increases hull roughness and frictional resistance that increase power and fuel requirements. Indeed, even minor levels of biofouling, such as biofilm formation, can add considerable drag, resulting in elevated fuel consumption, emissions, and costs for fleet operations and maintenance. It is likely the risk of introduction of invasive species via vessel fouling will increase in the next 20 years driven by (1) trends in maritime shipping and boating (increase in vessel number and size, changes in routes, transit speeds and port stays) and (2) the alteration of propagule pools and conditions in recipient destinations arising from climate change.

What actions can be recommended to prevent/minimize biofouling on vessels to control this vector of introduction and spread?

Recognize that vessel biofouling has been shown to be the vector responsible for the **highest number of marine NIS** (primary and secondary introductions), representing 30% in the North Sea, 69% in New Zealand, 70% in the continental USA, and 74% in Hawaii, advise the **highest urgency** in dealing with **mitigating introductions via vessel fouling**.

Recognize that biofouled **recreational vessels** pose a significant risk, advise they should be part of the control and management to minimize the transfer of invasive aquatic species.

Recognize the need for information on the **currently employed** vessel biofouling management regimens, advise **monitoring assessment and performance evaluation of the voluntary guidelines**.

Aware that the current antifouling tool box is limited, advise to concentrate effort on **active management**.

ToR d)

Current knowledge on HABs in the Arctic

Kimberly Howland, Christine Michel, Kaven Dionne, Jesica Goldsmit, Chris McKindsey, Cynthia McKenzie, Nathalie Simard, Fatma Dhifallah, Frederic Laget, André Rochon

There is an interest in better understanding prevalence and risks of harmful algae in the Canadian Arctic given warming ocean conditions and growing potential for transport of organisms with increased levels of shipping in this region. This presentation provided an overview of ongoing research efforts in Canada. These include a literature review of recent studies focussed on toxin-producing algae in the Arctic. Although there are no published studies in the Canadian Arctic, preliminary findings noted 12 studies for the wider Arctic (the majority in Greenland waters) and three more general studies on species composition of algae in the Canadian Arctic which contained data on toxin producing algae. Efforts are currently underway to develop a comprehensive Arctic phytoplankton database of species from 50 publications together with raw data sets from key phytoplankton researchers in Canada. Species are being categorized by Marine Ecoregion (Spalding 2007) and information on toxicity and invasion status are being noted if available. Approximately 25% of the species reviewed to date are potentially harmful, but many are considered rare or only occasionally occur in the Arctic. Other ongoing research include surveys of phytoplankton communities in the highest activity ports of the Canadian Arctic to provide baseline data and detect the arrival of potential nonindigenous species as well as ballast surveys to characterize diversity and relative abundance of phytoplankton communities in ballast waters of vessels arriving at Canadian Arctic ports. Results of port surveys generally show a decrease in diversity and abundance of dinoflagellate taxa and more specifically of harmful taxa with increasing latitude. Interestingly surveys indicate a substantial increase in the proportion of harmful taxa in the port of Churchill since 2007. Ballast surveys of vessels transiting from temperate to northern Canada have identified up to 15 non-indigenous species with potential to survive in colder waters, seven of which are potential toxin producers, confirming that shipping provides a pathway for transport of harmful taxa to the Arctic. A subset of five of these harmful species were modelled to predict the potential spatial distributions at Arctic and global scales using the Maximum Entropy (MaxENT) habitat model. Modelling was conducted under present environmental conditions and under two future global warming scenarios (2050 and 2100), representing intermediate greenhouse emissions (temperature anomaly of 2.4 °C by 2100). Results showed that predicted suitable habitat under current conditions was much greater and, in most cases, extended more poleward than documented occurrences. Overall a global loss of habitat is predicted for modelled species (mainly in tropical regions), but a slight increase in suitable habitat is expected in the Arctic under future climate scenarios.

**Climate change opens new frontiers for marine species in the Arctic:
current trends and future invasion risks**

Farrah Chan, Keara Stanislawczyk, Andrea C. Sneekes, Alexander Dvoretzky, Stephan Gollasch, Dan Minchin, Matej David, Anders Jelmert, Jon Albretsen, Sarah Bailey

Nonindigenous species (NIS) are increasingly threatening the Arctic environment due to the effects of climate change. The general warming in this region is promoting human-mediated introductions and natural spread of NIS. Additionally, the Arctic is becoming more suitable for temperate species, allowing for increased probability of successful establishment once introduced. In this review, we examined information on 47 introduction events of 31 NIS in the marine Arctic to better understand temporal and spatial patterns and to identify important source and introduced regions. We also studied single- and

multi-pathway introductions. The rate of introduction ranged from 0-3 new NIS per year during the studied period. The Norwegian Sea, Barents Sea, and Iceland Shelf had the greatest number of introductions. Many NIS originated from the Northwest Pacific, Northeast Atlantic, and unknown sources. Shipping has introduced the greatest number of NIS to the Arctic, including phyla Ochrophyta and Arthropoda. We found that a lack of baseline taxonomic data compromises the identification of new NIS. Therefore, further inventory of Arctic biodiversity is needed, particularly as climate change is creating a more hospitable environment for new species. Finally, we reviewed management techniques that may be effective in mitigating NIS in the marine Arctic when implemented promptly. The Arctic ecosystem is expected to undergo rapid changes that may facilitate the establishment of invasive NIS, thus further study and management of the area is crucial.

Other Business

Update on PICES NIS Activities in 2017

Tom Therriault (A/Chair PICES AP-NIS)

PICES and ICES have a long history of collaborating on many important marine issues, including non-indigenous marine species. Initial collaborations between the two organizations were centred on PICES WG-21 and more recently the PICES ADRIFT project that was looking at the impacts of debris generated by the tsunami resulting from the 2011 Great East Japan earthquake. However, PICES now has a longer-term expert group (an Advisory Panel in PICES lingo) related to non-indigenous marine species. This group met for the first time at PICES-2017 in Vladivostok and has a Term of Reference specifically dedicated to working with ICES and other international organizations to better understand and share information related to marine invasions.

In 2017, PICES, ICES, and CIESM hosted a joint theme session at the 2017 ICES Annual Science Conference in Fort Lauderdale, FL entitled “Bioinvasion trajectories and impacts in contrasting marine environments” co-convened by Cynthia McKenzie, Canada-ICES; Thomas Therriault, Canada-PICES; and Henn Ojaveer, Estonia. In addition to highlighting the need to work together on marine invasive species issues, a specific product that arose at the ASC was the desire to develop a viewpoint on biofouling. For PICES, 2017 also marked the end of its special 3 year project “Assessing the Debris-Related Impact of Tsunami (ADRIFT)” funded by the Ministry of the Environment of Japan. Two special issues, one in Aquatic Invasions and the other in Marine Pollution Bulletin, both available via open access, make project results available to the scientific community while highlights will be presented at a special session at the 6th International Marine Debris Conference in San Diego, CA in March 2018. In conjunction with ICES, PICES is also supporting the Marine and Freshwater Invasive Species Conference to be convened in Beijing in August 2018. In October 2018 PICES will be supporting the 10th International Conference on Marine Bioinvasions in Argentina and PICES and ICES will host a joint theme session at the 4th Climate Change Conference in Washington, DC in June 2018. With respect to scientific publications, PICES contributed to the ICES COOPERATIVE RESEARCH REPORT/RAPPORT DES RECHERCHES COLLECTIVES NO. 335: Alien Species Alert: *Didemnum vexillum* Kott,

2002: Invasion, impact, and control led by WGITMO with two additional collaborative papers in development – one on global invasion vectors led by WGBOSV and another applying the AI-ISK risk assessment tool led by WGITMO.

Understanding marine invasions is complex but PICES and ICES have worked well together (and with other organizations) in the past and there are many avenues for continued collaboration on this topic. Many joint theme sessions have been organized/are planned and there is ongoing dialogue and participation in each other's meetings. One specific action item following discussions at the ICES WG meetings in Portugal is using AquaNIS as a global marine invasive species database and information exchange portal. PICES will work to get existing data into a format that would be uploaded to AquaNIS that would enhance information exchange

Baltic Sea NIS Monitoring Strategy **Maiju Lehtiniemi**

Non-indigenous species (NIS) monitoring is to address all biotic components as NIS may belong to any trophic level and be found in various man-made as well as natural habitats. There is currently no coordinated monitoring specifically targeting NIS in the Baltic Sea. Some observations (e.g. plankton and soft bottom macrofauna species) are obtained through the HELCOM biological monitoring programme. In addition to joint monitoring programme, HELCOM coastal fish gill-net monitoring and BITS surveys provide information on NIS presence-absence, spread and abundance/biomass. The only targeted method to monitor NIS is the HELCOM/OSPAR Port survey protocol, which provides information on NIS found in ports to support decisions on granting exemptions from the IMO BWMC. In addition, a variety of targeted approaches and methods has been and are being developed, which may be used for NIS monitoring. These include rapid assessment surveys, monitoring of Marine Protected Areas, molecular methods, automated image analysis, public involvement (citizen science) and environmental impact assessments. However, as none of these covers all groups of organisms or habitats these approaches should be considered as additional parts of the NIS monitoring. A centralized database is the key element of the integrated NIS monitoring system. Thus, AquaNIS (the Information system on Aquatic Non-Indigenous and Cryptogenic Species) database complemented by data from coordinated monitoring has been agreed to be the data source for the assessments.