IMO GloBallast R&D FORUM ON BWM

6th GEF-UNDP-IMO GloBallast R&D Forum and Exhibition on Ballast Water Management

Montreal, Canada, 16 -18 March 2016

IMO-IMarEST Shipping Industry Forum

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PROCEEDINGS

Ballast Water Management Convention

Moving Towards Implementation

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Ballast Water Management Convention: Moving Towards Implementation

Proceedings of the 6th GEF-UNDP-IMO GloBallast R&D Forum and Exhibition on Ballast Water Management

and

the IMO-IMarEST Shipping Industry Forum

16-18 March 2016
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Acknowledgements

This publication contains a selection of presentations and papers from the 6th GEF-UNDP-IMO GloBallast Research & Development Forum on Ballast Water Management, held in Montreal, Canada, from 16 to 18 March 2016.

While it is impossible to name everyone, it is important to give credit to all the people and organizations that collaborated in the event and contributed to its success.

In first place, our very special thanks go to Mr. Marc Garneau, Federal Minister of Transport Canada, for his kind attention and willingness to deliver the inaugurating address of the Forum. We were greatly honoured by the presence of such a high ranking figure in our event. Many thanks are also due to the staff in Transport Canada for the support and advice prior to and during the event.

Special thanks are owed to the partners who made this event possible, in particular IMarEST, ICS and INTERTANKO, long-standing supporting organizations of the GloBallast Partnerships Programme that have always been available to help out and promote our events. Our appreciation is also extended to all the sponsors and exhibitors for their participation and contribution.

We are also indebted to Dr. Stefan Micallef, Director of IMO's Marine Environment Division, Dr. Andrew Hudson, Head of the Water and Ocean Governance Programme at UNDP, Dr. Braulio Ferreira de Souza Dias, Executive Secretary of the CBD, and Mr. Ted Thrasher, Chief of the Environmental Standards at ICAO's Air Transport Bureau, for their presence and inspiring opening remarks at the Forum.

Our sincere thanks to the chairpersons that so diligently facilitated and moderated the discussions during the Forum sessions, namely Dr. Kevin Reynolds, Dr. Tim Fileman, Dr. Thomas Waite, Mr. Jad Mouawad and Dr. Lilia Khodjet El Khil. They were essential in steering the debate and keeping the high level of interest from participants throughout the conference.

In particular, we would like to thank the members of the International Scientific Committee that helped us in selecting topics and papers for the Forum; and of course, thank you to all of those 36 experts for their papers, presentations and interventions in the discussions as well as for their knowledgeable contributions for publication in these proceedings. The conference success was mainly attributed to the active engagement of all the delegates and participants and we would like to extend our sincere appreciation for their continued support during the event.

We would also like to express our warm thanks to our colleagues at the International Civil Aviation Organization, Mr. Rick Lee, Mr. Christian Khouzam, Ms. Virginie Leblanc, Ms. Alexandra Pare, Ms. Vivian Iakovos and Mr. Jonathan Whyte-Pottermal, for their invaluable support with the local logistics for the event.

Finally, many thanks are also due to our IMO colleagues who supported the 2016 R&D Forum, in particular Mr. Dandu Pughiuc, Mr. Antoine Blonce, Ms. Aïcha Cherif, Dr. Murat Korçak and Mr. John Alonso.

Dr. Jose Matheickal
Chief Technical Adviser
GloBallast Partnerships Programme
International Maritime Organization

Foreword

I am very pleased to note the successful outcome of the IMO-GloBallast Forum on Research and Development (the R&D Forum) on Ballast Water Management (BWM), which was held at the initiative of the GEF-UNDP-IMO GloBallast Partnerships Programme in Montreal, Canada, from 16 to 18 March 2016. As the Secretary-General of IMO, I have always highlighted the importance of BWM and this Forum has regularly been benchmarked as the leading global event of its kind, under the umbrella of the Organization.

The significant progress made since the last edition of the R&D Forum, held three years ago in Busan, Republic of Korea, is worth highlighting. While in 2013 there were 33 ballast water treatment systems that had received their Type Approval Certificate, by the time of the meeting in Montreal this figure had almost doubled to 63. In parallel, the BWM Convention has become tantalizingly close to achieving the conditions for its entry into force, having received ratifications from some 50 countries representing just under 35% of world tonnage.

The theme of the R&D Forum was chosen to reflect these developments and focused on "Ballast Water Management Convention: Moving Towards Implementation". Some 140 experts at the forefront of research and development gathered at this key international event to share their knowledge and experience on treatment technologies and alternative methods and highlight the status of the current research related to BWM. The wide participation of eminent experts allowed for a productive discussion.

The R&D Forum was also a great opportunity to showcase many new technologies and systems that will cater for different ship types, environmental conditions and operations. This confirms that various technology solutions are now available and I believe that preparations for the implementation of the BWM Convention should not be delayed any further. The maritime community will have to rise to the logistical challenge of preparing ships for the entry into force of the Convention, implementing effective planning for systems installation on board ships.

I believe that this edition of the R&D Forum has made a positive contribution towards maintaining the global momentum to find optimal solutions to diminish the threats from the transfer of marine invasive species through ships' ballast water and sediments. The papers in this publication, selected through an International Scientific Committee, reflect the global interest in an issue of critical importance for preserving marine and costal biodiversity.

Finally, I take this opportunity to congratulate the GloBallast Partnerships Programme in its final year. GloBallast is a highly successful initiative between GEF, UNDP and IMO that has collaborated with the shipping industry to become a major catalyst in the development of new BWM technologies and the transformation of an industry, contributing to the environmental sustainability of shipping and reducing its impact on marine ecosystems.

I encourage all of you to continue such dialogue and information exchange, which is significantly contributing to our common efforts to protect the marine environment.

Kitack Lim
Secretary-General
International Maritime Organization
London, United Kingdom

OPENING SPEECHES

DR. STEFAN MICALLEF

Director

Marine Environment Division, IMO

Dr. Stefan Micallef graduated with a Ph. D. in marine toxicology from the University of Wales, UK. Dr. Micallef started his career with the UN in 1990 as a Programme officer at the UNEP/IMO - Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) based in Malta. In 2000, he joined UNEP's Division of Environmental Policy Implementation in Nairobi as Chief of the Disaster Management Branch and was responsible for policy and strategy formulation. In 2004, he moved to IMO Headquarters as Head of the Chemical & Air Pollution Prevention Section, Sub-Division for Pollution Prevention, Marine Environment Division. In 2007, he was appointed Deputy Director of the Sub-Division for Pollution Response and Technical Co-operation Coordination and was later appointed Director of the Marine Environment Division in January 2012.

Minister Marc Garneau, ladies and gentlemen,

It is a great pleasure, and privilege, to address you here in Montreal. The Secretary General of the International Maritime Organization, Mr. Kitack Lim, has asked me to convey his best wishes for a successful event and commends Transport Canada for their assistance with hosting this prestigious Forum.

I would like especially to thank you Minister, for taking the time from your busy schedule to join us here today. I would also like to thank Mr. Ted Thrasher and ICAO for providing this great venue in their beautiful Headquarters, which is the perfect illustration of the concept of working together as UN sister agencies for the purpose of "Delivering as one".

I would also like to thank the Executive Secretary of the Convention on Biological Diversity, Dr. Dias, for the work of the Secretariat of the CBD on invasive species and of course our appreciation goes to our long-term partner Dr. Andrew Hudson from GEF UNDP for his continuous support to the GloBallast Project.

As most of you are aware this is the sixth and last R&D Forum and Exhibition on Ballast Water Management organized by the GloBallast Partnerships Programme along with the IMO-IMarEST Shipping Industry Forum. The initial aim was to bring together scientific experts and academia with the maritime industry and leaders in technology development for ships' ballast water management.

As such, the Forum has been instrumental in promoting information exchange and fostering dialogue between key stakeholders, which are vital facilitators for the harmonized implementation of IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments. The wait has been long for the Convention to enter into force, although fulfilment of the remaining tonnage requirement – a mere 0.18% – seems now tantalizingly close. A total of 49 countries have now ratified the Convention, representing 34.82 % of the world's merchant shipping tonnage, while the entry into force trigger is 35%.

Minister, ladies and gentlemen,

Carrying ballast water is essential for the safe and efficient operation of ships proving stability and structural integrity. However as we all know only too well, when discharged overboard, ballast water has the potential to pose serious ecological, economic and human health threats due to the harmful organisms and pathogens that may be transferred from one marine ecosystem to another. The harmful impacts of established invasive species are in most cases irreversible. Canada, with one of the longest navigable coastlines in the world, bordering the Atlantic, Arctic and Pacific Oceans, as well as the St. Lawrence Seaway as the gateway to the Laurentian Great Lakes, has not been spared. The sea lamprey (Petromyzon marinus), zebra mussel (Dreissena polymorpha), ocephalus cernuus) and spiny water flea (Bythotrephes cederstroemi) have proven to be some of Canada's most significant invasive species challenges on the Great Lakes to date.

That said, Canada has always played a catalysing role in Ballast Water Management research since the harmful effects of unwanted species in ships' ballast water were first reported to IMO in 1988, when Canada informed the IMO's Marine Environment Protection Committee about invasive aquatic species in the Great Lakes. It is therefore only logical this BWM R&D Forum takes place here, in Montreal, at a time when the BWM Convention has never been so close from meeting its entry into force criteria.

IMO has done its part in supporting this process with painstaking work to facilitate the effective and globally uniform implementation of the BWM Convention. An update on recent developments in and achievements of the Marine Environment Protection Committee will be addressed later in a keynote presentation by Mr. Chris Wiley, Chairman of the IMO MEPC Ballast Water Review Group and who has chaired this group since MEPC 58 in October 2008. What I wish to stress now is that the significance of all this work must be understood in the wider context of growing concern about ocean health and marine biodiversity, and that the issue of good governance of the world's seas and oceans is being pursued actively at United Nations level.

In this connection, the impact of ballast water discharges on marine biosafety also features high on the UN agenda, most recently within the context of the adoption of the 17 Sustainable Development Goals (SDGs) by the UN General Assembly's 70th Regular Session on 28 September last year. One of the SDGs with particular resonance for our work to protect the marine environment and healthy and thriving ecosystems from the risks associated with ballast water is Goal 14, which concerns the conservation and sustainable use of the oceans, seas and marine resources for sustainable development. The SDGs are part of the 2030 Agenda for Sustainable Development, an ambitious set of targets with the potential to transform the world through a Global Partnership for implementation.

The GEF-UNDP-IMO GloBallast Partnerships Programme is an excellent example of IMO's success in establishing global partnerships with many different stakeholders in its global and regional technical cooperation projects. GloBallast is a technical cooperation project created to sustain global momentum in tackling the issue of the transfer of harmful aquatic organisms and pathogens in ships' ballast water. The Project has worked to expand government and port management capacities; instigating legal, policy and institutional reforms at national level; developing mechanisms for sustainability and driving regional coordination and cooperation. Today we, at IMO, can be proud to state that of the 15 GloBallast Lead Partnering Countries, 13 of them have national ballast water management strategies when this was not the case when we started the project. We are also proud of the fact that this project is being viewed as one of the most successful GEF global programmes ever that has made a transformational change in an industry sector to address one of the most serious threats to the world's oceans.

This R&D forum has been the flagship global event of this Project and I am particularly encouraged to see the continued interest in this Forum which we established 15 years ago.

Distinguished participants, ladies and gentlemen,

From IMO's wider perspective, international shipping will continue to play a pivotal role in supporting world trade and helping to build and expand the maritime economic potential of developing countries – that is, a "blue economy" based on the huge development opportunities offered by the seas and oceans and enabling less developed countries to realise their potential for growth and prosperity. Shipping is an important backbone of economic activity and underpins global commerce, providing the most efficient and cost effective, as well as safe and clean method for the mass transport of food, energy, materials, goods and products over great distances. IMO's conventions and numerous other regulatory instruments provide the necessary global standards, achieved on the basis of consensus, to ensure the safety, security and sound environmental performance of shipping in a level-playing field across the world. International regulatory frameworks on issues such as ballast water management, anti-fouling and biofouling contribute to the comprehensive canvas of IMO-agreed marine environmental measures and in this context I would like to inform you that "Shipping, indispensable to the world" is this year's World Maritime Day's theme. We should grasp the opportunity to let those outside the immediate confines of the maritime industry know the contribution of shipping to the social, economic and environmental pillars of sustainable development.

Minister, ladies and gentlemen,

This brings me to the principal message I wish to convey to this Forum.

The BWM Convention, to be effective, needs to enter into force. Only then will the spread of harmful aquatic species and pathogens through ships' ballast water and sediments discharges be minimized, and only then will it be possible to further improve upon the Convention by amending its provisions in order to achieve this noble objective in the most efficient and pragmatic way.

I wish to conclude by saying that the multi-faceted and complex nature of ballast water management has not deterred us from consistently working together to seek the most efficient as well as comprehensive solutions, and one that is a truly global partnership, integrating biological requirements of diverse marine ecosystems, innovative engineering solutions, economic parameters of a modern shipping industry, and civil society's demands for stringent regulation to protect the marine environment.

A Forum such as this provides an excellent platform to push the boundaries of human ingenuity in a collaborative spirit. I know that all of you are committed to making your own, distinct contribution through knowledgeable debate and open information exchange in the coming days. Together, we need to continue to be both creative and courageous, and ever more so, in order to save the oceans for future generations. I can assure that IMO, on its part, remains fully committed to the task in hand and to doing its bit for a sound, global system of shared responsibilities for good ocean governance.

Thank you.

MR. TED THRASHER

Chief of the Environmental Standards

Air Transport Bureau, ICAO

Mr. Ted Thrasher leads the analytical and technical work associated with ICAO's Standards on aircraft noise and engine emissions and coordinates related activities for ICAO's Committee on Aviation Environmental Protection (CAEP). He is also responsible for the development of ICAO's guidance material and support tools for the quantification of aviation's impact on the environment. Prior to joining ICAO, Mr. Thrasher was the Director of Simulation, Modelling, and Analysis for the engineering services firm CSSI in Washington, D.C. Mr. Thrasher holds a Bachelor of Science degree in Aviation Engineering from The Ohio State University, a Master of Science degree in Systems Engineering from Johns Hopkins University, and a commercial pilot's license.

Good morning and welcome to Montreal and to the ICAO Headquarters.

ICAO and IMO both have long histories that pre-date the formation of the United Nations itself. Understandably, IMO's history is a bit longer… at the time when the first international shipping treaties were being signed, the invention of the airplane was still more than 50 years away.

While we host many meetings on a very broad range of topics here, I have to admit that this is not the typical event that we see. For most of the ICAO staff with backgrounds in aviation, they may have a hard time trying to relate to the topic of managing ballast water. Of course, load balancing as aircraft burn fuel is a critical element of flying just as it is for shipping. However, we go about this in a very different way in the aviation world. We don't attempt to take on more weight in flight for balance or for any other reason. I understand that ships may inadvertently bring fish and other marine life on board when using water for ballast, so I guess the analogy would be for aircraft to ingest birds while in flight. We have no recommended procedures on the books for aviation where this could be a regular event.

On the other hand, ICAO's founding document, the Chicago Convention, includes Article 14 on the prevention of the spread of communicable disease through air travel. This is, in fact, quite similar to the aims of the IMO to address the transfer of harmful organisms by ships' ballast water, with the aim of protecting the world's oceans.

Although the operation of a ship and of an airplane is quite different, the work of ICAO and IMO on the environment have a lot in common and are often considered together. This is because international aviation and international maritime represent the two sources of "bunker fuels," that is, emissions that are international and therefore difficult to attribute to an individual country. In fact, it is because we are placed in close proximity on the agendas of many international meetings that we had the chance to see a very inspirational presentation at the Rio+20 conference a few years ago. At the time, ICAO had only recently launched its action plan on emissions reduction program. This initiative is a mechanism by which States communicate to ICAO the measures that they intend to implement to reduce the impact of international aviation on the global climate.

We had spent about a year and a half leading up to the Rio+20 conference, working with States to give them the tools that they needed to prepare comprehensive plans for aviation and the environment. We have been quite successful in this regard where we are closing in on having 90% of the world's air traffic covered by a State action plan on the environment.

But, at the time of the Rio+20 conference, what we didn't have was a mechanism to assist States with the implementation of those plans. And, of course, you can't deliver any benefits if you don't actually put in place the measures that you have planned to. We had been interested in obtaining funding through the Global Environment Facility, or GEF, but had understood that it really wasn't available for aviation projects.

This brings us to that fateful meeting at the Rio+20 conference, where we learned about the GEF-UNDP-IMO GloBallast Programme to address marine biosafety through global partnerships. What we heard IMO describe was exactly what we were hoping to do for international aviation. Knowing that our sister organization had been successful on the maritime side of things was an inspiration for us.

And, as they say, the rest is history. Today, we have our own UNDP-GEF project in place that is on track to deliver a renewable energy pilot project for airports. We have a team on site as we speak working with the local authorities to move forward to the procurement of the system. Assuming that it is successful, the intent is to replicate this project in other States, which will have a measurable reduction on the CO2 emissions from international aviation.

And it all started from learning from IMO and your work on ballast water management.

Again, we are very pleased to welcome you here and I wish you a successful meeting.

DR. ANDREW HUDSON

Head

WATER AND OCEAN GOVERNANCE PROGRAMME UNDP NY

Dr. Andrew Hudson joined UNDP in 1996 as Principal Technical Adviser for the UNDP-GEF International Waters Programme. He is currently Head of the UNDP Water & Ocean Governance Programme (www.undp.org/water) in the Sustainable Development Pillar of UNDP's Bureau for Policy and Programme support (BPPS). He oversees and provides strategic, policy and technical guidance on all aspects of the development, implementation and evaluation of UNDP's work in water and ocean governance with a currently active portfolio of about US$200 million working in over 100 countries. He also served as Principal Technical Adviser for the UNDP/GEF Persistent Organic Pollutants (POPs) programme, from 2001 to 2005. He coordinated the strategic development and start-up of UNDP's POPs portfolio and integration of the programme into UNDP's Chemicals Management/Montreal Protocol Unit. He also serves as the "Green Team Leader" at UNDP leading efforts to move the organization towards environmental sustainability in its operations, including minimizing the organization's carbon footprint.

Prior to joining UNDP, Dr. Hudson was Executive Director of The Center for Field Research at EARTHWATCH where he directed the development of EARTHWATCH'S annual field research program of 150 projects and over $3 million in grants. He has also taught at the university and secondary school levels and was active in oceanographic research in the 1970's and 1980's in areas such as hydrothermal vent geochemistry, sedimentary diagenesis, hydrography and air-sea exchange.

Dr. Hudson received his BS and MS in Earth and Planetary Sciences from MIT, was a doctoral student in Oceanography at the University of Rhode Island, and received his PhD in Environmental Sciences from the University of Massachusetts-Boston, specializing in Environmental Economics and Policy.

Excellencies, distinguished delegates, generous sponsors, ladies and gentlemen:
Good morning and, on behalf of the United Nations Development Programme, welcome to the 6th GEF-UNDP-IMO GloBallast Research and Development Forum and Exhibition on Ballast Water Management.

Some of you might wonder why UNDP, with its mandate related to the eradication of poverty and reduction of inequalities and exclusion, should be so interested in a highly technical issue like ship ballast water. In supporting countries to reduce poverty and achieve sustainable development, UNDP helps countries to integrate environmental considerations into development plans and strategies, including through managing and sustainably using natural resources. We do this by helping countries to develop policies, leadership skills and stronger institutions to sustain development results.

These strategies dovetail very clearly to the objectives and approaches of GloBallast such as through its support to ballast water legal, policy and institutional reforms. We know that invasive species not only can impact large scale infrastructure, but also local communities, for example via invasives preying on or outcompeting important fish stocks that people depend upon for their livelihoods and food security. By helping countries to reduce ship invasives risk, GloBallast is contributing to reducing poverty that can be caused by degraded marine environments.

Of the environmental challenges facing our oceans, such as overfishing, pollution and habitat loss, in many ways invasive species is the most pernicious. Some years ago, GloBallast estimated that globally, aquatic invasives cause about $100 billion in socioeconomic damage each year. While it is possible to reduce overfishing and pollution, allowing marine ecosystems to recover, there are few if any successful examples of an invasive aquatic being eradicated. This underscores the importance of the preventive approach built into the global convention on ship's ballast water and sediments and GloBallast's overall strategic approach to building national capacity for convention compliance.

It is quite remarkable that we are gathered here for a 6th time since the first GloBallast R&D Forum in 2000. I haven't been able to participate in every one, but when I have, I'm always amazed at the immense creativity and innovation that is being directed at addressing this challenge. Clearly the series of fora have been instrumental in bringing and sharing state-of-the art scientific, technological and policy knowledge and innovations on ballast water management which has led to many of the solutions and a massive new ballast water treatment and compliance monitoring technology market that we see now.

As I'm sure you all know, the Convention has reached 34.82% in terms of tonnage meaning just 0.18% to go and I think we are all confident that entry into force will happen soon. It might be fitting if one of the GloBallast pilot or current lead partner countries brought forth the final ratification that brings the convention into force, underscoring the catalytic impact the GloBallast program has had for over 15 years.

Since this final phase of GEF support to GloBallast programme will be ending in June 2017, this will be the last R&D forum under the GloBallast programme. Given the great success and catalytic impact the fora have had, it would be great if IMO, its Member States, private sector and other partners elect to continue to organize the Forum as this is a unique platform for information exchange and networking on state-of-the-art R&D related to ballast water management.

On both a personal and professional level, I want to thank a number of UN colleagues, past and present, at both UNDP and IMO, who have made key contributions to the many important impacts GloBallast has delivered over these 15 years. This includes people I worked with in the initial conceptualization of GloBallast like Henning Brathaug and Manfred Nauke at IMO, and Phil Reynolds at UNDP; the various heads of the IMO Marine Environment Division from Oleg Khalimonov to Jean-Claude Sainlos to Miguel Palomares to Stefan Micallef. Each of the IMO Secretary Generals over this period – Bill O'Neill, Efthimios Mitropoulos, Koji Sekimizu and Ki Tack Lim have all provided their unequivocal support to the programme over the years.

Lastly and perhaps most of all, I would like to thank and recognize the Technical Advisors the project has employed over the years – Dandu Pughiuc, Jose Matheikal, Fredrik Haag and Antoine Blonce – whose tireless efforts have enabled the GloBallast programme to deliver again and again and again. Dandu and Jose could not be with us at the forum this year so I would like to extend special thanks to them, and Dandu in particular, who will soon be retiring from IMO and has continued waving the GloBallast flag in his leadership on marine bio-security at IMO.

Thank you and wishing everyone a superb forum this week here in Montreal!

DR. BRAULIO FERREIRA DE SOUZA DIAS

Executive Secretary

Convention on Biological Diversity

Dr. Dias has over three decades of experience in biodiversity science and policy and its implementation at national and international levels. He brings a unique combination of scientific training and extensive experience in negotiation.

He obtained a BSc in Biological Sciences from the University of Brasilia and went on to obtain his PhD in Zoology from the University of Edinburgh in 1981. While working as division chief for environmental studies for the Brazilian Institute of Geography and Statistics, and as Associate Professor of Forest Protection and Ecology at the University of Brasilia, he became increasingly involved in the negotiations leading up to the adoption of the Convention on Biological Diversity. He was involved in the meetings of the Intergovernmental Negotiating Committee of the Convention on Biological Diversity in 1991 and 1992, served on the Brazilian Delegation for the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, as well as on the Intergovernmental Committee of the CBD in 1993 and 1994.

Dr. Dias' experience at the international level is informed by his work at the national level in Brazil in implementing the Convention on Biological Diversity. Among others, he coordinated the National Biodiversity Programme (PRONABIO) since 1994, coordinated the negotiations for the creation of Brazil's National Biodiversity Policy (1998-2002) and coordinated the National Biological Diversity Project – PROBIO (1996-2005). His interest in ways to mainstream biodiversity into the activities of other economic sectors was realized in his coordination of the National Biodiversity Mainstreaming Project – PROBIO II (2009-present) and his work on the relationship of business and biodiversity. Dr. Dias joins the Secretariat at the beginning of the United Nations Decade on Biodiversity and the first years of implementation of the Strategic Plan for Biodiversity 2011-2020.

Distinguished participants, ladies and gentlemen,

It is a great pleasure to welcome you to the city of Montreal, where the Great Lakes Waterway and the Saint Lawrence Seaway meet, on the occasion of the 6th GEF-UNDP-IMO Research and Development Forum and Exhibition on Ballast Water Management. I would like to start by congratulating GEF, UNDP, IMO and the GloBallast Partnerships for organizing this remarkable event that seeks to meet the global needs of technical and scientific cooperation in ballast water management. I would also like to thank the Government of Canada and supporting organizations for their contributions, and the many sponsors who, with their valuable donations, made this conference possible.

With the continuous expansion and development of international commerce, biological invasions have become a very real consequence of globalization. As the global international trade volume index expanded from 13 in 1950 to 109 in 2008, the number of marine, coastal and estuarine alien species increased from less than 200 to 10,000 species in the Mediterranean Sea alone. The increase in modern trade, travel and technology intensifies the risk of spread of alien species that includes unwanted pests and pathogens for many different countries across the world. I wish to remind you that invasive alien species are one of the direct drivers of biodiversity loss and have been estimated to cost our economies hundreds of billions of dollars each year due to the economic impact on both agricultural and ecosystem services as well as the high costs of eradication efforts. This does not even take into consideration the valuation of extinction of local species.

Article 8 (h) of the Convention on Biological Diversity states that "Each contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". In decision VI/23, the Conference of the Parties to the Convention adopted Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species. Furthermore, Aichi Biodiversity Target 9 aims that "by 2020, invasive alien species and pathways are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment". Although many countries have put in place measures and strategies to manage invasive species, the reality most countries face, especially developing countries and small island developing States, is that control and eradication of invasions in marine and coastal environments is far more difficult than that in terrestrial ecosystems. Early detection of invasions under water is hard to achieve, and rapid response in open water is simply hard to conduct. Therefore, prevention becomes a key measure for the management of aquatic invasions.

Around the world, a variety of fish, crabs, mussels, jellyfish and corals as well as microscopic pathogens are just some of the life forms that have created havoc after they were introduced. Most of these marine invasive species stow away in ship ballast and are then released in different biogeographic regions. They also hitch rides on the outside of ship hulls. Three to five billions of tons of ballast water are estimated to move around the world each year and while ballast water is essential for safe and efficient shipping operations in the sea, it has posed serious ecological, economic and health problems in countries with ports.

According to the fourth edition of the Global Biodiversity Outlook, progress has been made on a global scale in identifying the pathways through which both terrestrial and aquatic species enter alien environments and become invasive. However, weak border controls in many countries prevent this knowledge from being acted upon. Governments are increasingly taking steps to manage alien species invasions. More than half of the Parties of the CBD currently have national policies relevant to tackling this major threat to biodiversity. Overall, there has been some progress towards achieving Target 9 on invasive species, but additional actions are required if it is to be met by the 2020 deadline.

In 2006, the Conference of the Parties to the CBD urged Parties to ratify the International Convention for the Control and Management of Ships' Ballast Water and Sediments, or the BWM Convention. We rest positive that the BWM Convention will enter into force very soon. I have learned that the number of ratifications from States has surpassed the criteria, and the requirement of 35 per cent of world merchant shipping tonnage is very close to being achieved. This will represent a very important milestone in preventing the spread of invasive species, as ships in international traffic will meet international standards. To do so, cost-effective measures will be more desirable than ever.

CBD has been continuously collaborating with IMO and other organizations that oversee international regulatory frameworks related to invasive alien species. The IMO and its partners have made significant steps with setting various guidelines on ballast water management and the prevention of bio- fouling for large and small ships. Therefore, measures are continuously being developed and improved.

Ladies and gentlemen,

We must acknowledge that the implementation of effective measures on a global scale will be yet another great challenge due to the limited capacity in many parts of the world. CBD, in collaboration with experts and partners, has been working on capacity development to put measures in place. We urgently need to share experiences and best practices and enhance national capacity to expedite our collective implementation towards achieving Aichi Target 9. In this regard, the CBD Secretariat continues to collaborate with the Global Invasive Alien Species Information Partnership (GIASI Partnership) to provide Parties with up-to-date information on invasive alien species in terrestrial and marine environments.

Since COP 10, in 2010, the CBD Secretariat has facilitated a global process of better understanding the ecological or biological significance of the world's oceans, covering so far more than 80 per cent of the world's oceans with regard to the description of areas meeting the CBD's scientific criteria for ecologically or biologically significant marine areas. I hope that we can further facilitate the building of close linkages between the conservation of marine biodiversity and the sustainable development of maritime activities.

We are living in a critical era of Holocene extinction of species driven by human activities. The survival of humanity on this planet critically depends on biodiversity and thus, we bear an enormous responsibility to ensure that our utilization of biodiversity does not exceed nature's capacity to regenerate itself. The deep interconnectedness among people, other living organisms and ecosystems underpins the health and well-being of this planet and the life it sustains.

Recognizing this critical interconnectedness, I wish to invite all of you to join hands to address biodiversity considerations effectively in all facets of maritime activities, towards achieving our common goal of sustainable ocean development, as enshrined in the 2030 Agenda for Sustainable Development and the Sustainable Development Goals adopted by the United Nations General Assembly. This will require strategic partnerships among countries, regional and global partners and of course, the research and development community. We will work together in this spirit of collaboration, as envisioned in the Strategic Plan for Biodiversity, to live in harmony with nature.

With this, I wish you a successful conference with fruitful discussions. Thank you.

PROGRAMME

Day 1: Wednesday 16 March 2016

8:00 - 9:30	**REGISTRATION**
9:30 - 10:00	**OPENING SPEECHES**
	Dr. Stefan Micallef Director, Marine Environment Division, IMO
	Mr. Ted Thrasher Chief of Environmental Standards, Air Transport Bureau, ICAO
	Dr. Andrew Hudson Head, Water and Oceans Governance Programme, UNDP
	Dr. Braulio Dias Executive Secretary, CBD
	The Honourable Marc Garneau Minister of Transport, Government of Canada
10:00 - 10:30	**COFFEE BREAK + GROUP PICTURE**

1

SESSION-1: KEYNOTE SESSION
Chaired by Dr. Stefan Micallef, Director, Marine Environment Division, IMO

10:30 - 10:50	**Keynote 1:** Mr. Chris Wiley Chairman of the IMO MEPC Ballast Water Review Group
10:50 - 11:10	**Keynote 2:** Mr. Shaj Thayil Head of Global Technical Services with APL & Managing Director for Neptune Shipmanagement Services Pte. Ltd. (NSSPL)
11:10 - 11:30	**Keynote 3:** Mr. Vassilis Tsigourakos, IMO Consultant, RAC/REMPEITC - Caribe
11:30 - 11:50	**Keynote 4:** Mr. Antoine Blonce Technical Adviser, GEF-UNDP-IMO GloBallast Partnerships Programme

Day 1: Wednesday 16 March 2016 Continued

11:50 - 12:15	**Q&A / Roundtable**	
12:30 - 14:30	**LUNCH BREAK**	

2

SESSION-2: IMO-IMarEST SHIPPING INDUSTRY FORUM
Chaired by Dr. Kevin Reynolds, Principal Engineer, Glosten

14:30 - 14:50	**Ballast water treatment: urgent practical results needed,** Mr. John Stubbs, Director, Technical Services, FedNav Ltd.
14:50 - 15:10	**BWM Compliance - A Short Sea Shipping Perspective,** Mr. Nick Leak, Project Manager, CSA Ballast Water Research and Technical Evaluation
15:10 - 15:30	**The marine industry's perspective on exceeding regulatory compliance,** Ms. Françoise Quintus, Program Manager, Green Marine
15:30 - 16:00	**COFFEE BREAK**
16:00 - 16:20	**Experiences from the application of USCG and G8 Type Approval Processes** Mr. Jad Mouawad, Mouawad Consulting
16:20 - 16:40	**Experience from retrofit of a 1000-BWMS on board a Container ship,** Mr. Jad Mouawad, Mouawad Consulting
16:40 - 17:30	**Q&A / Roundtable**
18:00 - 20:00	**WELCOME RECEPTION**

Day 2: Thursday 17 March 2016

3

SESSION-3: TREATMENT TECHNOLOGIES AND ALTERNATIVE METHODS
Chaired by Dr. Tim Fileman, Business Development Manager, Plymouth Marine Laboratory & PML Applications Ltd.

9:00 - 9:20	**The GESAMP-BWWG Methodology: A living document,** Mr. Jan Linders, Chairman, GESAMP-BWWG
9:20 - 9:40	**Effect of Storage Time with Soluble Organic Compound and Oxidants on Fresh Water Algal,** Dr. Kitae Rhie, Professor, Kyung Hee University
9:40 10:00	**Comprehensive study on environmental risk due to operation of electrochlorination-disinfection on ballast water treatment,** Dr. J. Paul Chen, Professor, National University of Singapore
10:00 - 10:20	**The effects of various chemical additives on the production of disinfection by-products and plankton survival in simulated ballast water,** Dr. Myung-Baek Shon, Senior Surveyor, Senior Surveyor, Marine & Ocean Equipment Team, KR
10:20 - 10:40	**Application of Ultra-Low Frequency (ULF) Field in Ballast Water Disinfection,** Mr. Hwee Hong Chew, Managing Director, Semb-Eco Pte Ltd
10:40 - 11:00	**COFFEE BREAK**
11:00 - 11:20	**Evolution of Port-Based BWM Scenarios: Past, Present and Future,** Dr. T. D. Waite, Dept. of Marine and Environmental Systems, Florida Institute of Technology
11:20 - 11:40	**Mobile Treatment for Old Ships, Infrequent Discharges, and Emergencies,** Dr. Kevin J. Reynolds, Principal Engineer, Glosten
11:40 - 12:00	**The storm of ballast water compliance is brewing – Ports need to prepare,** Mr. Matthijs Schuiten, Product Manager, Damen Green Solutions

Day 2: Thursday 17 March 2016 Continued

12:00 - 12:20	**BWTBOAT-Treated Ballast Water Delivering Facility - Ready for Implementation,** Mr. Sandip Vitthal Patil, Surveyor, Indian Register of Shipping (IRCLASS)
12:20 - 12:50	**Q&A / Roundtable**
12:50 - 13:00	**SPONSOR'S PRESENTATION**
13:00 - 14:30	**LUNCH BREAK**

4

SESSION-4: FOCUS GROUP ON UV TREATMENT SYSTEMS AND RELATED APPROVAL PROCESSES
Chaired by Dr. T. D. Waite, Dept. of Marine and Environmental Systems, Florida Institute of Technology

14:30 - 14:40	**A Study to improve the UV disinfection efficiency to meet more stringent regulation,** Mr. Joseph (Young Chu) Ohg, General Manager, United States PANASIA CO., LTD.
14:40 - 14:50	**Can UV systems meet the USCG requirements for BWT,** Mr. Birgir Nielsen, VP of Business Development, OptiMarin AS
14:50 - 15:00	**NIVA's experiences with IMO and USCG testing of ballast water treatment technologies,** Ms. Stephanie Delacroix, Scientist, Ballast water testing project manager, Norwegian Institute for Water Research
15:00 - 15:10	**The Development of an Alternative Method to Quantify the Number of Living 10-50 um Organisms for Ballast Water Management System Type-Approval Tests,** Dr. Brian Petri, Research Director, Trojan Technologies
15:10 - 15:20	**Compared to what? FDA and CMFDA are flawed benchmarks for live/dead classification in phytoplankton,** Dr. Hugh L. MacIntyre, Researcher, Department of Oceanography, Dalhousie University

Day 2: Thursday 17 March 2016 Continued

15:20 - 15:50	**Q&A / Roundtable**
15:50 - 16:10	**COFFEE BREAK**

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SESSION-5: COMPLIANCE MONITORING AND ENFORCEMENT (CME)
Chaired by Mr. Jad Mouawad, Mouawad Consulting

16:10 - 16:30	**In-line fluid sampling method for obtaining representative samples,** Dr. Youngsoo Kim, Director of Marine Environment Division Korea Marine Equipment Research Institute,
16:30 - 16:50	**Practical experiences in on board ballast water compliance sampling,** Dr. Vladimiro Bonamin, VP Global Business Development Manager, Environmental Health & Safety Division of SGS Group Management Ltd.
16:50 - 17:10	**Revolutionary Microbial Testing for Pathogens in Ballast Water,** Dr. Paul R. McCright, Executive Vice President, Project Manager, Biotrack Diagnostics, Inc
17:10 - 17:30	**Compliance tools to rapidly detect living microorganisms in ballast water: How do they compare to traditional microscope counts?** Dr. Mario Tamburri, Maritime Environmental Resource Center, University of Maryland
17:30 - 17:50	**A conceptual Port State Control Decision Support System : DHI-PSCBallast,** Dr. Guillaume Drillet, Head of Section Ecological Processes, DHI Water and Environments
17:50 - 18:15	**Q&A / Roundtable**

END OF DAY 2

Day 3: Friday 18 March 2016

6

SESSION-6: SHIPBOARD INSTALLATION, SURVEY & CERTIFICATION: A CLASS SOCIETY PERSPECTIVE
Chaired by Ms. Tone K. Fiskeseth, Principal Engineer, Environmental Protection, DNV-GL - Maritime

9:00 - 9:20	**Role of recognized organizations in the implementation of the BWM Convention,** Mr. William Burroughs, on behalf of IACS
9:20 - 9:40	**Discussion on Current Guidance for Scaling of BWMS,** Mr. William Burroughs, Senior Principal Engineer, American Bureau of Shipping
9:40 - 10:00	**Technical consideration for successful ballast water management** Mr. J.K. Byun, Senior Surveyor, KR on behalf of Dr Keun-Hyung Choi
10:00 - 10:30	**Q&A / Roundtable**
10:30 - 11:00	**COFFEE BREAK**

7

SESSION-7: POLICY PERSPECTIVES ON BWM AND BIOINVASIONS
Chaired by Dr. Lilia Khodjet El Khil, Manager, Sustainability and Government Relations, Canada Steamship Lines

11:00 - 11:20	**Brazilian Maritime Standard on Ships' Ballast Water – 10 years of implementation,** Ms. Maria Cecilia Trindade de Castro, Lieutenant Commander Brazilian Navy
11:20 - 11:40	**Chile: Development of the national capacities towards the implementation of the BWM 2004 Convention,** Mr. Rodrigo Zambrano, Lieutenant Commander CG, Directorate General of the Maritime Territory and Merchant Marine of Chile

Day 3: Friday 18 March 2016 Continued

11:40 - 12:00	**Ballast Water Management from a IMO Member State perspective,** Dr. Murat Korçak, APO International Maritime Organization on behalf of TUBITAK-Marmara Research Centre
12:00 - 12:20	**The Baltic Sea approach in implementing the IMO Ballast Water Management Convention,** Dr. Anita Mäkinen, Chief Adviser to the DG of Maritime Sector, Finnish Transport Safety Agency
12:30 - 14:30	**LUNCH BREAK**
14:30 - 14:50	**Ballast Water Management – How to do it manual,** Dr. Natalia Martini, Senior Technical Adviser, Institute of Marine Engineering, Science & Technology (IMarEST)
14:50 - 15:10	**Priority pathways management to achieve Aichi Biodiversity Target 9 on invasive alien species in the oceans,** Dr. Junko Shimura, Secretariat of the Convention on Biological Diversity (CBD)
15:10 - 15:20	**Managing the arrival of unwanted Invasive Aquatic Species via vessel biofouling,** Dr. Ashley Coutts, Managing Director, Biofouling Solutions Pty Ltd
15:20 - 15:50	**Q&A / Roundtable**
15:50 - 16:00	**CLOSING REMARKS**

CONFERENCE PROCEEDINGS

Update on the status of the IMO Ballast Water Convention

Chris Wiley

2016 will likely be THE defining year for the Ballast Water Convention. (BWC) As of this date 49 countries representing 34.82 per cent of the world tonnage have ratified. However, it would appear that sufficient countries have indicated they will be able to ratify shortly to put the BWC “over the top” at some point during the next year. The BWC will come into force one year after 30 countries representing 35% of the world tonnage ratify. As such, the International Maritime Organization (IMO), ship owners and administrations will all be under pressure to ensure things are in place before the Convention comes into force.

The BWC will provide a standardized global approach for industry, enhanced protection of the environment and conservation of biodiversity.

It however has not been an easy way forward. Sufficient Guidance form IMO on uniform implementation of the BWC was required. No other IMO Convention has as many Guidelines. Sufficient numbers of Ballast Water Management Systems (BWMS) are required to be able to be installed aboard ships worldwide. Currently there are more than 50 BWMS that have been granted Type Approval by their administrations. Clear and practical implementation dates have been set. New ships will fit BWMS on entry of the Convention. Existing ship will be required to meet the discharge standard on after the date of entry into force. Most ship owners will fit a BWMS. It will be required to be installed at the first IOPP renewal survey after the Convention. A fair and consistent regime of Port State Control has been agreed upon. Unlike MARPOL Pollutants such as oil or sewage biological pollution is not visible. As such monitoring is required to ensure discharges from ships provide water that is in compliance with the IMO standard. Onboard technology will provide information to prove that the BWMS is operating as designed. However Port States will be able to sample and analyze the discharge though during a two to three year trial period, administrations are encouraged to refrain from applying criminal sanctions or detaining ships based on sampling alone during the trial period. IMO is currently undertaking a review of the type approval process (G8 Guidelines) to modernize it consist with the technological advances since the first version of the Guidelines were agreed on shortly after the BWC was signed. Ship owners are looking to ensure early movers that have fitted BWMS manufactured under the original G8 type approval are not penalized.

The sooner the BWC comes into force and ships are fitted with BWMS, the threat of the introduction of aquatic invasive species discharged in ballast water will be reduced or eliminated.

Ballast Water Management Implementation: APL's Journey as Early Adopter of Treatment Systems

Shaj Thayil, Head of Global Technical Services, APL

Abstract

Effective ballast water management (BWM) has been a hot topic of discussion among the global shipping industry and scientific community over the years. As technology advances and industry insight matures, the search for the best BWM solutions continues.

As a responsible global shipping carrier, APL is dedicated to protecting ocean biodiversity. In 2011, APL started installing ballast water treatment systems onboard its vessels to reduce the risks associated with the discharge of non-native aquatic species in foreign waters through the vessels' ballast water.

Today, almost 60% of APL's owned vessel fleet is equipped with ballast water treatment equipment. The remaining 40% deploys mid-ocean ballast water exchange, currently the most widely available method of mitigating the spread of non-indigenous species in ballast water.

APL remains resolved in overcoming the challenges to be ready for the impending ratification of the Ballast Water Management Convention - a key international measure developed by the International Maritime Organization to protect our oceans' marine life.

Introduction

APL is a global container shipping business that combines high-quality intermodal operations with the latest information technology to offer 80 weekly services at more than 150 ports worldwide.

As a responsible global shipping carrier, APL is dedicated to protecting ocean biodiversity. With ballast water identified as a major threat to the world's marine ecosystems, effective ballast water management (BWM) has been a hot topic of discussion among the global shipping industry and scientific community over the years. As technology advances and industry insight matures, the search for the best BWM solutions continues.

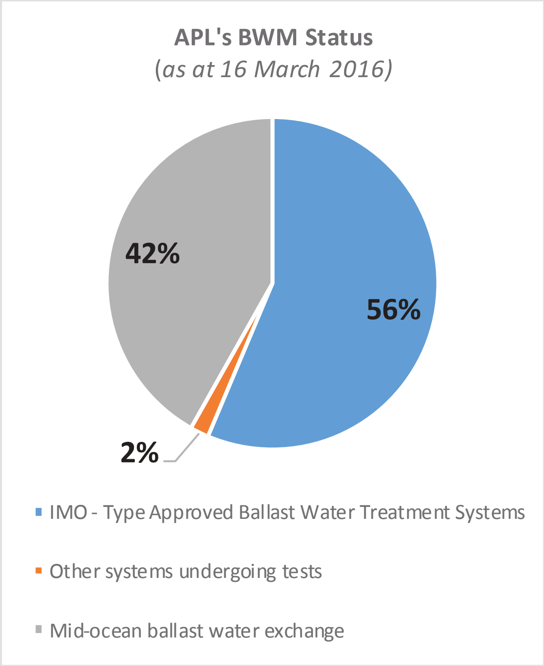
APL: a Front-Runner in Implementing BWM Treatment Technologies

In 2011, APL started installing ballast water treatment systems onboard its vessels to reduce the risks associated with the discharge of non-native aquatic species in foreign waters through the vessels' ballast water.

Key factors which determined APL's choice of treatment systems included:

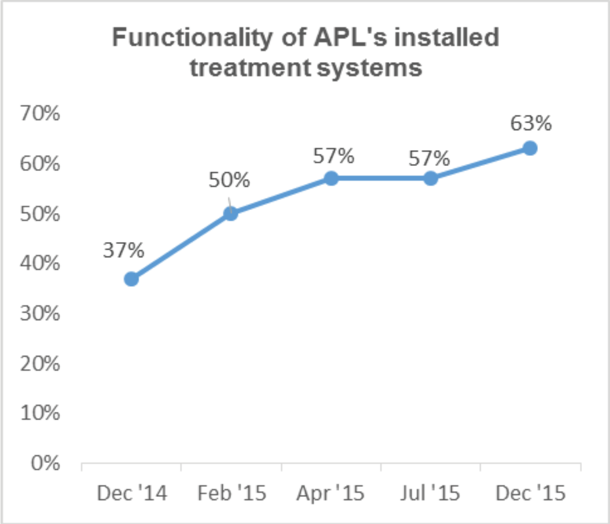
- Cost effectiveness and availability of components and services
- Power consumption
- Reliability of the supplier
- Training and support made available to APL's vessel crew for installed systems
- Assurance from manufacturers based on thorough research

Today, almost 60% of APL's owned vessel fleet is equipped with ballast water treatment equipment. The remaining 40% deploys mid-ocean ballast water exchange, currently the most widely available method of mitigating the spread of non-indigenous species in ballast water.



However, the technologies and applications that APL is pioneering with the industry and solutions providers are not perfect as yet. Preliminary implementation efforts saw equipment design flaws and operational issues while repairs and maintenance support by system makers are still inadequate.
APL remains resolved in overcoming the challenges to be ready for the impending ratification of the Ballast Water Management Convention - a key international measure developed by the International Maritime Organization to protect our oceans' marine life.

APL recognises that active engagement, coupled with on-going training efforts to educate system manufacturers and their representatives on maritime safety, is vital in achieving a common ground with stakeholders. Meanwhile, APL's maritime crew's rigorous operational procedures, supported by training and upgraded safety and control measures, helped to improve the optimal functioning of these treatment systems. Resulting from these ongoing efforts, close to 30% of APL's installed systems have improved in their functionality.
APL is also furthering its contributions to this important cause through strategic partnerships. This includes being a founding member and current chair of the Global Industry Alliance (GIA) for the GloBallast Programme. The GIA is a public-private sector initiative launched with IMO, United Nations Development Programme and Global Environment Facility in 2009, to jointly create sustainable and cost-effective solutions to ballast water issues.



Conclusion
Responsible environment management is an integral part of APL's global operations. Taking decisive action in implementing a comprehensive ballast water management strategy ahead of industry peers, was critical in enabling APL to live out its sustainability commitments. As the global shipping industry gets ready to comply with the Convention guidelines once it enters into force, APL will continue to actively support this global momentum in tackling the ballast water issue and developing effective solutions collaboratively.

Regional cooperation in the Wider Caribbean for reducing the transfer of harmful aquatic organisms and pathogens in ship's ballast water

Vassilis Tsigourakos[1]

The Wider Caribbean Region (WCR) comprises 36 States and Territories bordering the Caribbean Sea and Gulf of Mexico. The combined area of the Caribbean Sea and the Gulf of Mexico is approximately 5.3 million square kilometers. Due to an abundance of endemic flora and fauna, the WCR is considered as a 'biodiversity hotspot' (Krauss, 2006).

The economy of the Wider Caribbean Region is highly dependent upon tourism. In fact, the Caribbean is the region in the world most dependent on tourism for jobs and income with tourism directly and indirectly providing almost 12.0% of total employment and 13.0% of total Gross Domestic Product (GDP) (World Travel & Tourism Council, 2014). Aside from the social and ecological value of these environmental resources, the continued health of the region's coastal and marine ecosystems, including beaches, coral reefs, mangroves and sea grass beds, are essential to this economic driver.

The economies of the Wider Caribbean Region are similarly dependent upon shipping and the growing near-shore and offshore petroleum industry. Major shipping routes utilize the WCR area and countless commercial vessels provide the food, goods and fuel essential to the lives of the people of the region. In the Easter Caribbean region shipping moves as much as 96% of all imported goods (Singh, 2015). Commercial shipping creates jobs and delivers goods, but also generates emissions, garbage, and sewage, and exposes the natural environment to the risks posed by a release of oil or other HNS carried as cargo, oil from bunker tanks, in addition to invasive species carried in ballast water. A study carried by UNEP's Caribbean
Environment Programme (CEP) and CABI's Caribbean and Latin American Regional
Centre (CLARC) recorded a total number of 118 Marine Invasive Species in the WCR (Krauss, 2006). The most notable marine invasion in the region is the Lion Fish (*Pterois miles,* J. W. Bennett, 1828 *or Pterois volitans*, Linnaeus, 1758) invasion, causing in the invaded sites an immediate decline of endemic species which could cause, in the long term, irreparable damage in the reefs.

Since 2008, RAC/REMPEITC-Caribe is the Regional Coordinating Organization in the Wider Caribbean Region for the GEF-UNDP-IMO GloBallast Partnerships Programme. In the Wider Caribbean Region (WCR), five Lead Partnering Countries (LPC) (the Bahamas, Jamaica, Panama, Trinidad and Tobago and Venezuela) and several Partnering Countries (Dominica, Honduras, Nicaragua) have benefited from the funds and expertise of the project to develop a National Ballast Water Management Strategy and make a National Ballast Water Status and Economic assessment. In addition, these LPCs participated in several capacity building training to raise awareness and increase the expertise of national administrators in Ballast Water Management issues, as a recent workshop in Duluth, USA, in October 2015, on Port State Control under the BWM convention with emphasis on sampling and analysis of ballast water.

RAC/REMPEITC-Caribe has also coordinated the development of a WCR strategic action plan for ballast water management that was adopted by the Fifteenth Intergovernmental Meeting on the Action Plan for the Caribbean Environment Programme and Twelfth Meeting of the Contracting Parties to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region Punta Cana, Dominican Republic, 25 to 27 October 2012. This Action Plan provides a regional framework for the reduction of the transfer of Hazardous Aquatic Organisms and Pathogens, in addition

[1] RAC/REMPEITC-Caribe Presentation.

of enhancing regional cooperation and encouraging the accession of the BWM Convention by the WCR States.

For the remaining time of the GloBallast Partnerships Programme, RAC/REMPEITC-Caribe will work towards finalizing all national assessments, strategy developments with the LPCs. Most importantly, the Centre will make sure to increase collaborations with national institutes, marine biologist and national stakeholders with the result that by the end of the Project, selected maritime institutes will be training maritime experts in key aspects of shipboard BWM, and thus contributing in leaving a legacy to the Project after it comes to an end.

References

Krauss, V. L. (2006). National and Regional Capacities and Experiences on Marine Invasive Species.

World Travel & Tourism Council. (2014). Travel and Tourism Economic Impact 2014 Caribbean.

Singh, A., Asmath, H., Leung Chee, C., Darsan, J., (2015). Potential oil spill risk from shipping and the implications for management in the Caribbean Sea. Mar. Pollut. Bull. 93 (2015), 217-227, http://commons.wmu.se/lib_articles/251/

Ballast Water Treatment – Urgent Practical Results Needed

John T. Stubbs

The ballast water convention was agreed in 2004, twelve years ago. But few ships have treatment systems installed and even fewer ships where systems are being used. Although the Convention is close to ratification, there are likely to be further delays as the marine industry is presently in its worst financial crisis of a generation. Then there is the matter of what technologies really work in practice and which may not; the debate is on-going and possibly heading to court challenges.

Technically, there are still challenges as to whether the biological requirements are able to meet the Convention, let alone 10x, 100x or even 1000x more stringent. The present approach of producing an all-encompassing solution is not working for many reasons. Even if the Convention is ratified now, delays will be expected as owners trading to the USA will not procure treatment systems till they are USCG certified. Then there is the complex matter of retro-fitting the world's existing fleet, a near impossibility within a five year implementation period.

Considering the above, and the special interests of many Authorities bounding the Great Lakes of North America, Fednav decided to act as early as 2001 and spent millions of dollars in testing treatment systems and methods. After evaluating the many methods of treatment available, Fednav conducted its own controlled tests utilizing chlorine as an active substance which is widely used worldwide for disinfecting purposes. The conclusive tests provided a high degree of confidence in meeting the requirements of treatment standards. Consequently, in April 2015, Fednav announced the purchase of twelve Ballast Water Treatment Systems from a reputed Japanese manufacturer.

Presented herewith is an outline of the measures taken by Fednav to meet ballast water treatment requirements, the risks and benefits of being an early adopter of ballast water treatment, and of the many challenges that remain.

Fednav is an owner / operator of a fleet of 52 vessels, plus another nine vessels on order for delivery by mid 2018. The capital investment being faced in installing ballast water treatment systems to the owned fleet is of the order of $ 25 to 50 million dollars. So it is very important that the systems installed work and meet regulatory criteria with a high degree of confidence.

IMO have issued Type Approvals for about 57 systems at the time of writing. However, USCG have not accepted the IMO type approvals and have initiated their own standards and approval process. At the time of writing in March 2016, there are no USCG type approved ballast water treatment systems. For the about ½ of the worlds' fleet of vessels subject to installation of BWTS, it is not an issue as such vessels do not trade to the USA. But the foregoing could affect resale values of such vessels going forward.

For the approximately ½ of the remaining worlds' fleet, about 30,000 ships, the uncertainties posed by the disparity between the availability of many IMO approved systems and the lack of any USCG type approved system presently being available creates a situation impeding progress. No owner envisaging a vessel trading to the USA can take the risk of installing a non USCG type approved BWTS. Worthy of mention is the USCG AMS temporary certification process valid for up to 5 years, but if at the end of the AMS certification, if the system is not yet USCG type approved, then the system will require to be replaced.

Fednav has experience with three systems tested in full scale on-board owned vessels.

Before the ballast water convention was drafted, the first was a copper ion generator installed on 35,000 dwt bulk carrier 'Federal Yukon' in 2001. The concept was one of treating rest water in the bottom of ballast tanks, then filling up the tank at the port where ballasting operations would take place; thereby discharging copper within local allowable discharge levels. As the regulatory process for ballast water evolved, it became evident that the concept would not be acceptable and further development of the concept stopped.

In 2005, a preliminary installation of an electrodialytic system was retro-fitted to the 35,000 dwt 'Federal Welland'. The part installation encompassed retro-fitting a filter and modifying ballast piping to make a space provision for later installation of the treatment pipe. The latter never happened. Firstly, the retro-fitting served to highlight the difficulties, complexities and cost in making space, providing for interfaces and dealing with the changes in the performance of the ballast system with the addition of the treatment system. It cost much more than contemplated and the treatment system, then under development ended up getting more complex and costly. It was learnt that the system was not well suited for a bulk carrier fresh water application and the concept was abandoned. We learnt of the intricacies involved in retro-fitting and risks of extra costs.

In 2011 – 2012, the ballast water convention was then coming on seven years old, and more and more countries were becoming signatories

In mid- 2012, Fednav ordered a special high ice class bulk carrier with an 18 months lead time delivery. Because the vessel trades to remote, isolated areas and faced with the possibility that the BW Convention could be ratified and come into force within the lead time delivery period, the vessel has an ozone type BWTS installed. The system has many safety devices that need close attention for the safe operation of the system.

At about the same time, decisions were being made on the matter of fleet renewal at Fednav and it was important that new vessels deliver with BWT systems. There were concerns being expressed by regulators concerning the efficacy of UV type treatments, so a decision was made to test chlorine treatment of ballast full scale in ships ballast tanks. The Fednav owned vessel 'Federal Venture' was on a dedicated trade from the Saguenay River to Brazil, transiting southbound in ballast and returning loaded with a full deadweight cargo. Fednav worked with the University of Windsor, Dr. Hugh MacIsaac and his team. Ballast tanks were assigned in pairs as control tanks, as tanks treated by exchange only and tanks where the exchange was augmented by adding controlled dosages of 12 % hypochlorite to dose ballast tanks at 20 and 10 ppm chlorine. It was found that the exchange, augmented with chlorine treatment came very close to meeting the IMO standard without filtration. It was from the aforementioned experiment that Fednav came to select treatment by chlorination of ballast water.

With a series of newbuilding vessels delivering in Japan in 2015 and 2016, Fednav contracted with JFE to supply BallastAce systems. The system is IMO Type Approved and has USCG AMS certification for fresh water, brackish and salt water. The system is presently going through the USCG type approval certification process, It is expected that certification will be obtained in 2017.

Fresh water land based tests will be performed shortly within the Great Lakes ; while brackish and salt water tests will be performed on the US eastern seaboard. The 2015 delivered 35,000 dwt bulk carrier " Federal Biscay" will be the platform utilized for performing the certification on-board testing.

Traditionally, owners procure type approved systems for installation on vessels and operate over the life of the ship within regulatory requirements.

In the case of ballast water, the situation is very different and Fednav has had to become an active participant in the technical development and approval of ballast water treatment systems because:

- The regulatory requirements are not clear. The IMO G8 and US ETV requirements differ. Furthermore, the G8 standard is envisaged to be amended as soon as the BW Convention is ratified. Consistency and confidence in the uniformity of test results provided by accredited test facilities needs to be affirmed. Shipping is an international business so it is fundamental and essential that standards be harmonized and be consistent.

- There is a realization that the about 5 year cycle for an IOPP certificate renewal period is likely insufficient for something like 60,000 treatment systems to be built into new ships or retro-fitted into existing ships.

- What happens when the first USCG type approval is granted? How will competition between suppliers of treatment systems be handled? What happens to the USCG implementation extensions now being granted once the first USCG type approval is granted?

- How is port state control testing of BWTS to be handled? The process of testing for type approval involves the need of highly trained and experienced specialists to make biological determinations

- What are IMO's and USCG's contingency plans for implementation of the convention facing the uncertainties of type approvals, ratification and coming into force of the BW convention, port state control enforcement, lack of shipyard space to retro-fit BW treatment systems, the current financial situation facing most of the world's shipping ?

There is a pressing need for IMO and USCG to align and harmonize their requirements, addressing and providing solutions to the above listed issues and questions to avoid further delays which will likely lead to increased local regulation.

The marine industry's perspective on exceeding regulatory compliance

Françoise Quintus, Program Manager, Green Marine

Ballast water carried by ships is recognized as one of the principle vectors of aquatic invasive species from one part of the word to another, threatening global biodiversity and local ecosystems, and having negative consequences on the economy and human health. Ballast water management is one of the most important issues the marine industry worldwide has to deal with.
The Green Marine program provides a framework for ship owners, ports, terminals and shipyards to improve their environmental performance and gives recognition to those companies that demonstrate environmental stewardship above regulatory compliance.

Green Marine was launched in 2007 by the shipping industry operating in the St. Lawrence and Great Lakes region with the goal to build its social license to operate for the long term. By developing a voluntary environmental program, the industry committed to taking concrete actions to reduce its environmental footprint.

Today, Green Marine has an enrolled membership of more than 100 participants across North America. The success of the program is due to its incomparable and unique features:

- Comprehensive, targeting 12 key environmental issues
- Requiring the implementation of concrete actions
- Exceeding regulatory compliance
- Fostering continuous improvement
- Public reporting and third part verification of results
- Engaging all industry stakeholders

Key environmental issues for ship owners include Air Emissions (NO_x, SO_x & PM, GHG), Aquatic Invasive Species (ballast water and bio-fouling), Oily Water, Cargo Residues and Garbage Management. For each of these issues, participants rank their environmental performance on a scale from 1 to 5, according to a set of established criteria. This performance or results must be reported to Green Marine by April 1st every year for public disclosure. The Green Marine certification is awarded after independent verification of results and certifies that a ship owner has engaged in a process of continuous improvement beyond regulatory compliance.

The threat posed by aquatic invasive species via ballast water has been a priority issue since the beginning of the program. Despite an uncertain regulatory context and technological challenges of compliance in the Great Lakes and St. Lawrence waterway, ship owners participating in the Green Marine program have been proactive in advancing the issue by voluntarily adopting best management practices such as conducting salt water ballast water exchange and avoiding uptake of ballast water in adverse conditions. The program also recognizes the active participation in research and development to help advance science and technological progress. The ultimate recognition is awarded to participants that have installed and use a ballast water treatment system on board ahead of the Convention's enforcement. A recent review of the program has also broadened the scope of the issue by including bio-fouling as an equally important vector of aquatic invasive species. Anti bio-fouling measures, such as underwater hull inspections and cleaning are now additional requirements of the program.

Despite the voluntary nature of the program, ship owners made significant efforts in the battle against aquatic invasive species, as evidenced by the results. Approximately one third of ship owners reporting on this issue, score a level 4 or 5. At these stages, participants have invested important amounts of resources (financial and human) to reduce their impact on the environment.

Overall the program has proved to be successful as confirmed by the steady improvement of results and the growing membership. Average performance for all environmental issues increased from 2.0 to 3.1 (on a scale from 1 to 5) between 2008 and 2014. More specifically for Aquatic Invasive Species, performance improved from 2.6 to 3.2.

The success of the program has earned Green Marine wide support from renowned organizations, such as government authorities, environmental groups and NGOs, as well as research and academic institutions. The program is today endorsed by more than 50 supporters, such as WWF, Environmental Defense Fund, the Carbon War Room, Nature Conservancy Canada, Vancouver Aquarium, Puget Sound Clean Air Agency, Transport Canada, Ocean Networks Canada, etc. The program is also recommended by 19 North American marine industry associations that play an ambassador role and promote Green Marine's continued growth.

Many of these organizations are also actively involved in the program development and revision process, resulting in a unique collaboration model that promotes a culture of continuous improvement and advance environmental excellence.

BWM Compliance – A Short Sea Shipping Perspective

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Short Sea Shipping is a practice that exists in a number of regions around the globe and refers to the movement of cargo and/or passengers along the coasts, without crossing an ocean. Canada's inland and coastal waterways are located at the core of North America's industrial heartland and have been used for centuries to move large amounts of cargo in a safe and sustainable manner.

Short Sea Shipping in Canada serves a vital mining and grain industry and is an efficient and safe means of connecting domestic and continental trade flows with international trade. In addition, trades in the Great Lakes, St. Lawrence Waterway, Coastal and Arctic Waters provide economical and environmentally advantageous alternatives to road and rail use. Canadian Shipowners Association (CSA) members' vessels are specialized vessels and include Great Lakes bulk carriers and self-unloaders, general cargo, product tankers and tug/barges that are uniquely designed to maximize cargo operations within the confines of the lock systems in the Lakes and St. Lawrence Seaway. Trading routes for these vessels cross the border between Canada and the United States multiple times and vessels must transit multiple jurisdictions as they travel through the St. Lawrence Seaway System. CSA vessels also regularly call at U.S. ports due to the integrated nature of the North American economy.

BWM Compliance Challenges for the CSA Fleet

The regional regulatory context for implementation of ballast water regulation remains complex for CSA members. Canada is a signatory to the International Ballast Water Management Convention (BWMC) and is planning to implement convention requirements following its global ratification. The United States, Canada's principal trading partner, is not a contracting state to the BWMC and has developed its own regulatory framework through two different agencies and established its own protocols for testing and approvals for ballast water treatment systems to be operated in US waters to address aquatic invasive species moved by ships' ballast water.

However, there is currently no type approved equipment complying with the United States Coast Guard (USCG) requirements and it is not known when USCG compliant systems capable of operating in the waters and conditions of the Great Lakes will be available. Echoing this, Transport Canada advised in their March 2015 submission to the IMO that "were the BWM Convention to enter into force now, technical and regional compatibility factors would pose challenges to ships operating primarily in this region." [1]; this could occur rapidly with the imminent coming into force of the BWMC and result in adoption of inappropriate or inefficient technologies to maintain business trading.

There is additionally a continuing lack of confidence that any current ballast water treatment technologies can meet the discharge standards on a consistent basis within the CSA operating area, particularly for the often short voyages and high ballast flow rates experienced by CSA vessels. Regional conditions include extremely low salinity/very fresh water within the lakes, high levels of turbidity and very cold air and water temperatures that are prevalent for a large percentage of the sailing season. CSA vessel voyage times can be as short as a few hours to a few days, which is relevant for ballast treatment methods requiring prolonged contact times to be effective. Fast loading facilities and fast on-board self-unloading equipment are necessary to meet the demands of the North American supply chain therefore many CSA vessels commonly ballast and de-ballast at much higher rates than comparably sized ocean-going vessels. Ballasting rates of up to 5,000 cubic metres per hour with volumes approaching 30,000 cubic metres can be typical, further challenging many treatment processes.

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[1] See MEPC 68/INF.34, 'The current availability of appropriate technologies to permit Great Lakes ships to achieve the performance standard of the BWM Convention'.

With the imminent coming into force of the BWMC, Canadian-flagged vessels operating in the Great Lakes-St. Lawrence region of North America are facing complex regulatory and technological challenges. In an effort to address some of these challenges for its members the CSA launched a Ballast Water Research and Technical Evaluation Project in May 2015.

CSA Approach

The CSA project is aimed at systematically identifying mitigation solutions for ballast water management unique to the CSA Operating Area and operational requirements of the CSA fleet, and which are commensurate with the potential risks associated with domestic ballast water transfers. A key factor in achieving success will be an output that identifies the technologies, practices and processes that can be feasibly implemented on CSA vessels and that are environmentally and economically practical.

A series of initiatives were identified that fit within the project's scope and resources, with two main themes identified:

Theme 1: Technical Assessment

The objective of this theme is to provide independent, objective analysis to evaluate available ballast water management methods, focusing initially on evaluating current promising technologies that could potentially meet IMO or USCG discharge performance standards. Minimum criteria would be a demonstrated ability to meet the standards in all waters of the CSA Operating Area and for all times and conditions expected during the trading season.

The main deliverable will be a customized tool capable of managing large amounts of data and information, and evaluating multiple criteria (i.e. - technical, environmental, regulatory, performance, etc.) that, when integrated with the outputs from the CSA Aquatic Invasive Species (AIS) Transfer Potential Study, will provide a more comprehensive means to assess mitigation options and technologies for CSA vessels and support mitigation solution investment decisions.

For this theme the CSA has partnered with the National Research Council of Canada to conduct research and develop the customized tool required to support CSA member decision makers.

Theme 2: AIS Transfer Potential Study

The objective of this theme is to build on previous CSA work relating to potential AIS transfer risk and ballast water operations and evaluate the latest available data on species in the region, and to identify the non-indigenous species that may be candidates for potential risk of transfer. A better understanding of the potential risk/impacts associated with transfers within the context of domestic ballast water operations will be critical to the identifying of optimal mitigation measures and ballast water management options.

CSA has partnered with the Department of Biological Sciences of the University of Toronto at Scarborough, Ontario as a first phase. The work will leverage recognized applied science and research methodologies with a view to better defining the potential risks of AIS transfer associated with ballast water operations.

Integrating Themes

The next major step will be to integrate individual theme outputs to provide the means for holistic, objective, evidence-based analyses to identify mitigation options and serve as inputs to ship owner decision makers to apply specific vessel criteria and business requirements in considering investment options. Similarly for non-ship owner decision makers (i.e. - regulators, researchers, manufacturers, etc.), the outputs could serve as subsequent inputs to respective regulatory processes, identify areas for further research or development, promote further discussion and collaborations, etc.

Concluding Points

For the Canadian Short Sea Shipping fleet and its vessel configurations, operations and operating conditions, research and analysis to date has concluded that for Canadian-flagged vessels operating mainly on the Great Lakes and in the St. Lawrence Seaway System there is no single ship board solution evident in either the short or intermediate terms. Moreover, given the current regulatory uncertainties and the need for complying with the full suite of IMO, Canadian and U.S. ballast water performance standards and other regulatory requirements, ship owners need to be sure that by complying with a single ballast water regulation or discharge standard they are not being driven into non-compliance with other regulations or standards.

Solutions options are, therefore, most likely going to involve a hybrid of tailored technologies, processes, best practices and regulatory flexibility tailored for regional conditions and vessel criteria and all considered via a structured and holistic approach.

A much better collective understanding of a very complex problem set – namely the actual risks of potential AIS transfers in the Great Lakes and St. Lawrence Seaway System associated with ballast water operations - is also needed. This work should also include whether other concepts such as similar risk areas could be feasible approaches. Enhancing the quantification of the actual potential transfer risks will be critical so that mitigation measures optimized for this region can be identified. It is noted that no new invasive species have been detected in the Great Lakes since 2006.

Expanding partnerships and collaborations will continue to be vital to the ability to keep moving forward and could most certainly include support to research to further quantify AIS potential risk, adapting to changes in the science and regulatory landscapes, and exploring alternate mitigation approaches.

Lastly, time and flexibility are needed now more than ever in order to get this right. Further collaboration with government to identify the flexibility and feasible solutions is called for.

The GESAMP-BWWG Methodology: A Living Document.

Jan Linders, on behalf of the GESAMP-BWWG.

1. Introduction.

The GESAMP Ballast Water Working Group (BWWG) provides independent advice to IMO's Marine Environment Protection Committee (MEPC) for the approval of ballast water management systems (BWMS) that use Active Substances, in accordance with Procedure (G9) under the Ballast Water Management Convention (BWMC). The Methodology followed for evaluating the BWMS is considered to be a living document that may be adapted due to increased scientific knowledge gained during the evaluation process. The GESAMP-BWWG discusses new proposals to improve the Methodology in its Stocktaking Workshops (STW), which should take place at a yearly basis.

2. Stock taking workshop no. 7.

At the last STW, the seventh in a row, some of the items considered were the consequences for Procedure (G9) based on the ongoing review of Guidelines (G8), evaluation of new corrosion criteria, neutralization of TRO and overdosing of neutralizer, assessment of risk mitigation measures, appropriate detection limits for different Relevant Chemicals, new BWMS that employ chlorinated potable water as ballast and further quality assessment and finalization of the data in the GESAMP-BWWG Database. Most of these topics may have an influence on the GESAMP-BWWG's Methodology in the near future.

3. Results.

- *Consequences for Procedure (G9) Based on the Ongoing Review of Guidelines (G8)*

Although the GESAMP-BWWG evaluates ballast water management systems making use of Active Substances in accordance with Procedure (G9), a substantial part of the discussions at the Stocktaking Workshop were related to the ongoing review of Guidelines (G8). This is because treated ballast water, required for testing the acceptability of ballast water management systems in accordance with Procedure (G9), is prepared in conjunction with the tests required under Guidelines (G8). In addition, several of the issues being considered by the Correspondence Group on the review of Guidelines (G8) are related to Procedure (G9). Topics discussed in this regard were:

.1 environmental acceptability of the use of Active Substances in ballast water management systems, in particular related to the neutralization process in extreme conditions, and recommendations regarding the neutralization process and control scheme aimed at maintaining the maximum allowable discharge concentration at all times;

.2 five day period for Relevant Chemicals determination, ecotoxicity tests and WET tests under Procedure (G9) and recommendations regarding testing arrangements for Basic and Final Approval in conjunction with the anticipated amendments to tank holding time requirements under Guidelines (G8);

.3 allowing upgrades of ballast water management systems, which are recommended by the Committee when granting Final Approval in accordance with Procedure (G9), prior to type approval by the Administration;

.4 the importance of a unified approach in using additives for preparation of test water for the worst-case concentration of Relevant Chemicals;

.5 the agreement in principle, by MEPC 68, that Guidelines (G8) should provide mandatory guidance and the need for the Committee to also consider the possible mandatory status of Procedure (G9); and

.6 mitigating risks associated with ballast water discharges during shipboard tests of ballast water management systems.

- *New Corrosion Criteria*

The Workshop also revised the corrosion criteria requirements of the Methodology of the GESAMP-BWWG to be in line with the standards in the PSPC standard. The GESAMP BWWG is of the opinion that these criteria should be applied immediately as the criteria set out in the current Methodology were considered to cause an unsubstantiated burden for applicants. The now proposed criteria are described as follows:

For the BWMS to be found suitable for Final Approval, it should not fail in any test evaluation as specified below:

.1 ISO 4624: Adhesion: “Fail” if the adhesive or cohesive values at the treated panel are below that required in table 3.1 of IMO resolution MSC.215 (82). Annex 1.
.2 ISO 4628-2: Blistering: “Fail” if any blistering occurs.
.3 ISO 4628-4: Cracking: “Fail” if any cracking occurs.
.4 ISO 4628-3: Rusting: “Fail” if any rusting occurs.
.5 ISO 4628-8: Delamination and Corrosion: “Fail” if the delamination at the treated panel is greater than that specified in table 3.1 of IMO resolution MSC.215 (82). Annex 1.

- *Appropriate Detection Limits*

In recent years several discussions have been performed inside and outside the GESAMP-BWWG on the definition of appropriate detection limits. For some countries the best achievable detection limit (DL < 0.1 μg/L) is often considered too challenging especially with respect to costs. The GESAMP-BWWG developed new Detection Limit criteria for Relevant Chemicals based on the critical value for these chemicals. The critical value is defined as the value at which the PEC/PNEC ratio or the Risk Characterization ratio is above 1. Using the best achievable detection limit the ration between the critical value and the detection limit generally a value above 1000 was determined. Therefore, some detection limits were relaxed by a factor of 1000. The workshop considered that for this ratio a value ranging from 10 to 50 would be sufficient. Amongst the chemicals for which the detection limit should be relaxed are e.g. haloacetic acids, halonitriles and chloropicrin. Still there are Relevant Chemicals for which the generally available detection limit should be improved. Example chemicals are trichloroethene and trichloropropane. The list of newly defined detection limits for the Relevant Chemicals will be included in the next version of the Methodology.

- *Ballast Water Management Systems that Employ Chlorinated Potable Water*

The GESAMP-BWWG received some questions whether potable water based BWMS that include an active substance be submitted for (G9) review. Factual information available was that this type of systems generally generate potable water based on filtration (e.g. reversed osmosis) or distillation, that typically some chlorine was applied as powder or pellets, which were also used for direct human consumption. The GESAMP-BWWG considered that the concentrations were always low, enough to prevent regrowth of organisms, very few disinfection byproducts were formed at low concentrations, the discharge of this water as ballast water is very pure with low ion-concentrations and relevant vessels generally only discharge low volumes of ballast water. In addition, results of a case study performed in the US gave indications in the same direction. Therefore, the GESAMP-BWWG concluded that BWMS based on potable water generation with added oxidants should be submitted to the Administration to decide on the need for review under Procedure (G9).

- *Further Development of the GESAMP-BWWG Database of Chemicals Most Commonly Associated with Treated Ballast Water*

The Group uses ecotoxicological data for Environmental Risk Assessment. These data may be achieved by abstraction from existing databases or from direct new measurements. Although the GESAMP-BWWG invite applicants to submit new ecotoxicity data new studies have up to now not been submitted. Potential new studies ideally follows internationally recognized test guidelines and studies have QA/QC standards and meet test criteria specified in the test guidelines. The Group needs published details to confirm these criteria. Some on-line database values had been accepted without details but a further inquiry at these databases have been successful and e.g. the Japanese Ministry of Environment has supplied study details. Therefore, GESAMP-BWWG was able to confirm that relevant standards and criteria were met. Some chemicals for which the new information resulted in an adjustment of the ecotoxicity data were: tetrachlormethane, dichlorobromomethane, trichlorethene, 1,2 - dibromo-3 chloropropane, chloral hydrate, dibromoacetic acid, dichloroacetic acid, tribromoacetic acid, formaldehyde, trichloroacetic acid, dibromochloroacetic acid and dichlorobromoacetic acid.
GESAMP-BWWG continues its efforts to improve the database.

- *Conclusions and Recommendations*

GESAMP-BWWG concluded that the yearly STW showed very useful as much progress has been achieved in last years. The GESAMP-BWWG Methodology should still be considered as a living document. Sufficient new information comes available in the scientific literature to update the Methodology regularly. The scientific basis of the Methodology has improved by the determination of new criteria for Detection Limits and the extension of GESAMP-BWWG Database.

Some areas will be discussed by the GESAMP-BWWG in the forthcoming years. Several items need to be further developed like Emission Scenario Documents for specific ballast water discharge situations, an amendment of Human Exposure Scenario (“delivery, loading, mixing”: addition of scenarios for solids (dermal contact) and for inhalation; general public: addition of a tier 2 assessment). Factors affecting neutralization is a topic that should be developed further, probably in cooperation with the test facilities. GESAMP-BWWG may also propose additional tests with BW (Whole effluent testing using in vitro tests targeted at relevant endpoints, e.g. mutagenicity, Ames test or the micronucleus test, in saline waters, test system 'Mutatox'), but only after the Ballast Water Management Convention has entered into force.

It should be kept in mind that the intention of the GESAMP-BWWG Methodology is to facilitate the evaluation process and not to increase the burden of the applicants requesting the approval of the MEPC. It is expected that the interaction between Guidelines (G8) and Procedure (G9) will be strengthened in the coming years, especially via the test facilities joined in GloBal TestNet.

Effects of Storage Time with Soluble Organic Compound and Oxidants on Fresh Water Algal

Kitae RHIE

Abstract

The growth of Raphidocelis subcapitata and Chlorella vulgaris in cultures with glucose-added culture in neutralized TRO at day 1 and 5 after treatment were significantly lower than those treated culture neutralized at day 0. The growth response of C. vulgaris against treatment was rather slow than that of R. Subcapitata. The cellular viability of TRO treated glucose-added culture after neutralization was distinctively lower than that of the treated and neutralized culture without glucose. It is considered that the adverse effect on fresh water species with soluble organic matter is higher than that of insoluble organic matter, and the extended storage time to day 5 increases the eco-toxicity on algal growth.

Keywords: *Growth inhibition, Fresh Water Algae, Glucose, Neutralizer, Total Residual Oxidant (TRO) Storage Time, Treated Ballast Water, Flow Cytometry*

1. Introduction

It is reported that some test facilities add glucose to satisfy the test condition under G8 efficacy testing at the Land-based test for ballast water management system (BWMS) type approval. There are various kinds of additives reported in G8 test water to satisfy the organic contents level including lignin, starch, glucose etc. The soluble additives such as glucose may lead some un-considered factors due to rapid reaction with active substance and/or over-growth of bacteria may lead to increase of carbon content as an organic matter to potential reactants for active substances depending on storage time. Also, it is important view about algal toxicity from chemicals at fresh water with similar conditions like marine water, which is emphasized in current Methodology of GESAMP_BWWG.

2. Materials and methods

Raphidoceli subcapitata and *Chlorella vulgaris* from UTEX was cultured in the medium with or without treatment combinations of NaOCl, glucose or neutralizer. Each algal culture was treated with or without NaOCl for final concentration of 20mg/L TRO as Cl_2 after addition with or without 50mg/L of glucose as the additional organic compounds. TRO was neutralized by addition of Sodium thiosulfate. The inoculation concentration for *R. subcapitata* and *C. vulgaris* were 1.0 $x10^4$ and 2.0 $x10^4$ cells/mL, respectively, to the culture at 0, 1 or 5 days after setting of treatment combination. The algal growth was measured from each algal culture with variables of cell number, viability by FDA with Flow cytometer (Garvey *et al*., 2007).

3. Results

The growth of *Raphidocelis subcapitata* in cultures with glucose-added culture in neutralized TRO at day 1 and 5 after treatment were significantly lower than those treated culture neutralized at day 0 (Figure 1).

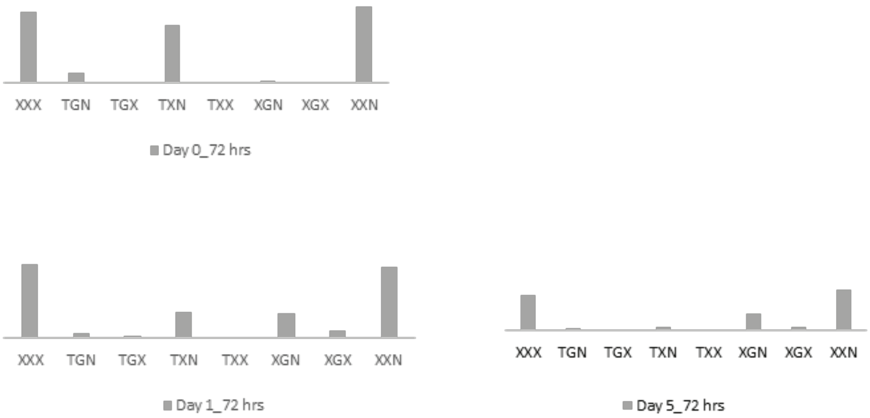

Figure 1. Comparison of treated Raphidoceli subcapitata (XXX-Control, w/o Glucose, TRO, Neutralizer, TGN-TRO, Glucose and Neutralizer treated, TGX-TRO and Glucose treated w/o Neutralizer, TXN-TRO and Neutralizer treated w/o Glucose, TXX-TRO treated w/o Neutralizer and Glucose, XGN-Glucose and Neutralizer treated w/o TRO, XGX-Glucose treated w/o TRO and Neutralizer, XXN-Neutralizer treated w/o TRO and Glucose).

4. Conclusion and discussion

Raphidoceli subcapitata was more sensitive species than that of *Chlorella vulgaris* for the cellular growth against potential adverse effects from the combined treatment of oxidant (TRO) and soluble organic matter (glucose). Longer the storage time after TRO treatment with glucose up to 5 days shows more the adverse effect on algal growth. The adverse effect of TRO with glucose is higher than that of starch (Lee, 2015). Algal growth comparison by cell counting and viability assessment by FDA with Flow cytometer shows simple reading for cellular physiology.

5. References

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The effects of various chemical additives on algal toxicity and bacterial bioluminescence in simulated ballast water

Chul Park, Hyung-Gon Cha, Taesup Choi, Jungsuk Lee, Mimjung Bae, Keun-Hyung Choi

Abstract

We examined the effects of various organic carbon additives on the consumption of total residual oxidant (TRO) and ecotoxicity of electrochlorinated seawater to simulate ships ballast water. TRO consumption during 5 day storage was higher in electrochlorinated seawaters amended with lignin and Metamucil compared with seawaters with other organic carbons. Algal toxicity of neutralized treated water tested with Isochrysis galbana, a marine haptophyte, showed significantly reduced growth in lignin and Metamucil added seawaters, but not in other seawaters of organic carbons. Bioluminescence of Vibrio fischeri sharply declined in un-neutralized seawaters of all types of organic carbons, but no toxicity manifested once the treated seawaters were neutralized with sodium thiosulfate. The present study suggests that different organic carbon additives can result in varying degree of outcome of ecotoxicity for testing of ballast water management system (BWMS), with consequences on Type Approval of BWMS. It might be better off eliminating the requirements of adding organic carbon to test water as long as natural water is used for land-based testing of BWMS.

Key words: electrochlorination, disinfection byproducts, ecotoxicity, ballast water

Introduction

Electrochlorination is a popular treatment technology accounting for more than a third of all ballast water management systems (BWMS) installed on ships (Lloyd's Register 2012). It uses electrical potential to destabilize the cell membrane potential, and produces powerful oxidants during electrolysis of salts in water. The oxidants disintegrate over time, but they are sufficiently stable to be able to react with organisms and kill or inactive them and can have lasting good disinfection effects. In addition to in situ electrochlorination of seawater, there has lately been a surge of BWMS of applying direct injection of commercially available chemical oxidants (e.g., PERACLEAN® Ocean or NaDDC (sodium diethyl-dithiocarbamate)), which may result in bleaching of light-harvesting pigments (Singh et al. 1989).

Although they are highly effective in killing organisms, a major drawback of electrolysis or direct injection of oxidants is that the oxidants also react with organic matter in water, producing disinfection by-products (DBPs) harmful to marine environment (Gonsior et al. 2015; Werschkun et al. 2014). Under the current guideline, the treatment systems of ballast water utilizing chemical disinfection must be approved by International Maritime Organization (IMO) for their environmental safety of the level of DBPs produced during treatment before installing onboard (Imo 2012).

Formation of DBPs can be affected by the natural organic carbon content of the water used at the test facility for approval of BWMS. However, the natural level of organic carbon content of the water can often be lower than what is required for formal testing of BWMS. For instance, the DOC and POC concentration for testing estuarine water should be > 4 mg C L^{-1} in ETV protocol and >5 mg C L^{-1} for IMMO G8 Guideline (Guard 2010; Organization 2008). In such case of lower natural level of carbon, addition of artificial carbon source is allowed in both type approval processes. The chemicals used to meet test conditions can greatly affects DBP formation, as the quantity of organic carbon added can produce concentrations that are much higher than would be found naturally. Addition of different type of organic carbon at land-based test facilities, however, may produce varying levels and compositions of DBPs even for testing the same BWMS (Delacroix et al. 2013). This can subsequently affect the outcome of human and environmental risk assessments addressing the DBPs (Delacroix et al. 2013; Nanayakkara et al. 2011). Therefore, a consistent approach may be required to enable objective comparison of chlorination-based BWMSs in which common organic carbon additives are used during land-based testing.

Here we examined total residual oxidants (TRO) consumption and algal and bacterial ecotoxicity of DBPs produced during electrochlorination of salt water containing additives of each different organic carbon. We used standard algal toxicity testing under guideline 9 (Imo 2012) of the Ballast Water Convention for the toxic effects of electrochlorinated seawaters. We also employed bacterial bioluminescence to examine whether bacterial bioluminescence is more sensitive than algal assay to examining toxic effects of DBPs.

Materials and Methods

An electrochlorination system was set up on a pier at the Korea Institute of Ocean Science and Technology (KIOST) in Jangmok Bay, Korea. Test seawaters (1 m^3, salinity 31-32) were prepared by pumping the surface water of Jangmok Bay into a 1 m^3 polyethylene non-toxic water tank on the pier. The seawater was prefiltered through 50 µm Nytex filters to remove large zooplankton. If required, the water temperature was raised to 15°C with a submersible thermostatic regulator (LifeTech Inc., China). The bay water contained a low concentration of DOC (<2 ppm, Cha et al., 2015) and POC (~1-2 ppm) (Cha et al. 2015).

Seawater served as a control and the remaining test seawaters were also amended with starch to increase the POC level to 5 mg C L^{-1}. A total of six different chemical additives were used to increase the DOC concentration (DOC, 5 mg L^{-1}) in seawater: glucose, lignin, sodium acetate, sodium citrate, Metamucil and methylcelluose (for details see Cha et al., 2015). Each of a total of eight different test waters were electrochlorination treated three times at 10 ppm for 20 min. After each chlorination treatment, seawater was collected in 10 L jars that were stored at 20°C for 5 days in the dark.

An YSI 6000 Sonde (YSI Inc., Yellow Springs, OH, USA) was placed in the test water tank during each treatment cycle. The temperature and salinity of the test waters were recorded prior to each test. The treated water was collected every 10 min into 500 ml glass beakers. The TRO concentrations in the treated waters were measured by the colorimetric DPD-method (Hach Method 8167) (Buchan et al. 2005). The method is based on the oxidation of N, N-diethyl-p-phenylendiamin (DPD) which turns to a pink Wurster-cation in the presence of strong oxidants. The intensity of the color is proportional to the oxidant concentration. The color intensity was measured using a Hach DR/2000 spectrophotometer (Hach Company, Loveland, CO, USA). The pH of the control and treated waters were also measured using a pH meter (Thermo Orion Model 720, Thermo Fisher Scientific Inc., Waltham MA, USA).

Treated water samples for ecotoxicity testing were collected into sterile 2 L bag and chilled on ice and sent to NeoEnBiz Laboratory within several hours. Microalgae, *Isochrysis galbana*, a marine haptophyte, was used for algal toxicity of treated water. The algae was grown on F/2 marine algae culture medium modified through the addition of triple the original vitamin concentration was used as the growth medium, which consists of a trace metals solution, a vitamins solution, two macronutrient solutions and 35 PSU seawater. Static non-renewal culture (30 ml of sample water in 50 ml flasks) was set up with serial dilution of treated water with original seawater. Cell density of 10,000-20,000 cells L^{-1} was inoculated into each flask and population growth inhibition was monitored for 72 h, with potassium dichromate used as a reference toxicant (Astm 2004).

Growth rate was calculated as

$$\mu = \left(\frac{log_{10} \frac{F_2}{F_1}}{t} \right)$$

where

μ is growth rate,
F1 is fluorescence at the beginning of the selected time interval,
F2 is fluorescence at the end of the selected time interval, and
t is elapsed time between the measurements of biomass.

For bacterial bioluminescence, we used N-TOX (Model 200, Neoenbiz Inc., Bucheon, Korea) *in vitro* testing system which uses lyophilized *Vibrio fischeri* (NRRL B-11177), a bioluminescent non-pathogenic, marine bacterium. The respiratory process of the bacterium is disrupted as a response to toxicity, resulting in a change in luminescence. The percent inhibition of the luminescence of *Vibrio fischeri* directly correlates to toxicity. Serially diluted treated water was prepared and introduced into 96-well plates (300 μL in each well). N-tox® system automatically injected the light-emitting bacteria (10 μL) to each well. Luminescence was measured from 3 to 5-minute intervals for a total of 30 minutes to track changes in the light intensity. Potassium dichromate and 3,5-dichlorophenol solutions were used as reference chemicals. Relative luminescence (RL, %) was calculated as

$$RL\ (\%) = \left(\frac{\text{luminescence in treated water}}{\text{luminescence in control water}}\right) \times 100$$

Log-linear model was used to calculate the Effective Concentration 50% (EC50) with 95% confidence limits.

No Observed Effect Concentration (NOEC) and Median Effective Concentration (EC50) were estimated using ToxCalc™ (v5.0, Tidepool Scientific Software, McKinleyville, CA, USA), specifically designed for environmental toxicity testing and compatible with U.S. EPA statistical guideline. The NOEC of the test was calculated using Dunnett's test applied the rules of percent minimum significant difference (% MSD) to meet the criterion of revealed toxicity.

Results and Discussion

After the initial drop in the first day, the level of pH remained nearly the same throughout the rest of days for incubation of post-treated waters for all types of chemical additives (Fig. 1). Meanwhile, TRO consumption was more variable among additives that seawaters treated with lignin or Metamucil showed decrease in TRO by as much as 3 -4 ppm during the 5 day incubation, whereas TRO treated with other additives declined about by 2 ppm for the other additives (Fig. 1). The results are in line with the findings of previous works that labile organic carbons of low molecular weight do not did not appear to consume TRO, comparable to the level for seawater only with no additives (Cha et al. submitted). The relative TRO consumption to the hypochlorite dosage has been reported to be significantly higher in tests with lignin compared with addition of methylcellulose (Delacroix et al., 2013). The Metamucil-added seawater also seemed to consume more TRO during 5 days of storage than labile organic carbons (Fig. 1). TRO consumption may be related to the molecular weight of the DOC that TRO concentration at day 5 was significantly different between waters containing low and high molecular weight organic carbons (Cha et al. 2016). However, it may also be related to chemical structure of organic carbon given that methylcellulose, despite its large molecular weight, does not appear to consume TRO either (Fig. 1), with the results consistent with those of Delacroix et al., (2013).

We used *Isochrysis galbana*, a well-known marine haptophyte, for algal toxicity of treated water examining growth inhibition by different organic carbons. In treated waters stored for 1 day, the phytoplankton exhibited toxicity for all types of organic carbon, showing reduced growth compared with the control waters (treated seawater only without any additives) even at the lowest dilution of the treated waters (Fig. 2). Once the treated waters were neutralized, however, the toxicity was all gone except for lignin-added water, which showed complete inhibition of growth at full strength of treated neutralized seawater. Metamucil-added water also showed about 20 % reduction in growth, but it was not deemed to be toxic as percent minimum significant difference to meet the criterion of revealed toxicity following Dunnett's test was < 23% (Epa 2000a; Epa 2000b). For treated waters stored for 5 days, lignin-added water showed a similar level of toxicity of that of day 1. In addition to lignin, Metamucil also showed some degree of toxicity with reduced growth by about 30% in full strength of treated water after neutralization (Fig. 3). Methylcellulose, despite its large molecular weight, did not show any enhanced toxicity compared to seawater only or other labile organic additives, consistent with the results of Delacroix et al., (2013).

Bioluminescence of *Vibrio fischeri* sharply declined in all waters of organic carbons for both day 1 and day 5 samples when un-neutralized treated waters were used (Fig. 4). Day 1 seawaters appeared to be more toxic than day 5 waters as demonstrated in higher EC 50 concentrations at day 5 samples (Fig. 4), consistent with the results of algal toxicity, which generally reflects higher concentration of free chlorine remaining at day 1 than day 5. The reduced bioluminescence compared with control seawater indicates that DBPs interfere cellular respiration of ATP and thus bioluminescence by the bacteria. However, once the treated waters were neutralized with sodium thiosulfate, no toxicity was manifested for all types of treated waters. Therefore, bacterial bioluminescence does not necessarily seem to be a more sensitive method for detecting toxicity of DBPs than algal toxicity testing.

The insensitivity of *Vibrio fischeri*, a Gram-negative bacteria, to neutralized electrochlorinated seawater may be related to its outer cell wall structure (Lambert 2002; Maillard 2002). It is known that Gram-positive bacteria are more susceptible than Gram-negative bacteria, as Gram-negative bacterial multi-layered structure are less permeable to toxicants as opposed to the thick peptidoglycan layer of Gram-positive bacteria absorbs toxicants such as antibiotics and chlorine products. *Isochrysis galbana* does not have thick cell wall as seen in thecated diatoms or dinoflagellates and may be very likely to be permeable to DBPs. Similar observation was made in the field that discharge of urban chlorinated sewage effluents may have had affected phytoplankton physiology negatively but not on heterotrophic bacteria, which showed a large increase in biomass during effluent discharges (Caron et al. 2015).

Addition of different chemical organic carbons to test water for chlorination during Type Approval testing of BWMSs can result in alteration of both DBP production and plankton mortality (Cha et al. 2016). In the present study, we demonstrated that the use of different organic carbon additives for electrochlorination of natural seawater can also affect ecotoxicity of both un-neutralized and neutralized seawater. Addition of lignin seems the worst scenario for environmental safety and ecotoxicity of produced water that will be discharged into harbors and estuaries. Addition of labile organic carbon seems not affect the production of DBPs (Cha et al. 2016) and ecotoxicity (Fig. 2, 3). However, heterotrophic bacteria can utilize those labile carbons as carbon substrates and rapidly grow especially under high temperature condition (Shiah and Ducklow 1994). Different types of chemical additives in test water can result in varying degree of outcome of ecotoxicity for testing of ballast water management system (BWMS), with consequences on Type Approval of BWMS. It may also confound the outcome of the testing of BWMS for its biological efficacy of killing bacteria including pathogenic ones given its varying level of bacterial and algal toxicity. It might be better off eliminating the requirements of adding organic carbon for test water as long as natural water is used for land-based testing of BWMS. A consistent approach across test facilities for the addition of chemical additives during type approval testing of BWMSs is proposed.

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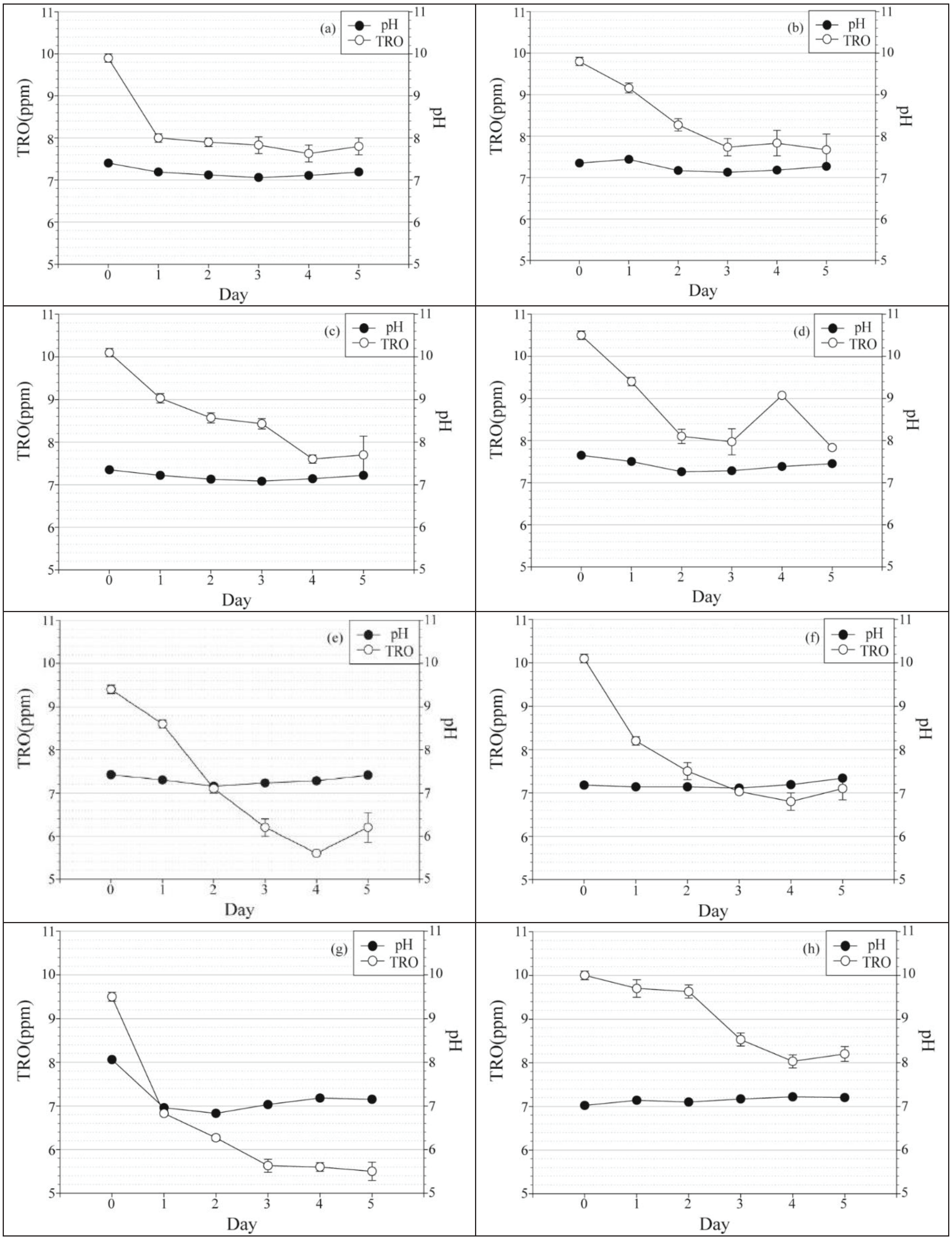

Figure 1. Variation of total residual oxidant and pH in electrochlorinated seawater over the five-day incubation after addition of various dissolved organic carbons. a) seawater only, b) starch added to seawater, c) starch + glucose, d) starch + sodium acetate, e) starch + sodium citrate, f) starch + Metamucil, g) starch + lignin, h) starch + methyl-cellulose

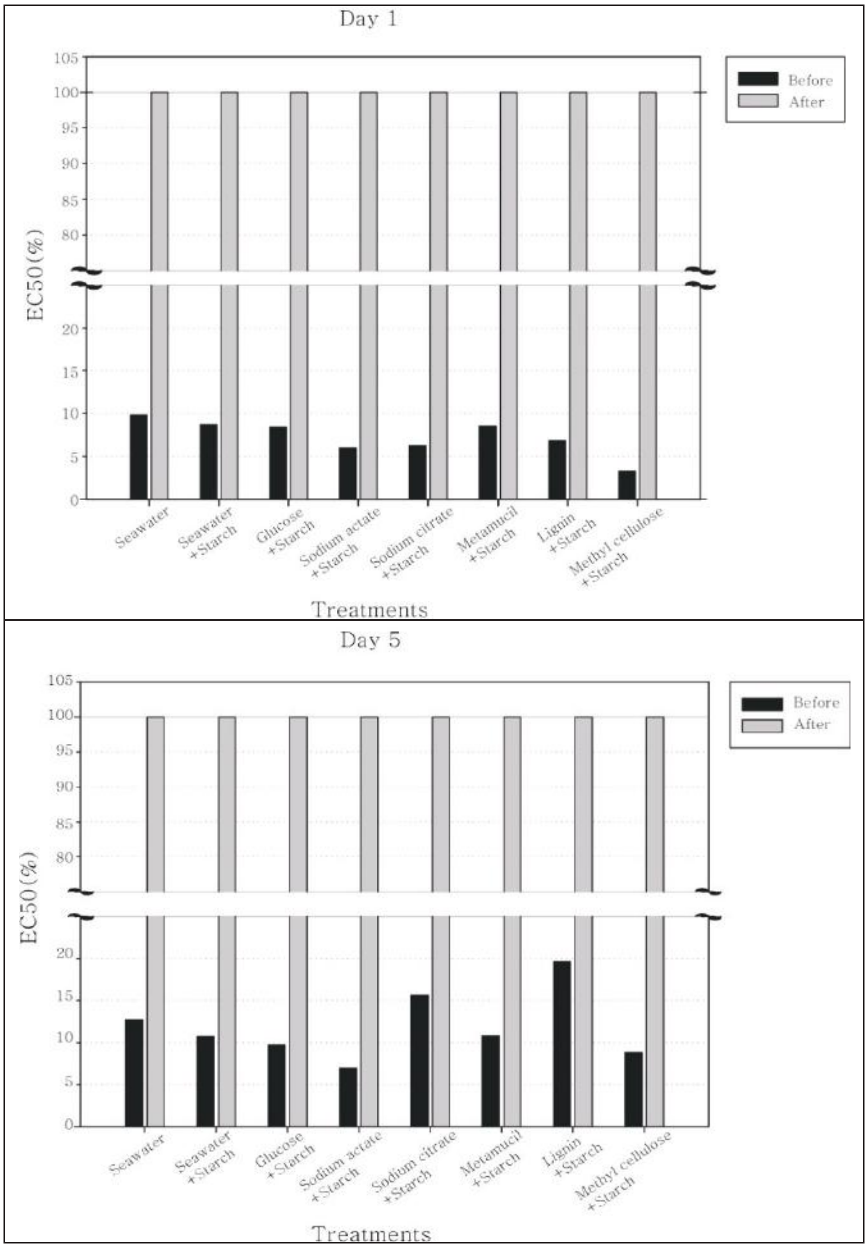

Figure 2. Relative growth rate (%) of Isochrysis galbana, a marine haptophyte, compared to control seawater, measured at 72 h of incubation survival after addition of various dissolved organic carbons. a) seawater only, b) starch added to seawater, c) starch + glucose, d) starch + sodium acetate, e) starch + sodium citrate, f) starch + Metamucil, g) starch + lignin, h) starch + methyl-cellulose

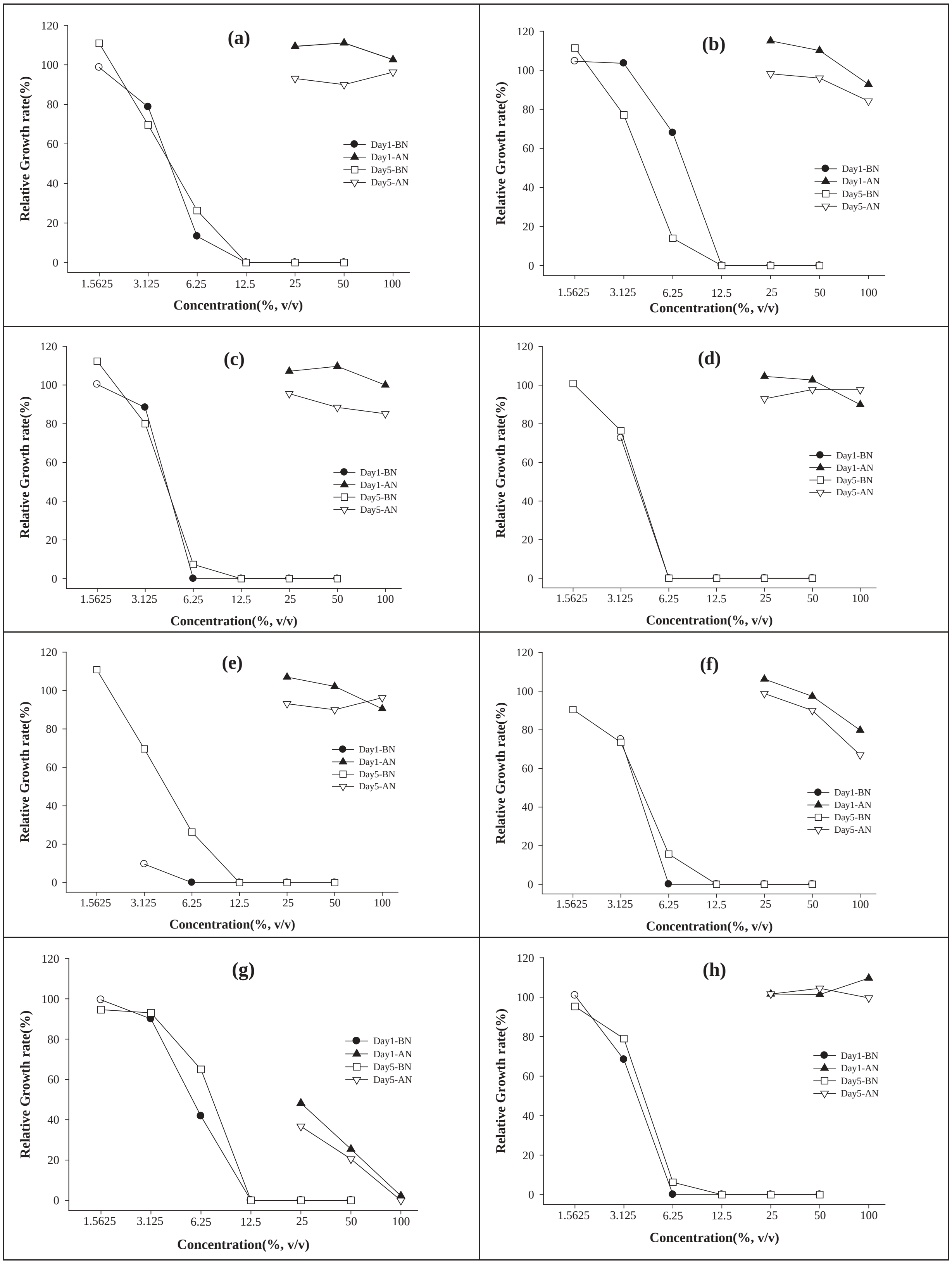

Figure 3. EC 50 concentration based on luminescence of Vibrio fischeri following 72 h incubation of treated seawater with different types of organic carbon additives. For neutralization of the treated seawater, sodium thiosulfate was used. (a)seawater only, (b)seawater+Stach, (c)Starch+Glucose, (d)Starch+Sodium acetate, (e) Starch+Sodium citrate, (f)Starch+Meta-mucil, (g) Starch+Lignin, (h)Starch+Methyl cellulose

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Application of Ultra-Low Frequency (ULF) Field in Ballast Water Disinfection

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Abstract

The use of mechanical filtration in combination with ultraviolet (UV) irradiation is a common combination of equipment in G8 ballast water management systems (BWMS) With the recent USCG dismissal of regrowth methods for evaluating the efficacy of UV-based systems (MPN method), it is expected that the acute mortality of organisms may require an increase UV power consumptions by as much as 400%. This may be a real constraint for many ship owners. We have tested and patented the use of time-varying ultra-low frequency (ULF) electromagnetic fields applied to marine water through wave emitters as part of UV-based BWMS. This approach a low energy consumption alternative to the increase of UV irradiation that the USCG position on MPN may indirectly require. The tests were conducted in Singapore using a full-scale BWMS incorporating a screen filter, a UV reactor, and an inline ULF emitter. Live/dead analysis using FDA/CMFDA methods showed that UV irradiation alone has only a limited effect on the acute mortality of phytoplankton cells although the analyses by MPN confirmed that UV is efficient over longer period of time. The sequential treatment by UV and ULF resulted in immediate decline in live phytoplankton organisms, fulfilling the requirements of USCG. Using ULF treatment in addition to a UV was estimated to increase the power consumption of our BWMS by only 10 kW per 500 m^3/h, confirming that this approach is an excellent alternative to an increase in the power of the UV reactors.

Keywords: *ballast water, ultra-low frequency, time-varying, biofouling.*

1. Introduction

The United States Coast Guards (USCG) preliminary decision on the use of most-probable number (MPN) method to determine the number viable organisms has effectively become a road block for most UV-based ballast water management systems (BWMS) towards achieving a USCG type approval [1]. For UV-based BWMS, achieving acute mortality on ballast water discharge may require that the UV dose and power consumptions be increased from 3 to 5 times [1], increasing costs, emissions, and introducing new safety-related issues, etc. This can be a real constraint to ships and definitely a burden to the ship owners.

We have developed a low-power ballast water treatment system based on mechanical separation and physical disinfection to meet the USCG acute mortality requirement without a significant increase in power consumption. While conventional UV-based systems would require a significant increase UV power consumption in order to successfully cross-over from IMO type approval to the more stringent USCG requirements, our ULF-based BWMS meets the USCG requirements through an small increase in ULF power of around 10 kW per 500 m^3/h. Therefore, we offer a low power alternative to the increase in UV dose through the application of ultra-low frequency (ULF) waves as a primary means of disinfection, complemented by a self-cleaning filter and a relatively small UV reactor.

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2. Semb-Eco BWTS – A ULF-based system

Semb-Eco ballast water treatment system comprises a self-cleaning filter, a biofouling control (BFC) unit, and an ultraviolet (UV) reactor. In the first stage of treatment, the self-cleaning filter system removes most of the organisms and particles above 50 µm from the main flow, resulting in significant reduction in organism population and much clearer water. In the second treatment stage, ballast water is exposed to high-intensity UV light. UV exposure disrupts the DNA of the microorganism cell, impeding its replicate ability. The final treatment stage proceeds through the BFC which converts the time-varying ultra-low frequency electrical signal to pulsating ULF wave in the range of 50 Hertz to 200,000 Hertz.

ULF wave excite parts of the ballast water to create an “avalanche current” effect which effectively destroy the cells completely. In contrast, moderate doses of UV light only impede the cell’s ability to reproduce, without actually killing the cell [2]. Unfortunately, cells which are still intact may possess the ability to repair itself and cause the cell population to rebound during long voyages [3]. The exposure to ULF on the other hand, ensures that invasive cells are permanently destroyed through an energy-efficiency pathway.

Turbid water also present a challenge for UV-based BWMS. In waters with low UV-transmittance (UVT), treatment efficacy is negatively impacted due to reduced UV light access to target microbes. Most UV-based BWMS incorporate a filter to remove suspended solids which can shield microbes from UV light. However, filtration alone is not sufficient since dissolved organic compounds also absorbs UV and cannot be removed by micro-filtration alone. Hence, UV systems tend to be grossly oversized to deliver excessive UV doses to maintain its efficacy in turbid waters. In contrast, ULF is not effected by turbidity and is able to operate at much lower UVT for similar power consumption as its UV counterpart.

3. IMO Type Approval

3.1 Pilot, Land-based and Shipboard tests

Semb-Eco BWTS was developed in Singapore as a joint-venture project between Sembcorp Marine Ltd. and Ecospec Global Technology Pte. Ltd. Pilot testing was completed in 2012 using a 16 m^3/h unit and a full scale 500 m^3/h unit test was conducted at the ballast water test facility at DHI Singapore between 2013 and 2014. The 500 m^3/h unit was installed onboard M/V PAC Suhail in late 2014, and a series of shipboard tests were conducted in U.S. and Asian waters in 2015 as part of the IMO type approval testing. Onboard sampling and analysis was conducted by the GoConsult and David Consult consortium. Both land-based and shipboard tests were conducted at conditions that were above and beyond the requirements stipulated in the G8 guidance document [4]. As shown in Table 1, the adopted test conditions are considered more stringent than the standard conditions outlined in G8 document.

Table 1. Comparison of Semb-Eco and standard G8 protocol

	Semb-Eco test conditions	Standard G8 test conditions
Flow rate	500 m^3/h	At least 200 m^3/h
Holding time	48 hours	120 hours
Test facility	First system to be tested successfully at a tropical test facility	Most successful systems were tested at test facilities located in the northern hemisphere
Spatial variations	Tested at Singapore, Phuket, Padang, Gulf of Mexico, and Chesapeake Bay.	Not required
Organism diversity	Use of *Tetreaselmis* sp. in addition to fulfilling minimum of 5 species from at least 3 different phyla/divisions	At least 5 species from at least 3 different phyla/divisions
Passing criteria (Land-based)	5 consecutive passes for each salinity for land-based test	5 passes for each salinity for land-based test
Passing criteria (shipboard)	Comply with regulation D-2 with vital staining	Comply with regulation D-2
	3 consecutive valid passes over duration of not less than 6 months for shipboard test	3 consecutive valid passes over duration of not less than 6 months for shipboard test

3.2 Scale-up tests

Following successful land-based and shipboard tests, the Semb-Eco system was scaled-up adopting the methodology outlined in [4] and [6]. Based on the scaling studies, the 1500 m3/h treatment rated capacity (TRC) unit was identified as being the most vulnerable and therefore selected as the scale-up unit to be tested to verify the mathematical model. Since no test facility worldwide is able to accommodate this 1500 m^3/h unit, the scale-up tests were carried out onboard the Semb-Eco Marine Laboratory (see Figure 1), a barge facility installed with a 1500 m^3/h engine-driven pump and adequately-sized ballast water tanks to enable onboard tests of such scale. Sampling tests were carried out by the GoConsult and David Consult consortium in presence of Lloyd's Register surveyor at different locations in Singapore waters.

Table 2. Official scale-up test results based on vital staining with CMFDA/FDA

Organisms	Unit	Uptake	Discharge
> 50 µm	org./m^3	9,499	1.7
10-50 µm	org./ml	1,016	n.d.

Figure 1. Towing of Semb-Eco Marine Laboratory during scale-up tests.

4. USCG Type Approval

A series of pre-test was conducted at DHI Singapore to ascertain if increasing the ULF energy will enable the Semb-Eco system to comply with the USCG discharge standard using CMFDA/FDA vital staining method. The Semb-Eco LUV500 (500 m^3/h TRC) was used for this purpose, the same equipment set-up that was used in the IMO type approval tests, except that an additional BFC unit was installed downstream of the first BFC unit. Hence, the pre-test comprises of one self-cleaning filter, one low-dose UV reactor,

and two inline BFC units. The first test was conducted with only one BFC unit activated, while the second test was conducted with two BFC units activated. The configuration and operation of the self-cleaning filter and UV reactor remain the same for both tests. Sampling and analysis was carried out by DHI site and laboratory personnel as per the standard DHI quality assurance project plan (QAPP) procedures.
Results showed that a combination of filtration, UV, and a single BFC is able to reduce the phytoplankton population significantly to meet the IMO discharge requirements using MPN method. With the addition of a second BFC unit, which represent an additional 10 kW of ULF power, the USCG acute mortality requirement with vital staining is met upon discharge as shown in Table 3.

Table 3. BWTS enhancement through additional ULF power (CMFDA/FDA results)

System config.	Total power (kW)	Organism	Uptake	Discharge
Filter + UV + 1 BFC	26	> 50 µm (org./m^3)	668,050	0
		10-50 µm (org./ml)	3773	159
Filter + UV + 2 BFC	35	> 50 µm (org./m^3)	481,233	0
		10-50 µm (org./ml)	4111	1

5. Conclusion

Semb-Eco ballast water treatment system, through the application of ULF wave, is an energy-efficient and environmentally-friendly solution to meet the USCG acute mortality requirement for ballast water discharges.

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Evolution of Port-Based BWM Scenarios: Past, Present and Future

T. D. Waite

The IMO Ballast Water Management Convention comes ever closer to entry into force, and regional BWM requirements are already in force. Over the past few years ship-board ballast water treatment technologies have become available and are being installed on ships. However, despite the availability of many different technologies, the industry in general is concerned about potential uncertainties in treatment capacity and lack of existing guidance on port-state BW control requirements. In order to alleviate some of these concerns from several stakeholders, an approach is being discussed among several groups: i.e. for the ports or port operators to provide some sort of contingency measure to ship-board BWTS; such as an emergency/backup ballast water treatment system. (e.g. a BWTS mounted on a barge in the port).

During initial discussions (15 yrs. ago) about BWMS, most stakeholders preferred ship-board treatment systems. Specifically; ship owners argued that a ship-based ballast water management system could assure the ship of free passage into any port. In like manner, the ports felt that the ships should treat their own ballast water, and that very little space existed in most ports for creation of ballast water treatment facilities. There are now discussions about the role Ports could play in the BWM arena.

Several studies of shore-based ballast water treatment schemes were undertaken during the past 15 years, and all have come to the same conclusions. Specifically, the advantages of shore-based treatment systems are: shore-based systems could utilize common water treatment systems, or even simpler systems therefore they would be less expensive than shipboard ballast water management systems. Because the effluent from these systems would either go to a wastewater treatment plant, or be discharged to surface waters, the required treatment (permitted) would not need to address invasive species as the discharges would be considered industrial wastes. There would be better control of treatment at a shore-based facility, and it could be designed to operate continuously (if needed) with no “down time”, thus preventing delays with ships’ operations.

The perceived disadvantages of shore-based systems are: connections to ships in order to offload ballast in a timely manner; large ports would require many points of connection to handle the ship traffic; and these large facilities would inevitably witness delays in shipping operation; many ships must ballast and/or de-ballast during a voyage or while entering ports, and this could not be accomplished if they did not have shipboard treatment systems.

The above pros and cons however, reflect the opinions of stakeholders in the absence of the convention entering into force. At this point, ship owners have little experience with the procurement, operation, and maintenance of shipboard BWM systems. Comparing this treatment challenge to that of the drinking water and wastewater treatment industries, it can be seen that the treatment technologies available for installation have not been tested extensively at sea, and therefore their reliability will be suspect. It can be argued that the shipping industry does not fully appreciate the operational challenges facing their crews from this shipboard equipment. In addition, the reliability of treatment of this equipment has not been proven on a large scale, as very little of this equipment is actually operational. It should also be noted that none of these systems (except chlorination) are used extensively in the drinking water or wastewater industry. Specifically, UV irradiation can only be utilized for disinfecting water streams that have very high clarity, and the level of disinfection capacity is extremely low compared to other treatment options. Fine screens (less than 100 µ) are not utilized on a large scale in the water industry, and only find application in selective industrial waste situations. It is also important to understand that unit operations commonly used in large-scale drinking water and wastewater treatment plants have been selected and designed for reason. These unit operations are robust, reliable, and consume the least amount of energy possible to achieve rigorous treatment goals.

Another issue affecting ballast water management in general, and with the decisions between shipboard and shore-based treatment systems, is the level of monitoring and enforcement that will be implemented once the convention comes into force. If ships will be monitored for treatment effectiveness of their onboard systems, given the discussion above, then there will be a definite need for shore-based facilities within ports in order to prevent delays, due to faulty or intraoperative shipboard ballast water management systems. If shipboard ballast water treatment systems are to simply be certified, once approved by a regulatory agency such as the US Coast Guard, and in-field monitoring is not undertaken at to a high degree, then there will not be a large demand for shore base facilities. This situation would be similar to the oily water treatment regulations implemented by IMO years ago.

As noted above most of the studies undertaken to evaluate the efficacy of shore base ballast water treatment systems have concluded that for certain types of vessels traveling on fixed routes a shore-based ballast water management system may prove economically feasible. This is an important point, as much of today's shipping activity is due to the rapidly growing container ship traffic. These ships were not considered a major threat in the past because the volume of ballast water carried during normal ships' operation is small. However, container ships are now becoming a major part of the world's fleet, and their impact on invasive species introductions is becoming significant. Container ships tend to sail on fixed routes between ports therefore a shore-based ballast water system would make sense for this type of activity. The volume of ballast to be handled from the ships would not be large, and would be occurring in fixed locations where a shore based facility could be built. If such facilities were available these container ships would not need to add expensive shipboard ballast water treatment systems, as they could rely on ballast water treatment at the ports they frequent.

In the summary, most ballast water management scenarios could utilize a shore-based facility somewhere in the mix of management schemes. The realization of this aspect of ballast water management is becoming more clear as ship owners begin to actually wrestle with expensive decisions concerning shipboard BWM systems.

The storm of ballast water compliance is brewing – Ports need to prepare.

Matthijs Schuiten – Product Manager – Damen Green Solutions

Summary

The storm of ballast water compliance is gathering pace. Once the convention enters into force it is estimated that every 30 seconds an on-board treatment unit will be fired up somewhere in the world. What if these treatment units do not perform in all water types or if they have a malfunction? On-board systems suppliers have already suggested that in some water types they cannot guarantee treatment performance and failing on-board systems will cause expensive delays in ports.

The answer lies in Damen's proprietary InvaSave; a mobile ballast water discharge system and the world's first port solution. Its specific discharge technology provides that, independent of the pre-treatment on board, the vessel can always discharge its ballast water system via the InvaSave. Damen's goal is to build a global network for InvaSave ballast water treatment in ports together with worldwide port operators. The InvaSave in a port will provide a solution in the event of a failing on-board system. The InvaSave system is fully containerised and, therefore, can easily be scaled up. A vessel needing to discharge its ballast water can connect and do so over the InvaSave unit, which then processes and discharges it to the surface water. Regardless of whether the Ballast Water Convention arrives next year or the year after, the shipping industry and ports have to start acting now in order to be ready.

Paper

It's a troubling horizon facing ship owners – black clouds hanging over a massive €60 billion bill for Ballast Water compliance. For years equipment manufactures have issued dire warnings of an impending retrofit bottleneck, but few owners have taken the plunge. And who can blame them? The IMO's Ballast Water Management Convention (BWMC) still hasn't entered into force after 10 years. But the storm is gathering pace. Various international associations reversed their long-standing lobby against ratification and the percentage of world tonnage now teeters on the edge of the threshold.

While there are certainly strong arguments for owners to act sooner rather than later, the history of regulatory compliance teaches us that most ship owners will wait until full ratification. It's a strategy not without risk, though. In the rush to compliance, owners could face lengthy delays during drydocking and find themselves at sea with poor installations that are more expensive to operate than those of their competitors.

Moreover other serious concerns have emerged. What if an emergency situation emerges (red tides, pathogens, other pest outbreaks) and ships and ports have to meet more severe standards? Will there be exemptions for vessels with fixed regional routes? What to do with older vessels close to scrapping? In fact, owners are wise to consider whether they want to install a ballast water treatment system solution at all. Mobile port-based ballast water management could be an alternative. This is also relevant for port authorities, who could face congestion problems if they don't have a contingency/emergency service in place. Ports may need to provide backup when a ship's onboard treatment systems fail.

This has led to the development of a truly pioneering Damen proprietary InvaSave technology, a mobile ballast water discharge system, which is a world first port solution.

The prototype InvaSave has been initially designed for the Wadden Sea National Park in the Netherlands. Damen teamed up with Groningen Seaports to develop a mobile treatment barge to keep alien invasive species out of the Wadden Sea. Other partners include the Dutch marine research institutes Imares &

MEA-NL, Van Gansewinkel, Wagenborg, CaTO Marine Ecosystems. Van Gansewinkel will be the operators of this first InvaSave barge. The project received a subsidy from the Waddenfonds.

The Wadden Sea is a protected UNESCO World Heritage Site and is a vulnerable ecosystem with an impressive biodiversity. Groningen Seaports and all organisations involved aim to be a good neighbours of this valuable marine and coastal area. The InvaSave barge will be operational in the ports of Eemshaven and Delfzijl after the IMO BWMC enters into force. The InvaSave technology is currently undergoing final tests for statutory type approval based on the requirements of the IMO and the Dutch flag state. Type approval is expected end of 2016.

The InvaSave system is fully containerised, therefore can easily be scaled up. Each container has a treatment capacity of 300 m3/h. The InvaSave container is selfsufficient with an own power generator and boosterpump. The 45ft high cube containers can also be put on a trailer. The technology is very simple to use – essentially it is a plug & play system.

A vessel needing to discharge its ballast water can connect and discharge its ballast water over the InvaSave unit, which then processes and discharges it at sea. The unique Damen mobile treatment technology is very cost effective because it allows ballast water to be treated at the point of discharge, whereas a conventional on board system has to treat the water both on intake and when it is discharged. No active substance or chemicals are used for treatment.

For vessels with much larger ballast water capacities, it is possible to interconnect several systems. If mobility is not required the InvaSave containers can also be stacked and interconnected on shore.

Port based ballast water treatment has added value for ports clients as it increases the support services offered to customers, it will prevent expensive delays in ports caused by failing onboard systems. And some types of vessels don’t need to invest in an onboard BWT system at all.

Whether the storm of ballast water compliance arrives next year or the year after, the shipping industry and ports have to start acting now. Groningen Seaports will be prepared.

BWTBOAT - Treated Ballast Water Delivering Facility: Ready for Implementation

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Abstract

BWM convention is likely to come into force this year; implementation schedule will require shipowners to decide on installing ballast-water-treatment-system onboard. While on one side there is ambiguity among shipping industry over type approval regime and efficacy of treatment systems, on the other, compliance dates may create demand-supply vacuum for particular treatment systems.

Though during forthcoming MEPC there will be positive discussions over G8 guidelines to remove ambiguity, at the same time it's also important that, industry should have clear alternative option of ballast water management. Recent submissions by India to MEPC 65 & 66 (in close association with IRCLASS- Indian register of shipping) resulted in acceptance of BWTBOAT concept- i.e. treated ballast water delivering facility to ships as an alternative solution with some of the queries to be clarified. In response to those queries, India is submitting a paper to MEPC-70, describing guidance over compliance and liability issues to be faced by ships using BWTBoats.

The paper being presented by us refers to India's final submission to MEPC-69 regarding BWTBOAT concept covering technological, financial, legal and operational aspects. This will provide further clear understanding of BWTBoats concept. By analyzing the pattern of ship voyages, ship owners and member states can come together for hassle free, effective and systematic provision of BWTBoats. Risk assessments using A-4 guidelines can further reduce the overall requirement of BWTBoats.
BWTBoats concept can be a viable option for regional, domestic, coastal and fixed-long charter vessels, amid high competition and low growth era of shipping industry.

Introduction

India submitted detailed concept paper (Ref. No. 66/2/8 and 66/INF.17) to MEPC 66 describing BWTBoat as an alternative approach for the faster and effective implementation of the Convention. With respect to request from Review group, committee invited further submission on the situation where ship is receiving treated water from BWTBOAT but not intending to discharge water to other boat or reception facility (refer section 2.40.6 of 66/21 report).

This paper also describes and focuses on various issues such as compliance, liability and ballast water treatment technology to be used on BWTBOATs etc.

Concept Overview

BWTBOAT is alternative ballast water management option where ship receives treated ballast water, which can be discharged at intended port complying BWM D-2 standards.
BWTBOAT is reinvented version of shore based ballast reception facilities. Major changes are as follows,

.1 Big storage tanks & pipe line networks are no more required to be built on shore but BWTBOAT is a small mobile boat or barge fitted with IMO type approved ballast water treatment system.

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.2 BWTBOAT doesn't receive water (except in case of contingency) at discharge port but gives treated water at ballast uptake port (cargo loading port).

Ballast water Treatment Technology on BWTBOAT & Guidance for Ships Receiving treated water from BWTBOAT

Query raised in the review group discussions - section 2.40.6 of MEPC 66/21 report.

> *"........ invited submissions on draft guidance for situations when ballast water is loaded from a BWTBoat to a ship not intending to discharge the ballast water to another BWTBoat or reception facility to MEPC 67;"*

Solution to tackle above situation in order to form draft guidance requested in MEPC 66/21 report is depending on Ballast water treatment technology used on BWTBOAT. Treatment technologies planned for BWTBOAT are based on UV or Chlorine disinfection.

UV technology

As per typical process, in case of UV system, water is being treated at both ports (i.e. ballast uptake and discharge) with UV units. So if this technology is to be used for BWTBOAT approach, then two BWTBoats will be required one each at ballast uptake and discharge. Thus BWTBOAT at discharge port will receive ballast water from ship to complete treatment cycle in order to comply with D-2 standards. Here BWTBOAT ultimately act like a Reception Facility as per G5 guidelines.

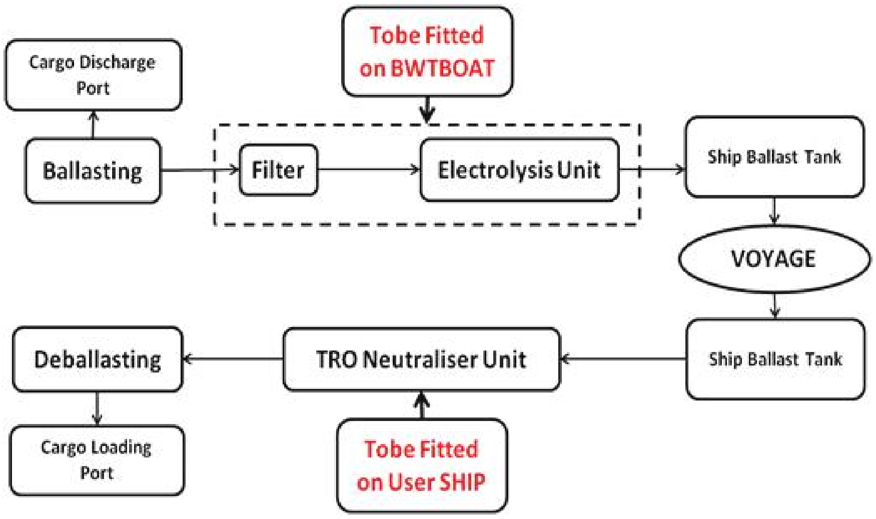
Thus as per query raised in section 2.40.6, with UV technology use, ships have to depend on availability of BWTBOAT arrangement at ballast discharge ports to complete treatment cycle.

Chlorination Technology

While in case of chlorine based disinfection; chlorine dose is given only at uptake. At discharge a separate process of neutralisation will take place in cases where TRO (Total Residual oxygen) exceeds 0.2mg/L as Chlorine.

Current research and dialogue with Ballast water treatment system manufacturers' shows that, TRO neutralisation assembly is smaller and cheaper compared to filter and electrolysis units. All three are part of single system (filter + chlorination + TRO neutraliser assembly) which gets type approval under G9 guidelines set for use of active substances.

Thus as per query raised in section 2.40.6 of MEPC 66/21 report, ship loaded with chlorination based treated ballast water from a BWTBOAT, need not change its intention or need not depend on availability of BWTBOAT at other port for ballast discharge if ship is fitted with onboard TRO neutralisation assembly. Possible division of process units between BWTBOAT and User Ship based on chlorination technology use, is as shown below.



Schematic Diagram – Port Based BWM using treated water delivering facility

Compliance

With reference to query raised in section 15 of MEPC 66/WP.6 report, on any BWTBOAT, IMO type approved systems will be used. Specifically in case of chlorination technology use, TRO neutraliser assembly fitted on board ship will be one of the part of type approved ballast water management system so regulatory point of view ship discharge water will be in full compliance with BWM convention D-2 standards.

Liability

BWTBOAT is a shared solution which can be implemented using understanding among two or more port states/parties to exempt vessels from fitting treatment systems onboard and use alternative ballast water management option. During such adoption, liability issue can be worked out by joint discussions in together for exempted vessels.

Conclusion

As per clarification given in above sections, while using BWTBOAT option with chlorination technology, ship would not need other BWTBOAT at discharge port if ship is fitted with TRO neutralisation assembly onboard. In such scenario BWTBOAT act more like a treated ballast water delivering facility.

Present G5 guidelines and regulation B 3.6 refers about water reception which fits perfect when BWTBOAT uses UV technology but contradicts little bit when uses chlorination technology. Some reference like MEPC circular or resolution or link is needed to be given in relation to G5 guidelines so that ship ballast water management certificate can explain use of treated water delivering facility in accordance with above guidance to comply BWM convention.

Reinvented and new version of BWTBOAT i.e. port based facility can be a game changer to save shipping industry from ongoing turmoil with implementation of BWM convention of IMO.

Can UV System meet the USCG requirements for BWT

Birgir Nilsen, VP of Business Development, Optimarin AS

Abstract

Optimarin AS, a pioneer in ballast water treatment, has become the first UV system supplier to meet the most stringent USCG marine water requirements, positioning the system for full USCG approval in 2016. In a series of land-based tests, both the standard MPN (regrowth) method and the more exacting FDA/CMFDA, or 'instant kill', benchmark was successfully assessed. DNV GL carried out testing of Optimarin's system at the NIVA test facility in Norway. Further testing of remaining water salinities are now scheduled for spring 2016, after which point USCG type approval (TA) is expected later in the year. The system is also being tested in parallel on a bulk carrier trading world wide for the ship board portion of the TA testing, planned to be completed April/May 2016. Optimarin's objective has been to keep the system that has been TA under IMO regime as is, so that existing users can continue to use it as a USCG TA system. The presentation will detail the challenges and differences with the USCG required ETV test protocol versus the G8 test protocol used for IMO TA testing, especially the challenges using UV to meet the CMFDA counting method for organism between 10 to 50 micron.

History

Optimarin delivered its first ballast system in April 2000 to Princess cruises. The system was based on solid separation through a low-pressure loss separator and low pressure UV. There was a total of seven of these systems delivered. There were several studies conducted through the Great Lakes Ballast Demonstration Project and California State land Commission. The system had great promise but when the Ballast Water Convention was adopted in February 2004, it was clear that changes had to be made to meet the new size-based treatment standard.

Optimarin launched a new system in 2007 using filters and medium pressure UV. The UV lamp used by Optimarin is unique in water treatment with its 35kW capacity. While testing for IMO TA at NIVA in 2008/9, both MPN and CFDA-AM staining method was used to analyze the efficiency of killing/inactivating the organism between 10-50 micron

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
CFDA	0.7 ± 0.6	0±0	0±0	0±0	0±0	3.3 ± 0.6	4.7 ± 2.1	7.7 ± 0.6	5.3 ± 2.1	5.3 ± 2.9	0±0	0±0
UVT	62.3 - 90 %											

Since then, Optimarin has sold more than 400 systems and it is important to us and our customers that the system that was IMO TA in 2009 can be USCG TA without being changed.

Product

The Optimarin Ballast System is based on Filtration and UV. Our customers can choose between three filters since we have tested and TA three different manufacturers: Boll & Kirch; FilterSafe; and Filtrex all using 40 micron and automatic back flushing filters.

Our UV is proprietary using a single lamp system inside a CuNi pipe. Our lamp can draw 35kW for up 167m^3/h. This high-powered UV lamp has proven to be crucial in killing the organism instead of rendering them non-viable.

USCG TA

The test results from the IMO TA testing gave us confidence that we would meet the USCG requirements using CMFDA and a proposal was sent to use the existing test date for USCG TA. This was declined because of Optimarin's presence during testing.

Preliminary testing using the ETV test protocol was conducted in the fall of 2015 and spring 2015 and we decided to start the official USCG TA program during the summer 2015.

To date we have completed the marine water with following results:

Date	14.08	23.09	7.10	14.10	22.10
> 50um org.	1,2	<1	<1	<1	<1
>10-50um org. CMFDA	<1	4	3	4	<1
UVT %	69.5	65	70.6	74	87

The testing will continue starting in April 2016 when natural life is present to complete the fresh and brackish water tests, and will be completed by May/June. The ship board testing has proven to be a challenge to find the required life for valid test but our objective is to complete these test onboard Saga Future in June. The environmental testing is on-going and will be completed in April. We will send the application for USCG TA as soon as possible.

Summary

Our conclusion is that UV can meet the stricter dead criteria set forward by USCG and the ETV test protocol. We are proud of the fact that we are still working with the system designed in 2006/2007 and that our customers will receive USCG TA Certificates retroactively. Optimarin is on schedule to submit our application for USCG TA and receive the system Certificates in the second half of 2016.

NIVA's experiences with IMO and USCG testing of ballast water treatment technologies

Stephanie Delacroix, August Tobiesen (NIVA)

Abstract

Norwegian Institute for Water research (NIVA) has the last 10 years conducted testing of many different Ballast Water Treatment Systems (BWTS) for Type Approval according to International Maritime Organization (IMO) and United States Coast Guard (USCG) guidelines. The USCG guidelines are similar to the IMO guidelines. However, some of the differences are crucial as the definition of "living" cells and the testing requirement of the technology performance limitations, so-called "vendor's claims" for example. While IMO approves treatment technologies capable of damaging reproduction capacity of the target organisms, the USCG goes further by demanding an instant complete metabolic death of the organisms at the ballast water discharge time. The energy required for instant kill will be significantly higher than for making a cell to be non reproducible. In an effort of harmonization of the BWTS testing guidelines, the revised IMO guidelines will probably also require more transparency on the BWTS performance limitations in the Type Approval certificate. BWTS suppliers are questioning how to satisfy both the regulators and ship owners requirements for both Type Approval and Compliance testing. NIVA will present results from IMO and USCG testing experiences regarding the most critical differences between these two regulations for both testing and analysis procedures.

Introduction

Since 2005, Norwegian Institute for water research (NIVA) has accumulated 10 years of experience in BWTS type approval testing according to IMO and USCG guidelines. The Ballast Water Convention of IMO was adopted in 2004, but still not entered in force in 2016. USCG implemented in June 2012 its own regulation for verification and certification of BWTS. NIVA's test facility was officially approved by USCG in 2015 as test facility sub-contractor of DNV-GL as Independent Laboratory (IL). NIVA started USCG testing already in 2014. NIVA performs both land-based testing and shipboard testing for IMO and USCG type approval, and Vessel General Permit (VGP) 2013 compliance testing as well. A total of 13 different technologies were tested at NIVA. Half of these systems was based on treatment that makes use of active substances, typically as chemical injection, electrochlorination or ozonation. The other half was using different treatment methods combination based on UV technology. Based on this extensive expertise, NIVA will present the main critical testing parameters for BWTS performance evaluation based on both IMO and USCG requirements with the aquatic environment protection as final purpose.

Main critical testing parameters for BWMS performance evaluation

Based on NIVA's 10 years of experience, the water quality of the source water is the main critical parameter for the BWTS performance results, specifically concentration and type of dissolved organic carbon (DOC) and concentration and robustness of the organisms present in the test water. But also temperature may affect the efficacy results of the treatment to be evaluated.

Regarding temperature, some of the land-based testing results performed during winter time in Norway indicated lower treatment performance in cold water than in temperate/warm temperatures. This might be explained by low metabolic activity of the organisms and/or by slow kinetic reaction for on-site production of oxidants in cold water.

Another factor influencing significantly the BWTS performance would be the nature and the concentration of DOC. As most of the test facilities has local water sources with too low natural DOC concentration according to IMO/USCG requirements, supplementary DOC has to be added to the source water. The nature of the used DOC additive will influence the test water property regarding oxidant demand or UV-transmission (UVT). Hence, aromatic compound as humus acid or lignin will increase significantly the oxidant demand, requiring increase of oxidant dosage (Delacroix et al., 2013). This also applies for UV-technologies, as these aromatic DOC additives decrease significantly the UVT of test water, requiring increase of UV dose. The use of alternative non-aromatic DOC additive as citrate acetate or methylcellulose does not change significantly the natural characteristics of the test water (Delacroix et al., 2013). As all technologies have their specific maximum dosage capacity, the maximum oxidant demand and/or minimum UVT will be critical limiting parameters of the BWMS. Therefore NIVA would recommend transparency in the final testing report regarding test water properties and preparation. As these critical parameters, so called "Vendor's claims" by USCG or "System Design Limitations (DSL)" by IMO, have to be identified and tested according to USCG and new G8 requirements, a combination of both aromatic and non-aromatic DOC additives must be used to produce the appropriate test water according to each BWMS specific limitations.

While USCG requires a minimum of 25mg/L Total Suspended solids (TSS) for all 3 salinity ranges (freshwater, brackish water and seawater), IMO requires 50mg/L TSS for freshwater and brackish water and only >1mg/L TSS for seawater. Therefore, the neutralisation capacity of a BWMS applying a fixed high oxidants dosage whatever the water quality of ballast water, is verified during IMO testing, but not during USCG testing. Hence, the oxidative treatment of test water with low TSS as in IMO seawater will result in low oxidant demand or low oxidant consumption and consequently in high residual toxicity of discharge ballast water if the maximum neutralisation capacity of the system is insufficient. Therefore test water with both low and high particle/dissolved compounds load should be required during performance testing of BWTS making use of active substances when relevant.

Regarding the minimum biological requirements of the source test water, USCG requires the use of a majority of ambient organisms rather than the use of robust standard test organisms. Therefore the BWTS performance results might be highly dependent on the robustness of the dominant species being present in the test water at the testing time. It is well known that the density of species, diversity of organisms and robustness of the dominant organisms might vary significantly during the different seasons at different locations. Therefore NIVA would recommend the use of a minimum density of well-known robust standard test organisms in source test water in order to guarantee minimum challenging conditions during testing of the BWTS performance.

Regarding the analysis method for the enumeration of ≥10-50µm organisms, USCG requires the use of staining method exclusively while IMO approves the use of both staining and culture methods. The staining method identifies living organisms by the presence of enzymatic activity. However, after UV treatment which inactivates organisms by damaging DNA, the enzymes of the organism will still be active for several hours or even days after a fatal UV dose. Therefore, false positives (living but non reproducible organisms) have been observed by NIVA in most of the UV-treated samples when analysed by staining method. NIVA conducted an UV exposure experiment where a green microalgae, *Tetraselmis suecica*, was exposed to different UV doses up to 600 mJ/cm^2. The samples were analysed with both staining and regrowth methods. The results showed that even at the high UV dose of 600mJ/cm^2, a high percentage of algal cells still showed enzymatic activity with staining method, while there was no reproduction observed with the regrowth method. The staining method therefore severely underestimates the inactivation capacity of UV treatment with regard to potential harmful invasive organisms. The regrowth method identifies living algae by its capacity of reproduction under specific culture conditions. .However not all organisms in the ≥10-50 µm size group will show regrowth under these culture conditions, notably heterotrophic organisms which need to be assessed by the staining method. Therefore staining and culture methods would give complementary data on living organism density in treated ballast water. Hence, living organism density results from culture method could be used for those species which are capable of growing in the culture medium while results from staining method could be used for those species not growing in the culture medium. This practice would limit the overestimation or underestimation of living organisms with staining method or culture method respectively. One should also take into consideration that a number of algal species do not stain using the USCG method and that these may grow in the culture method adding to the importance of having complementary methods.

Conclusion

Based on 10 years of experience with IMO and USCG BWTS type approval testing, NIVA would recommend the use of both staining and regrowth methods for the enumeration of ≥10-50µm organisms during land-based testing. Hence, staining and culture methods are complementary to each other as the densities of organisms observed in the regrowth method could be complemented by the living species observed with staining method for those species which are not growing on the culture medium. This practice would limit the number of false positive or false negative often observed with staining method during land-based testing. NIVA would recommend more transparency regarding the water quality of challenge test water. Hence, the results of the BWTS performance will depend directly on the nature of DOC used in the test water regarding oxidants consumption for oxidative technologies or UVT for UV technologies. Therefore the oxidants demand or the UVT of the test water should be referred to in the final testing report. For some of the systems using active substances, challenge test waters with low oxidant demand should also be applied during USCG land-based testing, as it is already required by IMO guidelines, for proper evaluation of the system's neutralisation efficiency regarding residual toxicity at discharge. NIVA would recommend more transparency regarding evaluation of critical parameters specific of each BWTS, i.e. maximum oxidant demand for relevant oxidative technologies and minimum UVT for UV technologies. The BWTS performance results will also depend on the robustness of the organisms present in the source water. Each test facility should ensure the addition of one or several robust ambient organisms during testing. Finally, NIVA would recommend a better harmonization of IMO and USCG testing protocol requirements during revision processes of both guidelines. The harmonization of BWTS testing procedure is already ongoing within some independent laboratories (IL) representing several test facilities. Hence, the same interpretation of the IMO/USCG requirements would be applied for different testing facilities for a specific IL. A similar harmonization process should be extended between all approved ILs.

Compared to what? FDA and CMFDA are flawed benchmarks for live/dead classification in phytoplankton

Hugh L. MacIntyre and John J. Cullen[1]

Summary

The U.S. Coast Guard method for enumerating living cells in ballast water discharge is based on the U.S. EPA's Environmental Technology Verification Protocol. Living cells are identified using two "vital" stains, fluorescein diacetate and 5-chloromethylfluorescein diacetate (FDA and CMFDA). Unstained cells that move are also classified as living. The stains assess membrane integrity and esterase function and are by definition the benchmark against which an alternative ballast water test must be evaluated if it is to be used for regulatory compliance. We assessed the accuracy of FDA, CMFDA, and FDA+CMFDA in discriminating live from heat-killed cells in cultures of 24 species of phytoplankton from 7 divisions. False negative errors (living cells classified as dead) and false positives (dead cells classified as living) were identified from the frequency distributions of per-cell fluorescence intensity in live and heat-killed samples, measured with flow cytometry. In the majority of taxa, overlap between the frequency distributions of living and dead cells led to unavoidable errors. In 4 weakly staining taxa, the mean fluorescence intensity in the heat-killed cells was higher than that of the living cells, inconsistent with the assumptions of the vital stain approach. Applying the criteria of both ≤ 5% false negative and ≤ 5% false positive errors, vital stains gave acceptably accurate results at best for only 10 (FDA) and 9 (FDA+CMFDA) species of the 24 tested. Of the 15 species inaccurately classified by FDA+CMFDA, 3 are inherently immotile, so errors for them cannot be avoided by checking for movement. CMFDA was the least effective stain and its addition to FDA degraded the performance of FDA alone.

Background

Existing (USA) and pending (IMO) regulations for ballast water management systems (BWMS) specify maximal concentrations of living or viable cells that are permitted following treatment (IMO 2008, USCG 2012). The literature on phytoplankton does not support clear-cut distinctions between living and dead cells (Franklin et al. 2006, Berges & Choi 2014) and to date no test has been demonstrated to be clearly, consistently, and comprehensively effective at making such binary classifications. At the recommendation of U.S. Environmental Protection Agency's Environmental Technology Verification (ETV) Program (USEPA 2010), the method adopted by the U.S. Coast Guard for assessing the effectiveness of BWMS for treating microorganisms, including phytoplankton, involves use of two "vital" stains, fluorescein diacetate and 5-chloromethylfluorescein diacetate (FDA and CMFDA), and detection of movement.

Both FDA and CMFDA contain a fluorescent molecule that is prevented from fluorescing by chemically bound side-groups. When these are cleaved by esterases or thiols, which are common in metabolically active cells, the product can be detected measuring green fluorescence. But since its earliest use, there has been clear evidence that the FDA stain is not uniformly effective at detecting viability in phytoplankton. There is high inter- and intraspecific variability in staining (Bentley-Mowat 1982, Dorsey et al. 1989, Agustí & Sanchez 2002, Garvey et al. 2007, Reavie et al. 2010, Peperzak & Brussaard 2011) and the intensity of staining can be strongly influenced by the cells' growth conditions (Gilbert et al. 1992, Brookes et al. 2000, Garvey et al. 2007). There is less information on the characteristics of CMFDA. Its incorporation into the ETV protocol was supported by the results of Steinberg and co-workers (2011), a study that was based on trials that the authors themselves described as "preliminary". A subsequent comparison of staining in living and formaldehyde-killed cells in 40 species of phytoplankton from 8 divisions (Peperzak & Brussaard 2011), indicated that CMFDA's staining properties were similar to those

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of FDA (i.e., with both inter-specific and intra-specific variability of the difference in staining intensity, as measured by flow cytometry). The study reported live/dead staining ratios for FDA and CMFDA but did not explicitly quantify error rates and did not test the combined stain. We have done so (MacIntyre & Cullen 2016) and conclude that the combination of FDA+CMFDA has an unacceptably high rate of live/dead misclassification with most of the taxa (24 species of phytoplankton from 7 divisions) that we tested.

Methods

Cultures were maintained in balanced and nutrient-replete, exponential growth in semi-continuous culture (MacIntyre & Cullen 2005). Under these conditions, all cells are actively growing, therefore alive. This was verified using Most Probable Number assays on 17 of the cultures. On harvest, each culture was divided; half was retained as a live control and half was heat-killed (50 °C, 10 min) according to Steinberg et al. (2011). The efficiency of the heat treatment was tested with MPN assays: the mean loss of viability was >99.9% in the five species tested.

The live and heat-killed cultures were stained with FDA+CMFDA according to Steinberg et al. (2011). Per-cell green fluorescence (staining intensity) was quantified by flow cytometry after calibration with Spherotech 8-peak beads. Each species in culture was assayed independently, 3–5 times, separated by intervals of a week to 11 months.

Findings

There were wide differences in the degree to which the frequency distributions of staining in live and heat-killed cells overlapped (Fig. 1). The misclassification rate was calculated by setting the fluorescence intensity of the 95th percentile of the distribution of heat-killed cells as a threshold for separating living from dead cells. This “statistically not dead” threshold sets a fixed rate of false positives (dead cells misclassified as living) of 5%. False negatives (living cells misclassified as dead) were assessed as the fraction of living cells with per-cell fluorescence below the 95th percentile of the dead cells’ distribution. These are potential propagules that may result in species introductions. Rates of false negatives ranged from <1 to >99% (Fig. 1).

Of the 24 species examined, 11 had rates of misclassification less than 10% (5% false positives plus ≤5% false negatives) when stained with FDA+CMFDA. However, one of these also had high cell losses when otherwise untreated cells were stained (39–70%, mean 55%), which would result in equal underestimates of the concentrations of living cells. Consequently, only 10 of the 24 species could be classified with an error rate less than 10%. At the other extreme, in 4 of the 24, the rate of misclassification was >95%. When FDA and CMFDA were used alone, 10 and 8 of 24 species were classified with an error less than 10%, respectively. Adams and co-workers (2014) also report no improvement in classification when CMFDA is added to FDA. The accuracy of classification was not related to taxonomic affiliation, cell size, or growth rate. There would, therefore, be no simple way to assess what components of a mixed assemblage of phytoplankton could be classified reliably and which could not.

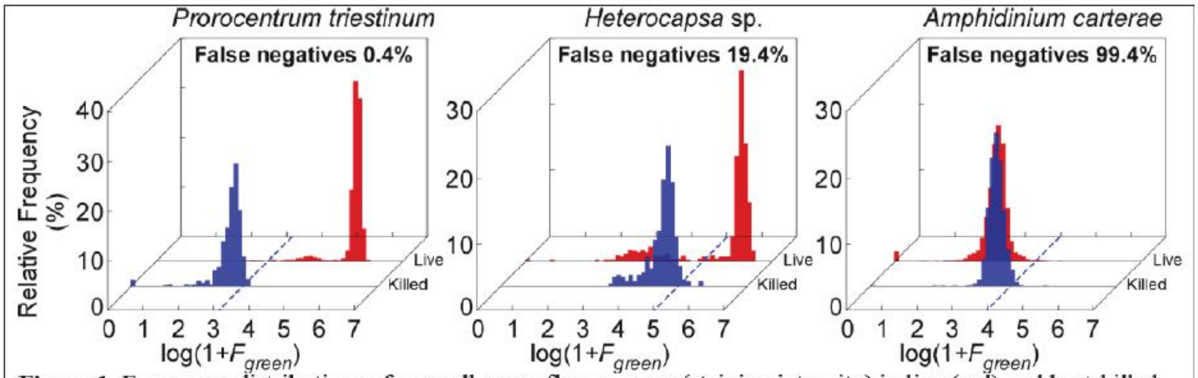

Figure 1. Frequency distributions of per-cell green fluorescence (staining intensity) in live (red) and heat-killed (blue) cells of 3 dinoflagellate species stained with FDA+CMFDA. Note the log scales for vital stain fluorescence (F_{green}). The dashed line indicates the 95th percentile of the distribution of heat-killed cells, which is used as a threshold for live/dead classification. False positives, which are dead cells with fluorescence higher than this, and thus classified as living, are set at 5% of the population. False negatives are live cells with fluorescence lower than this, which are therefore classified as dead. Rates of false negatives, which varied from <1% to >99%, are reported on the panels. Note that both *Heterocapsa* sp. and *Amphidinium carterae* can produce toxins and are classified as harmful algal bloom species. *Prorocentrum triestinum* is not.

These results show high rates of live cells misclassified as dead, i.e., false negatives. As we show in the publication, an alternative "statistically not alive" threshold could be set as the 5th percentile of staining intensity in living cells; this low staining threshold would set false negatives at 5%, with corresponding increases in false positive errors (dead cells misclassified as alive). This is inherently more protective of the environment in the context of BWMS, but the inaccuracy remains.

Flow cytometry, the detection method that we applied, is quantitative, objective, and lends itself to rapid analysis of staining in large numbers of cells. However, it does not detect movement, which has been recommended as a confirmatory indicator of live/dead status for phytoplankton (USEPA 2010). It is possible, therefore, that simultaneous testing for staining intensity and movement with a microscope could be more accurate for live/dead classification than analysis of stains alone. It is important to recognize, though, that the staining thresholds are valid only if they are readily detectable, e.g., using a microscope, and this could be difficult to verify when applied to natural communities of phytoplankton, especially for weakly staining cells. Further, movement is not a reliable indicator of living status in phytoplankton. Many phytoplankton (e.g. centric diatoms) are non-motile and even in actively-growing cultures of flagellates capable of swimming, significant fractions of the population (10–30%) may be non-motile (Sheng et al. 2010). It has long been recognized that swimming cells may rapidly become non-motile when examined under a microscope (Knight-Jones 1951). Because the combination of FDA+CMFDA is demonstrably prone to significant misclassification errors—i.e., 10–100% in the majority of the species that we tested—and because motility is not a reliable indicator of life, we argue that they are flawed benchmarks for live/dead classification, whether used singly or in tandem.

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Practical experiences in on-board ballast water compliance sampling

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Both the International Maritime Organization (IMO) and United States Coast Guard (USCG) have set limits to the amount of organisms allowed to be in ballast water discharge. These discharge limits are: less than 10 organisms per m^3 larger than or equal to 50 µm, less than 10 organisms per milliliter smaller than 50 µm and larger than or equal to 10 µm, less than 250 colony forming units per 100 milliliter of *Escherichia coli*, less than 100 colony forming units per 100 milliliter of enterococci and less than 1 colony forming unit per 100 milliliter of *Vibrio cholerae*. The only difference between the IMO and USCG discharge standards is that IMO states numbers for 'viable' organisms while the USCG states 'living' organisms. The guidelines for sampling and analysis show much larger differences between IMO and USCG.

IMO ballast water sampling and analysis guidelines

The IMO has detailed ballast water sampling and analysis guidelines. All ships are required to have sampling facilities and samples should be taken from from the discharge line close to the point of discharge during discharge. Samples have to be representative of the entire ballast water discharge and be of sufficient sample quantity and quality to test according to the standards. Sampling should be conducted in a safe and practical manner and the samples concentrated to a manageable size.

The regulations also call for 'isokinetic' sampling, where it should be clarified that the IMO understanding of isokinetic is different from the normal interpretation of the term isokinetic. The sample probe diameter should be between 1.5 and 2.0 times the isokinetic diameter and the opening of the sample probe should be chamfered. It is further recommended to use a removable sample probe to avoid problems with corrosion, fouling, etc.

There are further requirements on the type of valve used on the sample port. This is important in preventing damage to the organisms during sampling. Ball, gate and butterfly valves are generally to be avoided, although ball valves can be used if fully opened during sampling. Diaphragm valves or a similar valve type are recommended, as they do not cause damage to organisms even when throttled.

The IMO guidelines do not offer details on analysis methods, they only state that 'samples should be fully analysed within test method holding time limit using an accredited laboratory'.

United States Environmental Protection Agency Vessel General Permit ballast water sampling and analysis requirements

The Vessel General Permit (VGP) states that: 'samples can be taken by collecting a small volume sample from the ballast water discharge'. This is colloquially known as 'grab-sampling'. The requirements are less extensive than for the IMO, mentioning only sampling at discharge, isokinetic sampling and the use of a chamfered sample probe. The requirements for the valve type on the sample port are identical to the IMO requirements.

Contrary to IMO, the VGP states a limited selection of allowed methods and holding times for every parameter. However, the VGP only requires testing for two parameters from the discharge standard, *Escherichia coli* and enterococci, as well as one parameter not included in the discharge standard, total heterotrophic bacteria. Additionally there are limit values for chemicals (for instance TRO as Cl_2 less than 100 µg/L and ClO_2 less than 200 µg/L), as well as chemicals that should be measured but do not have limit values.

Practical experiences

The various challenges described below are based on the practical experiences SGS has in the field of ballast water sampling and analysis. During the years 2013 and 2014 SGS executed 103 ballast water sampling and analysis events according to the VGP, 93 of these tests were compliant. During these same two years 12 ballast water sampling and analysis tests were executed where the full range of IMO parameters was tested, 11 of these tests were compliant. These numbers do not represent the full number of tests SGS has executed, but only the test results of clients who agreed to the anonymous use of their data. No data is available yet for 2015, but the number of requests for ballast water testing is constantly increasing.

It should be noted that non-compliance is currently often a consequence of improper handling of the ballast water treatment system. A further point of interest is that non-compliance is not always due to an exceedance of the biological limit values; also the chemical limit values are sometimes exceeded.

Mistakes in the handling of the ballast water treatment system

There are a number of examples of situations where non-compliance was caused by insufficient knowledge on the part of the crew: the discharge consisted of untreated water because it was not known that it should be treated. Treatment is done shortly before or during the attendance of the inspector, resulting in extremely short treatment times. As an example, when for a chemical treatment the neutralization step is performed almost immediately after treatment the chemicals have very little time to work on the organisms. As a final example, sometimes an incomplete treatment is performed due to insufficient knowledge of the treatment process. This is particularly relevant for UV-based treatment systems where a second treatment is performed at discharge; due to circumstances sometimes samples were provided which had only had one UV treatment.

Sample port location

The regulations require a ballast water sample port, but do not state anything on accessibility. The ISO-11711-1:2013 standard has technical details for ballast water sample ports, but is too recent to be referenced by either regulation. The use of a removable sample probe needs at least 1.5 meters of free space in front of the sample port.

On board sample port

When faced with a sample port on board, there are a number of questions that cannot always be quickly answered. Does it have a sample probe inside? Is the sample probe centered, chamfered and in good condition? What are the dimensions of the sample probe? Can samples be taken in a safe and practical manner? What type of valve is installed?

Sample valves

The regulations do not forbid any specific kind of valve for the ballast water sample port; only the types to be avoided are listed. The recommended valve type is diaphragm ‘or similar’, this leaves room for interpretation. Of course the biological interpretation of ‘or similar low impact on organism viability during sampling’ is mentioned, but engineers may read this differently. A type of valve used more often for ballast water sample ports is the so-called globe valve. This type is not mentioned in the regulations, but it has an internal structure which will most certainly have an effect on organisms during sampling.

Holding time

Holding time is defined as the maximum time allowed from the moment of sampling to the start of analysis. The IMO regulations state that analysis should be performed within ‘test method holding time limits’. The VGP states holding times per parameter and method for all parameters included in this regulation. For ballast water biological samples (heterotrophic bacteria, Escherichia coli, enterococci) this holding time is 8 hours. Since time is also needed to leave the ship and to process the sample when it arrives in the laboratory, it is safer to calculate a maximum of 6 hours travel distance between ship and laboratory. For city-states such as Singapore or countries with (relatively) compact coastlines such as Germany this holding time does not pose and difficulties. For countries with long coastlines such as Italy it becomes more difficult to cover all harbors. For regions with many small islands such as the Caribbean this quickly becomes impossible.

Vibrio cholerae

Vibrio cholerae is part of the discharge standards, but is not a commonly offered parameter for analysis in laboratories. This makes finding a laboratory that offers the analysis very challenging in many countries. Laboratories will only set up equipment and expertise for classical *Vibrio cholerae* analysis methods if a guarantee can be given that sufficient samples will regularly arrive.

SGS uses an alternative based on Fluorescent In-Situ Hybridization (FISH). This uses fluorescent DNA or RNA markers to identify *Vibrio cholerae* and it requires about 8 hours of incubation. After incubation the bacteria are killed, making it safe to work with the samples.

VGP *Escherichia coli*

One of the required methods for Escherichia coli in the VGP is ISO 9308-1:2000. This ISO method was revised in 2014, one year after ballast water was added to the VGP. As part of standard procedure laboratories immediately switched to the new version of the method (ISO 9308-1:2014). However, the US EPA only accepts the old version of the method despite minimal changes between the two (for instance composition of the agar was changed). This means that for ballast water analysis laboratories have to maintain a supply of reagents for the old method

VGP chemical analysis methods

The VGP lists the required measurement parameters and methods for BWTSs using chemicals, but the methods are usually only EPA methods. EPA methods are commonly available in the US, but difficult to find in the rest of the world. This results in extra cost and effort because samples often have to be shipped to another country for analysis.

One parameter in particular causes difficulties, namely chlorine dioxide. The methods listed for this parameter in the VGP have short holding times (4 hours or less) and are unsuitable for use on board (for instance because they involve titration). A hand-held kit for chlorine dioxide has been EPA-approved for drinking water, but there is no decision yet if it can be used for ballast water.

Conclusions

The ballast water regulations were made as a best solution with information available at the time. Now that the demand for ballast water sampling and analysis is increasing, these experiences show practical challenges with the ballast water regulations. These practical challenges should be addressed as soon as possible, before the demand for ballast water sampling and analysis increases to a level that these practical challenges become insurmountable problems.

Revolutionary Microbial Testing for Pathogens in Ballast Water

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Objectives

Traditional testing for the presence of pathogens relies primarily on culturing microbial cells, which generally requires 48 hours to a week for identification of sample materials, depending on the micro-organism species targeted. To meet requirements for ballast water compliance monitoring and enforcement of international regulations, a rapid and highly accurate testing methodology is necessary.

Background

The International Maritime Organization (IMO) is a specialized agency of the United Nations and is the global standard-setting authority for the safety, security, and environmental performance of international shipping[i]. The taking on and discharge of ballast water, used in all steel-hulled shipping vessels, has now been recognized by Transport Canada, the U.S. Environmental Protection Agency and the Marine Environment Protection Committee as a growing hazard[ii]. Ballast water poses serious ecological, economic, and health problems due to the multitude of marine species carried in ships' ballast water which can survive to establish a reproductive population in the host environment and become invasive. These bio-invasions have increased, due to expanded trade and traffic volume over the last few decades, and have had devastating effects on various marine ecosystems around the world.

Canada's Ballast Water Control and Management Regulations (TP 13617 E) and section 222(1) of the Canadian Shipping Act (2001)[iii] detail regulations for shipping operating in Canadian waters. Transport Canada is the regulatory enforcement agency for operations in Canada.

The United States Coast Guard is charged with the enforcement of laws designed to protect the environment from foreign bio invaders, and it has issued various regulations regarding the same[iv]. The U.S. Congress has passed the National Invasive Species Act (1996)[v] and the Clean Water Act (1999)[vi] to combat these problems, as well. Included in these acts are mandates to confirm there are no pathogens in ballast water being dumped in Canadian and American waters.

Many other nations have their own regulations regarding ballast water management. The basic requirements tend to correlate across nations so that meeting the requirements of one leading nation such as Canada or the United States will also meet the requirements of most other countries[vii].

Issues

Global shippers are facing increasing scrutiny under these acts and other regulations intended to reduce detrimental effects on international harbor environments. Testing ballast water for the presence of potential pathogens such as bacteria and possible alien invaders like algae and plankton has a vital role to play in assuring that ballast waters brought from foreign ports are safe to discharge in the harbors of ports of arrival; however, testing methods may be inadequate. An article published in 2015 in *Marine Pollution Bulletin* notes that testing is often inadequate. Marine biologist Andrew Cohen notes that testing for the presence of non-harmful bacteria in ballast water and assuming that target pathogens respond in kind to kill treatments is a weak testing protocol.[viii] The lengthy periods necessary for testing with traditional culturing techniques are enormous hindrances to timely monitoring that can lead to appropriate actions determined from test results. Lengthy and costly delays in off-loading cargo will be reduced if accurate and timely test results can be made available to both shippers and regulators. Clearly, a targeted, accurate, and rapid testing methodology for pathogens in ballast water is seriously needed.

Technology

A revolutionary technique for microbial testing using cutting-edge DNA markers has been available in the European Union for four years. These techniques provide highly accurate definitive tests for the presence of specific targeted pathogens. DNA-marker diagnostics shortens the sample-to-results time from several days to under an hour at costs below those of laboratory-based culturing techniques. Rapid identification notifies responsible officials during a time window in which emergency response and remediation are possible and may be effective. This allows organizational responses that can limit microbiological contaminations. This proprietary technology tests water using fluorescently labeled DNA probes for many bacteria and protozoans recognized by the International Maritime Organization (IMO) as microbial contaminants[ix]. DNA-probes developed for the detection of coliforms[viii], Enterococcus spp.[ix] and Vibrio cholerae[x] (the pathogens specifically noted in IMO standards) have a firm scientific basis. Additional probes can be developed to meet new requirements.

This technology combines the reliability of filter cytometry with the speed of analysis and specificity of Fluorescent In Situ Hybridization (FISH) [xi] and Fluorescent Micro Agglutination (FMA) [xii]. Applications based on this technology are all validated according to ISO16140 using certified culturing techniques as reference method. This technology, now available in North America, is a significant game-changer in methods global shipping companies and port authorities may use to meet more stringent requirements.

Discussion

Monitoring of the microbial composition of ballast water is now easy and reliable with the use of this new rapid microbial detection methodology. Onboard monitoring of the number of coliforms, Enterococci, and Vibrio cholera in ballast water before and after commercial disinfection treatment during the ship's voyage and prior to discharge on arrival makes a rational ballast water monitoring and treatment system possible.

Utilized onboard a ship, all micro-organisms prohibited by regulations from the point of ballast intake at the port of departure through ballast discharge at the port of arrival can be effectively monitored. Such monitoring using the rapid detection technology can form an effective ballast water management system. Such biodata provides continuous insight into the microbiological status of ballast water while at sea and allows management to adequately and rationally manage ballast water. This allows for prompt reporting to port authorities prior to the arrival of a vessel, thus affording ship command and ship owners reduced or no "waiting time" and potentially reducing the number of overall shipping days. A wireless data transfer capability could significantly reduce ship "wait times" to dock due to the early transmittal of testing results to authorities. Such a capability provides potential savings to vessel owners while promoting improved port throughput of shipping cargos.

Using Rapid Microbial Detection Methodology at Sea

< Reliable microbial monitoring	< No delays upon arrival in port
< Proper planning of ballast water treatment	< More days of effective travel time
< Rational treatment of ballast water	< Automated record keeping and approval processing

In port, bio-monitoring using rapid microbial detection testing during inspections of sea-going vessels provides necessary information for responsible port management and rapid intervention. Targeted rapid detection instruments can monitor ballast water samples quickly and efficiently, thus allowing port authorities and in-country Coast Guards to keep automated records of compliance and provide improved planning information to ship owners and port operators. This technology allows port authorities to effectively investigate and observe the ballast water of incoming vessels prior to discharge. This allows more effective port management and promotes minimal environmental impact.

Using Rapid Microbial Detection Methodology in Port

< Complete analysis report per ballast tank	< Fewer port movements
< Rapid insight into ballast water quality	< Less quay time
< Minimal environmental impact for port	< More effective use of port authorities and Coast Guard personnel time

Conclusions

The new rapid microbial detection technology discussed here can serve as the conceptual and actual foundation of a ballast water management system that is effective in providing highly accurate monitoring for the presence of specific pathogen materials in ballast water. The results are well-documented, targeted, definitive, efficiently produced, and verifiable by regulatory agencies. This bio-informatics technology is based on sound, well-respected techniques from microbiology and genetics that provide reliable and accurate results. When applied at sea and in port, this revolutionary technology enables a more effective program for monitoring and control of international ballast water. A higher standard of compliance monitoring and enforcement is achievable using this technological breakthrough.

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[i] http://www.imo.org/en/About/Pages/Default.aspx
[ii] http://www.nepis.epa.gov
[iii] http://www.tc.gc.ca/eng/marinesafety/tp-tp13617-menu-2138.htm
[iv] Ibid.
[v] https://www.gpo.gov/fdsys/granule/STATUTE-110/STATUTE-110-Pg4073/content-detail.html
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[xi] http://www.genome.gov/10000206
[xii] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC279349/

A conceptual Port State Control Decision Support System: DHI-PSCBallast

Guillaume Drillet[1]

Introduction

In about 10 % of the cases, introduced species become invasive (Boudouresque and Verlaque, 2002) and create drastic and sometimes irremediable social and economic impacts, some of which were estimated to range from millions to billions of dollars annually in the USA alone (Lovell et al., 2006). Roughly, 2/3 of these new introductions are coming from the exchange of ballast water across ecosystems by the shipping industry (Gollasch, 2007). The International Maritime Organization (IMO) has adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (aka the Ballast Water Management Convention or BWMC) in 2004 (IMO, 2004). The entry into force of the convention is expected to reduce the amount of exogenous species transferred across ecosystems. In order to support the ratification of the convention, the IMO has adopted a series of guidelines and agreements (Graph 1). Issues raised about the G8 guidelines and the D-2 standards have pushed the member states to re-open the G8 guidelines to ensure the efficient Type Approval of treatment systems for example (Drillet et al., 2013, Cohen and Dobbs, 2015, MEPC 69/4/6, 2016). All of these actions have been supporting additional ratifications of the convention. The BWMC is to enter into force exactly one year after at least 30 countries representing 35% of the world merchant shipping tonnage have ratified (Article 18). With Belgium and Fiji ratifying the convention earlier this year, the number of states stands at 49 and the represented world's merchant fleet tonnage has reached 34.82 %, therefore making the convention entry into force imminent[2].

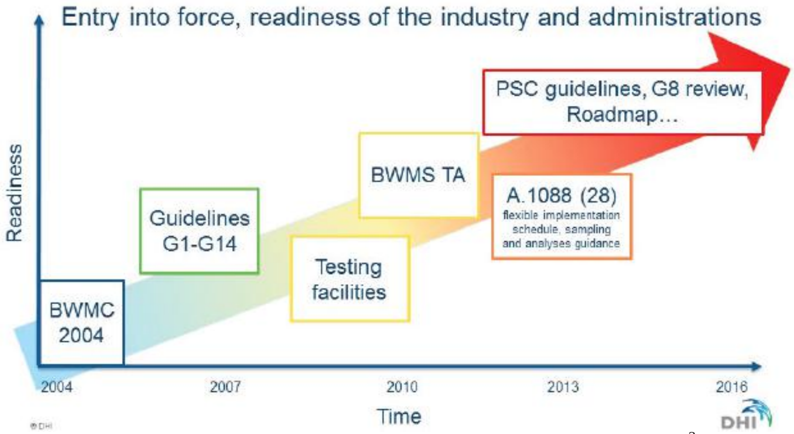

Figure 2: Readiness of the tools supporting the ratification of the convention[3]

Port State Controls

Port State control (PSC) refers to the inspection of ships from different flag state during their stay in ports. The PSC officers have the task to verify that the ships do comply with the requirements of international regulations from ILO (e.g. MLC 2006); IMO (e.g. SOLAS 1974, MARPOL 73/78) etc.

[1] DHI-NTU Research Centre and Education Hub / Ballast Water Technology and Innovation Centre, Singapore / gdr@dhigroup.com

[2] Legally, an increase of tonnage from any of the ratifying countries may put the convention into force is the global tonnage pass the 35% limit.

[3] Adapted from Markus Helavuori; IMO update on the BWM convention; Training on sampling and analyses of ballast water 2-4 June 2015, Gebze, Turkey

Based on the assumption that a ship calling a port in one area is likely to travel to multiple ports in the same region, PSC can improve their efficiency by avoiding double inspections or supporting each other to follow up non-compliance. Therefore, on the 6th of November 1991, the resolution A.682 (17) (IMO, 1991) was taken in order to promote regional cooperation by generating smaller agreements supporting the efficient work of PSCO. The first Memorandum of Understanding, the MoU of Paris, was already signed in 1978, before the IMO resolution. Nevertheless, the efforts in coordinating regionally the work of the PSCO have been taken seriously by Port States. 9 PSC regimes[4] are existing today and the United States Coast Guard also maintain an additional PSC regime.

1. Europe and the North Atlantic (Paris MoU);
2. Asia and the Pacific (Tokyo MoU);
3. Latin America (Acuerdo de Viña del Mar);
4. Caribbean (Caribbean MoU);
5. West and Central Africa (Abuja MoU);
6. Black Sea region (Black Sea MoU);
7. Mediterranean (Mediterranean MoU);
8. Indian Ocean (Indian Ocean MoU);
9. Riyadh MoU.

In order to share information between PSCs, database tools have been developed such as THETIS for the members of the Paris MOU; APCIS for the members of the MoU of Tokyo; BSIS for the members of the Black Sea MOU; IOCIS for the members of the Indian Ocean MOU; CIALA for the members of the Viña del Mar Agreement. However, because each of the MoUs are slightly different, the use and access to the databases are also different. MoUs nevertheless tend to share the results of their compliance monitoring (the inspections) between each other's areas of control. Some global databases are also existing and regroup the information that is transferred from the MoUs. This is the case for example for the EQUASIS[5] development and the IMO GISIS[6] .

The accumulation of the information from the PSC allows development of statistical tools to "rank" ships entering port for their risk of non-compliance. Generally, this is based on their Flag State, their type, and their class society, but not all MoU may use such tools and if so, the methods to calculate the rank of a ship are not necessarily easily accessible. The New Inspection Regime from the Paris MoU is based on a good example of transparent ranking which allows ships on the "white list" to be inspected less regularly than ships listed on a "black list" (Paris MoU, 2014). Eventually, PSC inspection and the development of ranking systems which inherently have existed under many forms have generated a tendency for some ships to do Flag-hopping and Class-hopping (Cariou and Wolff, 2011).

Potential consequence of the entry into force of the convention on PSC and their tools

Once the BWM convention has entered into force, PSC will bear an additional task to verify that ships entering their port are compliant with the regulation of the BWM Convention. To support the preparation of Port State Control, the IMO has offered training workshops to PSC officers and has gotten the 4 stage approach PSC guidelines prepared and approved through the resolution MEPC 252 (67) (2014). The 4 stages proposed are:

1. the "initial inspection"
2. the "more detailed inspection“
3. the "Indicative sampling"
4. the "detailed analysis"

[4] Note that it is possible to be part of multiple MoU.
[5] http://www.equasis.org/EquasisWeb/public/HomePage
[6] https://gisis.imo.org/Public/Default.aspx

However, the BWMC is unique in that it is the first convention dealing with living organisms. The question “What is in the Water?” is crucial for the successful implementation of the convention and the reaching of its objectives. There are two main challenges in the application of the convention that still remain:

First, the risk of non-compliance to the D-2 standards may not be directly linked to the improper usage of the Type Approved equipment (Ballast Water Management Systems, BWMS). The testing of such equipment during Type Approval is carried out following the G8 guidelines and requires that each test is carried out against the D-2 standards which allows a few organisms to survive the water treatment. This theoretically could generate an accumulation of organisms in tanks over many cycles of ballasting and de-ballasting water during normal operations. Eventually, the regrowth of such organisms or their sudden resuspension in the tanks may generate a non-compliance at discharge while the BWMS has been used properly. The questions of accumulation of organisms and eggs in the tanks and the difficulty to sample them properly have been discussed (Drillet, 2014, Miller et al., 2011) and the regrowth has been a central question of the G8 changes in the last 2 years (MEPC 69/4/6, 2016). There is obviously no proper answer to this challenge because the regrowth in tank is likely to occur and its assessment during TA testing is difficult. Additionally, there are differences in between the testing regimes of accredited test facilities (MEPC 69/4/4, 2016) which may affect the evaluation of systems during type approval. Therefore, a normal inspection following the PSC guidelines stage 1 and stage 2 may not be enough to assess the compliance against the D-2 Standard. The two first stages proposed by the PSC guidelines will merely assess the “administrative compliance” but not the “biological compliance” (the D-2 discharge standard). It is very likely that to protect our natural environments, PSCO will still be required to randomly evaluate the presence of organisms in the tanks through a 3rd stage or 4th stage inspection even if the two first stages show perfect administrative compliance. This is absolutely in line with the text of the convention itself which prevails over the guidelines (Article 9.1 and 9.2)[7].

Second, the MoUs are acting at regional scales which may not encompass different climate regions, and therefore their temperature and saline differences. In term of efficacy and survivability of the organisms in the tanks, this may have a very important effect on the ranking of a ship for it compliance or non-compliance in different regions. This is supported by that some BWMS may not be efficient under all climates. Here again, temperature, which is structuring aquatic environment globally, is also a parameter which has been intensively discussed during the revision of the G8 guidelines and elsewhere (MEPC 69/4/6, 2016, Drillet et al., 2013).

The question that arises, therefore, is how do we rank which ships are likely to be non-compliant to the BWM convention regulations if these uncertainties exist? The tools that are used by PSCO are not adapted enough to answer that question today because they do not incorporate biological information and information on the type of equipment on board.

PSC Ballast

In our Research Centre at DHI-Singapore[8], we have initiated the conceptualization of a software to rank ships entering ports with a risk of non-compliance score. The tools are expected to be developed as a web-based system which can be used by every port in the world to rank ships entering local waters from the most likely to the least likely to be in compliance with the BWMC (Figure 2). The web-based format allows the development to be accessible from every simple device in the world without having the obligation of developing additional applications for mobile phones and their updates. This allows PSCBallast to be a low cost tool for every PSC in the world. The “pay as you go” (per ship entry) approach has the advantage that it allows large and small port terminals to enjoy similar tools, supporting the sharing of information on type approved ballast water management systems performances in different areas in the world. Therefore it is also likely that the information generated by the PSCBallast will be

[7] Article 9.1.c stipulates: “a sampling of the ship’s ballast water. Carried out in accordance to the guidelines to be developed by the Organization….”
[8] DHI-NTU Research Centre and Education Hub

shared with MoU around the world to support the ranking of ships based on the state of knowledge in BWM.

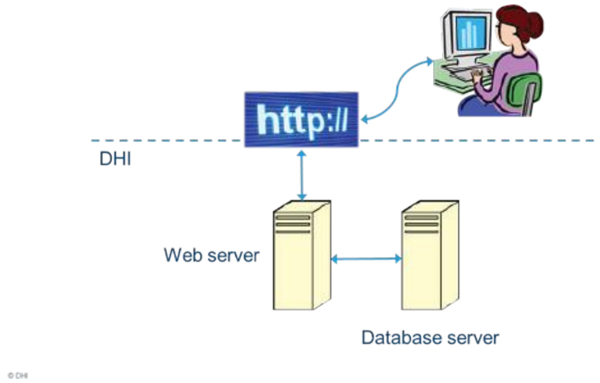

Figure 3: Simplified overview of the PSCBallast

The PSCBallast will include modules such as:

- User administration: This module supports multiple users for multiple port authorities.
- Ship information: A module to enable port authorities to input all relevant ships' information as well as results from checking/testing of ships.
- Intelligent risk evaluation system generated based on the ship information input by the PSCO to PSCBallast. The risk of non-compliance score becomes more and more robust over time, learning from past compliance testing carried out by participating PSC
- Eventually, the PSCBallast can also incorporate a biological risk based on routes that ships have been taking and the Risk Assessment generated by authorities, universities, institutions, etc.

In fine, the PSCBallast will support the day to day work of PSC officers in accomplishing their duties more efficiently, therefore protecting the aquatic environment. By using the PSCBallast, additional information is created and can be used to better advance the global capacities in Ballast Water Management (i.e. evaluate both the BWMS efficacy in different environment as well as the different indicative sampling method and equipment available).

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Getting ready for implementation of the BWM Convention

International Association of Classification Societies (IACS)

Introduction

As the conditions for entry into force of the Ballast Water Management Convention draw nearer, the attention of IACS and its Members is now focussing on the how the tens of thousands of ships to which the Convention will be applicable can be surveyed and issued with certificates in an effective and efficient manner.

At a practical level, the paper discusses and explains the process by which it is expected that compliance with the provisions of the Convention will be verified. The paper also explains the work that IACS identified as being necessary in relation to the installation of ballast water management systems, in particular the development and adoption of an IACS Unified Requirement relating to the installation of such systems.

Application provisions

The Convention applies to ships[1] designed or constructed to carry ballast water. The Convention will not apply to ships not designed to carry ballast water; ships only operating in waters under the jurisdiction of a party; any warship, naval auxiliary or other ship owned or operated by a State and used only on Government non-commercial service; or ships with permanent ballast water in sealed tanks.

Ships of 400 GT and above are subject to surveys and certification (excluding floating platforms, FSUs and FPSOs). However, as per IMO circular BWM.2/Circ.46, mobile offshore units should comply with the provisions of the Convention and should be surveyed and issued with an International BWM Certificate, while Offshore Support Vessels should comply as recommended by IMO circular BWM.2/Circ.44.

For existing ships, the original implementation schedule is provided in regulation B-3 of the Convention. However, the IMO Assembly has adopted resolution A.1088(28), with a view to easing and facilitating the smooth implementation of the Convention. According to this resolution, compliance with the D2 Standard will be at the first Renewal Survey conducted for the International Oil Pollution Prevention (IOPP) Certificate following the date of Entry Into Force (EIF) for ships the keels of which were laid before the EIF; or at delivery for ships the keels of which are laid at or after the EIF. Recognizing that the BWM Convention cannot, for legal and procedural reasons, be amended before it enters into force, it is expected that, as soon possible after EIF of the Convention, regulation B-3 will be amended to be consistent with the understanding reflected in IMO resolution A.1088(28).

To facilitate the process of certifying the fleet of existing ships at the EIF, it will be possible to issue the International Ballast Water Management Certificate prior to EIF of the Convention once the conditions for EIF have been satisfied, provided the certificate is annotated to state that validity will begins from the EIF date (BWM.2/Circ.40).

IACS Members acting as certifying bodies

Acting on behalf of Administrations, IACS members can be involved in the approval of a Ballast Water Management System (BWMS[2]), as required by regulation D–3 of the Convention. Regulation D-3 states

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[1] The 'term' ship is defined in Article 1 of the Convention as "a vessel of any type whatsoever operating in the aquatic environment and includes submersibles, floating craft, floating platforms, FSUs and FPSOs."

[2] A BWMS means any system which processes ballast water such that it meets or does not exceed the ballast water performance standard in regulation D-2 of the Convention. The BWMS includes ballast water treatment equipment, all associated control equipment, monitoring equipment and sampling facilities.

that this approval is to take account of Guidelines developed by the Organization. In this regard, IMO has adopted the G8 and G9 Guidelines on Guidelines for approval of ballast water management systems, and the Procedure for approval of ballast water management systems that make use of active substances, respectively. It should be noted that the IMO has embarked upon a revision of the G8 Guidelines and that IACS, based on the experience of its Members in undertaking this approval work and using these Guidelines, is actively participating in this work.

IACS Members societies acting as Recognised Organisations

Administrations may delegate IACS members, as recognized organizations, to conduct surveys as required by the Convention (regulation E-1 of the Convention), issue International Ballast Water Management Certificates (regulation E-2), and approve Ballast Water Management Plans (regulation D-3).

Ships that require to be issued with International Ballast Water Management Certificates shall initially be subject to an initial survey before the ship is put in service or before the International Ballast Water Management Certificate is issued for the first time. This survey shall verify that the BWMP and any associated structure, equipment, systems, fitting, arrangements and material or processes comply fully with the requirements of the Convention. Thereafter, the ship shall be subject to a survey regime that comprises annual surveys, intermediate surveys and renewal surveys. The renewal survey is to be conducted at intervals specified by the Administration, but not exceeding five years. This renewal survey shall again verify that the BWMP and any associated structure, equipment, systems, fitting, arrangements and material or processes comply fully with the applicable requirements of the Convention.

The scope of the Initial survey will include the following main points (based on the Interim Survey Guidelines provided in IMO circular BWM.2/Circ.7):

➢ Plan approval
  - examining the ballast water management plan (regulation B-1);
  - examining the design and construction with respect to removal of sediments (regulation B-5);
  - examining the plans for the installation of the BWMS (regulation D-3); and
  - if applicable, examining the plans for the installation of prototype ballast water treatment technologies (regulation D-4).

➢ Documentation
  - confirming that the Ballast Water Management Plan has been approved and provided; and
  - confirming that the Ballast Water Record Book has been provided.

➢ If a BWMS is required to be installed then the following additional verification activities will be undertaken:
  - operations and technical manual for the BWM System has been provided, which is specific to the ship and approved by the Administration;
  - equipment manuals for major components has been provided;
  - Installation specifications / commissioning procedures have been provided;
  - initial calibration procedures have been provided;
  - sampling facilities have been provided;
  - BWMS is in conformity with the Type Approval Certificate;
  - BWMS installation carried out in accordance with the technical installation specification / manufacturer's equipment specification / approved drawings;
  - control and monitoring equipment operates correctly;
  - sufficient active substances are provided on board (if applicable); and
  - satisfactory installation and operation of the BWMS, including any audible or visual alarms.

IACS Members as Classification Societies

IACS has developed a specific Unified Requirement (UR) regarding the installation of Ballast Water Management Systems. A copy of this document can be downloaded from:

www.iacs.org.uk/document/public/Publications/Unified_requirements/PDF/UR_M_pdf2793.pdf

This UR is to be uniformly implemented by IACS Societies for BWMS, where an application for installation is made on or after 1 January 2017; or which is installed in ships contracted for construction[3] on or after 1 January 2017.

The background to the development of this UR is the type approval procedure for ballast water treatment systems, which, according to the IMO's G8 and G9 Guidelines:

- pre-test evaluation of system documentation;
- risk assessment;
- performance tests; and
- environmental tests

The risk assessment phase included the identification of hazards, the purpose of which was to identify hazards posed by different types of BWMS and to identify hazards related to the arrangement and installation of the BWMS in the ship. When the hazards had been identified, they were categorized by applying a risk index matrix, in which the risk index combined the frequency index and the severity index.

As result of the above analysis, 50 hazards were identified and allocated a risk index. The main risks identified were: a spark or hot surface; mechanical damage caused by internal shock; power failure; gas leak; and gas being present in the ballast water.

IACS UR M74 includes general installation requirements, such as: piping systems; electrical installations; the arrangement of the BWMS compartment; additional requirements applicable to BWMS installations on tankers; and automation arrangements.

[3] The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of "contract for construction", refer to IACS Procedural Requirement (PR) No. 29.

Discussion on Current Guidance for Scaling of Ballast Water Management Systems

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Abstract

Ballast water management systems (BWMS) undergo testing in accordance with detailed procedures to receive type approval by an Administration. Most of the type approval testing has been conducted on models with treatment rated capacities (TRC) approximating 250 m3/h (suitably rated for smaller bulkers, car carriers, cruise ships, shuttle tankers, etc.). A review of published test information indicates that land-based testing has not been conducted above 500 m3/h and shipboard testing has been conducted at 1000 m3/h or greater TRC for only a few BWMS.

International Maritime Organization's (IMO) Guidance on scaling of ballast water management systems provides recommendations for scaling of BWMS. IMO states "the most vulnerable model should be tested according to the requirements for shipboard tests." However, the term "most vulnerable" is not clearly defined in the Guidance and no administration has published clear scaling guidance. A review of 47 type approval certificates provided to IMO by Administrations indicates only two BWMS have type approvals specifying a greater flow rate for scaling. The IMO Correspondence Group for revision of the Guidelines for Approval of Ballast Water Management Systems (G8), has identified the need to improve the reporting of scaling conducted.

This paper incorporates discussions with shipowners about their experiences with operating BWMS; some revealed higher incidence of operational issues for systems with TRC more than 1500 m3/h. This paper identifies patterns between operational hurdles with higher flow rate systems and scaling variables. The paper also provides suggestions for model validation used to support BWMS scaling.

Key Words: MEPC, Ballast Water Management, scaling, Guidelines (G8), D-2 standard, BWM Convention

Introduction

The International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) developed two guidelines for the approval of ballast water management systems (BWMS) to comply with the D-2 performance standards of *The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (Ballast Water Management (BWM) Convention): *Guidelines for Approval of Ballast Water Management Systems (G8)* (MEPC.174(58)) and *Procedure for Approval of Ballast Water Management Systems that make Use of Active Substances (G9)* (MEPC.169(57)). The Guidelines (G8) state that the BWMS should be "tested at its rated capacity" for land-based testing and that "[t]he amount of ballast water tested … should be consistent with the normal ballast operations of the ship and the BWMS should be operated at the treatment rated capacity for which it is intended to be approved" for shipboard testing. The Guidelines (G8) also defines shipboard testing as "a full-scale test of a complete BWMS." Even though the need for testing at normal ballasting operations is consistently mentioned, the only scaling provisions in the BWM Convention and the Guidelines (G8) are for downscaling of a BWMS to support physical limitations of land-based testing facilities. Subsequently, IMO has agreed to two circulars on the scaling of BWMS (BWM.2/Circ.28 and BWM.2/Circ. 33) which mention the need for both up and down scaling. However, and no firm requirements have been established.

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This paper discusses problems with the scaling and subsequent approval of BWMS with treatment rated capacities (TRC) 1000 m^3/h or greater. These larger TRC BWMS (suitable for Suezmax tankers, Aframax tankers, larger bulk carriers, etc.) should be given more consideration when approving BWMS models than is evident from a review of available type approvals due to the flow rates and duration of operation required.

Current guidance for scaling BWMS

BWM.2/Circ.33 (*Guidance on scaling of ballast water management systems*) recommends that shipboard testing be used to verify assumptions (i.e., mathematical model and/or calculations) in scaling the system. Additionally, the Circular suggests, where all discrete models are land-based tested, the "most vulnerable model" should be shipboard tested to demonstrate the ability of the BWMS to operate in normal ships' conditions. Although BWM.2/Circ.33 does not define "most vulnerable model", earlier sub-committee submissions provide some insight on the use of this term by providing an example of a larger filter (IMO, 2010).

To type approve a BWMS beyond its currently approved TRC without additional land-based testing, BWM.2/Circ.33 provides the following guidance:

- Key performance parameters, physical/environmental conditions, dosage considerations and design parameters should be identified,
- Validated mathematical model and/or calculations should be used to predict key performance parameters will be achieved in the scaled unit and that the fundamental operating mechanism is not changed,
- Shipboard testing should be used to verify the key performance parameters from the model and/or calculations, and
- Modeling should address efficacy and environmental impact and actual analysis for disinfection by-products should be performed (where necessary).

BWM.2/Circ.33 also recommends that "[a] representative number of scaled systems capacities, taking into account the treatment technology, should be tested according to the requirements for shipboard tests."

Concerns for improperly scaled BWMS

The BWM Convention will be one of first shipboard environmental requirements where port state control may conduct sampling for compliance. Owners and operators are the responsible parties that may have to demonstrate compliance with the ballast water discharge standards. While Resolution MEPC.252(67) *Guidelines for Port State Control under the BWM* Convention only envisions sampling in the third or fourth stage, the sampling decision is at the discretion of port state control. There is concern that a ship with a system that is otherwise operating normally may fail compliance testing. In such a case the shipowner/ operator may not understand the complete reason when non-compliance is due to insufficient scaling of the BWMS.

As the parties responsible for appropriate testing, Administrations and vendors should develop appropriate scaling criteria and make all scaling documentation publicly-available when shipowners are evaluating BWMS for their vessels. Once the BWM Convention has entered into force, special consideration could be provided to these "early movers" with larger TRC BWMS.

Review of available type approval documentation

Administrations have submitted type approval documentation to the IMO Marine Environment Protection Committee (MEPC). A review of Administration submittals for 47 BWMS revealed most of the type approval testing has been conducted on models with TRC's approximating 250 m^3/h and only two BWMS have approvals specifying a greater flow rate for scaling.

A review of the publicly-available test information indicates that land-based testing has not been conducted above 500 m^3/h and shipboard testing has been conducted at 1000 m^3/h or greater TRC for only a few BWMS. Many of the type approvals list TRC models significantly greater than land-based and shipboard tested models with no scaling information in the publicly-available test reports.

In a recent BWM Program update presentation, the USCG summarized the status of Alternate Management Systems (AMS) by reporting that 56 AMS acceptances from 14 foreign Administrations have been granted. The USCG also observed that scaling was not conducted per the Guidelines (G8) for approximately 80% of systems (USCG).

It appears that IMO scaling guidance has not been taken into account for many type approvals.

BWMS operational experience

In early 2016, 15 shipping companies met at ABS World Headquarters to discuss lessons learned as early movers of ballast water management regulations. These shipping companies had more than 150 BWMS installed. The majority of these were operational and being utilized. Case studies were discussed to review lessons learned and problems encountered. The case studies covered various types of vessels, both retrofit and new construction projects, and a wide range of TRC. While each experience was unique to the individual vessels and system types, common issues included filter problems, piping leakage, prefabricated piping errors, sensor failures, software problems, major component failures, and insufficient electrical power for auxiliary systems. Shipowners were only able to report reliable operation of two installed BWMS.

Information was also gathered on the technical characteristics of the BWMS (e.g., type of technology, TRC) to identify possible trends. An important point of the information from the shipowner's meeting is that approximately two-thirds of the BWMS installed have TRC greater than or equal to 1000 m^3/h.

Generally, BWMS with lower TRC (< 1000 m^3/h) have achieved greater operational success. BWMS with capacities greater than 1000 m^3/h have limited success (i.e., commissioning delays, extended time required after vessel delivery to achieve operating status). Shipowners have been concerned with getting the equipment to operate on a routine basis. The ability to demonstrate the D-2 ballast water performance standards was not the major concern.

During MEPC 67, the IMO agreed to a study on the implementation of the D-2 performance standard. Responses to the study are contained in the *Final report on the study on the implementation of the ballast water performance standard described in regulation D-2 of the BWM Convention* (MEPC 69/4/4). In the D-2 study, Track 1 looked at the similarities/differences in testing and certification and Track 2 looked at the BWMS operational performance.
In Track 1, Administrations, other Government agencies and recognized organizations were asked "How do you evaluate and certify BWMS for multiple units in a model series, sizes, and/or flow rates (system scaling)?" The responses included:

.1 in accordance with BWM.2/Circ.33;
.2 CFD analysis and mathematical modelling;
.3 use of land-based testing as minimum and shipboard testing as maximum for scaling systems;
.4 manufacturer calculations.

The analysis of this study question indicated that some Administrations rely on their recognized organizations to deal with scaling with no indication on how type approval certificates are issued for the scaled units. Some responses indicated that certain Administrations deviated from the approach in BWM.2/Circ.33 in their evaluations.

Track 2 of the D-2 Study focused on Operational Performance of BWMS and asked about the most common failures or problems. The responses identified the main problems were failures and mechanical malfunctions with sensors, controls, piping/valve systems, and filtration. These responses align with information from the ABS-facilitated shipowner meeting.

The MEPC Correspondence Group on the review of the Guidelines (G8) also discussed the need for improved scaling of BWMS. In the *Report of the Correspondence Group on the review of the Guidelines (G8)* (MEPC 69/4/6), it was noted that guidance for scaling is already available in BWM.2/Circ.33 and agreement was made on a need for the circular to be reviewed to ensure that it remained relevant. Additionally, suggestions were made for the whole of the text (BWM.2/Circ.33) to be transferred into the revised Guidelines (G8). The correspondence group observed, in part, that the details of the process and methods for scaling decisions should be communicated to the Administration. The majority of correspondence group favored validation of modeling through full-scale shipboard testing. Further discussion on scaling is to be included as next steps for the correspondence group.

Suggested BWMS scaling improvements

From the information presented, the BWM Convention should identify a means to ensure a consistent scaling approach by Administrations. Scaling of a BWMS should be supported by the treatment equipment manufacturer's modeling (i.e., mathematical calculations, computational fluid dynamics, performance related parameters, etc.). If sufficiently detailed, the modeling can provide an understanding of the technologies sensitivity to disturbances and non-optimum operating conditions. The Administration reviewing the BWMS type approval and modeling documentation should thoroughly evaluate the vulnerabilities of each technology used.

Validation of scaling may not always require full-scale testing (i.e., land-based and/or shipboard testing). Some design criteria data may be validated using pilot plant and/or bench tests where the performance parameters can be sufficiently adjusted and manipulated to determine the treatment technology responses. Multiple bench/pilot tests could be run to validate the technology responses to changes in performance parameters.

Some examples of performance parameters that can be validated using bench/pilot plant testing include:

- Ballast water temperature, salinity, UV transmittance, dissolved and particulate organic carbon (technologies can be evaluated to determine the minimum and maximum of parameters),
- Pre-treatment filters (standard methods similar to ISO 16889-2008, *Hydraulic fluid power – Filters - Multi-pass method for evaluating filtration performance of a filter element* could be adapted and used to determine follow-on disinfection technology vulnerabilities to the differences between filter screens) and
- UV lamp output spectrum (outputs should be analyzed for potential changes in efficacy within and between organism size classes).
- Where bench/pilot plant testing cannot adequately validate the design criteria, the Administration should require full-scale validation (i.e., shipboard testing). The number and TRC of models requiring shipboard testing should cover the full range of the proposed type approvals. The extremes of the TRC range should be tested and several models in-between tested to demonstrate correlation to the modeling predictions (i.e., whenever practical, interpolation should be used in favor of extrapolation). Where testing results for mid-range BWMS models does not correlate with the modeling predictions, the design criteria and performance parameters should be reviewed and corrections made. This may require additional bench/pilot and/or full-scale testing to re-validate the revised modeling.
- Some examples of performance parameters that should be validated by full-scale shipboard testing:

- Sizes and types of ships (changes to installation elevations, piping sizes and lengths, side-stream and neutralization mixing efficiencies, etc.),
- Total Residual Oxidant (TRO) monitors (longer distances between ballast piping and TRO monitors for potential variations in true TRO values and control system time delays) and
- Extended total holding time on active substance depletion (especially where re-treatment upon discharge is not included in the treatment process due to larger vessels having much longer voyage times than the 5 day G8 hold times for type approval testing).

Based on available information, the scaling guidance for BWMS can be improved to ensure BWMS are operable for larger TRC systems and that all model sizes are able to provide compliance with the D-2 performance standards for in-services vessels. The scaling requirements should not be overly burdensome due to the time and cost for BWMS testing, but key components for scaling needs to be clearly identified and included in the requirements for BWMS testing. Transparent scaling of BWMS will be provide shipowners and Administrations more confidence for shipboard compliance.

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Update on Ballast Water Management Systems

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Abstract

It is anticipated that the Ballast Water Management (BWM) Convention will enter into force soon following a recent ratification by additional Member States. This means the tens of thousands of ships to which the Convention applies will be required to install the BWMS according to resolution A.1088 (28) In the interest of a smooth implementation and compliance with the Convention, ship owners should take into account various factors when selecting and installing an appropriate BWMS on their ships, and when discussing retrofitting of BWMS with manufacturers, classification societies and shipbuilders in order to meet the requirements of class rules and the Convention.

KR has summarized the factors that ship owners will need to consider prior to BWMS installation, such as a type approval certificate for BWMS, the capacity of BWMS, the required space for the installation of BWMS, gas safe or not, sufficient power to operate the BWMS, any negative effects on the ship, etc. The major concern for ship owners are likely to be the type of BWMS suitable for its vessels and how can a suitable BWMS best be selected?

We would like to introduce and discuss our process for the retrofitting procedure for ships which fall under the BWMS Convention, which is explained in five steps – First step: feasibility study; Second step: established detail plan; Third step: Approval document; Fourth step: Execution; Final step: Commissioning. Based on our experience and case study results we would also like to present and discuss examples of BWMS installation on vessels fitted with chemical tanks, crude oil tanks and gas cargoes.

Keywords: Ballast water, installation, retrofit, type approval, Ballast water Management Convention,

1. Introduction

Belgium and Fiji ratified the BWM Convention on 7 and 8 March 2016 but a further 0.12% is required before the Convention can enter into force. The Amendments to the convention, to be implemented after it enters into force, will be considered soon. Since 2006 however, several BWMS have been approved and the total approved number is gradually increasing. Once BWMS manufacturers achieve type approval certificates issued by administration(s), the BWMS industry must then face the challenge of installing the systems on existing and new build ships. This paper explains how to choose and install a BWMS.

2. Considerations for a ship owner prior to BWMS installation

To install a BWMS on board your ship, it must be 'type approved‘. If the system uses active substances, basic and final approval from the IMO needs to be obtained before the type approval can be granted. A BWMS has a "Total Capacity Rate“, which is an indicator showing how many cubic meters of ballast water can be processed per hour. You will need to choose a system with a TCR high enough to handle your ship's ballast capacity, and an operational pumping rate system with a footprint ranging from approximately 0.25m² to 145m² depending on its TCR. You will need to review the specification of your selected BWMS. For tankers, the BWMS will be installed in the "Gas Dangerous Zone“, and therefore it will need to be approved as "Gas Safe“. Considering the additional power that will be required to operate a BWMS, you should check to see if you will need to run another generator when the BWMS is in operation, or consider installing an additional generator set, or have a spare breaker available in the electrical distribution board to provide power to the BWMS. Corrosion is a potential negative consequence that may be brought on by the BWMS substances and processes. Therefore, corrosion inside the ballast water tank or the negative impact on the coating must be considered. Whichever BWMS you

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adopt, training will be required for the safe operation and maintenance of the system. Training requirements will need to be included in the ballast water management plan required by the Convention. The main cost factors to be considered include less power consumption, easy maintenance and installation, running and installation cost (USD 400,000 ~ 830,000: 1,000m/h). Service network is also one of important factor for choosing BMWS. Manufacturer's will need to increase production to meet the anticipated number of orders.

3. Example of a BWMS installation onboard

Ship's stability must be checked as shown in the flow chart below. The ship owner, designer or engineer is responsible for preparing a ship's stability booklet. To do that, it is important to estimate the exact weight of the BWMS and other fittings then compare that with the light weight data of the subject vessel. Then as can be seen from Figure. 1, the vessel either applies to 1) or 2), and the vessel is subjected to inclining tests and the stability data needs to be revised and approved.

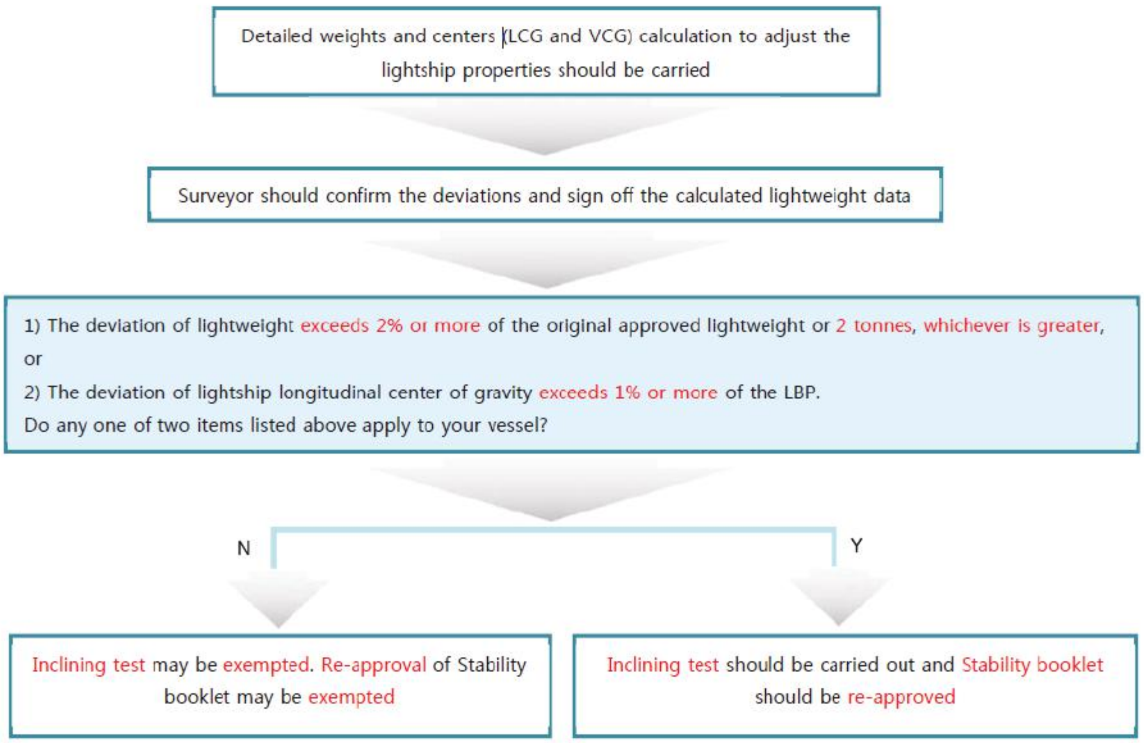

Figure. 1 Flow chart for ship's stability

3.1 Special considerations for vessels carrying solid cargo

BWMS can be installed in the E/R, S/G room and the provision stores near the accommodation and additional enclosed spaces on deck. Generally, this type of ship has two ballast pumps and two G/S pumps for ballasting or de-ballasting. Special ballast stripping eductors are installed in order to fully load cargo. The ballast water tanks are generally arranged on the side of the cargo holds and those are defined as safety zones.

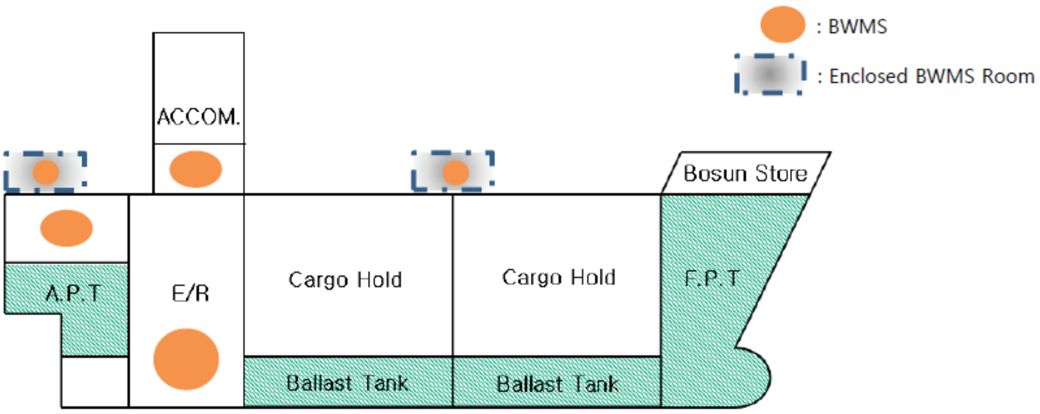

Figure. 2 Consideration for Solid Cargo Ship

3.2 Special considerations for vessels carrying liquid cargo

There are basically two types of liquid cargo ships – oil tankers and chemical tankers, and their hull forms are quite similar. Figure. 3 shows a tanker with a B/P (or C/P Room), conventional oil and chemical tankers have cargo pump rooms or pump rooms where ballast water pumps are fitted. As can be seen in Figure.3, the area in front of the E/R where the ballast water tank is situated is defined as a hazardous area, and the ballast system in the E/R is not available for this ballast water tank. To deal with ballast water in B.W.T in a designated hazardous area, ballast pumps must be arranged in the B/P or C/P room according to IEC Regulations. Ballast water in APT, which is a safe zone, can be handled by G/S pumps in the E/R.

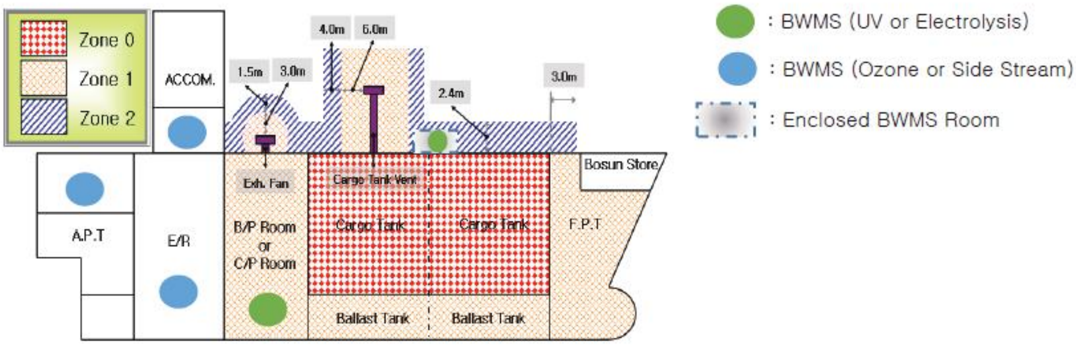

Figure. 3 Consideration for liquid cargo ship

3.3 Special consideration of vessels carrying gas carrier

Gas carriers are categorized as either LPG and LNG and have similar ballast systems. The ballast water tank surrounding the cargo tank is a hazardous area, except in LPG Carriers Type C, but ballast water pumps can be installed in the E/R in accordance with IGS code 3.7.5. Two ballast pumps are similarly installed in a general cargo ship carrying solid cargoes:

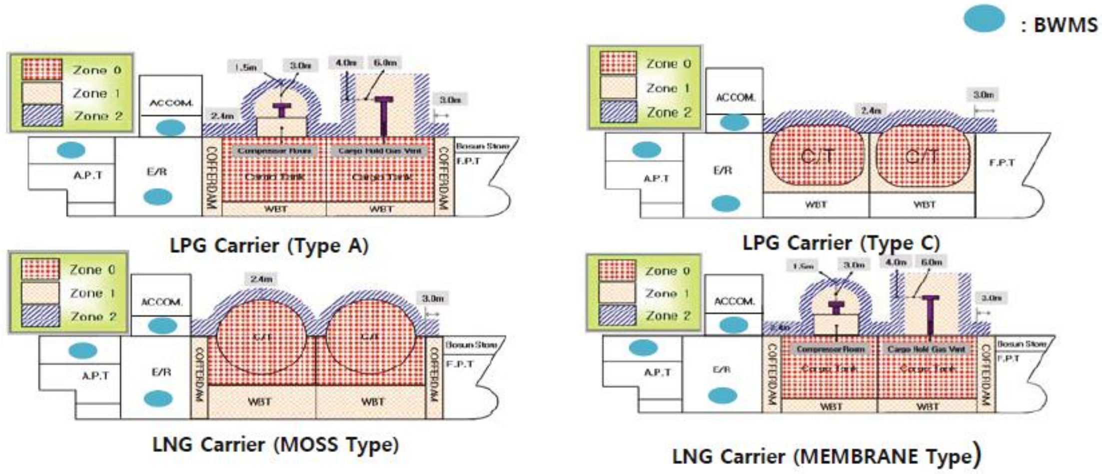

Figure. 4 Consideration for gas carrier

4. Step-by-step process of how to choose and install/retrofit

Prior to retrofitting a BWTS, it is recommended to research viable systems in order to find the most appropriate system for the subject vessel.

With regard to this research there are three key stages. First, identify the ship characteristics such as voyage pattern, sailing route and ship's equipment. Second, identify the characteristics of the BWTS, focusing on installation space, power consumption and estimated costs to understand whether it is applicable to the subject vessel. Lastly, confirm the reliability of the manufacturer.

The purpose of analyzing the ship's characteristics is to verify whether the proposed BWMS can perform adequately. In the case where the ship sails into a fresh water zone, it also necessary to consider the salinity which might affect the performance of BWTS. Available space to retrofit the BWTS must also be assessed. Where the machinery room is too small to install, you may need to consider re-arranging machinery to ensure more space. In this instance, additional costs may be incurred. A 3D scanning technique is useful when investigating available space. Additionally, by understanding ship characteristics the capacity of the BWMS based on the number of ballast pumps and their capacity should also be considered. In order to determine the capacity of BWMS, the estimated optimum ballast pumping rate is important and the capacity of BWMS is to be equal to the total capacity of ballast pumps and GS pumps. If the BWMS is located on the freeboard deck, it is also necessary to factor the hydraulic head as, if necessary, ballast pumps may need to be replaced. Lastly, the power consumption of the BWMS should be considered as an electric load analysis is required. This is because the BWMS will be used most during cargo operations.

The purpose of analyzing the characteristics of a BWMS is to verify whether it can be installed in the subject vessel effectively. Based on the available space in the ship, the required space to install BWTS equipment should be examined. Here, it is necessary to confirm the compatibility between the existing ballast system onboard and the new BWMS. To evaluate the most economical BWMS, both the CAPEX and OPEX of each BWTS should be considered. To successfully research the viability, you should also review the data regarding the performance of the BWMS and its power consumption. If necessary, the data can be verified by the manufacturer. In the instance that hazardous equipment or chemicals are provided, safety provisions for protecting the ship's crew should be provided onboard. Additionally, pipes to transfer dangerous gases such as ozone, chlorine gas or hydrogen gas will need to be protected by safety measures such as a double wall or an optimizing system should also be considered, depending on the ship's characteristics. Finally, to confirm a manufacturer's reliability, it may be necessary to review the product’s market record, as well as recent customer reviews. Moreover, it will be vital to ensure government approval, no matter how good a quality and inexpensive the BWMS seems to be. The BWMS cannot be installed without government approval. The manufacturer’s service network is also important. In most cases installation of BWMS is carried out during dry docking, however, occasionally it can installed while the vessel is in service. If the vessel is in service, the work time for retrofitting needs to be examined, discussed and agreed with the respective parties. A BWTS guarantee should also be considered.

Moving to the second stage, in which a detailed plan on the BWMS installation is to be established and followed through by a professional engineer, first and foremost special attention needs to be given to the ballast operation pattern, period, and method, which should also be discussed with crew members. The reason for this is that it is directly related to the BWMS operation. In general, to determine the available space a visual check is widely used, however, to improve the accuracy and reduce check time and man hours, a 3D scanning method can also be used. The 3D scanning technique is not only good for investigating the available spaces but is also advantageous for developing drawings as it is compatible with design software - work hours can also be saved.

In the third stage, eight items would be revised to retrofit the BWMS, and all revisions are to be approved and confirmed by Class or Administration before the BWMS is installed. In particular, when checking where the BWMS is to be installed, ex-proof type of electric equipment should be used when the electric equipment will be installed in hazardous area. After approval of the revisions is completed, the BWTS retrofitting work may begin.

Figure. 5 Approval scope by class or administration

Finally, after the BWTS retrofit is completed, a BWMS warrant will be conducted and this process is observed by Class Society or the administration. Warranty is based on the maker’s checklist and Class checklist, and both should be confirmed by each ship owner and class. After everything is passed, Class or administration will issue the relevant certificates to the ship owner and then you are ready to go. Bon Voyage!

Brazilian Maritime Standard on Ships' Ballast Water – 10 years of implementation

Maria Cecilia Trindade de Castro[1,2]*; Cecília Fonseca Poggian*[2]

Abstract

Ballast water is the subject of an international convention adopted by the International Maritime Organization (IMO) in 2004 (International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004) which is expected to reach the required percentage of shipping tonnage in 2016 and to come into force in 2017. Ballast water is also addressed in regional agreements and unilateral standards. In June 2005 Brazil launched the Brazilian Maritime Standard on ships' ballast water (NORMAM-20), a binding unilateral rule on ballast water. After a vacatio legis of 4 months, on 15th October 2005, the rule started being enforced in Brazilian Jurisdictional Waters. The aim of this paper is to summarize what effect the Brazilian standard has had since its adoption. In the last ten years of enforcement, the rule has evolved to address the demands from the Brazilian maritime community and to update requirements such as the imminent application of ballast water management systems on board ships. Although Brazilian regulation is rarely cited in policy or research papers when unilateral rules on ballast water are discussed, it should be emphasized that Brazil showed a proactive approach with the adoption of the NORMAM-20 and since then has focused on its proper implementation with a view to making it really feasible and enforceable.

Keywords: *Brazil – Ballast Water – National Standard – Coastal State – IMO*

1. Introduction

It is generally accepted that shipping represents about 90% of the international world trade. A global and growing demand for goods in a higher industrialized world added to advances in technology, turned shipping into a more and more efficient and preferable method of transport (IMO, 2012). From this perspective, it can be stated that the world as we know is only possible because of the shipping industry. However, since not all is rosy, shipping also represents a threat to the marine environment being responsible for a significant source of sea pollution generated by accidental spills and from sources inherent to a ships' operation, like ballast water (Leal Neto, 2007).

Shipping has been recognized as the main source of unintentional transferences of non-native species by means of ballast water discharges and because of ships' biofouling, a vector considered as important as ballast water (Ruiz et al., 2000; Coutts & Taylor, 2004; Drake & Lodge, 2007). International initiatives have been taken to avoid the transference of non-native species initially through ballast water with the adoption of voluntary guidelines which recommended the ballast water exchange in the mid-ocean as a ballast water management option (IMO's Marine Environment Protection Committee Resolution MEPC.50(31), IMO Assembly Resolution A.774(18) and IMO Assembly Resolution 686(20)). Finally on 13th February 2004, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by consensus. Nevertheless, its adoption foregrounded complex discussions on sampling and analysis issues related to the Convention's D-2 regulation.

All things considered and after huge problems aroused with the introduction and spread of the golden mussel (*Limnoperna fortunei*), Brazil acting as a flag, port and coastal State decided to adopt the Brazilian

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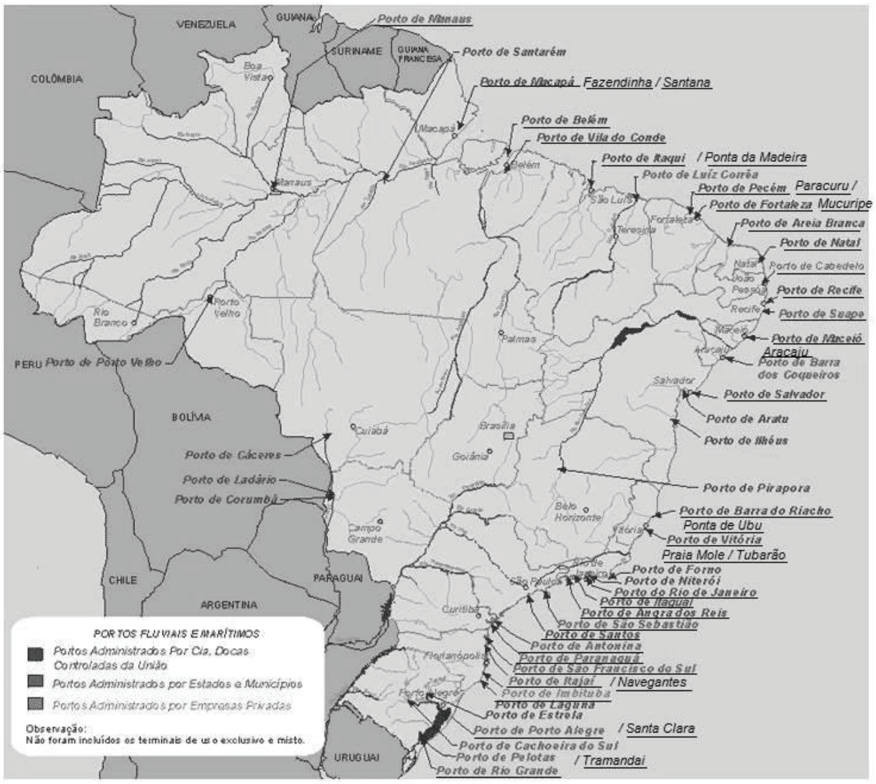
Maritime Standard on the Management of Ship's Ballast Water meaningfully to protect its jurisdictional waters and minimize the threat represented by invasive species.

The main objective of this study is to present results achieved during a ten-year enforcement period of the Brazilian Maritime Standard on ballast water, internationally publish through IMO's circular on ballast water management (BWM.2/Circ.1), circulated on 22nd September, 2005.

2. Methodology

2.1. Area of study

This study focus on the Brazilian coast, specifically on 39 ports and terminals selected according to the geographic approach adopted by the Brazilian Maritime Authority (BMA), held by the Brazilian Navy Commander. The ports / terminals are spread along seven Naval Districts and are represented in figure 1. 3



1st Naval District (1° DN): Ports / Terminals of Rio de Janeiro, Angra dos Reis / Itacuruçá, Itaguaí / Sepetiba, Vitória, Praia Mole / Tubarão, Ponta de Ubu, Barra do Riacho / Portocel;
2nd Naval District (2° DN): Ports / Terminals of Aracaju, Salvador;
3rd Naval District (3° DN): Ports / Terminals of Fortaleza, Recife, Natal / Termisa, Suape, Pecém, Paracuru, Mucuripe, Maceió, Cabedelo, Areia Branca;
4th Naval District (4° DN): Ports / Terminals Itaqui, Alumar, Belém, Ponta da Madeira, Fazendinha / Santana, Vila do Conde, Macapá;
5th Naval District (5° DN): Ports / Terminals of Rio Grande, Imbituba, Itajaí, São Francisco do Sul, Paranaguá, Antonina, Navegantes, Porto Alegre, Tramandaí, Santa Clara;
8th Naval District (8° DN): Ports / Terminals of São Sebastião, Santos;
9th Naval District (9° DN): Port of Manaus.
Figure 1: Main ports and terminals of Brazil. The 39 ports and terminals considered by the present study are underlined in the figure.

2.2. Port State Control reports

During the period between the compulsory adoption of the Brazilian Maritime standard for ships' ballast water on 15th October 2005 and June 2015, the Port State Control Officers (PSCO) on their shipboard inspections provided a dedicated report on ballast water practices adopted by 4 ships arriving in Brazilian ports and terminals. The data provided were mainly related to requirements such as the ballast water management plan's minimum requisites, the ballast water management practices adopted by the ship and salinity tests conducted on board during the inspections. Moreover, during the inspection the information provided by the ship in ballast water reporting forms previously sent to local Brazilian Port's Captaincies was compared with ship's records.

In order to conduct this study, all the data collected from the mentioned PSC reports were transferred to worksheets and analysed. In a second moment ports and terminals where mainly ore, grains, fertilizers and bulk liquid are handled were further analysed.

3. Results

All the available data from the PSC reports in terms of compliant / non-complaint ships, from October 2005 to June 2015, including a 6 month ballast water campaign from April to October 2014, were considered by this study. Overall results are shown in figure 2.

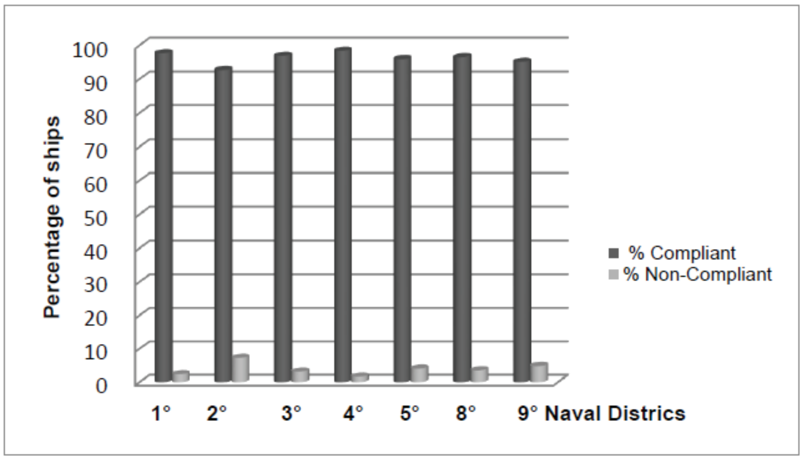


Figure 2: Ships compliance to the Brazilian Maritime Standard on ballast water (results englobe ships inspected for ballast water any time between October 2005 and June 2015)

The seven largest ports with high potential to import ballast water are Tubarão, Ponta da Madeira, Ilha Guaíba (Sepetiba), Itaguaí, Santos, Ponta Ubu and Paranaguá. These ports / terminals handle mainly ore, grains, fertilizers and bulk liquid. 5

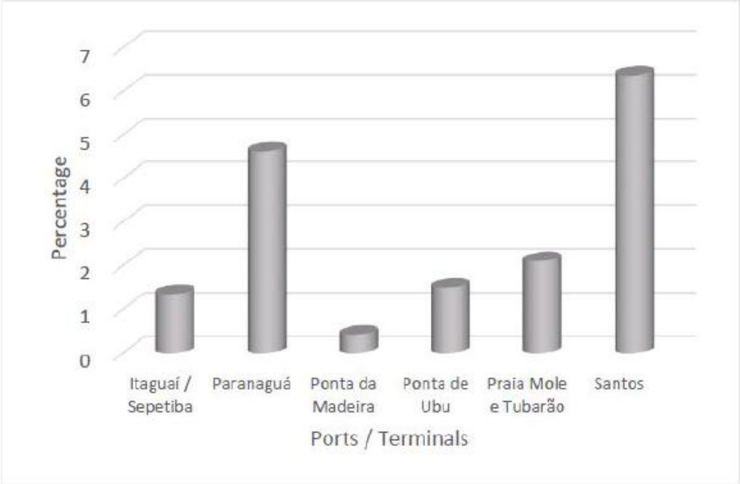


Figure 3: Percentage of non-compliance ships in the main ballast water importers' ports / terminals.

4. Discussion

First results of PSC enforcement procedures in Brazilian Jurisdictional Waters were present in 2009 (Castro & Poggian, 2009). After that, a more recent evaluation of Naval Inspection reports showed that from October 2005 to May 2012, the number of non-compliant vessels had decreased gradually, reaching values below 5% of the total number of inspected ships (Poggian, 2014). In the present study, the available data indicated the tendency previously observed, which means that non-compliant ships are decreasing in numbers, reaching a global value of about 3%. The higher risk ports / terminals in terms of ballast water discharge in the Brazilian coast are those where mainly mineral ore and grains are handled. As mentioned the largest seven are Tubarão, Ponta da Madeira, Ilha Guaíba (Sepetiba), Itaguaí, Santos, Ponta Ubu and Paranaguá. The first four export iron ore in huge quantities thus increasing the risk of introduction of alien species mainly from Asia, when considering their preferential routes. Furthermore, bulk vessels known as *Valemax* operate in these ports and terminals. These are the biggest mineral vessels in the world, each with capacity for 400,000 tonnes of ore. Pereira (2012) estimated volumes between 10,000 to 120,000 m3 per journey of 'foreign' seawater being discharged into Brazilian coastal areas as a result of mineral ore exportation.

Among the higher risk ports and terminals, PSC reports on ballast water showed only Santos and Paranaguá to be above the national average for non-compliance, with 6.4% and 4.6% respectively. The most inspected terminal, Ponta da Madeira, located in the State of Maranhão, Northern Brazil, where almost 13 percent of the total inspection effort was located, showed less than 0.5% non-compliance.

5. Conclusions

The found results can provide a simplistic overview of what has been detected by the Brazilian PSC in terms of compliance to the national compulsory standard. Since the adoption of NORMAM-20 and the beginning of enforcement procedures by PSCO, the main goal of the Brazilian Maritime Authority has been to prevent and minimize a problem of huge proportions and serious consequences. The entire effort through PSC inspections dedicated to ballast water however being below the ideal represents the Brazilian commitment to the marine environment protection and to international laws to which the country is legally bond, like the United Nations Convention on the Law of the Sea, the Convention on Biological Diversity, the Ballast Water Management Convention among many others. Moreover it represents in our point of view the best approach to verify the standard's implementation and consequently to ratify / rectify ongoing procedures.

Notwithstanding the adoption of a national legislation and the implementation of an inspection regime, the work on the subject is far from over requiring further scientifically validated data for evaluation of its efficacy, besides monitoring and surveys campaigns, prerequisites for non-indigenous species control and management (Lehtiniemi et al., 2015).

Finally, it is important to add that ballast water reports provided by the PSCOs is an open-ended task and all the data is used to assist Brazilian Port's Captaincies Authorities with cases of non-compliance, besides being part of an ongoing research project conducted by the Brazilian Navy's Marine Research Institute Admiral Paulo Moreira (IEAPM).

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Chile: Building National Capabilities for the Implementation of the Ballast Water Management Convention

Rodrigo Zambrano[1]

1. Objectives

a) Identify the support provided by the IMO and the GloBallast Partnerships Project.
b) Describe lines of action for strengthening national capabilities.
c) Share experiences that may be useful for other developing countries.
d) Introduce the major challenges for the establishment of monitoring and analysis capacities at national level.

2. Outcomes

The GloBallast Project, the International Maritime Organization and the Global Environment Facility have significantly contributed towards building Chile's national capabilities for the implementation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention) through our National Maritime Administration (DIRECTEMAR). Equally important has been the assistance provided by the Permanent Commission for the South Pacific (CPPS), an international organization that, through the South-East Pacific Action Plan, has facilitated the transfer of technical knowledge and training among the region's countries. The efficient work schedule of the GloBallast Project has allowed national focal points (NFP) to centralize efforts and gather support. At national level, it is worth to mention the funding obtained to develop the National Strategy, a comparative revision of existing gaps in the national legislation and an economic assessment of the costs related to the implementation of the BWM Convention. Given the complexity of the topics addressed, human resources capabilities have been reinforced through their active participation in courses and conferences offered in Chile, Argentina, Brazil, Colombia, Korea and United States.

The knowledge gained has been shared with other entities of the Chilean State Administration involved in sea-based activities. In 2012 the National Task Force (GTN in Spanish) was created under the direction of the Ministry of Foreign Affairs and the participation of the Ministries of Public Health, Transport and Telecommunications, Environment, Economy and Tourism, as well as the Undersecretariats of Fishing and Aquaculture and of the Armed Forces. Chile is a long and narrow strip of land with 4,300 kilometers of coastline and 105 port facilities, which along with limited resources and multiple needs, demand an adequate intersectoral coordination.

Additionally, DIRECTEMAR participates in the National Integrated Program for the Control of Invasive Alien Species (IAS) of the Operational Committee for the Control of Invasive Alien Species, coordinated by the Ministry of Environment and consisting of public entities related to this issue. During the year 2014, the national strategy for the Invasive Alien Species was presented and during 2015 efforts were oriented to develop a national action plan for Invasive Alien Species, incorporating the issue of the harmful aquatic species.

According to the priorities defined by the National Focal Point, DIRECTEMAR also interacts with the academic community and research centers to disseminate the scope of the Convention. To date, a university in the port city of Talcahuano has developed a specific line of research on this issue and new alliances continue to be explored.

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In June 2015, a pilot program on ballast water sampling and analysis was implemented in the ports of San Antonio, Talcahuano and Valparaíso. Specific areas were selected for their representativeness -as during the year 2014 they concentrated 33,5 percent of the country's cargo movement- and for the availability of specialists knowledgeable on the implementation of the Convention and of analysis laboratories.

The outcomes of this program will allow for the improvement of parameters, procedures and sampling technologies in accordance with the national reality.

As a complement, and using the organization's technological resources, a web application is being developed to allow a ballast water form to be sent prior to the arrival of the ship, in compliance with IMO resolution A.868(20) and with the national Circular A-51/002 updated in 2012. Although there are similar alternatives at international level, this new application will be part of the Integrated System for Ship Assistance (SIAN 2.2), a comprehensive platform under the concept of "single window" implemented by the National Maritime Administration to manage all services and procedures required by ships, involving all the parts participating in the operation (ship's agencies, transport, pilotage, Maritime Authority). The information available will be used for the operational planning of the monitoring and verification activities for the compliance of the Convention.

A significant activity carried out during the process was the "National course on monitoring and implementation of the BWM Convention with a focus on ballast water sampling and analysis" held in December 2015. This course was organized with the collaboration of the GloBallast Project, IMO and CPPS, and was oriented to scientists and Port State Control Surveyors of the Administration, as well as to representatives of the shipping industry, fisheries authorities, marine resources researchers, academic experts and specialists in laboratory analysis. Our Organization is proud to have offered this course conducted entirely by national instructors who had previously attended training activities funded by the GloBallast project and IMO, giving us the opportunity to strengthen national capabilities and to share the knowledge gained.

3. Conclusions

3.1 The contribution of the GloBallast Project has been essential to strengthen national capabilities for the implementation of the BWM Convention and to facilitate the development of locally based initiatives. The results obtained and the on-going activities are still generating opportunities for improvement and exchange of experience. However, it is recommended to focus efforts in creating opportunities to exchange information and experience (technological equipment, profile of surveyors, definition of indicators, experiences on financing).

3.2 The multidisciplinary and integrated work carried out with other actors has allowed us to optimize resources and combine capabilities.

3.3 In this regard, the National Maritime Administration is working to develop and implement the capabilities required to comply with the BWM Convention, once it enters into force and it is ratified by Chile, in accordance with its foreign policy, aiming to minimize the entry of aquatic nuisance species and pathogens and, as a result, its impact on biodiversity, the national economy and people's health.

3.4 The implementation of a monitoring and control protocol for ballast water has been complex due to the vast geographical size of the national coast, with 8 ecoregions with different characteristics and realities. The above mentioned reinforces the importance of experience exchange and technical and finance assistance for the development of risk evaluations that target efforts; such as the establishment of a baseline of our aquatic native species in the major ports, among others.

Ballast Water Management from a Member State Perspective

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Dr. Arzu Olgun- Tübitak-MAM
Mr. Turgay Buyuran- Turkish Maritime Administration

Abstract

International Convention on the Management of Ships' Ballast Water and Sediments (BWM Convention) aims to provide a common and globally uniform ballast water management (BWM) approach and to eliminate of the introduction risk of invasive species with the scientific approach and applications. This paper puts forward some recommendations on management issues from a member state point of view due to the significant experiences of Republic of Turkey. Turkish experience on the implementation of ballast water management starts from 2006 with a bilateral project between the Turkish Maritime Administration and The Scientific and Technological Research Council of Turkey. (MEPC 59/INF.14) From that date, Turkey carried out a pilot implementations on sampling in some of the ports located on the Eastern Mediterranean coasts in order to improve the ballast water sampling capability and to detect difficulties of the process. Also a Ballast Water Risk Assessment System was developed as an assisting tool on the assessment of exemptions according to the IMO Convention Regulation A-4, which can also be used by port state inspector to identify the shipping routes, ports, and vessels with a high risk of marine organism's transportation. The success and the applicability of management options and other requirements of the Convention depend on many factors in the implementations. This paper deals with two major drawbacks of the Convention defined by the Turkish authorities during the implementation processes. These are Ballast Water Sampling for the Compliance and Monitoring and Risk Assessment for the Exemptions under the scope of the Convention. It is aimed to recommend some solutions for the mentioned drawbacks and create an initiative for the member states for future implementations and probable amendments to the convention.

Key words: *Ballast Water Sampling, Risk Assessment*

Introduction

Republic of Turkey as a contracting state for Ballast Water Management Convention is supporting the effective implementation and urges countries that have not already done so to ratify the Convention. The national legislation of Turkey is already prepared and waiting for Convention to enter into force to start the national implementations. This paper aims to define two major obstacles faced during the preparation period of a national ballast water management system in Turkey.

Ballast water sampling is one of the key factor on the implementation as well as a drawback for the convention to be ratified. Republic of Turkey is following the latest achievements and technological developments very closely about ballast water sampling. Also Turkey carried out a pilot implementation on sampling in some of the ports located on the eastern Mediterranean coasts of Turkey in order to investigate the difficulties on implementation. This study includes the training of the personnel, providing the sampling equipment, inspections on ships and analysis of more than 100 samples in a laboratory. (MEPC 60/INF.16) On the other hand, Turkey hosted and actively participated as a trainer statute to the Train the Trainers Workshop on Sampling and Analysis of Ballast Water on 2 to 4 June 2015 in Gebze/Turkey under the umbrella of ITCP activities of IMO. This workshop was a key step to evaluate the latest technologies and methodologies on ballast water sampling. On this occasion it can be clearly stated that Turkey has a significant experience and trained personnel on ballast water sampling issue.

Ballast Water Risk Assessment is another important factor which needs a global approach. The administrations needs a proper risk assessment procedure for defining exemptions with respect to the regulation A-4 of the Ballast Water Management Convention. Ballast Water Risk Assessment Software was developed by Turkish authorities as an assisting tool on the assessment of exemptions according to the Convention, which can also be used by port state inspector to identify the shipping routes, ports, and vessels with a high risk of marine organism's transportation.

How to tackle with sampling issue

The Ballast Water Management (BWM) Convention will establish a global legislative regime to control the discharge of ballast water and in particular the discharge of invasive species into the sea. This requires shipowners to install expensive management and treatment systems and train personnel to use them. The shipowners shares the concern on to have an economic and reliable equipment on board which can fulfill the needs during port state inspections

The BWM Convention calls for sampling of ships' ballast water during port state inspections. Turkey however believes that port states should accept a ship's International BWM Certificate as evidence that its equipment fulfils the requirements of the Convention. The inspection is only needed to check the reporting requirements and if the treatment facility operated due to its design parameters and ballast water management plan.

We appreciate IMO's work on producing guidance on sampling and also for port state control (BWM.2/Circ.42 and Res. MEPC.252(67)). We believe that these guidance is a good initiative to regulate the sampling issue. However we want to indicate that there are impassable drawbacks on ballast water sampling. These can be briefly stated as;

.1 The inspection officers who will deal with sampling needs a significant training on an issue which they are not inclined to with respect to their educational background.

.2 In order to take the indicative or detailed samples both ship and inspection officer need to be provided unconventional and expensive equipment which needs regular maintenance and calibration. Also with respect to the equipment some chemicals needs to be provided and carried on board of the ship.

.3 State of the art sampling equipment is not compact as to carry during the routine inspections.

.4 There is always a lack of confidence when the biologic samples taken if the sampler and the analyser are from different educational background.

.5 The undue delay of the ships is a problematic issue also needs to be solved.

.6 After sampling the transportation of the samples to the laboratory can be problematic in most situations.

The interpretation of the sampling and port state control procedures by some administrations suggests a lack of confidence in the approval process using the G8 guidelines. We are aware that the IMO guidelines for the approval of ballast water treatment systems (G8 guidelines) need strengthening to ensure that acquired systems are fit for worldwide use and compliant performance is possible under real operating conditions.

On the other hand we strongly believe that sampling should not be used as a part of the inspection procedure. It is essential that the port state control officer should not be responsible to check or evaluate the confidence of type approval procedure. Type approval process should be continued in the hands of experts within a different process than the port state control in order to have a holistic approach.

The Guidelines for PSC under the BWM Convention Res. MEPC.252(67) is a very important instrument. However when this guideline is evaluated, it is foreseen for the inspectors that sampling can be used within a four staged inspection as one of the last steps after defining clear grounds. These clear grounds are defined with 12 paragraphs in the guideline like as lack of ballast water management certificate, plan, recording book or designated officer.

It is understand from The Guidelines for PSC under the BWM Convention that a system is recommended which sampling is still an available option. The port state control officer can decides to take sample when an extraordinary situation occurred which is defined as clear grounds.

With respect to our experiences Turkey believes that an implementation due to the PSC guideline will be resulted with a sampling decision in only a very few cases. On this occasion a more practical way should be found to avoid countries from an intense training of personnel, providing expensive equipment and try to solve the other obstacles defined above.

In this context we are suggesting a more practical implementation. We believe that an instrumental monitoring tool can be installed to the treatment equipment as a component part which can report the compliance to the port state control officer like as oil discharge monitoring meter. This approach would be a more practical solution than to be equipped port state control officers with heavy and unpractical equipment for taking samples.

It is recommended to take a leading decision which clearly states that the article 9 of the Convention will be amended when the convention enters into force with an intention which sampling be taken out from the scope of inspection of the ships.

How to tackle with risk assessment issue

The risk assessment software was developed by Turkish authorities mainly;

- To assist the administration in national or regional ballast water management activities for the identification of shipping routes, ports, and vessels with a high risk of marine organisms transportation.
- The results of risk assessment can also be used as a decision support tool, where vessels are applying for exemption according to the IMO Convention Regulation A-4.

This tool uses different databases and software to calculate the risk by using the Globallast risk assessment methodology.

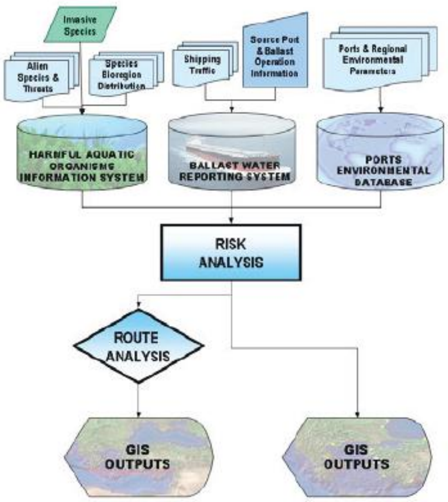

Figure 1. Architecture of the software

The outputs of this system are the evaluation of the risk of donor ports to the port on your concern and a route analysis to define if ballast water exchange is possible or not during this voyage. The software can provide this outputs via Geographical Information System(GIS) maps and as a text formatted report.

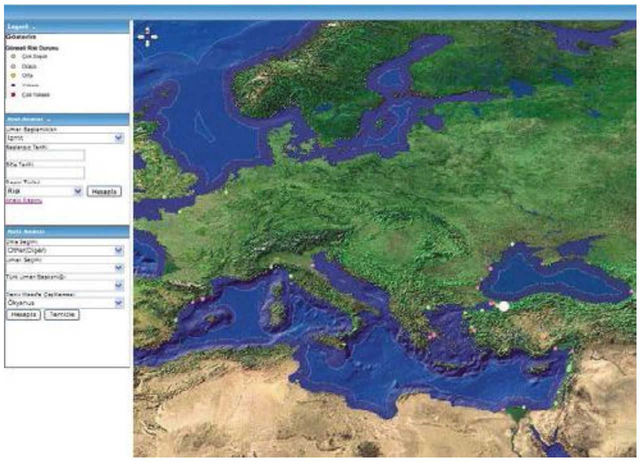

Figure 1. GIS output of the software

Conclusion

It is believed that a leading decision to address the obstacles on sampling issue and to take out from the scope of inspection of port state control would be a driving force for more ratifications to the convention. On the other hand there is a need for a Risk Assessment Software_which can globally used to fulfill the requirements for dedicating exemptions.

The Baltic Sea approach in implementing the IMO Ballast Water Management Convention

Anita Mäkinen[1], Maiju Lehtiniemi[2] & Hermanni Backer[3]

The Baltic Sea is a semi enclosed brackish water basin with very vulnerable characteristics surrounded by nine riparian countries. It has a strong salinity gradient from south to north from 20 to 3, and due to these exceptional salinity conditions, a unique combination of freshwater and marine biota. Salinity is the major factor constraining the distribution of species, the species richness is low and vacant ecological niches are available for invasive alien species.

The rate of introductions of invasive species in the Baltic Sea has been studied by Gollasch and Leppäkoski (2007). During the years 1820 – 2007 altogether ca. 130 species have been introduced in the whole Baltic Sea area and 80 of them have established. In the northern Baltic Sea with lower salinity 46 species of ca. 65 introduced have established.

According to Zaiko et al. (2011) the main source areas for the invasive species in the Baltic Sea are Ponto-Caspian (29 %) and the North-America (28 %) and the main vectors shipping (53 %) and stocking (27 %).

In the Baltic Sea region the major body of the international environmental co-operation since 1974 has been HELCOM as the Governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea. There are 10 contracting parties in HELCOM (9 Baltic Sea Coastal States and the European Community). The main task of HELCOM is to protect the marine environment of the Baltic Sea from all sources of pollution.

Accordingly, HELCOM works towards environmentally friendly shipping and favorable status of biodiversity and thus the work to mitigate invasive species through ballast water is high on Agenda. The HELCOM Maritime group which is dealing with shipping has 1-2 Annual Meetings and is working e.g. on effective and harmonized implementation of IMO rules (1992 Helsinki Convention Annex 4, Reg. 1). There are ca. 50 participants per meeting from all the BS country, the EU and a growing number of observers.

HELCOM Ballast Water Road Map was adopted as part of the 2007 HELCOM Baltic Sea Action Plan to facilitate ratification and harmonized regional implementation of the IMO BWM Convention (Unified A-4 implementation). In the Road Map the HELCOM Contracting Parties agreed to ratify the IMO BWM Convention no later than by 2013. Four of the nine contracting parties have fulfilled the commitment: Sweden (November 2009), the Russian Federation (March 2012), Denmark (September 2012) and Germany (February 2013). The remaining five HELCOM countries (Estonia, Finland, Latvia, Lithuania and Poland) are preparing for ratification.

Furthermore, the Road Map is focusing on challenges which are specific for the Baltic Sea (low salinity, relatively small sea area) and concluding that Ballast water exchange is not a management option for intra Baltic shipping. The cooperation with the North Sea (OSPAR) on ballast water related issues was established therein.

As an outcome of regional collaboration there are voluntary guidances on ballast water exchange among the Mediterranean Sea, the North East Atlantic and the Baltic Sea as follows: Joint HELCOM/OSPAR guidance in specified areas: North-East Atlantic – OSPAR area and the Baltic Sea, IMO circular BWM.2/Circ.14., since 1 April 2008, and the Baltic Sea - OSPAR area, IMO circular BWM.2/Circ.22.,

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since 1 January 2010. And Joint HELCOM/OSPAR/ REMPEC guidance in specified areas: Mediterranean - the North Atlantic/the Baltic Sea, IMO circular BWM.2/Circ.39, since 1 October 2012.
HELCOM and OSPAR Contracting Parties agreed in 2013 on a Joint Harmonized Procedure (JHP) (http://www.helcom.fi/Documents/Ministerial2013/Ministerial%20declaration/Adopted_endorsed%20documents/Joint%20HELCOM_OSPAR%20Guidelines.pdf) on exemptions under Regulation A-4, as a form of regional cooperation enabled by Article 13.3 of the BWMC to ensure that exemptions are granted in a constant manner that prevents damage to the environment, human health, property or resources.

During the agreed JHP process exemption applicants must collect data via port surveys according to the specified methodology, use this as a basis for a risk assessment and attach the results to the application to the port states.

The data should cover each stopover port on the route for which the exemption is applied. A port survey is to be regarded valid for granting exemption for a maximum of 5 years, from the date of the first of the two sampling visits. The purpose of this process is to collect the data necessary to enable risk assessment as required by the BWMC according to its G7 Guidelines. (http://jointbwmexemptions.org/ballast_water_RA; bw_reader as user name and balwat as password).

So far, JHP port survey methods have been tested out in more than 15 ports worldwide e.g. in Estonia, Finland, Germany, Latvia, Netherlands, Poland, Spain, Sweden and the U.S. (Great Lakes).

This JHP will be under continuous review by the HELCOM and OSPAR Commissions, together with the consideration of introducing a transitional period and burden sharing mechanisms once the Convention will be enforced.

An updated regional Baltic Sea implementation plan for BWMC is under development in the HELCOM MARITIME ad Hoc Correspondence Group on Ballast Water Management for adoption by MARITIME16 meeting later this year.

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Ballast Water Management – How to do it: a useful tool still under development

Dr Natalia Martini[1]

Introduction

The IMarEST, through its Ballast Water Expert Group (BWEG), has been supporting, on a voluntary basis, the International Maritime Organization (IMO) in the production of a manual entitled "Ballast Water Management – How to do it". The 2nd draft of the manual was submitted to the third session of IMO's Pollution Preparedness and Response Sub-Committee (PPR3) (16 to 19 February 2016).

The publication "Ballast water management – How to do it" will be published by the IMO to provide advice on the process of ratification, as well as to promote effective compliance with, and implementation of, the Convention. The overall aim of the manual is to provide useful practical information to Governments and Administrations, particularly those of developing countries. The manual will also provide guidance on issues of concern to ship owners, port State control authorities, and other stakeholders on the implications of ratifying, implementing and enforcing the BWM Convention.

The process

The IMarEST BWEG was established in 2010 and is comprised of senior IMarEST members (who act independently and impartially) with expertise in all areas of ballast water management, including testing, treatment, sampling, monitoring and compliance. In addition, the BWEG has representation from other relevant constituencies, including classification societies, the International Chamber of Shipping, the North Sea Ballast Water Opportunity (NSBWO) Project, various national Administrations associated with the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (hereby the Convention), and others. The manual was produced with the additional support of the IMO secretariat and a number of member States (e.g. Singapore, the Netherlands, and France).

The overall aim of this revision is to obtain a manual which is factual and reflects the intent of the BWM Convention and its Guidelines, while avoiding subjective interpretations or views. This newly revised version, submitted at PPR3, also incorporates the latest developments from relevant IMO Committees and Sub-Committees, including MEPC 67, MEPC 68. Under this Subcommittee, PPR3, a Drafting Group (DG) was established with the aim to work on the IMarEST version of the manual as follows: address the comments made in plenary; prepare a final text of the manual; leave in abeyance sections 8.3, 8.4 and 9.1 and chapter 14; and submit an oral report to plenary.

The Drafting Group provided comments also on other parts (e.g. sections 9.5 and 9.6, chapters 4 and 5) and addressed the comments made in plenary. As a result, parts related to an extensive description of surveys and inspections, and delegation of duties by the Administrations, chapters 20 and 21, were partially deleted and references were made to the IMO Code for Recognised Organizations (ROs). Moreover, the Drafting Group inserted the references to the IMO guidelines, resolutions, and circulars throughout the manual, and reduced the level of detail, where appropriate, in order to make the text more user-friendly for the target audience. Here, some text modifications were carried out to align with the wording of the Convention, guidelines and resolutions.

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The content

The manual framework is organised in the following main sections: Part I on rights and obligations; Part II meeting the obligations; Part III legal aspects; Part IV implementation; Part V technical aspect of enforcement; Part VI on organizations. Considering the scope of this paper, more details of the manual content is provided for Parts IV, V and VI below.

IV - The newly revised implementation section covers Implementing Section A – General provisions; Section B – Management and control requirements for ships; Section C – Special requirements in certain areas; Section D – Standards for ballast water management; Section E – Survey and certification requirements for ballast water management; Ballast water sampling; Approval of ballast water management systems (Guidelines (G8)); Approval of ballast water management systems using Active Substances (Procedure (G9)); Duties of ship owners and operators; Ballast water management options available for ships. The references to the relevant IMO guidelines, resolutions and circulars have been inserted throughout the manual, and Chapter 4 on Jurisdiction was deleted and key information inserted in other (appropriate) sections.

V - The section on technical aspect of enforcement provides guidance on the detection of non-compliance, applicability of exchange or performance standards and the methods of achieving those standards. It also draws attention to the recognition of pollution (i.e. residual active substances from the transfer of invasive species, contingency plans, response and mitigation measures). It provides guidance on verification of compliance by Port State Control, with details of the four-stage process of initial and detailed analysis and indicative and detailed sampling, as well as on violations.

VI - This last section looks at the spectrum of potential training requirements from the Administration's own staff through to a ship's masters and crew. It suggests some options including cooperation with other Administrations, raising technical competence by training or recruitment, organising national seminars and courses, and learning opportunities, including courses for seafarers and training for ship owners. The last chapter provides a comprehensive and updated list of Guidelines, circulars and other IMO publications relevant to the BWM Convention; references to these documents have been inserted throughout all sections of the manual.

Ongoing discussions and chapters in abeyance

There are ongoing technical discussions on some important ballast water management topics, both at MEPC and in this Sub-Committee (MEPC 69; MEPC 70 and PPR4). It was decided, in consultation with the IMO Secretariat, to keep certain parts of the manual in abeyance as they would be affected by the outcomes of those discussions and it therefore makes more sense to finalize them at a more appropriate time in the future. This is applicable for the following parts of the manual:

1. sections 8.3 and 8.4, dealing with exceptions and exemptions (regulations A-3 and A-4), in light of ongoing discussions on these topics;
2. section 9.1, dealing with ballast water management for ships (regulation B-3), in light of the pending amendment of this regulation;
3. chapter 14, dealing with the *Guidelines for approval of ballast water management systems* (G8), in light of the ongoing review of these guidelines;
4. trial period for BW sampling analysis, in light of ongoing work on these topics(13.2.3);
5. contingency measures placed in abeyance due to ongoing work: Guidance on contingency measures to be developed (18.2).

These parts are provided in square brackets, to indicate that their text cannot be considered final at this stage. Pending the Sub-Committee's decisions on the continuation of this work, further text would be developed in line with consultation with the Secretariat as and when those issues are resolved.

In addition, it should be noted that a review of the text of the draft manual from a legal perspective has not been undertaken as yet. This is relevant for the entire manual, but in particular parts I, II and III. This legal review could be undertaken after finalisation by PPR4 and prior to the final submission to MEPC.

A living document

The publication entitled "Ballast water management – How to do it", once finalised, will be published by the International Maritime Organization (IMO) to provide advice on the process of ratification, as well as to promote effective compliance, and implementation of the Convention.

The manual is a living document which will always provide key information on the latest IMO developments related to the BWM Convention. This is an essential process for the manual to fulfil its aim. This important tool should, in fact, provide useful practical and updated information to Governments and Administrations, particularly those of developing countries. The manual also addresses issues of concern to ship owners, port State control authorities, environmental agencies and other stakeholders on the implications of ratifying, implementing and enforcing the BWM Convention.

Priority pathways management to achieve Aichi Biodiversity Target 9, on invasive alien species, in marine environments

Junko Shimura[1], Joseph Appiott, Robert Höft and David Cooper

Introduction

In 2010 the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) adopted the Strategic Plan for Biodiversity 2011-2020 with twenty Aichi Biodiversity Targets.(1) Among these targets, Aichi Biodiversity Target 9 calls for, by 2020, invasive alien species and pathways to be identified and prioritized, priority species to be controlled or eradicated and measures to be put in place to manage pathways to prevent their introduction and establishment. Similarly, target 15.8 of the United Nations Sustainable Development Goals (SDGs) adopted in 2015(2) calls for introduction by 2020 of measures to prevent introduction and significantly reduce the impact of invasive alien species. Taking preventive measures and minimizing risk and impact of invasive alien species are thus vital actions that the global community has agreed for the coming 5 years.

Prioritization of biological invasion pathways in marine environments

The decisions on invasive alien species of the Conference of the Parties to the Convention on Biological Diversity(3) and other globally harmonized measures, including the guidelines and guidance related to the implementation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments,(4) continue to guide Governments and relevant sectors. The collaborative work of the organizations that set the international regulatory framework should continue to improve global guidance to address the risk of biological invasions.(5) However, a wide range of stakeholders are involved in shipping and transport in marine environments, often with different priorities and limited capacities. This could impede the process of achieving targets related to invasive alien species. Further strategic approaches are required for effective implementation given limitations in technical expertise and financial resources.

With regard to the pathways of invasive alien species, under the CBD process, standardized pathway categories were proposed by experts to facilitate global data compilation and analysis.(6) Among the pathways, a global database(7) clearly showed that "Transport-stowaway" pathways via ballast water, biofouling, boat "hitchhikers" (unintentionally attached alien species on boats) and bulk containers are frequently identified in the recorded cases of introduction to both terrestrial and marine environments.(6) A retrospective analysis focused on the aquatic environment in the European region revealed that the pathways related to shipping (corresponding to "Transport-stowaway" and "Transport-contaminant" pathways under the standard categories) and "Corridor" categories were the most frequent pathways for biological invasions during the period 1950 through 2010.(8) It is noteworthy that introduction of alien species via inland water transport in the region was found to be well managed and no significant introduction has been observed since 1960,(8) although the number of records for inland waters was smaller than the number of records for the marine environment.

In the marine environment, the network of links between ports is highly complex and intensely developed, as was visualized by experts.(9) The visualizations also showed that container ships follow regularly repeating routes. This evidence implies that these ships' routes should be appropriately managed to reduce risks associated with these paths. A separate study, using the data on global links among ports, modelled potential origins of introduction (i.e. source countries and international foreign ports) for the highly invasive Khapra beetle (*Trogoderma granarium*).(10) In that study, Australian ports most likely to receive

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this invasive species in future were identified with a simulation using a probabilistic pathway model. The prediction of future invasions is a prerequisite for management of spread of high risk species in marine environments. A modelling approach to simulate the successive global spread of marine alien species using global ship movements and environmental conditions predicted the ecoregions most likely to be invaded next under climate warming.[11] Such studies help identify priority sites for monitoring and rapid response. In the context of comprehensive approaches for prioritization of pathways,[12] susceptible sites with the greatest exposure to invasive species propagules and high probability that these propagules will establish in the area should be prioritized for management of potentially invasive alien species. Therefore, priority susceptible sites include the ports of potential origin of introduction for high-risk species and the potential ports of entry located in as yet pest free regions. With regard to prioritization, experts further elaborated a comprehensive approach to assist Parties to prioritize pathway management, with additional consideration of the importance of the sites where sensitive species and areas exist.[12] Such sensitive areas include ports of islands where highly endemic ecosystems and species are known to be vulnerable to biological invasions,[13] and areas where invasion will have the greatest environmental, economic or social impact.

Pressures from invasive alien species should also be integrated into broader management frameworks, including through integrated coastal management and marine spatial planning, to address the full range of pressures facing marine ecosystems. This should be supported by an understanding of the vulnerability of the components of marine ecosystems to different pressures. In this context, scientific and technical work under on invasive alien species[5, 6] under the Convention on Biological Diversity, the description of ecologically or biologically significant marine areas (EBSAs),[14] and the development of guidance on marine spatial planning, integrated coastal management, environmental impact assessments and area-based management tools can contribute to effective implementation towards achieving Aichi Biodiversity Target 9 on invasive alien species, as well as to related targets such as Aichi Biodiversity Target 10 on vulnerable ecosystems and Target 11 on protected areas.

The retrospective analysis on marine invasions also illustrated that Lessepsian migrants compose major alien populations in the eastern Mediterranean Sea.[8] The management of ships' ballast water and biofouling is urgently needed to minimize the risks of introductions through "Transport-stowaway" and "Corridor" pathways associated with the anticipated expansion of inter-basin marine transport globally.
Importantly, the guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species,[15] adopted by the Conference of the Parties to the Convention on Biological Diversity, guides Parties to take the precautionary approach with reference to risk analysis. Invasion risk assessment, especially in light of increasing ship traffic and corridors, is needed. Results of such assessments, and the necessary risk reduction measures, should be communicated widely, so that relevant stakeholders, including the environment authorities in the areas receiving alien species, can take informed decisions towards achieving Aichi Biodiversity Targets and targets under the Sustainable Development Goals.

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Managing the Arrival of Unwanted Aquatic Invasive Species via Vessel Biofouling – The Other Transport Mechanism

Ashley Coutts[1], Nick Gust, Rene Reinfrank, Patrick Lewis, Jeremy Lane

Abstract

Vessels have long been recognised as important vectors for the dispersal of Aquatic Invasive Species (AIS). The key mechanisms for AIS transport by vessels involve the translocation of both ballast water and biofouling organisms. Effective management of vessel related AIS transport requires addressing both ballast water and biofouling transport mechanisms. However to date this has rarely occurred, with global management effort typically heavily focused on ballast water. The effectiveness of this approach is questionable, particularly since recent research suggests that in many parts of the world vessel biofouling has been responsible for more AIS introductions than any other mechanism. The imminent ratification of the International Convention for the Control and Management of Ships' Ballast Water and Sediments represents a major milestone in the global management of AIS. Unfortunately gains from implementing this convention are undermined by absent or ineffective biofouling management of vessels. On a global scale the management of vessel biofouling is a daunting task in its infancy. The International Maritime Organization (IMO) has developed voluntary guidelines for the control and management of ships' biofouling to minimize the transfer of AIS. Two regional authorities (e.g. Western Australian Department of Fisheries, and the State of California), and a Port State (New Zealand) have also developed (or are currently finalising) mandatory biofouling management requirements. To ensure that AIS transport risks associated with vessels are managed efficiently and effectively it is now time to shift focus to the neglected transport mechanism of vessel biofouling. Here we provide a broad overview of the context and challenges ahead.

Key Words: Aquatic Invasive Species, ballast water, biofouling, shipping, vessels.

Introduction

A variety of vectors are known to be responsible for translocating Aquatic Invasive Species (AIS) around the world including shipping, fisheries, mariculture, and the aquarium trade (e.g., Carlton, 1985, 1987, 1992; Cohen and Carlton, 1995; Thresher et al., 1999; Ruiz et al. 2000; Minchin and Gollasch, 2003; Hewitt et al., 2004). Of these vectors, international shipping is widely considered responsible for the majority of inadvertent AIS introductions around the world (e.g., Carlton, 1987; Cranfield et al., 1998; Eldredge and Carlton, 2002; Hewitt and Campbell, 2010).

Vessels are capable of translocating AIS via a variety of ways, including: a) release of eggs, larvae and adults through ballast and bilge water discharges; b) through the reproduction, dislodgement and voluntary departure of biofouling organisms; and c) via transfer of infauna attached to anchors and chains (e.g., Schormann et al., 1990; Carlton et al, 1995; Lewis, 2002; Fofonoff et al., 2003). For the past three decades, ballast water discharges were thought to be the most significant vector for the dispersal of AIS. Consequently, in 2004 the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments. While this Convention has yet to be ratified, many Port States have already implemented mandatory ballast water management requirements to significantly reduce the likelihood of AIS transport via this mechanism.

Interestingly, numerous studies over the past two decades suggests that vessel biofouling has been responsible for more AIS introductions in many parts of the world than any other vectors and mechanisms (e.g., Cohen and Carlton, 1995; Cranfield et al., 1998; Hewitt et al., 2004; Eldredge and Carlton, 2002;

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Gollasch 2002; Fofonoff et al., 2003; Hewitt et al., 2007; Hewitt and Campbell, 2010; Farrapeira et al., 2011; [2]Chan et al., 2015). So what is being done to manage this important shipping vector?

Vessel Biofouling Management

In 2012, the IMO released guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species. The "Guidelines" provide a globally consistent approach to the management of biofouling by offering guidance on the development of biofouling management plans and record books, anti-fouling system installation and maintenance, in-water inspections, cleaning and maintenance, vessel construction and design, dissemination of information as well as training and education. However, the "Guidelines" are only voluntary. See http://www.imo.org/en/OurWork/Environment/Biofouling/Pages/default.aspx.

Some Port States have developed (or are currently finalising) mandatory biofouling management requirements. For example, the New Zealand Ministry for Primary Industries have developed mandatory vessel biofouling management measures known as the "Craft Risk Management Standard" which will become enforceable under their *Biosecurity Act 1993* for all arriving vessels in 2018. See https://www.mpi.govt.nz/importing/border-clearance/vessels/requirements/.

The California State Lands Commission has been developing proposed regulations since 2005. Currently proposed mandatory regulations are entitled "*Article 4.8, Biofouling Management to Minimize the Transfer of Nonindigenous Species from Vessels Operating in California Waters*" and were due for implementation on 1 July, 2016. However at the time of writing, these requirements have been withdrawn and will be reviewed in May, 2016. See http://www.slc.ca.gov/Laws-Regs/Proposed-MISP.html.

The Western Australian Department of Fisheries (WA DoF) has arguably been leading the world in the effective management of vessel biofouling for the past eight years. The WA DoF identified the threat of new AIS arriving in Western Australian waters with oil and gas vessels/infrastructure movements associated with the industry's expansion since 2008. The WA DoF utilised their existing legislation, namely their *Fish Resource Management Act 1994* and the *Fish Resource Management Regulations 1995* as the basis for management. Their overarching aim was to ensure that vessels/infrastructure pose a low/acceptable likelihood of transferring any "live non-endemic or noxious fish" into Western Australian waters.

The WA DoF has learnt many valuable lessons over the past eight years about the effective and pragmatic management of vessel biofouling which will be invaluable for any future biofouling management measures to consider. Arguably, one of the most significant contributions WA DoF has made is the development of their "Vessel Check", which is an online decision-support tool designed to assess the theoretical risk of vessels introducing any "live non-endemic or noxious fish" into Western Australian waters. See http://www.fish.wa.gov.au/Sustainability-and-Environment/Aquatic-Biosecurity/Vessels-And-Ports/Pages/Vessel-Check.aspx Vessel Check is a tool intended to enable vessel managers to take an active role in management of biofouling on their vessels, and reduce their risk of moving "live non-endemic or noxious fish" into and around Western Australia. However, this tool could be tailored and used by any other jurisdiction or Port State and would make a significant contribution towards educating vessel owners/operators about the risks posed by vessel biofouling and how they can reduce the likelihood of their vessels translocating AIS.

Now that the International Convention for the Control and Management of Ships' Ballast Water and Sediments is close to being ratified, it is time to focus on this neglected vector to ensure that all AIS risks associated with vessels are managed efficiently and effectively as possible. Such a commitment also will

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also greatly aid in meeting the Convention on Biological Diversity Aichi Biodiversity Target 9 which calls for all invasive alien species and pathways to be identified and prioritized, prior species to be controlled or eradicated and measures to be put in place to manage pathways to prevent their introduction and establishment by 2020.

Conclusion

In many parts of the world vessel biofouling is attributed to more AIS introductions than any other mechanism. However to date effective management of vessel biofouling has been neglected. Now that the Convention for the Control and Management of Ships' Ballast Water and Sediments is close to ratification, it is time to focus on the effective management of vessel biofouling.

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Following the success of the original Global Ballast Water Management Project, known as 'GloBallast', IMO has again joined forces with the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), Member Governments and the shipping industry to implement a five-year follow-up project, to sustain the global momentum in tackling the ballast water problem and to catalyse innovative global partnerships to develop solutions.

The main aim of **GloBallast Partnerships (GBP)** is to assist developing countries to reduce the risk of aquatic bio-invasions mediated by ships' ballast water and sediments. The project is being implemented by UNDP and executed by IMO, under the GEF International Waters portfolio, using a multi-component, multi-tiered approach involving global, regional and country-specific partners, representing government, industry and non-governmental organizations (NGOs):

- A global component, managed through a Project Coordination Unit at IMO in London, providing international coordination and information dissemination, including the development of toolkits and guidelines, and establishing a strong cooperation with industry and NGOs.

- A regional component, providing regional coordination and harmonization, information sharing, training, and capacity building in the application of ballast water management tools and guidelines.

- A significant country component to initiate legal, policy and institutional reforms to address the issue and to implement the International Convention for the Control and Management of Ships' Ballast Water and Sediments. 15 countries, from 5 high priority regions, are taking a lead partnering role focusing especially on legal, policy and institutional reform. All told, more than 70 countries in 14 regions across the globe are directly or indirectly participating and benefiting from the project.

The "Global Industry Alliance" (GIA) is an alliance of maritime industry leaders working together with the GEF-UNDP-IMO GloBallast Partnerships Programme on ballast water management and marine bio-security initiatives. The objective is to reduce the transfer of harmful organisms via ships, and to maximize global environmental benefits from addressing this issue in a sustainable and cost-effective manner. The current GIA members include four major shipping companies; BP Shipping, Vela Marine International, Daewoo Shipbuilding & Marine Engineering Co., Ltd., and APL.

The current GIA members include four major shipping companies; BP Shipping, Vela Marine International, Daewoo Shipbuilding & Marine Engineering Co., Ltd., and APL. It is expected that new members will be added to the GIA to increase the representation from various maritime sectors.

For further information on GloBallast Partnerships and the GIA, please contact:

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IMO is the specialized agency of the United Nations with responsibility for ensuring that lives at sea are not put at risk and that the environment is not polluted by international shipping. The Convention establishing IMO was adopted in 1948 and IMO first met in 1959. IMO's 168 member States use IMO to develop and maintain a comprehensive regulatory framework for shipping. IMO has adopted more than 50 Conventions, covering safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping. IMO's main Conventions are applicable to almost 100% of all merchant ships engaged in international trade.

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The GEF unites 183 countries in partnership with international institutions, civil society organizations (CSOs), and the private sector to address global environmental issues while supporting national sustainable development initiatives. Today the GEF is the largest public funder of projects to improve the global environment

www.thegef.org

UNDP partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations.

www.undp.org

6TH GEF-UNDP-IMO GloBallast R&D Forum and Exhibition on Ballast Water Management

Ballast Water Management Convention: moving towards implementation