Great Lakes and Lake Champlain Invasive Species Program

Great Lakes Ballast Water Research and Development Plan

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Direction is provided within the Vessel Incidental Discharge Act to develop, achieve type approval for, and pilot shipboard or land-based ballast water management systems (BWMS) applicable to commercial vessels operating solely within the Great Lakes. Vessel operational issues associated with BWMS function and impacts of water quality on BWMS function can best be understood while aboard vessels plying the Great Lakes. The changes in version 6 of the Plan reflect those realities and describe a shift from smaller projects to larger scale testing (e.g. land-based and shipboard). Further stakeholders provided valuable comments to version 5 of the Plan. Actual stakeholder comments are provided in Appendix A and where appropriate included in version 6. In addition, this version more clearly aligns with GLRI Action Plan III. The numbering of research areas and associated tasks has been realigned to create a more coherent Plan.

PURPOSE

The Vessel Incidental Discharge Act of 2018 (VIDA) was passed into law as part of the Frank LoBiondo Coast Guard Authorization Act of 2018 and established the Great Lakes and Lake Champlain Invasive Species Program (GLLCISP). The GLLCISP has several stated purposes related to ballast water management including:

- Early detection monitoring of aquatic nuisance species (ANS) within the Great Lakes and Lake Champlain Systems;
- Rapid response to ANS introduction and transport within the Great Lakes and Lake Champlain Systems;
- Monitor ballast water operations likely to be contributing to the introduction or spread of ANS; and
- Develop, achieve type approval for, and pilot shipboard or land-based ballast water management systems (BWMS) applicable to commercial vessels operating solely within the Great Lakes and Lake Champlain Systems.

Although several vectors for introduction of ANS exist within the Great Lakes (e.g., organisms in trade and water recreation), it is believed that commercial shipping accounts for approximately 60% of known invasions since the opening of the St. Lawrence Seaway in 1959 (Pagnucco et al., 2015). Commercial vessels that operate exclusively within the Great Lakes System (i.e., Laker vessels) are not major contributors of novel invaders into the Great Lakes. However, Laker vessels do pose a risk of accelerating the secondary spread of introduced ANS within the Great Lakes, especially given the high frequency of ballast water discharge events, the large volume of ballast water discharged per event, and short voyage times that ensure discharge of relatively healthy propagules (Rup et al., 2010). A ballast water monitoring study conducted in 2017 onboard United States and Canadian Laker vessels documented five ANS species not previously reported in Lake Superior in samples collected from ballast water being discharged to commercial ports within western Lake Superior. The documented ANS species

included *Hemimysis anomala*, *Nitrokra hibernica*, *Heteropsyllus nunni*, *Schizopera borutzkyi*, and *Thermocyclops crassus* (Cangelosi et al., 2018).

Questions remain regarding the acceptable level of environmental risk associated with discharge of ballast water from Laker vessels and the methods available for these vessels to manage their ballast water to reduce environmental risk. Risk associated with ANS establishment is a function of many variables, including number of propagules and frequency/magnitude of ballast discharge events (i.e., propagule pressure), and the relative differences between source and receiving environments (Aliff et al., 2018). Congress established the GLLCISP to assess the risk of ANS introduction and spread via ballast water as a vector within the Great Lakes System and identify and develop ballast water management practices for use by commercial vessels as necessary to prevent the spread of ANS within this System.

In many cases, environmental risk (i.e., reduction of propagules) associated with the ballast water vector can be substantially reduced through installation and operation of a BWMS, with the perceived protective effect established globally through a numeric discharge standard from the International Maritime Organization (IMO) D-2 Standard, USCG regulations at 33 CFR Part 151, and Environmental Protection Agency's (EPA) 2013 Vessel General Permit (VGP). However, Great Lakes water quality (e.g., low salinity, low temperature, high turbidity) and the unique operations of Laker vessels (e.g., high ballast flow rates, large ballast volumes, short voyage times) have proven difficult obstacles to overcome in the development of effective and practicable ballast water management technologies for use on Laker vessels. In addition, the Great Lakes market is not as attractive to BWMS developers because it represents a very small fraction of the total global market. According to Burroughs (2019), the worldwide fleet with a deadweight tonnage (DWT) of >2,000 DWT is approximately 53,600 vessels, whereas the number of vessels operating exclusively in the Great Lakes System with >2,000 DWT is approximately 50 (0.09% of the worldwide fleet; T. Rayburn, personal communication, 26 June 2019). Further, a substantial portion of these approximately 50 vessels are uniquely constructed, unlike seagoing ships of similar size, making installation and operation of a BWMS more complicated. Historically, targeted development of Great Lakes-applicable BWMS has been done by academic researchers and small start-up companies that do not have the capital needed to fully develop their technology for large-scale operation and testing. All these challenges and issues have led to Great Lakes-relevant technology development that is very slow in comparison with technologies developed for seagoing vessels.

Given these realities and in the context of this plan, an important first question is whether existing USCG type-approved BWMS can treat Great Lakes ballast water effectively to meet the current discharge standard, either using existing test methods or adapted methods adjusted to reflect the different environmental conditions of the Great Lakes and the operational realities of Laker vessels. Depending on the outcome of that research, further evaluation will be performed on use of a modified USCG type-approved BWMS, a BWMS otherwise approved under IMO protocols, or use of some other type of treatment equipment to either meet the existing national discharge standard, meet a discharge standard different than the national standard, or simply operate in such a way as to effectively reduce ANS risk associated with ballast water discharges (through an "equipment standard") in the Great Lakes System. Longer term, emerging technologies may be identified that can meet the current (national) discharge standard. In the interim, there may be best management practices (BMPs), other methods, and technologies available that are capable of effectively reducing ANS risk associated with ballast water

discharges in the Great Lakes System, including practical approaches for managing ballast water from shoreside facilities.

Per VIDA, the primary goal of this Research and Development (R&D) Plan is to identify approaches, methods, and best available technologies that can be applied to ballast water discharges that are effective at reducing propagules in Great Lakes ballast water, thereby decreasing the environmental risk associated with the ballast water vector from vessels operating exclusively within the Great Lakes System. Projects outlined in this R&D Plan will also consider the implications of these ballast water management approaches for vessels that operate in the Great Lakes System, but not solely within these waters. For example, a seagoing vessel that may visit the Great Lakes once a year may still be faced with having to treat Great Lakes water using a BWMS that has never been tested in Great Lakes water quality and biological conditions. In addressing these goals, ballast water treatment will be considered in addition to alternative approaches, such as ballast water best management practices. Importantly, the research projects outlined in this plan will provide essential scientific and technical information that will support science-based decisions during the VIDA rulemaking and implementation processes.

The research questions addressed within this R&D Plan assume the following:

1. The focus of the research is on the ballast water vector exclusively.
2. The primary research area is the waters of the Great Lakes System, defined in the U.S. Clean Water Act §118(a)(3) to mean all the streams, rivers, lakes, and other bodies of water within the drainage basin of the Great Lakes. ‘‘Great Lakes’’ means Lake Ontario, Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, Lake Superior, and the connecting channels (Saint Mary’s River, Saint Clair River, Detroit River, Niagara River, and Saint Lawrence River to the Canadian Border; (Clean Water Act, 2002). Lake Champlain is not included in the study area. However, by addressing the ballast water vector of ANS introduction and secondary spread in the Great Lakes System, this plan addresses the primary source of ANS introductions into Lake Champlain (Lake Champlain Steering Committee, 2018).
3. Research objectives will address ballast water associated with United States and to a less extent Canadian commercial bulk carrier vessels having a cargo-carrying capacity of greater than 1,600 gross registered tons and trading within the Great Lakes System VGP , 2013). The primary focus will be on such vessels operating exclusively within the Great Lakes System but will also address other vessels that do not operate exclusively within these waters but that do uptake or discharge ballast water in the Great Lakes System.
4. The projects described in this plan will be implemented over a seven-year timeframe; any reduction in resources (i.e., time and/or funding) or changes to scope would require prioritization of the proposed work and a commensurate rescoping of each research area.
5. The data generated during the implementation of this R&D Plan is intended to be considered during the five-year (or sooner, if appropriate) review of the ballast water discharge standards established under VIDA by the U.S. EPA and will inform any post-review revision of established discharge standards.
6. This R&D Plan is a living document, and the proposed projects may be revised to reflect the outcomes of project planning meetings (see Stakeholder Group Involvement).
7. The University of Wisconsin-Superior’s Lake Superior Research Institute (UWS-LSRI) will lead and manage the implementation of the projects described in this R&D Plan as part of the Great Waters Research Collaborative (GWRC), in cooperation with and with oversight from, the U.S.

Department of Transportation Maritime Administration (MARAD). All project planning and implementation activities will be closely coordinated with, and communicated to, the U.S. EPA Office of Water, U.S. EPA Great Lakes National Program Office, the United States Coast Guard (USCG), and their subcontractors (as needed).

8. The projects described in this plan will build on ballast water research conducted by the U.S. EPA Office of Research and Development, U.S. Coast Guard Research and Development Center, Naval Research Laboratory, Canada's Department of Fisheries and Oceans, and other institutions.

GREAT LAKES BALLAST WATER R&D PLAN SUMMARY

The R&D Plan Summary Table below reflects a shift in the Plan's focus to large scale research and testing (e.g., land-based and shipboard) and calls attention to the GLRI Action Plan III objectives.

Research Area	R&D and GLRI Action Plan (underlined) Objectives	Key Research Question(s) Addressed by Project	Project(s)
RESEARCH AREA 1: IDENTIFICATION OF METHODS/ALTERNATIVES AND ASSESSMENT OF COST FOR GREAT LAKES BALLAST WATER MANAGEMENT	**R&D Objective 1:** Determination of Operational Characteristics of Commercial Vessels Trading within the Great Lakes System. **GLRI 2.1**: Prevent introductions of new invasive species by understanding pathways through which invasive species can be introduced.	1. What are the typical (and more challenging) ballasting operational characteristics of United States and Canadian-flag commercial vessels that trade within the Great Lakes?	Determining Operational Characteristics of Great Lakes Vessels
	R&D Objective 2: Land-Based Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water. **GLRI 2.3:** Develop invasive species control technologies by conducting field testing of innovative control technologies and methods to prevent introduction.	1. Are there existing BWMS available on the global market that can treat Great Lakes ballast water effectively to reduce ANS risk using existing test methods (i.e., *Generic Protocol for the Verification of Ballast Water Treatment Technology*; U.S. EPA, 2010)? 2. When evaluated at a land-based scale using the newly developed, Great Lakes-adapted protocols, how do these BWMS perform? a. What is the level of living organism reduction that can be achieved in the Great Lakes based on land-based testing?	Land-Based BWMS Evaluation
	R&D Objective 3: Shipboard Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS as well as Non-typed Approved BWMS Capable of Treating Great Lakes Water. **GLRI 2.3:** Develop invasive species control technologies by conducting field testing of innovative control technologies and methods to prevent introduction.	1. Are there existing BWMS available on the global market that can treat Great Lakes ballast water effectively to reduce ANS risk using existing test methods (i.e., *ETV Protocol*), and two approaches: a. Conducting shipboard BWMS trials onboard Laker vessels in a variety of different Great Lakes commercial ports and over at least one Great Lakes shipping season. 2. When evaluated at a shipboard scale using the newly developed, Great Lakes-adapted protocol, how do these BWMS perform? a. What is the level of living organism reduction that can be achieved based on shipboard testing?	Shipboard BWMS Evaluation

Research Area	R&D and GLRI Action Plan (underlined) Objectives	Key Research Question(s) Addressed by Project	Project(s)
IDENTIFICATION OF METHODS/ALTERNATIVES AND ASSESSMENT OF COST FOR GREAT LAKES BALLAST WATER MANAGEMENT (CONTINUED)	**R&D Objective 4:** Evaluating the Effectiveness of Ballast Water Best Management Practices Including Hybrid Solutions. **GLRI 2.3:** Develop invasive species control technologies by conducting field testing of innovative control technologies and methods to prevent introduction.	1. Can filtration technologies and practices be improved for ballast water management in the Great Lakes? 2. Is stand-alone filtration a viable, beneficial option, at least until suitable USCG type-approved BWMS for Lakers are identified?	Ballast Water Filter Performance
	R&D Objective 5: Evaluating the Feasibility and Significant Impacts of Ballast Water Reception Facilities within the Great Lakes	1. What are the technical, economic, and environmental considerations of using ballast water reception facilities if utilized within the Great Lakes?	Feasibility Study of Reception Facility Treatment
RESEARCH AREA 2: TOWARD DEVELOPMENT OF GREAT LAKES RELEVANT BWMS TESTING PROTOCOL	**R&D Objective 1:** Characterizing BWMS Challenge Conditions in the Great Lakes System. **GLRI 2.1:** Prevent introductions of new invasive species by understanding pathways through which invasive species can be introduced.	1. What are the ranges of living organism densities/composition and water quality parameters found within Great Lakes commercial ports where the uptake of ballast water occurs? 2. Given data collected for #1, are the minimum challenge condition requirements specified in the *ETV Protocol* appropriate (i.e., challenging, but not rare natural environmental conditions) for evaluating BWMS performance in the Great Lakes?	Characterize BWMS Challenge Conditions
	R&D Objective 2: Development of a Great Lakes-Adapted Protocol for Verification of BWMS	1. What changes to the existing *ETV Protocol* approach are appropriate for its use to evaluate BWMS effectiveness for Great Lakes vessels?	Protocol Development
RESEARCH AREA 3: ASSESSING THE RISK OF AQUATIC NUISANCE SPECIES TRANSFER FROM BALLAST WATER DISCHARGE	**R&D Objective 1**: Establishment of Great Lakes Focal Ports to Determine Interlake Transfer. **GLRI 2.1**: Prevent introductions of new invasive species by understanding pathways through which invasive species can be introduced and conduct early detection and surveillance activities.	1. What is the risk of ANS interlake transfer via ballast water? 2. What is the relative ANS loading associated with the various vessel voyage patterns within the Great Lakes, and are there significant differences that may warrant different technologies or practices for these different situations?	Quantifying ANS Transfer
	R&D Objective 2: Using Semi-Field Methodologies to Determine the Impact of ANS Reduction in Managed Ballast Water	1. Using existing semi-field methodologies and a variety of freshwater taxonomic groups, can the impact of ANS reduction in Great Lakes ballast water be determined under a variety of ballast water management scenarios?	Determining Impact of ANS Reduction

PROPOSED BALLAST WATER R&D PLAN TIMELINE

The Great Lakes Ballast Water R&D Plan will be implemented over a period of seven federal fiscal years, approximately 01 October 2020 to 30 September 2027 (Figure 1). There are three research areas outlined in version 6 of the Plan, plus the stakeholder group activities. Many of the projects outlined in the R&D Plan will be designed and implemented during the early years because the data generated will form the foundation for subsequent projects. Shading indicates the proposed year(s) during which each activity will occur.

Research Area - Project	Project Description	Year 1 10/1/20 - 9/30/21	Year 2 10/1/21 - 9/30/22	Year 3 10/1/22 - 9/30/23	Year 4 10/1/23 - 9/30/24	Year 5 10/1/24 - 9/30/25	Year 6 10/1/25 - 9/30/26	Year 7 10/1/26 - 9/30/27
Stakeholder Group Involvement								
S1	Form Stakeholder Group/Kick-Off	■						
S2	Form Data Working Group/Data Mining and Sharing	■						
S3	Stakeholder Group Engagement	■	■	■	■	■	■	■
Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management								
1 - 1	Determining Operational Characteristics of GL Vessels	■	■	■	■			
1 - 2	Land-Based BWMS Evaluation	■	■	■	■	■		
1 - 3	Shipboard BWMS Evaluation	■	■	■	■	■	■	
1 - 4	Ballast Water Filter Performance		■	■	■			
1 - 5	Feasibility Study of Reception Facility Treatment			■	■			
Research Area 2: Toward Development of Great Lakes Relevant BWMS Testing Protocol								
2 - 1	Characterize BWMS Challenge Conditions		■	■	■	■	■	
2 - 2	Protocol Freshwater Revision and Validation					■	■	
Research Area 3: Assessing the Risk of Aquatic Nuisance Species Transfer from Ballast Water Discharge								
3-1	Quantifying ANS Transfer			■	■	■		
3-2	Determining Impact of ANS Reduction	■	■	■	■			
	Final data summary and reporting/publication						■	■

Figure 1. Great Lakes Ballast Water Research and Development Plan Seven-Year Timeline by Federal Fiscal Year.

GREAT LAKES BALLAST WATER RESEARCH AND DEVELOPMENT PLAN COORDINATION AND REVIEW

The U.S. Department of Transportation Maritime Administration and members of the R&D Plan implementation team will participate in the semi-annual U.S. Coast Guard – U.S. Naval Research Lab program review (associated with ballast water/aquatic nuisance species research). Members of the R&D Plan implementation team will also participate in other meetings hosted by other national and international government agencies as well as meetings convened by NGOs and professional trade meetings.

These meetings will ensure regular communication and close coordination with agencies conducting ballast water research projects within the Great Lakes System and eliminate any duplication of effort during project implementation.

STAKEHOLDER GROUP INVOLVEMENT

Given the magnitude, complexity, and importance of this Ballast Water R&D Plan, stakeholder involvement will be critical to each project's successful design, implementation, and dissemination of project results. It is recommended that a stakeholder group be engaged as early as possible in the design of the projects proposed within this plan, and that this group be involved throughout the seven-year implementation period. The overarching objectives in this plan will likely not change; however, the proposed projects outlined in this Ballast Water R&D Plan will evolve from conceptual project ideas (as currently described) to separate project plans (i.e., in the form of Quality Assurance Project Plans and Test Plans) containing scientifically defensible experimental design and fully-formed implementation details. Members of the stakeholder group may serve as project partners and supply critical historical data that will be used to identify data gaps and research needs (see Objective 2). Throughout the implementation of the plan, stakeholder involvement will be strictly advisory in nature. The role of the stakeholder group is not that of a decision-making body; all project design, implementation, data interpretation decisions, and recommendations will be made by the project principal investigators in cooperation with MARAD. Stakeholder involvement will ensure that the projects described in this plan best serve the needs of the Great Lakes region.

A. APPROACH AND OBJECTIVES

Objective 1: Formation of Ballast Water R&D Plan Stakeholder Group and Kick-Off Meeting

Key Question: Which organizations are key for input on the goals and direction of the R&D Plan?

MARAD and UWS-LSRI will lead the formation of the stakeholder group. The stakeholder group will include the U.S. EPA's Office of Water and Great Lakes National Program Office (GLNPO), and the GLLCISP collaborators listed in VIDA including U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration (including Great Lakes Environmental Research Laboratory and Great Lakes Aquatic Nonindigenous Species Information System), U.S. Geological Survey, and U.S. Coast Guard. The stakeholder group should be binational in nature, and include representation from additional organizations in the Great Lakes region, including: Transport Canada, Department of Fisheries and Oceans Canada, Tribal agencies, Great Lakes states and provinces, Great Lakes Commission (including Great Lakes Panel on Aquatic Nuisance Species), U.S. and Canadian shipping companies with vessels operating in the Great Lakes System, representatives from the ballast water equipment manufacturing industry, Great Lakes ports, St. Lawrence Seaway organizations, non-governmental/policy organizations, and academic researchers. Additional experts from academia will participate in Stakeholder Group/project planning meetings on an as-needed basis.

MARAD will function as the neutral facilitator of the R&D Plan's Stakeholder Group. As the facilitator, MARAD will be responsible for convening the stakeholder group, including academic experts as needed, and providing logistical and technical support for stakeholder group meetings. MARAD will not contribute to meeting content, is non-partisan, and will not drive the direction of the R&D Plan projects.

Within three to six months of receiving approval for public release of the R&D Plan from the U.S. EPA's Office of Water, a stakeholder kick-off meeting will be held. This meeting will be led jointly by MARAD

and UWS-LSRI, and its purpose will be to introduce the stakeholder group to the plan's objectives and projects and solicit initial feedback from stakeholders on project design and planning with a focus on the first year of the seven-year implementation period.

Objective 2: Formation of Data Working Group and Mining, Sharing, and Compiling Existing Data

Key Questions:

1. **Which stakeholder member organizations should form the data working group?**
2. **What is the process for mining, compiling, and sharing critical existing data that will inform project design?**
3. **Based upon published literature and data from the working group, what are the data gaps that must be addressed through R&D Plan projects?**

Ahead of the kick-off meeting, a working group will be formed consisting of stakeholder member organizations who may have data that would feed directly into the projects described in this R&D Plan. This working group will meet separately in conjunction with the kick-off meeting. Literature review will be an integral part of R&D Plan project planning and will be an ongoing process throughout the seven-year implementation. Therefore, the data working group will remain engaged throughout the Year One to Year Seven planning processes. During this initial working group meeting, the process by which these data will be mined, compiled, and shared will be discussed and agreed upon. The details of this agreement will be shared with the larger group of stakeholders. Once all data from the working group has been shared, data gaps will be identified and shared with the larger group of stakeholders, and this R&D Plan will be revised to reflect any necessary changes to project design.

Objective 3: Engaging Stakeholders during R&D Plan Implementation

Key Question: Is the Ballast Water R&D Plan on track and are there any necessary updates based on the current state of affairs?

Following the initial kick-off meeting, the stakeholder group will meet at least once each year over the seven-year R&D Plan implementation period. The first meeting, to take place during the first or second quarter of each calendar year, will discuss findings from the previous year, have a project planning and experimental design focus, and discuss next research steps. Project principal investigators will outline each of the projects planned for that year and will receive input from the stakeholder group regarding research questions, data needs, experimental design, potential project partners, etc. The principal investigators will consider feedback and incorporate into that year's project plans. One- to two-page project summaries will be sent to stakeholder group members at least one week ahead of each meeting to allow ample time for preparation.

During the seven-year implementation of the R&D Plan, impromptu meetings with the stakeholder group may be necessary. These meetings will be scheduled on an as-needed basis in order to share and discuss any critical results and decision points.

B. Timeline

Figure 2 outlines the planned timing for the tasks associated with the formation of a stakeholder group and future engagement activities.

Research Area - Project	Project Description	Year 1 10/1/20 - 9/30/21	Year 2 10/1/21 - 9/30/22	Year 3 10/1/22 - 9/30/23	Year 4 10/1/23 - 9/30/24	Year 5 10/1/24 - 9/30/25	Year 6 10/1/25 - 9/30/26	Year 7 10/1/26 - 9/30/27
Stakeholder Group Involvement								
S1	Form Stakeholder Group/Kick-Off							
S2	Form Data Working Group/Data Mining and Sharing							
S3	Stakeholder Group Engagement							

Figure 2. Timing of Tasks Associated with Stakeholder Group Involvement in the Great Lakes Ballast Water R&D Plan.

Data Management, Sharing, and Availability

A. Great Waters Research Collaborative Data Management Structure and Process

All projects conducted as part of the R&D Plan must conform to the documents and records management processes outlined in the *Lake Superior Research Institute Quality Management Plan* (LSRI QMP; LSRI, 2018). Project-specific requirements above and beyond those outlined in the LSRI QMP will be detailed in each Quality Assurance Project Plan, which are prepared by the project lead(s) and reviewed by the Quality Assurance/Quality Control Manager or Program Manager.

Organization and Management of References

Literature review will be an ongoing process throughout implementation of the R&D Plan. Reference management software is used to collect, organize, cite, and share references among project team members. References are searchable by research area, project, title, author, and several other search terms.

Organization and Management of Data

LSRI's Egnyte Ballast Water File Server is the storage location for all existing data gathered as part of the Data Working Group efforts and primary data generated through implementation of R&D Plan projects. This cloud-based storage is protected by Egnyte's security system, and at the user level through password protection. User names and passwords for LSRI's Egnyte Ballast Water File Server are only issued to project staff. Data within Egnyte are organized by R&D Plan project and data type.

Project data will be recorded by hand on pre-printed data collection forms and/or in bound laboratory notebooks that are uniquely identified to the R&D Plan project. Automated electronic data (e.g. generated by BWMS software) will be downloaded and stored on Egnyte according to above procedures. All documentation is required to conform to LSRI's good documentation practices and completed data collection forms will be secured in uniquely-identified, three-ring binders specific to the project. All hand-written data will be scanned and saved to LSRI's Egnyte File Server as soon as possible after generation. All original, raw (hand-recorded) data will be archived in LSRI's secure archive room for a period of at least seven years after project completion.

B. Project Data Sharing and Availability

The data generated during R&D Plan project implementation will be publicly available.

R&D Plan Stakeholder Group Organizations

The members of the R&D Plan Stakeholder Group will be given access to preliminary, summarized project data ahead of Stakeholder Group meetings. Project data will be provided at least one week prior to each meeting to allow enough time for members to prepare for discussion. A newsletter will be provided to the R&D Plan Stakeholder Group semi-annually to provide the group with updates on R&D projects.

General Public

The public will be given access to final project data after publication and final presentation, and after data have undergone GWRC's data verification and validation process. Project output, in the form of a peer-reviewed publication or technical report (where appropriate), will be publicly available.

I. Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management

Waterhouse et al. (2013) used ballast discharge data and voyage patterns to identify five vessel types that represent all U.S.-flag vessels operating exclusively within the Great Lakes System. Vessel types identified are as follows:

- Intermediate to Large Capacity 1000': Primary trade route from western Lake Superior to southern Lake Michigan or Lake Erie;
- Large Capacity 1000': Primary trade route from western Lake Superior to southern Lake Michigan and Lake Huron;
- Older, Smaller Capacity 700' to 800': Trading routes from southern Lake Michigan to northern Lake Huron and western Lake Erie;
- Newer, Intermediate Capacity 800' to 900': Trading routes vary from northern Lake Michigan and northwest Lake Huron to southern Lake Michigan, southern Lake Huron, and western Lake Erie; and
- Small Capacity River Class 600' to 700': Several varied long (e.g., northern Lake Michigan to western Lake Erie) and short (e.g., within western Lake Erie) trading routes.

The Laker fleet, represented by these five vessel-types, has unique operating characteristics that make it distinct from the global fleet. Ballast water management options that are broadly applicable to many vessels in the global fleet may not be appropriate for the relatively small number of vessels constructed for the specific conditions in the Great Lakes that comprise the Laker fleet. Relative to seagoing vessels, voyage routes for Laker vessels are short (i.e., 8 to 72 hours), and the vessels are designed for high-efficiency cargo loading and unloading with very high-capacity ballast flow rates with respect to vessel size (i.e., 2,000 to 10,000 m^3/hour; Wren et al., 2013). It is necessary to determine the operating characteristics of the five vessel types identified by Waterhouse et al. (2013), including Canadian-flag vessels, in order to identify ballast management options that may be applicable to vessels operating exclusively in the Great Lakes System.

One study (Mueller & Dooley, 2017) found that no U.S. Coast Guard type approval testing of market-available BWMS has been conducted within the Great Lakes System. To our knowledge, there has been one land-based U.S. Coast Guard type approval test of a BWMS that took place within the Great Lakes, which tested an electro-chlorination system (Cangelosi et al., 2018b), and one shipboard type approval test of a second BWMS that included two trials within the Great Lakes, which tested a chemical-injection system (Cangelosi et al., 2017). This lack of data begs the question of whether market-available, type-approved BWMS tested under Great Lakes relevant conditions during testing will still meet a discharge standard. Evaluation of BWMS in the Great Lakes must be conducted in order to answer this important question.

There may be approaches to Great Lakes ballast water management that could be utilized in advance of, and possibly in lieu of, successful development (and testing) of BWMS for use on board certain Great Lakes vessels. Even with installation of an operational BWMS on board a Great Lakes vessel, there may be instances of BWMS malfunction in which another approach is needed to reduce ANS discharges. There may also be situations in which a BWMS is rendered ineffective or inoperable due to challenging biological/water quality conditions within a port (e.g., during infrequent weather conditions). Increasing frequency of extreme weather events and resulting significant overland flooding will increase the likelihood of these challenging water quality conditions within Great Lakes commercial ports in future years. A partially effective BWMS or component (e.g. filter) of BWMS still may prove useful in reducing the propagule load. Great Lakes vessel owners and operators need a suite of management options that can be effectively utilized to reduce ANS discharges.

In addition to on board ballast water management options, there may be alternative, shore- or barge-based reception/treatment facilities that could be utilized by Laker vessels. Wren et al. (2013) examined several options with respect to the U.S.-flag Laker fleet, including publicly-owned treatment works and dedicated reception facilities, and found that either option may be a viable solution for vessels with dedicated voyage routes. Regardless, these reception facilities would require a substantial infrastructure investment (Wren et al., 2013). A ballast lighter vessel, which is a barge or other vessel that accepts and manages ballast from a commercial vessel, is an option that has not been explored in the Great Lakes System but has been utilized elsewhere (i.e., Europe, India, and Iran, Prihoda et al., 2020 draft in review).

For all potential ballast water management options being considered by this R&D Plan, the biological efficacy data, in combination with a better understanding of environmental risk must be weighed against the cost associated with each potential management option. The data collected under Research Area 1 will allow for determination of the best management options available to Laker vessels by generating biological efficacy data on a wide variety of management strategies along with accurate cost estimates for each option being considered.

A. Research Approach and Objectives

Objective 1: Determination of Operational Characteristics of Commercial Vessels Trading within the Great Lakes System

Key Question: What are the typical (and more challenging) ballasting operational characteristics of United States and Canadian-flag commercial vessels that trade within the Great Lakes?

This objective will be implemented through a foundational, multi-year project. This project will build upon the work that was done by Waterhouse et al. (2013), and will focus on the five vessel types identified through this study. This project will focus on U.S.- and Canadian-flag vessels operating exclusively within the Great Lakes System but will also take into consideration other vessels that load and unload cargo/ballast within the Great Lakes. The operational characteristics of U.S.- and Canadian-flag Lakers operating exclusively within the Great Lakes System will be contrasted to those of seagoing vessels that trade within the Great Lakes. In addition, data will be gathered on the number of seagoing vessels entering the Great Lakes System, including, voyage patterns within the Great Lakes, the volume of Great Lakes ballast water taken onboard these vessels annually, and the volume of ballast water discharged from seagoing vessels within the Great Lakes System annually.

Current data on Laker vessel operational characteristics will feed into several of the projects described in this R&D Plan, including all the proposed projects in Research Area 1, development of a Great Lakes-adapted BWMS testing protocol, and quantifying the risk of ANS transfer from ballast water of Laker vessels. The parameters of interest in this project are as follows:

- Voyage patterns, including ballast water uptake and discharge locations within various Great Lakes ecoregions (Figure 3, as described in *The Great Lakes*, 1995)
- Voyage durations (ballast hold time)
- Ballast volumes and durations of ballast water uptake/discharge operations
- Ballast flow rates
- Ballasting system characterizations (pump and piping arrangements, etc.)
- Ballast water best management practices

Potential project partners such as the Lake Carriers' Association and Chamber of Marine Commerce, will be called upon for existing data (see Stakeholder Group Objective 2). Data will also be gathered through publicly available sources (e.g., National Ballast Information Clearinghouse). Through this data-gathering process, the operational characteristics of Laker vessels will be determined. This project will also examine voyage patterns in the context of the various U.S. and Canadian Great Lakes ecoregions (Figure 3, *The Great Lakes*, 1995). Voyages within an ecoregion may not contribute greatly to secondary spread of established ANS compared to voyages between one or more Great Lakes ecoregions (Figure 3). This examination of voyage patterns in the context of ballast water discharge monitoring data to determine ANS loadings (*Quantifying ANS Transfer Project*) will allow for development of science-based and adaptive ballast water management strategies.

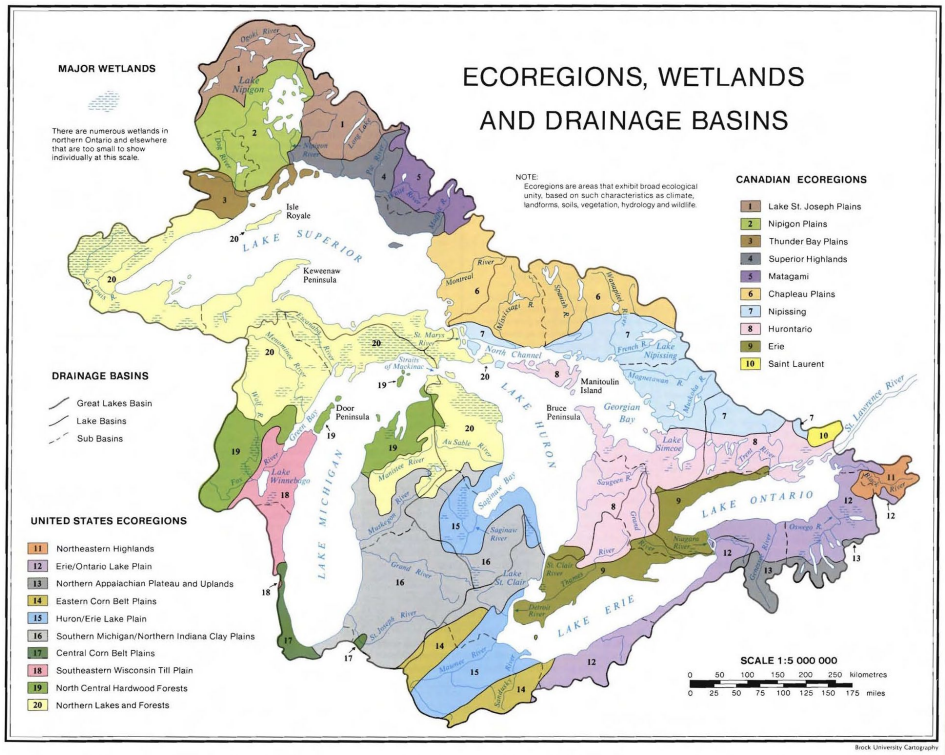

Figure 3. U.S. and Canadian Great Lakes Ecoregions from "The Great Lakes: An Environmental Atlas and Resource Book" (Government of Canada and U.S. EPA, 1995).

Objective 2: Land-Based Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

Key Questions:

1. **Are there existing BWMS available on the global market that can treat Great Lakes ballast water effectively to provide a high level of organism reduction, including reduction of ANS taxa?**
2. **When evaluated at a land-based scale using the newly developed, Great Lakes-adapted protocol (see *Protocol Development Project*), how do these BWMS perform?**
    a. **What is the level of organism reduction, including reduction of ANS taxa that can be achieved in the Great Lakes based on land-based testing?**

This objective will be addressed through implementation of a single, five-year project. This project is designed to gather data on the operational and biological effectiveness of BWMS under Great Lakes biological and water quality conditions and using existing test methods, i.e., *Generic Protocol for the Verification of Ballast Water Treatment Technology* (U.S. EPA, 2010), hereafter *ETV Protocol*. Selection of diverse ballast water treatment technologies for land-based testing will be conducted using a request for proposal (RFP) method. Only those technologies designed to treat fresh water (and ideally for a salinity <1 PSU) and very cold water will be selected. Other Laker-specific considerations, such as the potential of the treatment to cause corrosion of the ballast tanks, and the requirement for a source of salinity (i.e. electrolysis systems) will factor into the ultimate selection of technologies for testing. It should be noted, testing the effect of active substances on a ship's structure (i.e., corrosion) is beyond

GWRC's land-based capabilities. Given successful biological efficacy and environmental acceptability testing GWRC can facilitate a discussion and make recommendations for corrosion testing.

Promising BWMS will be obtained, either through BWMS manufacturer lending/leasing of a unit or through direct purchase. The *ETV Protocol* will be used to verify the biological efficacy, operation and maintenance of at least three BWMS. Biological efficacy will be measured against the current U.S. ballast water discharge standard. All technologies will be evaluated at the GWRC operated UWS-LSRI Montreal Pier Facility (Superior, WI), against challenging but realistic water quality conditions.

Data from the BWMS land-based evaluations will be assessed in the context of operational and biological performance outcomes. Land-based testing will provide data on the scalability and applicability of these land-based testing methods to a shipboard application and will also provide data on the performance of these technologies using the validated methodology that was developed specifically for Great Lakes water quality and biological conditions. The "adapted" protocol will be used to verify the technology's biological efficacy. In this case, biological efficacy will be determined as a reduction in propagules over a maximum of five test trials in addition to comparison to a discharge standard. The reduction in propagules will be applied to ballast water monitoring data from shipboard testing and ANS monitoring, to determine if any of the BWMS evaluated provide an acceptable level of propagule reduction while also performing reliably and predictably over time.

Objective 3: Shipboard Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

Key Questions:

1. **Are there existing BWMS available on the global market (either type-approved under the IMO Convention or by the U.S. Coast Guard) that can treat Great Lakes ballast water effectively to provide a high level of organism reduction, including reduction of ANS taxa?**
2. **When evaluated at a shipboard scale using the newly developed, Great Lakes-adapted protocol (see *Protocol Development Project*, (Research Area 2 – Project 2), how do these BWMS perform?**
    a. **What is the level of organism reduction that can be achieved based on shipboard testing?**

This project is designed to determine the biological and operational effectiveness of BWMS onboard vessels operating in the Great Lakes System. The data generated during Objective 3 will add to existing shipboard research and development data obtained from the U.S. Coast Guard, Department of Fisheries and Oceans Canada, and others. Input during the stakeholder group meetings will ensure that lessons learned from previous Great Lakes shipboard research and development testing will be considered and addressed in the project plan. This project which will be a six-year project involving multiple vessels, will greatly increase the data on BWMS performance under real-world operational conditions and in a variety of Great Lakes commercial ports. The data obtained during shipboard testing will feed into many proposed projects in this R&D Plan, including:

- Real-world operational characteristics of Laker vessels
- Filter performance
- Characterizing Great Lakes challenge conditions

- Development of methods for ballast water sample assessment and
- Assessing the risk of ANS transfer

Multiple vessels of opportunity will be selected to participate in this project. Vessels of opportunity must trade within the Great Lakes System, have a BWMS installed or plan to have a BWMS installed, and be willing to allow GWRC scientists on board the vessel during the six-year project period. Vessels of opportunity may also include mobile (port- and/or barge-based) ballast water treatment options with the potential for Great Lakes applicability. A minimum of five vessels of opportunity will be selected over the course of the first two years of the R&D Plan implementation. Following vessel and BWMS (technologies designed to treat freshwater) selection, project planning and logistics will begin. Other Laker-specific considerations, such as the potential of the treatment to cause corrosion of the ballast tanks, and the requirement for a source of salinity (i.e. electrolysis systems) will factor into the ultimate selection.

The data from the BWMS shipboard evaluations will be assessed in the context of operational and biological performance outcomes and with consideration of input from the stakeholder group. Testing will occur over multiple Great Lakes shipping seasons with a goal of conducting a minimum of five test trials on each vessel. The adapted protocol will be used to verify the technology's biological efficacy, determined as a reduction in propagules, in addition to comparison to a discharge standard by reviewing data from previous shipboard visits. The propagule reduction data will be compared to the *Quantifying ANS Transfer Project*, to determine if any of the BWMS evaluated provide an acceptable level of propagule reduction while also performing reliably and predictably over time. Furthermore, data from BWMS autolog and crew log operations will be collected and analyzed in relation to Great Lakes water quality data collected in the shipboard and characterizing challenge conditions projects of the R&D plan to identify ways to overcome obstacles to system operation and performance.

Objective 4: Evaluating the Effectiveness of Filtration Technologies.

Key Questions:

1. **Can filtration technologies and practices be improved for ballast water management in the Great Lakes?**
2. **Is stand-along filtration a viable, beneficial option for ANS risk reduction, at least until suitable USCG type-approved BWMS are identified?**

Objective 4 is comprised of a research project designed to fill data gaps associated with filter performance under Great Lakes conditions of water quality and biology. This project will determine the impacts of parameters that present an operational and performance challenge to ballast water filters, e.g., ice, filamentous protists, and high concentrations of total suspended solids. The *ETV Protocol* specifies an acceptable water temperature range for BWMS testing from 4 - 35°C. Great Lakes water temperatures can be consistently <4°C for several months of the shipping season, and during the winter months the presence of pack ice and freezing water could cause operability issues for BWMS. BWMS filters are typically tested with solids that have diameters in the micron range, which is substantially smaller than the diameter of floating lake ice that could be taken up during ballasting. Similarly, operation of filters at low temperatures in fresh water can also lead to icing on filter elements. Great Lakes protist populations may also cause filter performance issues. Specifically, filamentous diatoms and

cyanobacteria, some of which have filaments well over 100 µm in length, taken up in ballast can rapidly clog filter systems necessitating near-constant filter backflushing and decreased ballast flow rates and cargo off-loading operations. Commercial ports with high concentrations of suspended solids may create a similar operational challenge.

A call will be made to filter manufacturers (e.g., representatives from the ballast equipment manufacturing industry) to participate in this research project, which will determine performance of market-ready filters using a standard set of operational variables under extreme, but not rare, Great Lakes-relevant conditions. Filter performance will be assessed at the UWS-LSRI Montreal Pier Facility (Superior, WI), which will allow for controlled evaluations of each filter to be conducted. Filters will be selected through a "Request for Applications" process, wherein filter manufacturers apply to participate in this research in exchange for very valuable data on the performance of their filter system. A similar approach was used successfully during a previous land-based study (Cangelosi et al., 2014), in which performance of eight commercially-available ballast water filter systems manufactured by five companies were evaluated.

Data on total suspended solids and protist densities at commercial ports within the Great Lakes will be obtained to provide a benchmark for filter experiments. The target concentration of total suspended solids and target density of protists for this evaluation will be selected to create a "challenging but not rare" test condition. Each filter participating in this project will undergo at least three test trials under these challenging conditions, and at the upper-end of the Montreal Pier Facility's flow rate capacity (i.e., maximum flow rate of 340 m^3/hour). The following variables will be measured during this evaluation:

- Filter back-flush frequency
- Flow rates pre- and post-filter
- Filter back-flush volume
- Filter throughput
- Duration of backflush cycle
- Pressure pre- and post-filter
- Differential pressure
- Total suspended solids removal
- Particulate organic matter removal
- Organism removal
    - Zooplankton
    - Protists

Baseline data on filter performance will be collected during warmer months (late spring – early fall) and prior to the ice/icing test. Impact of ice/icing on filter performance will also be evaluated on the filters participating in this research project. This evaluation will also take place at the Montreal Pier Facility while the water surrounding the pier is ice-covered. Ballast water filter systems must be operated in above-freezing temperatures; thus, each filter will be operated in an indoor heated space during this evaluation. A simulated ice pack will be created in the water adjacent to the pier, and a trash pump (i.e., portable pump designed to pump large volumes of water that contains hard and soft solids) will be used to deliver the ice-laden water to the filter system being tested. This evaluation will measure filter performance in terms of a reduced set of operational parameters compared to that previously described.

Objective 5: Evaluating the Feasibility and Significant Impacts of Ballast Water Reception Facilities within the Great Lakes

Key Question: What is the feasibility, economic, and environmental impact of reception facilities if utilized within the Great Lakes under certain scenarios or locations?

Objective 5 will be carried out as a single, three-year project. In a study conducted by Wren et al. (2013), which examined the feasibility of municipal treatment of ballast water and dedicated reception facilities, the authors suggest that these options may only be viable for vessels with dedicated trade routes. In addition, mathematical modeling has shown that prioritizing development of high-volume, ballast water reception facilities based on network centrality could be a potentially effective strategy for reduction of secondary spread of ANS (Kvistad, 2019). The five U.S. Laker vessel types classified by Waterhouse et al. (2013), in combination with existing literature and the vessel operating characteristics determined for U.S. and Canadian Lakers during the *Determination of Operational Characteristics of GL Vessels Project* will be examined to determine which vessel types and voyage patterns would be most conducive to utilize reception facilities for ballast water management. There may also be scenarios in which pre-treatment reception facilities could be utilized to improve BWMS performance. In all cases, the feasibility, and significant impacts (i.e., cost, infrastructure needs, permitting, and environmental risk) of this alternative treatment or pre-treatment option (ballast water reception facilities), will be independently assessed and reported. The assessment will consider:

- All sectors of the U.S. and Canadian Great Lakes fleets, including all commercial vessel types and operations
- Scenarios in which ballast water reception facilities may be more feasible options than installation of a BWMS, such as for vessels on dedicated trade routes
- Scenarios in which pre-treatment of ballast via reception facilities may lead to improved BWMS performance

B. Timeline

Figure 4 outlines the planned timing for the five research projects identified in Ballast Water R&D Plan Research Area 1.

Research Area - Project	Project Description	Year 1 10/1/20 - 9/30/21	Year 2 10/1/21 - 9/30/22	Year 3 10/1/22 - 9/30/23	Year 4 10/1/23 - 9/30/24	Year 5 10/1/24 - 9/30/25	Year 6 10/1/25 - 9/30/26	Year 7 10/1/26 - 9/30/27
Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management								
1 - 1	Determining Operational Characteristics of GL Vessels	■	■	■	■			
1 - 2	Land-Based BWMS Evaluation	■	■	■	■	■		
1 - 3	Shipboard BWMS Evaluation	■	■	■	■	■	■	
1 - 4	Ballast Water Filter Performance		■	■	■			
1 - 5	Feasibility Study of Reception Facility Treatment		■	■	■			

Figure 4. Timing, by Federal Fiscal Year, of Projects Implemented under Research Area 1 of the Great Lakes Ballast Water R&D Plan.

II. RESEARCH AREA 2: TOWARD DEVELOPMENT OF A GREAT LAKES RELEVANT BWMS TESTING PROTOCOL

Two major obstacles in the development of BWMS in the Great Lakes are the lack of relevant water quality and biology "challenge" data from within Great Lakes commercial ports, and a generic testing protocol for independent land-based and shipboard BWMS evaluation that is not tailored to these Great Lakes conditions. The adequacy of the protocols used to evaluate BWMS for purposes of IMO compliance and U.S. Coast Guard type approval has long been a point of scientific debate (Kim et al., 2016; Global TestNet, 2018; Silkin et al., 2018; Reavie & Cangelosi, 2020). The *ETV Protocol,* which outlines the methods required to evaluate BWMS during land-based and shipboard type approval testing, may need to be adapted for Great Lakes water quality, biology, and the operational realities of the Great Lakes fleet.

In a recent publication by Reavie & Cangelosi (2020), the relevancy of land-based type approval test requirements to the Great Lakes are discussed in the context of ten years of experience with BWMS testing. Reavie & Cangelosi (2020) state that requirements related to protists are especially problematic because of the stark difference between the protist challenge condition requirement and the reality of the Great Lakes ecosystem. The focus of this publication is on the requirement that ballast uptake during land-based testing must have at least 1000 cells/mL of organisms ≥10 µm and <50 µm in minimum dimension (U.S. EPA, 2010). This size class of organisms, the majority of which are protists, is dominated by phytoplankton. Within the Great Lakes, protists are abundant in the ecosystem, forming the basis of the food web. However, the proportion of protist propagules (either free-living cells or cells that are part of a larger colony) larger than 10 µm *in minimum dimension* is low. Protists in the Great Lakes System are composed of many genera of colonial forms, and although the entities themselves are well over 10 µm, the cells that comprise the entities are often less than 10 µm *in minimum dimension*. Figure 5 presents data from samples collected at the Montreal Pier Facility (Superior, WI) in 2013, which shows the abundance of protists in the St. Louis River Estuary of Lake Superior, and the low proportion of those protists that fit the strict definition of the size class. Protist densities ranged from 1,000 to 6,000 cells/mL, however, the proportion of that population fitting the strict definition of the size class was always less than 1,000 cells/mL (Figure 5). This trend extends from Lake Superior to the Great Lakes System. As demonstrated in Great Lakes monitoring data from 2001 – 2015, protist densities are very clearly abundant throughout the Great Lakes System, averaging well over 1000 cells/mL with a maximum density of greater than 5000 cells/mL, in samples collected in the months of April and August (n = 2145 samples; Reavie & Cangelosi, 2020). Figure 6 from Reavie & Cangelosi (2020), shows the distribution of protist cell sizes (by density) in Great Lakes monitoring samples, and clearly demonstrates that most of the propagules within these samples are <10 µm in minimum dimension.

In order to evaluate BWMS in the Great Lakes System according to the *ETV Protocol* requirements, a substantial proportion of the protist population is not counted (i.e., all of the cells in the grey-shaded area in Figure 5, as well as all of the "small" cells and some of the "transitional" cells in Figure 6 would be present in ballast water samples but ignored). The result is that during type approval testing, the impact of ballast water treatment is not being evaluated against these organisms, which include genera that produce harmful algal blooms (e.g., *Microcystis* and *Dolichospermum*; Figure 7). Effects of BWMS should be measured against a much larger proportion of the Great Lakes protist population than is

currently required. Effects of BWMS against microcystin-producing cyanobacteria should be measured, especially considering the impact of the microcystin toxin on the Great Lakes region's drinking water supply.

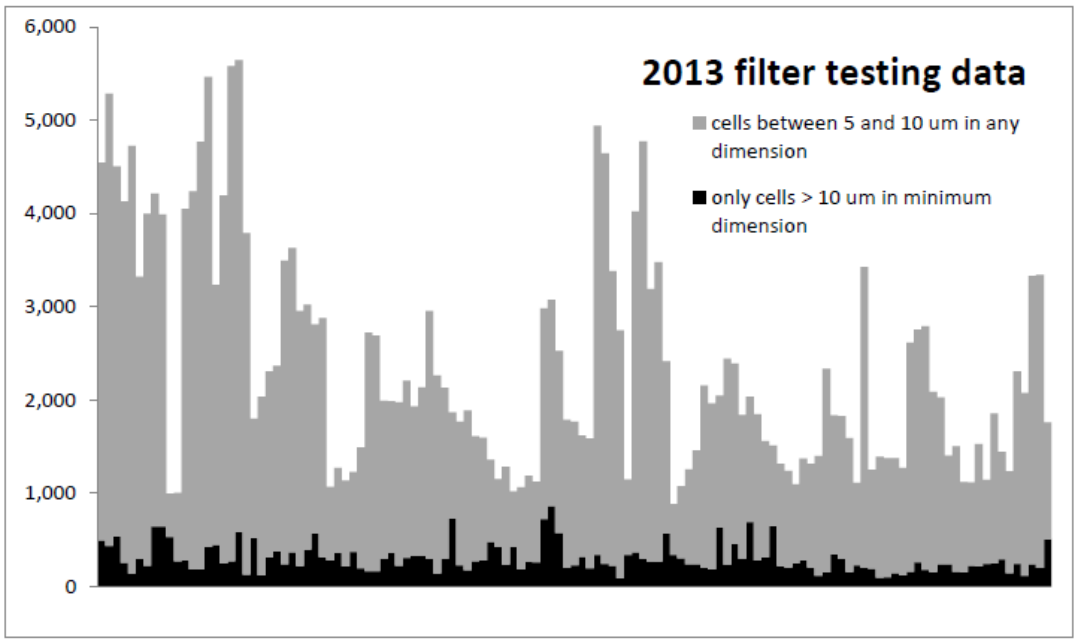

Figure 5. Protist Densities (cells/mL) in Samples Collected from Montreal Pier Facility in Summer 2013 (Author Credit: Euan Reavie, 2013). Grey-Shaded Areas Representing Density of Protist Propagules ≥5 µm in any Visible Dimension and Black-Shaded Areas Representing Density of Protist Propagules ≥10 µm in Minimum Dimension. Samples are ordered by sample time and date.

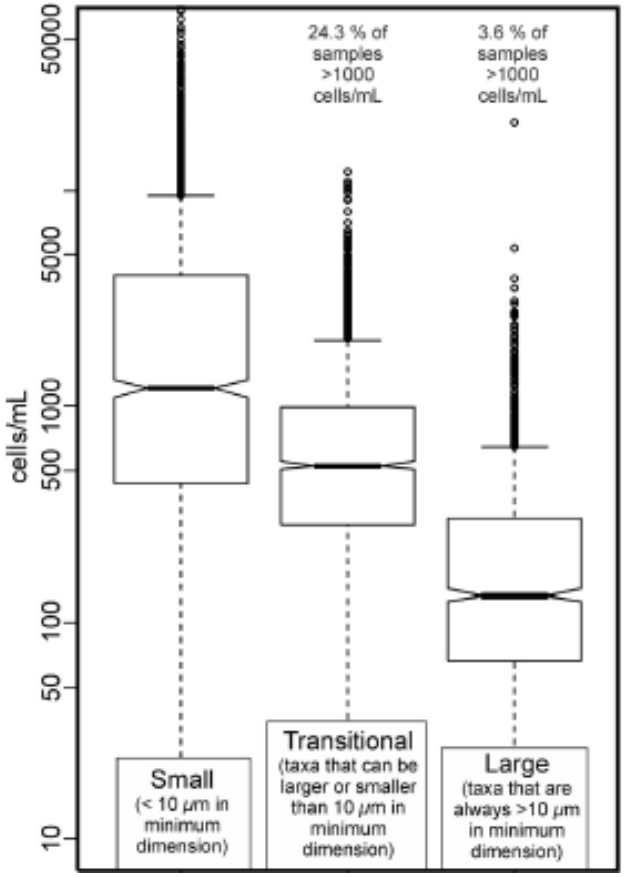

Figure 6. Figure from Reavie & Cangelosi (2020) Showing the Protist Cell Size Distribution, by Density, in Samples Collected over 14 Years throughout the Great Lakes. Boxes Represent the Lower and Upper Quartiles, Whiskers Represent the 1.5 Interquartile Distance from the Lower and Upper Quartiles, and Small Circles are Outliers.

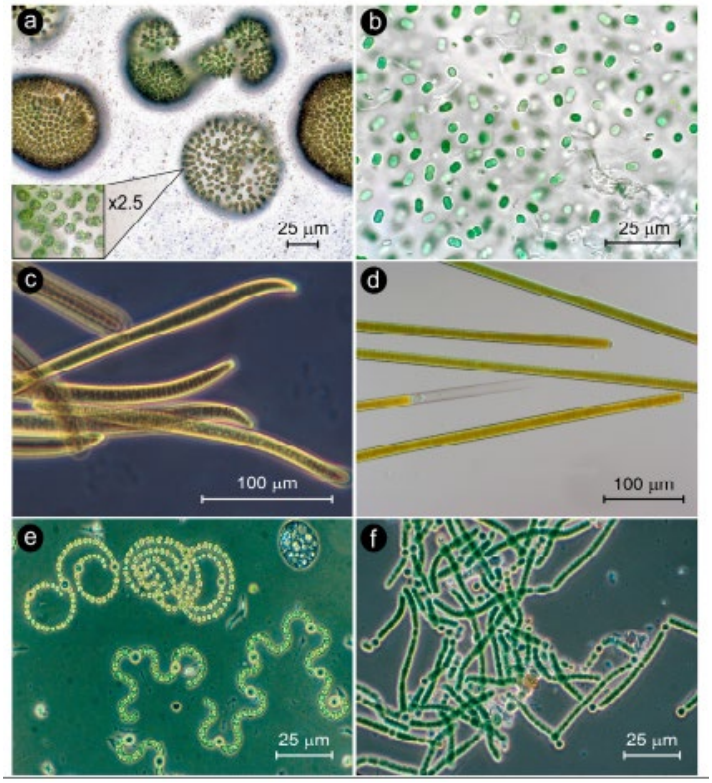

Figure 7. Photomicrographs (Paerl, 2018) of Coccoid and Filamentous Cyanobacteria Genera (a) Woronichinia sp.; (b) Synechococcus sp.; (c) Oscillatoria sp.; (d) Lyngbya sp.; (e) Dolichospermum sp.; (f) Nodularia sp.

Moreover, this strict size class definition necessitates augmentation to increase the density of those few cells that are ≥10 µm in minimum dimension. Augmentation also increases the density of cells that do not fit the size class definition, compounding the number of protists that are present in samples but ignored during testing. The *ETV Protocol* was designed to evaluate BWMS under water quality and biology conditions that represent "extreme, but not rare, natural environmental conditions" (Hunt et al., 2005). However, current challenge condition requirements for protists, which are required to be measured on the minimum dimension, necessitate augmentation to such a degree that the original objective of the *ETV Protocol* (i.e., challenging but not rare natural environmental conditions) is difficult to achieve. Conversely, the water quality challenge condition requirements are likely underrepresenting the extreme, natural conditions within Great Lakes commercial ports.

The projects outlined in Research Area 2 allow for the development of a Great Lakes-adapted, "ETV-like" testing protocol for BWMS with application in the Great Lakes System and beyond, as these methodologies will have application to freshwater systems globally.

A. Research Approach and Objectives

Research Area 2 will consist of a data-gathering phase, followed by a decision-making phase that will lead to land-based and shipboard testing protocols that are consistent with many aspects of the *ETV Protocol*, but are adapted for Great Lakes vessel operational characteristics and Great Lakes biology and water quality conditions. The newly developed Great Lakes-adapted protocol will be used to evaluate market-available BWMS during both land-based and shipboard testing.

Objective 1: Characterizing BWMS Challenge Conditions in the Great Lakes System

Key Questions:

1. **What are the ranges of living organism densities/composition and water quality parameters found within Great Lakes commercial ports where cargo off-loading/ballasting occurs?**
2. **Given data from #1, are the minimum challenge condition requirements specified in the *ETV Protocol* appropriate (i.e., challenging, but not rare natural environmental conditions) for evaluating BWMS performance in the Great Lakes?**

The first objective will be accomplished through a five-year project. Through an examination of publicly-available data on Laker vessel trade patterns, including ballast water uptake and discharge locations and ballast volumes, and the "connectedness" of ports within the Great Lakes shipping network (Kvistad, 2019), a list of priority commercial ports for which monitoring data are needed will be generated. For each port, biological and water quality data relevant to BWMS performance will be sourced from existing literature (e.g., peer-reviewed and published data, publicly available databases, technical reports). A call for existing data collected from Great Lakes commercial ports will be sent to members of the stakeholder working group (see "Stakeholder Involvement" section, Objective 2). Water quality samples will be obtained during ship sampling events in support of the shipboard evaluation of the effectiveness of IMO compliant and USCG type approved BWMS, but in order to get spatial and temporal data for priority ports given the unpredictability of ship schedules data will be generated through sample collection and analysis. In some cases, there may be existing monitoring programs (e.g., implemented by U.S. Geological Survey, Army Corps of Engineers, U.S. Fish and Wildlife Service, and/or state and local agencies) that could add the parameters of interest to their current monitoring program. This option will be explored during stakeholder group meetings. For those ports for which there are insufficient data, a port-specific monitoring plan for Great Lakes uptake ports which have the highest ballast water volume will be developed to augment data for the parameters of interest listed below, frequency of collection per port, and analysis methods. Monitoring will take place quarterly at a minimum over the course of multiple Great Lakes shipping seasons (i.e., approximately late March to early January) to capture variations at each location in biology and water quality as a result of seasonal trends and weather events. Sampling will take place from within identified priority commercial ports or from ballast water uptake while a vessel is off-loading cargo in these ports.

- Biological parameters of interest:
    - Zooplankton taxonomy and size distribution
    - Protist taxonomy, functional form, and size distribution
        - Proportion of population comprised of single-cell forms
        - Proportion of population comprised of multicellular entities, including cyanobacteria and harmful algal bloom
- Water quality parameters of interest:
    - Temperature
    - Salinity/specific conductivity
    - Dissolved oxygen
    - pH
    - Turbidity
    - Total suspended solids

- Dissolved organic carbon
  - Composition
- Transmittance of ultraviolet light at 254 nm
- Particulate organic matter
  - Composition
- Mineral matter

For each parameter of interest, project partners will be identified to implement sample collection and/or analysis. For example, microbiology experts may assist with identification of Great Lakes-relevant pathogen indicator organisms. Monitoring data will be incorporated into an online, publicly available Great Lakes Commercial Port Database developed by GWRC.

Objective 2: Development of a Great Lakes-Adapted Protocol for Verification of BWMS

Key Question: What changes to the existing *ETV Protocol* are appropriate for its use to evaluate BWMS effectiveness for Great Lakes vessels?

Objective 2 is the decision-making phase of Research Area 2, wherein, the results of Objective 1 will be evaluated to determine adaptations that would be needed to the existing *ETV Protocol* to ensure Great Lakes applicability. Decision points will include:

- Biological challenge condition criteria, including organism type and size
- Water quality challenge condition criteria
- Alternative/emerging viability assessment methods
- Environmental acceptability methods and pass/fail criteria

The results from Objectives 1 and 2 will be communicated to the stakeholder group members, along with the science-based recommendations for Great Lakes revisions to the freshwater testing requirements in the *ETV Protocol*. Recommendations will be made solely by the project principal investigators in cooperation with MARAD. The stakeholder group will be given an opportunity to comment on recommendations and protocol development, and comments will be considered prior to finalization of the revisions. The deliverable from this project will be recommendations for inclusion into a revision to the current *ETV Protocol* that captures Great Lakes realities (R&D Plan Deliverables).

B. Timeline

Figure 8 outlines the planned timing for each of the projects described for Ballast Water R&D Plan Research Area 2. This figure includes the timing of the Great Lakes-adapted ballast water treatment technology testing protocol.

Research Area - Project	Project Description	Year 1 10/1/20 - 9/30/21	Year 2 10/1/21 - 9/30/22	Year 3 10/1/22 - 9/30/23	Year 4 10/1/23 - 9/30/24	Year 5 10/1/24 - 9/30/25	Year 6 10/1/25 - 9/30/26	Year 7 10/1/26 - 9/30/27
Research Area 2: Toward Development of Great Lakes Relevant BWMS Testing Protocol								
2 - 1	Characterize BWMS Challenge Conditions							
2 - 2	Protocol Freshwater Revision and Validation							

Figure 8. Timing, by Federal Fiscal Year, of Projects Implemented under Research Area 2 of the Great Lakes Ballast Water R&D Plan.

III. RESEARCH AREA 3: ASSESSING THE RISK OF AQUATIC NUISANCE SPECIES TRANSFER FROM BALLAST WATER DISCHARGE

Determination of acceptable environmental risk associated with Great Lakes ballast water discharges is a daunting task given the complexities associated with ANS establishment. Focused monitoring efforts within the Great Lakes are necessary to better understand propagule pressure (i.e., number of ANS) in Laker vessel ballast water discharge. The U.S. Coast Guard and Smithsonian Environmental Research Center (SERC) have been sampling ballast water on vessels within established "sentinel sites" for several years. The current sentinel sites are in Chesapeake Bay, Tampa Bay, and San Francisco Bay. The Coast Guard is working toward identifying one or more of these sentinel sites within the Great Lakes System. Ballast water monitoring at established focal ports within the Great Lakes facilitates the collection of critical data on propagule pressure, which is one step toward determining the probability of ANS establishment (Figure 9). Research has shown that the number of species released in ballast water (i.e., colonization pressure) is greatly affected by die-off of more sensitive species during voyage time, reducing the number of species discharged to only those most tolerant of selection pressures within a ballast tank (Briski et al., 2012). Monitoring conducted at the Great Lakes sentinel sites would add to current scientific knowledge of colonization pressure in ballast discharge, and the relationship between propagule pressure and colonization pressure. In 2008, the U.S. EPA conducted a modeling effort to determine the Great Lakes ports at greatest risk for invasion, and concluded that the ports of Toledo, Ashtabula, and Sandusky, OH; Gary, IN; Duluth, MN; Milwaukee and Superior, WI; and Chicago, IL were priority ports for monitoring efforts (U.S. Environmental Protection Agency, 2008). More recent modeling efforts have found that indegree centrality, or the degree of "connectedness" between ports, is perhaps an even more important factor determining the secondary spread of ANS within the Great Lakes than ballast water discharge volume (Kvistad, 2019). This study determined the top ten most central ports within the Great Lakes are: Superior, WI; Cleveland, OH; Detroit, MI; Two Harbors, MN; Sandusky, OH; Toledo, OH; Marquette, MI; Calcite, MI; Duluth, MN; and Ashtabula, OH (Kvistad, 2019). These two studies, along with other historical data, will be used to prioritize the ports for which Great Lakes sentinel sites should be established.

The question of how much the probability of ANS establishment is reduced given a commensurate reduction in viable organism densities in ballast water, i.e., through ballast water management, can be answered in part using semi-field (mesocosm) experiments (Aliff et al., 2018; Branstrator et al., 2019). In a mesocosm study conducted in 2013, the freshwater phytoplanktonic diatom *Melosira varians* was used as a surrogate to determine the risk-release relationship in multiple freshwater trials, and it was determined that the inoculation density (a proxy for propagule pressure) needed for *M. varians* establishment was approximately 12 cells/mL (Aliff et al., 2018). Aliff et al. (2018) suggest additional experiments be conducted with a variety of organisms and conditions to better understand the risk-release relationship. A mesocosm study conducted in 2015 using the nonindigenous and invasive zooplankter *Bythotrephes longimanus* (now *Bythotrephes cederströmii*) concluded that inoculation density was the best predictor of *B. longimanus* reproductive output (a proxy for establishment; Branstrator et al., 2019).

While the endpoint of mesocosm experiments may provide context to a numerical discharge standard (Aliff et al., 2018 and Branstrator et al., 2019), defining an acceptable level of environmental risk for

ballast discharges in the Great Lakes System may or may not include the use of a numerical discharge standard. A holistic, integrated approach is needed to assess the incredibly complex question of how effective a given ballast water management practice or approach must be to achieve an acceptable level of ANS reduction (decreased propagule pressure) in ballast water discharges. Research Area 3 presents an opportunity to tie all of the projects conducted in this R&D Plan together.

A. Research Approach and Objectives

Objective 1: Establishment of Great Lakes Focal Sites to Determine Interlake Transfer

Key Questions:

1. **What is the risk of ANS interlake transfer via ballast water?**
2. **What is the relative ANS loading associated with various vessel voyage patterns within the Great Lakes, and are there significant differences that may warrant different technologies or practices for these different situations?**

Research Area 3 will supplement the efforts already initiated by the U.S. Coast Guard and SERC, who have received funding from U.S. EPA Great Lakes Restoration Initiative to establish several sentinel sites within the Great Lakes from which ballast water will be sampled from Great Lakes vessels. The first step in this project will be development of a plan for collaboration between U.S. Coast Guard/SERC and the agencies responsible for implementing this R&D Plan for identifying appropriate sentinel sites within the Great Lakes System, considering the objectives of the current U.S. Coast Guard/SERC effort and the objectives described in this R&D Plan. Other potential project collaborators will be identified during collaboration planning.

Once the focal ports have been identified and implemented by U.S. Coast Guard/SERC, ballast water monitoring will take place using the methodology already established. GWRC will monitor crustacean zooplankton diversity and associated abiotic conditions at four Great Lakes shipping ports that are at high risk for interlake ballast water transfer by Lakers. The focal ports will include the ports of Duluth-Superior (Minnesota and Wisconsin), Marquette (Michigan), Toledo (Ohio), and Two Harbors (Minnesota). This monitoring will produce contemporary information on ANS detection while concurrently creating a baseline of taxonomic and ecosystem information against which future monitoring results can be compared. Zooplankton taxonomists at LSRI are skilled in identifying non-indigenous zooplankton in Great Lakes samples, and will analyze zooplankton samples using a methodology from previous ballast water monitoring projects (Cangelosi et al., 2018) to identify the non-indigenous zooplankton in these samples.

Objective 2: Using Semi-Field Methodologies to Determine the Impact of ANS Reduction in Managed Ballast Water

Key Question: Using existing semi-field methodologies and a variety of freshwater taxonomic groups, can the impact of ANS reduction in Great Lakes ballast water be determined under a variety of scenarios?

This objective will be addressed through a multi-year project that utilizes existing mesocosm methodology (Aliff et al., 2018 and Branstrator et al., 2019) to better understand the risk-release

relationship in a variety of freshwater organisms and under a variety of biotic and abiotic conditions. A series of mesocosm experiments will take place at the Montreal Pier Facility (Superior, WI). Researchers with expertise in invasion ecology will be critical project partners during design and implementation of this project and will assist with selection of planktonic organisms that will function as surrogate invaders. A total of 22, one-cubic meter mesocosms (for invertebrate surrogates) and a corresponding set of 20-L mesocosms (for protist surrogates) will be used for each risk-release relationship experiment. The mesocosms are in a laboratory building at the Montreal Pier Facility that is climate and light controlled. The mesocosms will be filled simultaneously with water pumped from the Duluth-Superior Harbor. The water quality and biology (i.e., native organism concentration and composition) conditions of the water used to fill the mesocosms will be determined. The selected surrogate invader for each experiment will be added to the mesocosms in varying densities, above and below the current national ballast water discharge limits for organisms ≥50 µm or ≥10 µm and <50 µm. During each experiment, mesocosms will be regularly subsampled for surrogate and community analysis, and water quality will be measured using a multiparameter water quality sonde. At the conclusion of each experiment, reproduction of the surrogate invader (i.e., establishment) will be measured by analyzing samples collected during the life of the experiment to determine the dynamics of the surrogate invaders. In addition, the water quality and biological (i.e., native organism concentration and composition) conditions will be measured.

The data gathered during these mesocosm experiments will provide context to the ANS data gathered from the *Quantifying ANS Transfer Project*. Propagule pressure, as estimated from focal port area monitoring, will be combined with the mesocosm data for establishment probability of a variety of taxa (like Figure 9). These data will be evaluated in the context of the biological efficacy of a variety of ballast water management options investigated through this R&D Plan. Given all these datasets, the ability to approximate the impact of various management strategies on the risk of ANS transfer through Great Lakes ballast water can be modeled.

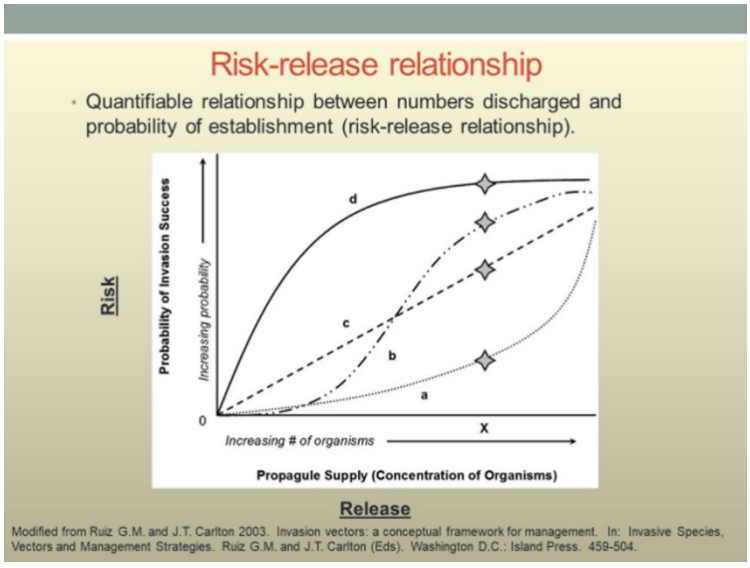

Figure 9. Risk-Release Relationship Curves as Modified from Ruiz and Carlton (2003).

B. TIMELINE

Figure 10 outlines the planned timing for the research projects described in Ballast Water R&D Plan Research Area 3.

Research Area - Project	Project Description	Year 1 10/1/20 - 9/30/21	Year 2 10/1/21 - 9/30/22	Year 3 10/1/22 - 9/30/23	Year 4 10/1/23 - 9/30/24	Year 5 10/1/24 - 9/30/25	Year 6 10/1/25 - 9/30/26	Year 7 10/1/26 - 9/30/27
Research Area 5: Assessing the Risk of Aquatic Nuisance Species Transfer from Ballast Water Discharge								
3 - 1	Quantifying ANS Transfer			[redacted]				
3 - 2	Determining Impact of ANS Reduction	[redacted]						

Figure 10. Timing, by Federal Fiscal Year, of Projects Implemented under Research Area 3 of the Great Lakes Ballast Water R&D Plan.

IV. PROGRAMMATIC CAPABILITY AND PAST PERFORMANCE

MARAD was established in 1950 and is responsible for the waterborne transportation system in the U.S. (maritime.dot.gov). MARAD's mission is to foster and promote the U.S. Merchant Marine and the U.S. maritime industry, and to strengthen the maritime transportation system, including commercial ports, shipbuilding, and labor. MARAD's Office of Environment supports ballast water and hull fouling research, ballast water treatment, compliance technology development and testing, among many other maritime environmental issues. This support has included the design, development, and improvement of ballast water treatment testing facilities in the U.S., including the only facility located within the Great Lakes, the Montreal Pier Facility located in the Port of Superior, WI (formerly the Great Ships Initiative Research, Development, Testing, and Evaluation Facility).

The UWS-LSRI (uwsuper.edu/lsri) was formed in 1967. Its mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities. LSRI established an independent Quality Management System (QMS) in 1991 and is committed to a comprehensive quality assurance (QA) and quality control (QC) program in its environmental data operations. The LSRI QMS is based on U.S. EPA requirements as outlined in the *Quality Assurance Project Plan Standard*, Directive # CIO 2105-S-02.0 (U.S. EPA, 2023). LSRI's environmental data operations must adhere to the requirements outlined in the LSRI Quality Management Plan. The QA requirements of each project are met by the cooperative effort between project management and project staff.

MARAD's relationship with UWS-LSRI began more than 10 years ago, as many LSRI staff worked on ballast water research and technology testing projects conducted under the Great Ships Initiative (Northeast-Midwest Institute; Washington, DC). In 2017, MARAD and LSRI entered into a Cooperative Agreement, the purpose of which is to support the evaluation and verification of ballast water treatment technologies and other green shipping initiatives. As a result of this agreement, GWRC was born (https://www.uwsuper.edu/academics/research-and-innovation/lake-superior-research-institute/gwrc/). GWRC is devoted to conducting high-quality environmental research and providing independent testing services to support green shipping and promote the sustainable industrial, commercial, and public use of the great freshwater bodies of the world. The GWRC is comprised of

experienced researchers with diverse expertise; the team has more than 15 years of experience working together on ballast water research within the Great Ships Initiative and now LSRI's GWRC. GWRC is lead and managed by LSRI, with engineering services provided by AMI Consulting Engineers P.A. and protist ecology and taxonomy services provided by researchers from the Natural Resources Research Institute at the University of Minnesota-Duluth.

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Appendix A. Stakeholder Comments on Great Lakes Ballast Water R&D Plan, Version 5

16 May 2023

Mark Riggio Comments on R&D Plan, V.5

RESEARCH AREA 1: IDENTIFICATION OF METHODS/ALTERNATIVES AND ASSESSMENT OF COST FOR GREAT LAKES BALLAST WATER MANAGEMENT

Objective 1: Determination of Operational Characteristics of Commercial Vessels Trading within the Great Lakes System

Project 1: Determining Operational Characteristics of Great Lakes Vessels (Year 1)

1. What are the typical (and more challenging) ballasting operational characteristics of United States and Canadian flag commercial vessels that trade within the Great Lakes?

Suggestions / Comments

The focus of this research is existing data and record reviews of publicly available data (National Ballast Information Clearinghouse), however this will result only in learning what the current, normal operational parameters for vessels operating in the Great Lakes are. It does not account for potential non-invasive changes to normal ballasting practices that can influence and improve the protection against the spread of invasive species (i.e.: reduced ballast rates, pre-ballasting operations or delaying ballasting in challenging ports, potential shifts in ballast times due to estuary conditions, etc.).

This also relies on reported data, rather than onboard operational observations and crew interviews to help determine critical areas of ballast management that need to be accounted for.

I would suggest that the program would greatly benefit from a directed, purposeful visit to each vessel in the confined Great Lakes fleet to witness a ballast and deballast operation and determine through onboard records, operational data, and crew interviews, the true nature of the challenges and needs of the vessels for ballasting. This onboard attendance could also be used to capture water quality data (see Research Area 2, Project 1) directly from the ballast pump, to be shipped back to a centralized location, where it could be analyzed without bringing the water quality test equipment to the vessel for each attendance.

Objective 2: Land-Based Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

Project 2: Land-Based BWMS Evaluation (Year 1-3, 5, 6)

1. Are there existing BWMS available on the global market (either type-approved under the IMO Convention or by the U.S. Coast Guard) that can treat Great Lakes ballast water effectively to meet the current U.S. discharge standards using existing test methods (i.e., Generic Protocol for the Verification of Ballast Water Treatment Technology; U.S. EPA, 2010)?

Suggestions / Comments

VIDA requires the development of a viability method for assessing the effectiveness of BWMS and specifically requires a methodology that does not use a stain (i.e. ETV Protocol). Within this research area there is a clear omission of testing existing BWMS available on the global market utilizing the testing protocols accepted by the IMO for assessing the effectiveness of BWMS in reducing the potential for ANS invasions (especially those approved under the IMO Convention, and specifically the BWM Code, MEPC.300(72)). Not testing using both methodologies (ETV Protocol and MEPC.300(72)) has the strong potential of negating a potential answer to the challenges of Great Lakes water for systems which are designed to be assessed using viability (i.e. UV-based systems).

I would suggest that in addition to measuring the effectiveness of systems in accordance with the "existing test methods" (i.e.: ETV Protocol), this research area should focus on assessing the effectiveness of systems using both existing test methods (IMO and ETV) and use this to inform the assessment of a viability methodology for assessing the effectiveness of BWMS as required by VIDA as well as to establish the relative effectiveness of each test methodology in assessing a BWMS' ability to significantly reduce the spread of ANS. This point also has direct bearing on Research Area 2, Projects 2, 3, and 4.

2. When evaluated at a land-based scale using the newly developed, Great Lakes-adapted protocol (see Research Area 2, Objective 3), how do these BWMS perform? A. What is the level of ANS reduction that can be achieved in the Great Lakes based on land-based testing?

Suggestions / Comments

Similar to my comments above, I would suggest that in addition to measuring the effectiveness of systems in accordance with the "existing test methods" (i.e.: ETV Protocol), this research area

should focus on assessing the effectiveness of systems using both existing test methods (IMO and ETV) and use this to inform the assessment of a viability methodology for assessing the effectiveness of BWMS as required by VIDA as well as to establish the relative effectiveness of each test methodology in assessing a BWMS' ability to significantly reduce the spread of ANS.

Objective 3: Shipboard Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

Project 3: Shipboard BWMS Evaluation (Year 1-3, 5, 6)

1. Are there existing BWMS available on the global market (either type-approved under the IMO Convention or by the U.S. Coast Guard) that can treat Great Lakes ballast water effectively to meet the current discharge standards using existing test methods (i.e., ETV Protocol), and two approaches: a. Conducting shipboard BWMS trials onboard Laker vessels in a variety of different Great Lakes commercial ports and over at least one Great Lakes shipping season. B. Sampling ballast uptake and discharge of seagoing vessels with installed BWMS that are trading within the Great Lakes System.

Suggestions / Comments

My comments on this item are identical to Research Area 1, Project 2.

2. When evaluated at a shipboard scale using the newly developed, Great Lakes-adapted protocol, how do these BWMS perform? A. What is the level of ANS reduction that can be achieved based on shipboard testing?

Suggestions / Comments

My comments on this item are identical to Research Area 1, Project 2.

Objective 4: Evaluating the Effectiveness of Ballast Water Best Management Practices Including Hybrid Solutions

Project 4: Ballast Water Filter Performance (Year 2, 3)

1. Can filtration technologies and practices be improved for ballast water management in the Great Lakes?

Suggestions / Comments

Has there been any studies done on the viability of organisms for transfer as ANS in temperatures >1° C? It would seem that if there was data gathered under Research Area 2, Project 1 that indicated that once water temperatures had dropped below a certain level that filtration and potentially BWMS operation could be suspended due to the lack of viable organisms in the water and this would potentially assist with the known issues with BWMS in extreme temperatures. Recommend that this be a point of focus for Research Area 2, Project 1.

Project 5: Ballast Water BMP Effectiveness (Year 2 – 4)

2. What are the efficacies of potential, promising BMPs in reducing the concentration of ANS in ballast water discharge within the Great Lakes?

This project appears to be missing from the R&D Plan Rev. 5. The plan appears to go from Objective 4, Project 4 directly to Objective 5, Project 6. Has this project been canceled or delayed? If not, would the committee welcome a project plan for this item?

Objective 5: Evaluating the Feasibility and Significant Impacts of Ballast Water Reception Facilities within the Great Lakes

Project 6: Feasibility Study of Reception Facility Treatment (Year 2)

1. What is the feasibility, economic, and environmental impact of reception facilities if utilized within the Great Lakes under certain scenarios or locations?

Suggestions / Comments

During the recent stakeholder meeting, it was additionally noted that the flow rates of ballast systems on Great Lakes vessels can be very high and it can be challenging to pipe ballast water from a shore-based facility onto or off of a vessel using existing infrastructure at each port where a vessel may trade. Therefore the cost of implementing a reception or ballast water supply facility may be very challenging in the Great Lakes.

Each type of BWMS has limitations on it's operations. UV systems are constrained by UV Transmissivity, turbidity, and the need to pass the CMFDA/FDA stain assessment within 6 hours of discharge. Heat systems are limited by the available onboard waste heat, particularly in port. Chemical injection systems are limited by the disinfection byproducts generated in fresh water and by necessary hold times. Inert gas systems are limited by Lakers not having an inert gas

generator onboard. Electrochlorination systems are limited by the absence of salt water to use for the creation of the disinfectant as well as hold times.

I would suggest that potentially it is much simpler to supply a brine supply through a much smaller pipe, and at much lower quantities, to vessels that utilize a slip-stream electrochlorination system and that by supplying this brine solution, it may be practical and possible for these IMO and USCG type approved systems to function normally on the Great Lakes, even with the shortened voyage times. Positioning of a few centralized brine loading stations or brine-loading barges may assist with the distribution across the multitude of ports in the Lakes, allowing vessels that are unable to load enough brine before entering the Lakes to top up their brine supplies at various locations convenient to their normal trading routes, regardless of the location of the final port of call.

I believe that under this project, this would be a much more practical solution to the question of whether or not reception facilities could be installed in the Great Lakes.

Objective 6: Assessing the Cost of Ballast Water Management Strategies on Commercial Vessels Operating Exclusively within the Great Lakes System

Project 7: Management Strategy Cost (Year 5, 6)

1. How do ballast water management strategies compare in terms of ANS reductions and cost for installation and operation?

No comments on this section.

RESEARCH AREA 2: TOWARD DEVELOPMENT OF GREAT LAKES RELEVANT BWMS TESTING PROTOCOL

Objective 1: Characterizing BWMS Challenge Conditions in the Great Lakes System

Preamble

Suggestions / Comments

In the preliminary write-up for this section, there are two primary assertations regarding the challenge of ANS in the Great Lakes:

1. Many protists are below 10 um in minimum dimension (even though they may be much larger than 10 um in MAXIMUM dimension); and

2. Resting-, larval-, and egg-states all create boundaries to assessing whether or not an organism is living during type approval and discharge testing

Both of these issues are relevant because the ETV Protocol specifies that a CMFDA/FDA stain combination be used to assess whether an organism is living or not. During the assessment of the fluorescence which is the principle means of establishing "living", organisms are scored based on size by the evaluator. This evaluator then eliminates any organisms which do not meet the minimum size dimension of the discharge standard. Additionally, the use of motility (both in addition to staining, and for non-staining organisms) as an assessment of "living" precludes the evaluation of organisms in a resting or dormant state of being assessed as living. Lastly, as the CMFDA/FDA stain method damages organisms, it requires the assessment of all ballast water samples within 6 hours of collection. Therefore, organisms in a larval or egg state will have no time to incubate or grow and potentially be assessed as a living organism.

As outline above under my comments for Research Area 1, Project 2, the IMO-approved MPN method for assessing organism viability does not have any of these limitations. Organisms in the assays are not measured for minimum dimension, but instead are simply scored if they are captured in the 10 µm collection nets. As is well known, these capture techniques may capture organisms with minimum dimensions smaller than 10 µm provided their largest dimension is greater than or equal to 10 µm. Additionally, as MPN assays are developed from ideal growth media and are incubated over an extended time, organisms in a resting state, larval state, or in an egg-state will have time to fully mature, recover, or reanimate and be scored as viable.

I would suggest that much of this section becomes less critical if a viability assessment which allows time for growth, does not eliminate organisms based on the minimum dimension, and does not allow short-term resting periods to prevent mobility is used and accepted for assessment of the effectiveness of BWMS on the Great Lakes.

Project 1: Characterize BWMS Challenge Conditions (Year 2)

1. What are the ranges of living organism densities/composition and water quality parameters found within Great Lakes commercial ports where cargo offloading/ballasting occurs?

2. Given data collected for #1, are the minimum challenge condition requirements specified in the ETV Protocol appropriate (i.e., challenging, but not rare natural environmental conditions) for evaluating BWMS performance in the Great Lakes?

Suggestions / Comments

Recommend adding assessment of organism density and viability under 1°C to assess whether BWMS and/or filtration operation could be suspended once water temperatures reach this threshold. See comments in Research Area 1, Project 4.

Objective 2: Evaluating Alternative/Emerging Sample Analysis Methods for Ballast Water Treatment Technology Testing

Project 2: Viability Assessment Method Development (Year 1-2)

1. What are the potential emerging or alternative viability assessment methods for BWMS biological efficacy evaluation, and how effective are those methods?

A. Are there viability assessment methods that can be utilized for the Great Lakes in order to evaluate treatment effects on planktonic organisms?

B. Is it feasible to implement these methods during land-based evaluation of BWMS?

C. Is it feasible to implement these methods during shipboard BWMS evaluation?

Suggestions / Comments

This section implies the use of USCG VIDA Draft Policy Letter (CG-OES 01-19) as the baseline for establishing the viability methods for assessing BWMS. This document discounts the significant amount of research supplied directly to the Coast Guard regarding the MPN methodology as well as the body of scientific evidence which was used to gain approval of this methodology for international use under the IMO's Ballast Water Management Convention (which applies to over half of the confined Lakers and nearly every vessel trading in the Great Lakes but not permanently confined to the Lakes).

I would suggest that discounting a methodology without scientific evaluation and without a rigorous proof that the methodology is inferior to the proposed methodology (CMFDA/FDA staining as outlined in the ETV Protocol) can have a deleterious effect on ANS protection in the Great Lakes and can have a considerable financial impact on implementation as is being evaluated in Research Area 5, Project 2.

Project 3: Eggs/Resting Stages Method Development (Year 1-2)

2. Are there assessment methods for evaluating the mortality and/or viability of eggs and resting stages of organisms exposed to ballast water treatment?

Suggestions / Comments

See my comments to the preamble to this section above.

Project 4: Ballast Discharge Toxicity Method Development (Year 1-2)

3. Is there a method that can be used to accurately assess the environmental acceptability of treated and neutralized ballast water upon discharge?

a. Is there an adequate benchmark value/environmental acceptability standard that can be used to ensure protection of Great Lakes ports receiving ballast?

b. Is it feasible to implement this method during shipboard BWMS evaluation?

Suggestions / Comments

See my comments to the preamble to this section above.

Objective 3: Development of a Great Lakes Adapted Protocol for Verification of BWMS

Project 5: Protocol Development (Year 4)

1. What changes to the existing ETV Protocol are appropriate for its use to evaluate BWMS effectiveness for Great Lakes vessels?

Suggestions / Comments

As commented previously, I would suggest that this Project specifically assess the applicability of the MPN method to assessing BWMS performance in Great Lakes waters.

RESEARCH AREA 5: ASSESSING THE RISK OF AQUATIC NUISANCE SPECIES TRANSFER FROM BALLAST WATER DISCHARGE

Objective 1: Establishment of Great Lakes Focal Ports to Determine Interlake Transfer

Project 1: Quantifying ANS Transfer (Year 2-4)

1. What is the risk of ANS interlake transfer via ballast water?

2. What is the relative ANS loading associated with the various vessel voyage patterns within the Great Lakes, and are there significant differences that may warrant different technologies or practices for these different situations?

No comments on this section

Objective 2: Using Semi-Field Methodologies to Determine the Impact of ANS Reduction in Managed Ballast Water

Project 2: Determining Impact of ANS Reduction (Year 1-4)

1. Using existing semi-field methodologies and a variety of freshwater taxonomic groups, can the impact of ANS reduction in Great Lakes ballast water be determined under a variety of ballast water management scenarios?

No comments on this section

LAKE CARRIERS' ASSOCIATION

Thank you for the opportunity to comment on the Great Waters Research Collaborative (GWRC) Great Lakes Ballast Water Research and Development Plan, Version 5 to be referenced as R&D Plan in the comments.

General Comments

- Funds for the R&D Plan should only be awarded to U.S.-flagged vessel operators for shipboard testing as U.S. companies have been excluded from the direct award of Canadian research efforts in the Transport Canada Ballast Water Innovation Program (BWIP). This is also consistent with the Administration's Buy America policy and related laws. The Great Lakes and Lake Champlain Invasive Species Program authorized under VIDA calls for research for "vessels operating primarily on the Great Lakes." GWRC is being funded via the EPA and MARAD with Great Lakes Restoration Initiative (GLRI) funds. U.S.-flagged vessels operate exclusively on the Great Lakes, while Canadian vessels operate on the Great Lakes, St. Lawrence Seaway and in many cases the Arctic and East Coast. Canada has also recently announced its Great Lakes Restoration Initiative program. We do not believe American entities will be eligible for funding under that program either. We are also not aware of other GLRI funds being paid to foreign entities for research, restoration, or any other purpose.
- The amount to be awarded from a Request for Proposal (RFP) should not exceed the amount in the announcement unless an additional announcement is made.
- The R&D plan is difficult to read because a lot of extraneous details are included that are not pertinent to the plan. If a full revision is being conducted, more direct text is suggested.
- Re-titling of the Research Areas and Objectives is needed. It is difficult to track Research Area 1 has Objective 3 and Research Area 2 also has an Objective 3. The numbering would either include both items, e.g., Objective 1-3 (for Research Area 1 Objective 3) or have sequential number that does not restart for each Research Area.

Text Specific Comments

- Proposed …Timeline (page 11). The following items should be included in Year 4 of the project:
  - 1-3 Shipboard Ballast Water Management System (BWMS) Evaluation
  - 2-1 Characterize BWMS Challenge Condition
  - Timelines may need to be updated throughout.

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- **Stakeholder Group Involvement (pp. 13-15)**:
  - Objective 1: The GWRC needs to be consistent with those included in the Stakeholder Group. Both the Lake Carriers' Association (LCA) and Chamber of Marine Commerce (CMC) need to be included as representatives of the impacted shipping community. Also, any shipowners with vessels included in research projects should be included. The most recent meeting (May 2023) included these shipowners but only after requests were made.
  - Objective 2: LCA has not seen or been part of any meetings specifically addressing "formation of data" but should be included in the data working group as identified in the text. LCA has provided some of the GWRC researchers with reports and U.S.-fleet-wide data applicable to this research. GWRC also needs to follow the listed frequency (i.e., twice per year) of the meetings.
  - Objective 3 also states that meetings will be held twice each year, but this has not occurred. LCA supports maintain the listed frequency of meetings so that issues are addressed in a timely manner.
  - A project plan listing meetings and sampling events would allow all stakeholders to be engaged in the R&D efforts and adequately plan for events.
- **Data Management, Sharing, and Availability (p. 16-17)**:
  - B. Project Data Sharing and Availability – R&D Plan Stakeholder Group Organizations. GWRC needs to improve data sharing with the R&D project participants because too much time elapses between data gathering and reporting for the longer-term R&D projects, i.e., shipboard testing participants. Ship crews frequently change and any comments or questions about the sampling event should be addressed by the crew who were present for the event. Therefore, a third group to be included should be "R&D Participants". This should be the first group listed then followed by the "Stakeholder Group" and followed by "General Public". Short summaries need to be provided to the R&D participants within two weeks of a distinct sampling event. The R&D participants also should review and approve any data taken from their vessels that will be presented to the "Stakeholders Group" and the "General Public". The R&D participants should be given at least two weeks to review the data. This review is to ensure that GWRC and the R&D participant agree on the data to be presented.
- **Research Area 1 (pp. 18-28)**:
  - The LCA disagrees with the five categories of vessels listed and recommends the following the five categories that LCA has consistently presented to the U.S. Environmental Protection Agency (EPA) and Great Lakes States:
    - 1,000-foot long vessel with large capacity manifolded ballasting system
    - 1,000-foot long vessel with large capacity independent ballasting system
    - 690-foot to 806-foot converted bulkers to self-unloaders with a manifolded ballasting system
    - 500-foot to 800-foot newer build self-unloading ships and barges with a manifolded ballasting system
    - Purpose-built barges with a manifolded ballasting system
  - The reasons for this recommended change are:
    - Differentiates between independent and manifold ballasting systems - this is crucial for operation of the vessel and integration of any technology.

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    - Does not differentiate between operating patterns. The GWRC group assumes that vessel size is limiting or determining the vessel operating pattern. This is incorrect. LCA members operate in ports where the cargo is available. Larger vessels may have some limitations due to ports, but intermediate or smaller capacity vessels will operate through the Great Lakes including Lake Superior.
    - Aligns with the technical challenges of a technology based standard required by the U.S. EPA for future regulations.
- GWRC should also evaluate operation into Lake Ontario because this could be a more significant vector for movement of invasive species through the Great Lakes.
- Regarding the statements of BWMS testing in the Great Lakes. In 2018, no BWMS received USCG type approval that was tested in the U.S. While Ms. Cangelosi was part of the team testing the Evoqua SeaCURE BWMS, U.S. Coast Guard (USCG) type approval was not issued until June 2021. The USCG does not release any BWMS testing reports, so no reports of the testing can be found. The Evoqua SeaCURE BWMS has not undergone BWMS Code type approval so no data on the type approval testing is available. The Evoqua SeaCURE BWMS is also no longer available. For these reasons, excluding these statements is recommended.
- <u>Objective 2 (Land-based Evaluation):</u>
    - BWMS using active substances that exceed State Water Quality Criteria should not be evaluated. LCA has identified that all BWMS with active substances exceed Great Lakes Water Quality Criteria by a factor of 10, at a minimum. The neutralizing units on BWMS are ineffective with many not achieving the existing U.S. EPA limits. In addition, these technologies are very corrosive to the uncoated ballast tanks of Lakers.
    - The focus on BWMS type approved as part of the USCG ballast water regulations and the International Convention for the Control and Management of Ship's Ballast Water and Sediments, 2004, as amended, (BWM Convention) may be too narrow and limit the options. Operation of BWMS onboard lower ballast water flow-rate Lakers has been found to be problematic both regarding BWMS operation and on impacts to ship operations. Research has also focused on what BWMS manufacturers supply but not on what the Great Lakes community may be able to support. Traditional BWMS manufacturers are not interested in this small percentage of ships for business purposes. We are suggesting that it is time to think outside of the BWMS "box" and research whether other options may be available that reduce number of live organisms but are not tied to achieving the established BWM Convention performance standards or USCG ballast water discharge standards.
    - A "key question" could be "Do new methods/technologies exist to research that reduce organism transfer that do not impact vessel operations and achieve different discharge standards yet to be established?".
    - As a beginning, we suggest that different ballast pumps be evaluated for their impact/lethality to organisms. Vessels were previously asked to use ballast pumps instead of gravity for loading tanks to decrease the number of living organisms in ballast tanks. We are unaware if the effectiveness of this has been evaluated on

a large scale. This may seem simple, but it could be a building block for other tests.

- The reports from each of the projects should include details on the equipment (i.e., sizes, flow rates), the time the treatment required, and description of any decrease in processing from the intended treatment rated capacity of the equipment. For example, if a piece of equipment is being tested that was rated for 200 m^3/h but the processing occurred at 100 m^3/h, this should be clearly listed in the report.
- LCA has provided information on steel corrosion research to the U.S. EPA.

- Objective 3 (Shipboard Evaluation):
  - As previously stated for Objective 2, BWMS using active substances that exceed State Water Quality Criteria should not be evaluated. LCA has identified that all BWMS with active substances exceed Great Lakes Water Quality Criteria by a factor of 10, at a minimum. The neutralizing units on BWMS are ineffective with many not achieving the existing U.S. EPA limits. In addition, these technologies are very corrosive to the uncoated ballast tanks of Lakers.
  - As previously described for Objective 2, addition of a new "key question" – "Do new methods/technologies exist to research that reduce the risk of organism transfer that do not impact vessel operations and achieve different discharge standards yet to be established?" This research effort would look for new ideas/methods/technologies to test on a ship that are not tied to achieving the BWM Convention/USCG ballast water discharge standards.
  - As previously mentioned, an evaluation of different ballast pumps should be conducted to determine their impact/lethality to organisms.
  - Rather than concluding whether any tested BWMS provides "an acceptable level of propagule reduction", which is undefined in this plan, LCA recommends that the shipboard evaluations provide EPA with as much data as possible on the tested BWMS' biological efficacy, reliability, predictability, and impact on vessel operations, then EPA would evaluate the extent to which the research results support a regulatory output for Great Lakes vessels.
  - Shipboard sampling events should be pre-planned and discussed with the ship owners. GWRC could be more efficient with identifying specific weeks/time periods where sampling on each of the ships in the program are visited. This would also allow samples to be taken during the same time of the year for possible evaluation.
- Objective 4 (Filtration):
  - GWRC needs to contact directly other filter manufacturers. The filters tested have been limited to one manufacturer (i.e., Filtersafe), which is not the predominant provider worldwide, and a new filter, Albion that is not included in other BWMS. LCA supports the use of a filter not used in other BWMS but feels that other major filter manufacturers (i.e., Filtrex) need to be contacted.
- Objective 5 (Reception Facilities):
  - LCA has provided the Preliminary Cost Estimate for the Shoreside Ballast Treatment and Supply for the U.S. Great Lakes conducted by Hull & Associates in

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February 2017. The report was conducted by a third party that addresses the issues. The issues identified in the report should be addressed by any new study.
    - The quantity of ballast water from one Laker is significant and would be difficult to manage without using a similarly sized vessel. Also, multiple ships can visit a port in a single day that would result in a reception vessel needing to accommodate all the ships for the given day.
    - Ballast water reception facilities may be a better emergency option for seagoing vessels experiencing BWMS operational issues.
  - Objective 6 (Costs):
    - A new question would be "What are the other impacts (i.e., increased emissions) resulting from BWM Strategies? Vessels are being required to address air emissions, such as greenhouse gases. The overall impact of increased ANS control vs. emissions or other impacts should be addressed.
    - The LCA and CMC should be asked to provide information on overall costs for proposed compliance. Some of these details may have been submitted to the U.S. EPA as part of ongoing rulemaking actions. Literature searches will provide little information. Also, the USCG Costs from 2012 significantly underestimated the cost for BWMS installation and operation.
  - Regarding seagoing vessels, we agree that these vessels should be studied but funds from U.S. grants should not be paid to foreign shipowners. These shipowners could provide their own funding or partner with a U.S. entity that directly receives the funds. This would be similar to the Transport Canada approach and align with U.S. Buy American initiatives. Many of these vessels have BWMS installed to meet the BWM Convention requirements; however, it is unclear if they are effective in the Great Lakes or if their effluents are within state water quality standards.
  - For each of the research projects (land-based and shipboard), the research conducted should follow the agreed upon test plan signed by all parties.
  - The parties of the research should not be limited to those receiving funds directly from the University of Wisconsin Superior. Shipowners may wish to have a representative, such as their trade association, BWMS manufacturer, BWMS maintenance contractor, or technical advisor included in all discussions. These parties would be listed in the submitted proposal. Trade associations do not wish to reduce funds to their members and thus do not charge for their services. They do, however, bring valuable technical and trade information to the project.
- **Research Area 2 (pp. 29-38)**:
  - The water quality parameters of interest listed on page 35 of 50 should be sampled for all R&D events.
  - Additional Key Question – "What are the ranges of water quality parameters (listed on pp. 35 of 50) within the Great Lakes commercial ports where ballasting and deballasting occur"?
  - If an adapted protocol is used, this would need to be clearly listed in all publications. It also well be needed to address the differences and how previous data collected may be impacted if comparisons are to be made.

  - Explanation of why existing Whole Effluent Toxicity (WET) testing is not applicable to the Great Lakes is needed. WET testing is used worldwide in a variety of salinities. Please note that WET testing is only applicable with regarding to chemical addition in water. This may not be applicable due to Great Lakes Water Quality Criteria limiting technology options.
- **Research Area 5 (pp. 39-42)**:
  - Research performed regarding inter-lake transfer should test all samples against either the existing ETV Protocol or the to-be-developed Great Lakes Adapted Protocol so that the discharge of dead organisms is not counted as an inter-lake transfer of organisms.

[redacted]

Hi Christine,

Thanks for the opportunity to provide comments on R&D Plan 5. The Alliance for the Great Lakes would like to see the focus narrowed to concentrate on getting systems that work on Lakers. Shipboard evaluation of more systems on more vessels should be the highest priority for this research. This program was established with this goal in mind. The Alliance for the Great Lakes supports this emphasis even if it means other objectives cannot be pursued at this time. Testing should focus on the top five ballast water management systems that are most relevant and most likely to work on Lakers or to be adjusted to work on the Laker fleet. Narrowing the scope of testing and doing a thorough job of testing the top ballast water management systems across seasons and at as many ballast source ports as possible is critical to the success of this program. I'm happy to provide more detailed comments about this point or discuss it with you if it's helpful. Right now, I'm a bit underwater (no pun intended) at work, but I wanted to convey this critical comment. Thank you for your consideration.

[redacted]

[redacted]
Alliance for the Great Lakes
www.greatlakes.org
[redacted]

[redacted]

Good afternoon,
Thank you for the opportunity to participate virtually in the Great Waters Research Collaborative meeting on May 2nd and 3rd. We appreciate the chance to learn about the progress and future direction of ballast water management system research in the Great Lakes. Michigan offers the following feedback to inform the next version of the R&D plan:

1. **Research on risk reduction for lakers should not be limited to USCG type approved systems. USEPA should provide more clarity and direction to include testing on filtration only, IMO settings on UV systems, or other ballast management system components that can be modified or operated to reduce risk.**

   As stated in Michigan's letter to USEPA dated December 24, 2020:

   > *"USEPA must consider technology that can be used to reduce the risk of ANS transfer within the Great Lakes that may be able to meet a lesser standard and should not be artificially constrained by the International Maritime Organization (IMO) numeric discharge standard for living organisms or the U.S. Coast Guard (USCG) type-approval process in this analysis. VIDA indicates the USEPA should evaluate and establish the application of the best available technology economically achievable for categories and classes of vessels, which shall result in reasonable progress toward the national goal of eliminating discharges of all pollutants. As such, complete treatment is not required, rather, reasonable progress towards the aforementioned goal."* (See text under section c) on page 4 of the attached).

   Similarly, the Great Lakes Panel on ANS submitted comments to the Great Waters Research Collaborative dated March 31, 2021, including this text:

   > *"Incremental improvement is the goal; focusing effort on the largest knowledge gaps and areas where most significant progress can be made should be the goal of this plan, ensuring progress is not impeded by the need for perfection."*

   During the meeting conversations were cut short about testing filters without the UV component of a system running and testing UV systems on the IMO setting rather than the USCG setting. We recognize the intent of the meeting was aimed at science rather than policy; however, these conversations are critical to direct research that explores alternatives. USEPA, GWRC, and stakeholders should bring this conversation to a resolution so suitable research is conducted that will inform policy and regulatory requirements.

3. **Shipboard testing should be expanded and accelerated.**

   Shipboard evaluation of more systems and more vessels should be a very high priority for the GWRC. We recognize the logistical complexities of this work and organizational flexibility

required; however, these data are crucial and testing needs to be expanded.

2. **Stakeholder group involvement should be more frequent and should be broadened.**
   We would like to reiterate comments submitted by the Great Lakes Panel about Stakeholder Group involvement (see attached). Given the substantial GLRI investments and important policy and regulatory implications of this work, timely and routine engagement with a broader group should be required. In addition, EPA cited the GLLCISP section of VIDA, 312(g), as guiding the R&D work. This section also includes Section 312(g)(4), which requires collaboration with state, federal, and tribal agencies as well as other research entities or stakeholders, as appropriate.

4. **Response to comments should be provided to stakeholders.**
   To increase transparency and understanding, GWRC should share stakeholder comments, how comments are being considered, and if any adjustments are being made to the R&D plan in response to comments.

Please let us know if you have any questions or would like to discuss.

[redacted]
[redacted]

[redacted]
[redacted]
[redacted]
Michigan Department of Environment, Great Lakes, and Energy
[redacted]
Michigan.gov/invasives | Michigan.gov/EGLE

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
OFFICE OF THE GOVERNOR
LANSING

GARLIN GILCHRIST II
LT. GOVERNOR

December 24, 2020

VIA E-MAIL

Mr. Andrew Wheeler, Administrator
United States Environmental Protection Agency
William Jefferson Clinton Building
1200 Pennsylvania Avenue, NW (4504T)
Washington, DC 20460

Dear Administrator Wheeler:

SUBJECT: Governor's Objection on the Proposed Rule Under the Vessel Incidental Discharge Act (VIDA) Standards of Performance
Docket No. EPA-HQ-OW-2019-0482

By way of this letter, I am submitting my objection pursuant to Clean Water Act (CWA) Section 312(p)(4)(A)(iii)(III) to the United States Environmental Protection Agency (USEPA) on the Proposed Rule Under the VIDA Standards of Performance.

The state of Michigan objects to the following proposed national standards of performance for marine pollution control devices for discharges incidental to the normal operation of a vessel:

Subpart C – Standards for Specific Discharges Incidental to the Normal Operation of a vessel §139.10 Ballast tanks

- §139.10(c) Ballast Water Best Management Practices (BMPs)
- §139.10(d) Ballast Water Discharge Standard
  - §139.10(d) (1) Biological parameters
  - §139.10(d) (2) Biocide parameters
- §139.19 Fire protection equipment
- §139.21 Graywater systems

Subpart E – Procedures for States to Request Changes to Standards, Regulations, or Policy Promulgated by the Administrator

- §139.50 Petition by a Governor for the Administrator to Establish an Emergency Order or Review a Standard, Regulation, or Policy

These objections are discussed in more detail below, including the scientific, technical, or operational factors that form the basis of the objection, as required by VIDA. These

objections are submitted in addition to the following submissions:

- Michigan's comments and a joint comment letter from Michigan, Minnesota, and Wisconsin, submitted to the USEPA on September 9 and November 26, 2019, respectively, prior to the publication of the proposed standards
- A request for extension of the 30-day comment period on the proposed standards, dated November 20, 2020
- Comments on the proposed standards, dated November 25, 2020

§139.10(c) Ballast Water Best Management Practices (BMPs)

The proposed standards for ballast water uptake avoidance for ocean-going vessels and lakers are not as stringent as the 2013 Vessel General Permit (VGP) and weaken protections against Aquatic Nuisance Species (ANS) introductions and pollutants from ballast water discharge without basis.

VIDA requires that the USEPA's regulations not be less stringent than the VGP requirements.[1] Under Section 2.2 of the 2013 VGP[2], EPA requires mandatory ballast water management practices, including but not limited to management measures to minimize or avoid uptake of ballast water in the following areas and situations:

- Areas known to have infestations or populations of harmful organisms and pathogens (e.g., toxic algal blooms).
- Areas near sewage outfalls.
- Areas near dredging operations.
- Areas where tidal flushing is known to be poor or times when a tidal stream is known to be turbid.
- In darkness, when bottom-dwelling organisms may rise up in the water column.
- Where propellers may stir up the sediment.
- Areas with pods of whales, convergence zones, and boundaries of major currents.

The USEPA provided the following rationale in support of these BMPs not being carried over from the VGP:

> *"The proposed deletion is based on the finding that such measures are not practical to implement. These conditions are usually beyond the control of the vessel operator during the uptake and discharge of ballast water and thus it is not an available measure or practice to minimize or avoid uptake of ballast water in those areas and situations."*

[1] 33 U.S.C. § 1322(p)(4)(B)(iii).
[2] 2013 Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels, section 2.2.3.3, Mandatory Ballast Water Management Practices: Management measures required of all vessel owner/operators, pg. 27-28.

Environmental conditions are not under the control of vessel operators; however, vessel operators are still capable of adjusting vessel operations to minimize or avoid ballast water uptake in situations that may cause environmental impacts from ballast water discharges. The above rationale is not consistent with anti-backsliding or antidegradation requirements of the CWA. Furthermore, the citation of 33 U.S.C. 314(b)(2)(B) is neither adequate in bypassing anti-backsliding and antidegradation requirements or sufficient support for deleting BMPs from the proposed standards. The USEPA does not cite a mistake in the VGP or cite new data or studies that support removing these protections that have been in place for over a decade.

In lieu of these more protective BMPs aimed at preventing the uptake of ballast water with harmful contents by both lakers and ocean-going vessels, the USEPA argues that states can submit a petition requesting an emergency order. The proposed process of putting the onus on States in a reactive manner is not a workable solution and would not be as protective as continuing to require these BMPs. The proposed regulations require that the USEPA grant or deny a petition for an emergency order no later than 180 days after the petition is submitted (§ 139.50(c)(1)); this is a long time period during which vessels could continue to uptake ballast water from areas more likely to contain harmful organisms while failing to protect human health, aquatic life, and the Great Lakes from pollutants.

In addition, as indicated in the Ballast Equipment Manufacturers Association's comments to the USEPA on the proposed standard dated November 24, 2020, these BMPs are important to prevent/minimize scenarios where water quality conditions can overburden a ballast water management system (BWMS), which may result in system underperformance and increased risk of ANS.

The USEPA must retain the existing protective BMPs for ocean-going vessels and lakers included in Section 2.2 of the 2013 VGP or develop new protective measures that are no less stringent, or it will be in violation of VIDA.

§139.10(d) Ballast Water Discharge Standard

The USEPA's consideration of discharge standards, BMPs, and timelines for lakers is inconsistent with VIDA requirements.

a) The USEPA neglected to consider key research done by the Great Waters Research Collaborative (GWRC) in developing the proposed performance standards. The GWRC 2019 study on lakers, "Potential Ballast Water Best Management Practices: Risk Reduction, Feasibility, Cost, and Other Significant Impacts," was designed to inform regulatory efforts. The GWRC performed a

literature review and qualitative evaluation of BMPs for lakers. One goal of the project was to decipher "what existing ballast water best management practices are used by U.S. and Canadian vessels trading in the Great Lakes and how frequently are they used." Another goal was to identify potential ballast water BMPs that could be implemented by laker vessel operators. Preliminary results presented to workshop participants on October 2, 2019, do not support the removal of avoidance uptake BMPs for lakers and may indicate the feasibility of other BMPs or technology; however, there is no evidence that the USEPA considered this work.

b) VIDA requires that the USEPA's regulations not be less stringent than the VGP requirements.[3] The 2013 VGP requires Lakers built after January 1, 2009, to meet numeric discharge standards.[4] Elimination of this requirement in the proposed standard is clearly less protective, and the USEPA fails to provide an alternative timeline or approach to mitigate this change. Michigan, in partnership with Minnesota and Wisconsin, previously expressed concern to the USEPA regarding the VGP exemption of pre-2009 Lakers (Joint Great Lakes States Letter on Ballast Water and VIDA, dated November 26, 2019).

c) The USEPA exempts vessels that operate exclusively on the Great Lakes from numeric discharge standards for living organisms. While BWMSs for lakers may not be able to meet the discharge standards for living organisms that are applied to ocean-going vessels, the USEPA must consider technology that can be used to reduce the risk of ANS transfer within the Great Lakes that may be able to meet a lesser standard and should not be artificially constrained by the International Maritime Organization (IMO) numeric discharge standard for living organisms or the U.S. Coast Guard (USCG) type-approval process in this analysis.

   VIDA indicates the USEPA should evaluate and establish the application of the best available technology economically achievable for categories and classes of vessels, which shall result in *reasonable progress toward* the national goal of eliminating discharges of all pollutants. As such, complete treatment is not required, rather, reasonable progress towards the aforementioned goal.

   The USEPA provides incomplete evidence of an analysis to meet a lesser standard for lakers; therefore, we believe the USEPA fails to meet the requirements of VIDA. During conversations with the USEPA regarding the laker research and development plan, the USEPA requested input from states as

[3] 33 U.S.C. § 1322(p)(4)(B)(iii).
[4] 2013 Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels, section 2.2.3.5.3.3, Vessels That Operate Exclusively on the Laurentian Great Lakes (Commonly Known as Lakers) Built Before January 1, 2009, pg. 39.

recently as October 21, 2020, about the regulation of the VanEnkevort Tug and Barge's Michigan Trader, a laker with a DESMI UV system installed. This example does not align with the USEPA's conclusion there are no BWMSs available for lakers.

The federal government of Canada has undertaken a technical review indicating the feasibility of controlling aquatic invasive species discharges from vessels operating within the Great Lakes.[5] The USEPA should align the United States' approach towards protecting the region from further introductions and the spread of invasive species and their economic impacts; the USEPA does not provide adequate evidence to support exempting all lakers. By exempting all lakers from meeting national standards, the USEPA is effectively precluding any consideration by the USCG of standards for lakers within the yet-to-be-proposed USCG rulemaking for VIDA's corresponding implementation, compliance, and enforcement regulations, a rulemaking that will occur two years after EPA's national standards of performance.

Based on the information above, the USEPA should fully consider all available information to develop BMPs and/or best available technology economically achievable (BAT) for lakers including consideration of BWMSs for lakers that may not be able to consistently achieve the numeric discharge standards for living organisms, but provide some level of risk reduction for the secondary spread of ANS. Installation of BWMSs (e.g. existing type-approved UV BWMSs) or components (e.g. filtration) may be considered a BMP; BMPs do not need to have a numeric endpoint. The USEPA and states, including Michigan, have effectively included and utilized BMPs in a variety of permitting programs, including Concentrated Animal Feeding Operation (CAFO), Combined Sewer Overflows (CSOs), and Municipal Separate Storm Sewer Systems (MS4), and industry specific permits, like fish hatcheries and paper mills.

§139.10(d) Ballast Water Discharge Standard (1) Biological Parameters

Michigan objects to the proposed standard for living organisms in ballast water discharges on the basis that the USEPA did not perform an adequate analysis of BAT for BWMSs; therefore, the USEPA's proposed ballast water discharge standards are arbitrary and capricious.

The CWA requires that point source discharges meet technology-based requirements and meet state water quality standards, whichever are more stringent. Regarding the technology-based requirements specified in the proposed VIDA Standards of

[5] See Government of Canada "Comments on Draft Vessel Incidental Discharge National Standards of Performance," November 12, 2020. Docket #: EPA-HQ-OW-2019-0482-0624.

Performance, Michigan is concerned about fundamental flaws in the USEPA's process by failing to use crucial data.

a) The USEPA failed to independently review all existing and available ballast treatment technologies. The USCG has land-based and shipboard test data for BWMSs) that have been type-approved by the USCG. These data are essential for the USEPA to evaluate the efficacy of BWMSs at reducing the concentration of organisms and determining BAT. The USEPA did not effectively use these data to set the requirements. While Michigan recognizes some aspects of the type-approval process include proprietary information and are, therefore, confidential, the USEPA has a responsibility to work with the USCG to obtain and evaluate BWMSs performance data, including challenge conditions, test results, and quality control records to determine BAT. The USEPA provides no evidence of working with the USCG on this issue; rather, they rely on an incomplete subset of data provided by Ballast Water Equipment Manufacturers Association (BEMA). The USEPA's evaluation of only 11 BWMSs selected by industry of the 38 USCG type-approved systems[6] (with nine additional systems pending review) does not provide adequate characterization of available technology. Thus, the USEPA included less than one-quarter of the available data on BWMSs in its analysis of BAT and relied on an industry organization, instead of an independent laboratory, to provide the data for that analysis. Without having properly identified the BAT and its capabilities, the USEPA has not determined the BWMSs that are best technologically available and economically achievable. Michigan's Ballast Water Control General Permit (GP) has established higher-level technology that has been shown to be achievable.

   The United States 2nd Circuit Court of Appeals decided in 2015 in *NRDC v. EPA* that the USEPA acted "arbitrarily and capriciously" in setting the numeric ballast water discharge standards in the VGP because it failed to review data on BAT that was available at that time.[7] The USEPA is now essentially making the same arbitrary and capricious decision on the same standards under a different law with a similar statutory command. Having failed to conduct a BAT assessment, the USEPA does not know what standards the BAT could meet yet concludes that current technology cannot meet a standard more stringent than the VGP's standards.

   The USEPA must conduct a thorough investigation into what constitutes the best available and economically feasible ballast water treatment technology prior to setting ballast water discharge standards to implement VIDA. Failure to do so will result in an arbitrary and capricious final action that will subject the U.S. to

[6] https://www.dco.uscg.mil/Portals/9/MSC/BWMS/BWMS_Approval_Status_17NOV20.pdf
[7] *Natural Resources Defense Council v. EPA*, 808 F.3d 556 (2nd Cir. 2015).

standards that are neither protective of U.S. waters nor reflective of available and economically feasible technology.

b) Even considering the data omission outlined above, the use of USCG type-approved BWMSs does not necessarily represent the best technology available and economically achievable. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has reviewed several USCG type-approved BWMSs that do not meet the technology requirements specified in Michigan's Ballast Water Control GP. As an example, use of hypochlorite at concentrations well below an application rate of 10 mg/L (i.e., Michigan's Ballast Water Control GP requirement) are listed as type-approved BWMSs, while BWMSs that achieve an application rate of 10 mg/L exist. Therefore, it is difficult to argue that type-approved BWMSs using these lesser conditions are the best "technologically available and economically achievable." Further, including the type-approval process to determine adequate technology, and not specifying the dose rate for ultra-violet (UV) applications also does not meet the best "technology available and economically achievable." Michigan has reviewed UV BWMS that may not meet the dose rate specified in Michigan's Ballast Water Control GP. Therefore, Michigan believes that technology standards need to be set that are the best BWMSs that are technologically available and economically achievable.

   Operational requirements are a component of BAT as specified in CWA. Examples of operational control requirements in combination with BAT are available from the NPDES program. These include the Combined Sewer Control program that utilizes nine minimum controls to operate the system to minimize raw sewage discharges and the Municipal Separate Storm Sewer System program that relies on six minimum operational controls in order to protect surface waters. Both of these are examples of technology controls. Michigan's Ballast Water Control GP sets a high level of technology operational requirements that exceed the type-approvals the USEPA is relying on for the draft standards. Effective implementation and compliance with Michigan's Ballast Water Control GP demonstrates the BAT specified in the GP are attainable and economically feasible. The operational requirements for BWMSs specified in Michigan's Ballast Water Control GP should be included in the draft standards.

§139.10(d) Ballast Water Discharge Standard (2) Biocide Parameters

The USEPA's proposed standard allows for violations of Michigan's water quality standards and other laws that protect the Great Lakes.

The inability to meet water quality standards contradicts the goals of the CWA. Section 101(a)(2) of the CWA states that it is necessary to achieve "the national goal that whenever attainable, an interim goal of water quality which provides for the protection of fish, shellfish and wildlife and provides for recreation in and on the water

by July 1, 1983. ….” As proposed, in all cases the proposed standard may allow for violations of Michigan’s water quality standards/fails to protect Great Lakes waters. The fundamental basis for VIDA is the development of uniform national standards for discharges incidental to the normal operation of vessels. This is a fundamental goal of the CWA. In fact, many aspects of VIDA recognize the unique water quality aspects of the Great Lakes and special habitats like marine sanctuaries. The following pollutants are among those that do not meet Michigan’s Water Quality Standards (WQS):

a) Residual biocides
   i. The proposed standard for chlorine dioxide is 200 ug/L, which will likely allow Michigan’s WQS for chlorite of 13 ug/L to be exceeded.
   ii. The proposed standard for total residual oxidizers is 100 ug/L, which exceeds Michigan’s WQS for total residual chlorine (TRC) of 38 ug/L.
   iii. The proposed standard for peracetic acid of 500 ug/L, which exceeds Michigan’s WQS of 230 ug/L.

Michigan has worked with some manufacturers of ballast treatment technologies that are capable of meeting Michigan’s WQS and technology limitations for TRC of 38 ug/L and peracetic acid of 230 ug/L. Michigan is still investigating options to use chlorine dioxide and achieve the chlorite WQS of 13 ug/L, but some options include operational control and BMPs like hold time, monitoring for chlorite, and restricted discharge time. If necessary, VIDA does not preclude regional standards when warranted.

§139.19 Fire Protection Equipment

The USEPA fails to protect human health and the environment by allowing the use of PFAS containing firefighting foams in the event of an emergency without required BMPs and notification.

The USEPA states in the preamble of the proposed standard:

> *“EPA reviewed numerous foam Safety Data Sheets for bioaccumulative or toxic or hazardous materials and identified several potential foam options that vessels owners and operators may be able to use if the Agency moved forward with this approach in the final rule (EPA, 2020). However, EPA was unable to compile adequate information on the availability and economic achievability considerations of using non-fluorinated foams that do not contain bioaccumulative or toxic or hazardous materials to justify proposing a requirement that would limit the types of non-fluorinated foams that could be used for testing, training, maintenance, inspection or certification.”*

Instead of continuing to gather information, the USEPA moved forward with the proposed standards and is requesting feedback on multiple issues related to PFAS and alternatives.

The Great Lakes are a source of drinking water for millions of North Americans and the USEPA is obligated to protect the Great Lakes as a drinking water source. It is negligent for the USEPA to ignore the bioaccumulative nature of some of the PFAS chemicals, particularly Perfluorooctanesulfonic acid, and advancements made in PFOS-free foams. The USEPA also fails to define conditions under which PFAS-containing foams can be used and include BMPs. Michigan's PFAS Action Response Team (MPART) is recognized as a national leader in identifying and reducing exposures to PFAS substances. Related to PFAS containing foams, MPART is educating first responders on PFAS, working with manufactures to produce and certify PFOS/Perfluorooctanoic acid (PFOA)-free foams, and is completing a program to pick up and dispose of PFOS/PFOA foams. The USEPA should be following Michigan's example and expanding on these actions instead of continuing to allow the use of these harmful foams. A poster produced as part of EGLE's MPART can be found in the **PFAS Foam** section on MPART's website.

§139.21 Graywater Systems

The USEPA's proposed standard allows for violations of Michigan's water quality standards and other laws that protect the Great Lakes.

Michigan considers gray and black water discharge as sewage discharges; that is, they must meet requirements for sanitary sewage. While the proposed standards include some protections for surface water resulting from graywater discharges, the standards are less protective than Michigan's current laws. Michigan's Part 95, Watercraft Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, prohibits discharges like graywater. Vessels have the ability to hold graywater for on-shore disposal; therefore, graywater discharge should be prohibited in the Great Lakes.

§139.50 Petition by a Governor for the Administrator to Establish an Emergency Order or Review a Standard, Regulation, or Policy

As stated in the Joint Great Lakes States Letter on Ballast Water and VIDA dated November 26, 2019, emergency response timetables on the order of weeks and months would be untenable; decisions, plans, and actions (including state-assisted rapid responses) to mitigate ANS invasions or redistribution risks must occur on timescales of hours or days in an effort to have a chance at being successful. The emergency order process as detailed in the proposed standard allows up to a 180-day timeframe for evaluation of such orders. Imminent threats calling for emergency orders in nearly real

time do not align with a 180-day timeframe. The USEPA should work with affected states and tribes to develop a regulatory framework to streamline the emergency order process.

It is unacceptable for the USEPA not to consider the protection of Michigan waters and the unique qualities of the Great Lakes. The USEPA must ensure that appropriate technology-based requirements and BMPs are established and water quality standards are achieved. The proposed approach for vessel discharges undermines the CWA's requirement of preventing, reducing, and eliminating pollution into the nation's waters and the interim goal of meeting water quality standards. Michigan urges the USEPA to provide adequate consultation with states and revise the proposed regulations to contain standards as stringent as those promulgated by states, in compliance with the intent of the CWA.

Sincerely,

Gretchen Whitmer
Governor

cc: Ms. Dana Nessel, Michigan Attorney General
Mr. Kurt Thiede, Regional Administrator, USEPA, Region 5
Mr. Jack Faulk, USEPA
Ms. Holly Galavotti, USEPA
Ms. Kara Cook, Governor's Office
Ms. Dana Sherry, Governor's Washington Office
Mr. Robert Reichel, MDAG
Mr. S. Peter Manning, MDAG
Ms. Liesl Eichler Clark, Director, EGLE
Mr. Aaron B. Keatley, Chief Deputy Director, EGLE
Mr. James Clift, Deputy Director, EGLE
Ms. Teresa Seidel, EGLE
Mr. Phil Argiroff, EGLE

Great Lakes Panel
ANS
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March 31, 2021

Dr. Matt TenEyck, Director, Great Waters Research Collaborative
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Belknap and Catlin Ave
Superior, WI 54880

Dear Great Waters Research Collaborative director,

We are writing on behalf of the Great Lakes Panel on Aquatic Nuisance Species (Great Lakes Panel) to submit comments on the Great Lakes Ballast Water Research and Development Plan. The mission of the Great Lakes Panel is to coordinate the development of education, research, and policy to prevent new aquatic invasive species from entering the Great Lakes basin and to control and mitigate those AIS populations already established. The Panel carries out this mission through various activities, per Section 1203 of the federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 as amended by the National Invasive Species Act of 1996. Notably, the Great Lakes Panel is authorized to:

- Provide advice to public entities, private sector groups and other interested parties concerning AIS prevention and control;
- Coordinate AIS program activities in the Great Lakes in areas related to information and education, research and policy as well as other areas that are not cited directly in the 1990 Act; and
- Provide a forum for interagency/organizational communication and serve as a vehicle for regional dialogue and discussion on AIS issues.

The comments shared here represent the collective point of view of the Great Lakes Panel and do not reflect the perspective of any specific member organization. The Great Lakes Panel's review of the Great Lakes Ballast Water Research and Development Plan was led by its Research Coordination Committee and open to participation from any Great Lakes Panel member. Those who participated in the review of the plan represent a wide range of perspectives (e.g., U.S. and Canadian members; state, provincial, regional, and federal agencies; NGOs; private entities) and experiences (e.g., academic; management; shipping industry; etc.). The committee reviewed each section of the plan and provided initial comments for discussion, from which formal comments were developed. The primary focus of this review and discussion was centered on how to apply available resources most efficiently to develop management solutions to those ballast water treatment issues that are uniquely challenging for the Great Lakes. Members were also asked to consider where there may be knowledge gaps, duplication of effort, or key relevant literature that was missing.

Generally, it is the view of the Great Lakes Panel that this plan spreads resources too thinly between numerous research objectives and questions. It is the Great Lakes Panel's considered opinion that it would be more beneficial to focus this plan on a smaller number of objectives that can make the greatest contributions to the management of Laker ballast water in the Great Lakes, and to concentrate on the most important objectives/knowledge gaps to move this work forward. We believe that the efficiency of this plan would be further increased by focusing on challenges that are unique to the Great Lakes, doing a smaller number of projects very well, and coordinating with the international ballast water research

community to address other problems. The specific comments that follow are intended to help focus the efforts and resources of the Great Waters Research Collaborative on the highest priority and most value-added research questions.

We greatly appreciate the opportunity to review and provide comments on the Great Lakes Ballast Water Research and Development Plan, and we look forward to continued collaboration between the Great Lakes Panel and the Great Waters Research Collaborative.

Respectfully,

Eric Fischer
Great Lakes Panel Acting Chair
Signed on behalf of the Great Lakes Panel membership

Great Lakes Panel on Aquatic Nuisance Species
Comments on the Great Lakes Ballast Water Research and Development Plan

Executive Summary

It is the view of the Great Lakes Panel on Aquatic Nuisance Species (GLP) that the Great Lakes Ballast Water Research and Development Plan (R&D Plan) spreads resources too thinly between numerous research objectives and questions. The GLP recommends focusing this plan on a smaller number of objectives that can make the biggest contributions to the management of laker ballast water in the Great Lakes. The comments that follow are intended to help focus the efforts and resources of the Great Waters Research Collaborative (GWRC) on the highest priority and greatest value-added research questions. These recommendations are based on the assumption that:

- It is better to focus on the most important objectives/knowledge gaps to move this work forward and do a smaller number of projects very well, and
- It would benefit the efficiency of this plan to focus on challenges that are unique to the Great Lakes and rely on the rest of ballast community to address larger-scale problems

In the view of the GLP, the highest priority objectives of the R&D Plan are to:

1. Improve management of ballast water from the Laker fleet
2. Test effectiveness of ocean-going vessel BWMSs that comply with operational needs of the Laker Fleet (e.g., UV systems) when operated in the Great Lakes

The R&D Plan needs to be clearer about how each of the research questions will be applied to the problem that this plan is trying to solve (i.e., preventing/reducing secondary spread of future introductions through the ballast water pathway). The GLP recommends greater emphasis on evaluation and shipboard testing for treatment systems that lakers are most likely to use (e.g., UV and other non-corrosive systems), including identifying and conducting testing that is required to bring these technologies to market.

- A key research priority for improving pathway management and risk reduction is assessing the effectiveness of these technologies across the range of Great Lakes conditions that are seen as the biggest constraints to operational adoption by the laker fleet (e.g., ballast flow rates, cold temperature extremes, high turbidity), with a focus on environmental conditions at dominant ballast-source ports
- Incremental improvement is the goal; focusing effort on the largest knowledge gaps and areas where most significant progress can be made should be the goal of this plan, ensuring progress is not impeded by the need for perfection

The GLP is also concerned that the Duluth-Superior location may be limiting the scope and relevance of this work given that location is not representative of the range of environmental conditions present across the Great Lakes. The GLP recommends expanded testing in the lower Great Lakes at dominant ballast-source ports (e.g., Toledo and Conneaut, as well as top Laker source ports Detroit, Gary, St. Clair, Nanticoke, Indiana Harbor, Cleveland, Sault Ste. Marie, Hamilton (Rup et al., 2010; NBIC database) under both typical and more challenging conditions for treatment systems (e.g., high turbidity and algal blooms).

- The GLP also encourages MARAD to relocate their portable testing barge (formerly at MERC) to the Great Lakes so that testing can be more easily undertaken in lower Great Lakes ports
- Given the expertise of the GWRC and the constraints for land-based testing across the full range of treatment conditions at Duluth-Superior, additional focus on shipboard testing of any and all ships with BWMS coming into Duluth-Superior will best make use of institutional capacity

Additionally, a thorough and extensive literature review needs to be conducted prior to moving forward with any of the research/projects presented below to fully understand the current global knowledge base and avoid duplication of effort. This comprehensive literature review is a high priority and essential for the success of a long-term research program.

- Since literature reviews have not yet been conducted for a number of these research areas and objectives, it is difficult to provide meaningful comment without knowledge of specific plans for research (e.g., methods)

Finally, the GLP recommends that above all else that the role of the R&D Plan and associated projects be to quantify treatment effectiveness and identify risks. It is the role of regulatory/management agencies to determine if a treatment method is effective enough for use (assuming those standards are not already set in policy). Refocusing this plan away from policy questions and ensuring full open access to results and data generated, rather than just whether a system passed or failed a testing standard, is critical to managers making these policy decisions.

Comments Directory

The submitted comments on the R&D Plan are organized using the same structure as the R&D Plan as published. Comments are in blue font to differentiate them from the objectives and research questions of the R&D Plan, and all comments relevant to each objective/research question are noted directly under them in text. If an objective or research question does not have blue text directly under it, then the GLP does not have any comments specific to that objective/research question.

Stakeholder Group Involvement

Objectives

1. Formation of the Ballast Water R&D Stakeholder Group and kick off meeting
2. Formation of data working group and mining, sharing and compiling existing data
3. Engaging stakeholders during R&D Plan implementation

- The GLP recommends more regular engagement with the stakeholder advisory group.
    - Engaging with stakeholders on an annual or semi-annual basis makes it extremely difficult for the stakeholder to provide meaningful feedback and engage with the R&D plan. Given the breadth of work contained in this plan, and the overlapping nature of many of the projects' time-lines, providing more frequent opportunity for stakeholder group members to provide feedback is necessary for this group to be a true collaborative effort
- The GLP also recommends focusing meetings on a smaller number of objectives so the advisory group has the time to read and dive deep on these issues with the research team.
    - Covering a large amount of materials at stakeholder meetings mean stakeholder members may not have sufficient time and opportunity to read through, respond to, and ask questions about the plan or other materials. This can lead to a lack of opportunity for stakeholder members to engage in meaningful dialogue on the plan and projects.
    - Providing detailed project plans (e.g., hypotheses, methods, etc.) and ample meeting time dedicated to discussing the project plans would go a long way towards securing meaningful engagement with stakeholders
    - The opportunity to meet more frequently, and have each of those meetings cover a smaller amount of material, is the best way to ensure meaningful engagement with the stakeholder advisory group
- In reviewing the structure of this collaborative there needs to be a consultation and governance process that empowers stakeholder groups and facilitates more open dialogue, e.g., a neutral facilitator to empower the stakeholder advisory group. The GLP recommends clarifying a mutually accepted (i.e., between GWRC/funders and the stakeholder advisory group) process by which GWRC will consider and formally respond to feedback from the stakeholder advisory group.
- In accordance with established literature on the function of collaboratives and collective impact, the following should also be considered in further developing the relationship between GWRC and the stakeholder advisory group:

Comments: Stakeholder Group Involvement

Governance/ Facilitation	**Initial champion/Core group**- 2-3 initial champions could request funding to start and drive the creation of a collaborative. The right champions should be trusted and recognized for their ability to bring people together. Let the needs and wants of the collaborative membership determine the direction.
	Neutral backbone organization- Organization that could provide staff support and convene the collaborative but not necessarily be an active member in driving the direction of the collaborative. This organization coordinates communication and updates, meeting support, travel funds and other necessary logistics. Ideally the backbone organization would be different from the funder to solve issues of potential bias.
	Steering committee- The steering committee could make decisions as a cooperative management group with a co-chair system or smaller leadership team to help drive decision making.
	Technical committees- Technical committees could include diverse representation from many different focus areas. Create a chair system or leadership team to help advise decision makers. Diversity and the ability to think strategically are key, along with not pushing a personal or agency agenda.
Membership	Consider membership of researchers and managers, along with universities. Need both those who receive information and those who have specific resources or expertise with a management responsibility.
	Clarify roles between members. Someone heavily involved in reaching specific outcomes (such as a researcher or member of industry) might not be able to be a decision maker. Let the process reflect the needs of the group as a whole.
Flexibility/ Evaluation	Consider practicing adaptive management and exercise the ability to review and revise goals or direction, and to track progress.
	The funding agency should be flexible and allow the neutral backbone organization to administer funds without restrictions on outcomes or process.
Clear Endpoint/ Defined Goals	Members should work towards the same goals through complementary actions.
	Consider establishing clear goals, milestones and strategic direction or pathway to reach agreed end point.
	Consider establishing a shared measurement system to ensure consistency and that goals are being met.

Braun, H. A., Kowalski, K. P., & Hollins, K. (2016). Applying the collective impact approach to address non-native species: A case study of the Great Lakes Phragmites Collaborative. *Biological Invasions, 18* (9), 2729-2738. doi:10.1007/s10530-016-1142-1

Kania J, Kramer M (2011) Collective Impact. *Stanford Social Innovation Review 9* (1): 36-41

Kania J, Kramer M (2013) Embracing emergence: how collective impact addresses complexity. *Stanford Social Innovation Review*. http://ssir.org/articles/entry/embracing_emergence_how_collective_impact_addresses_complexity. Accessed 13 Sept 2016.

Newcomb et al 2021. https://afspubs.onlinelibrary.wiley.com/doi/epdf/10.1002/fsh.10536

Comments: Stakeholder Group Involvement

Research Questions

1. Which organizations are key for input on the goals and direction of R&D plan? **(Obj. 1)**

- The list of stakeholders is quite government focused with relatively few academics; the addition of more content experts who have previously been involved with similar research is key to the success of this plan
    - E.g., Nick Welschmeyer (Golden Bear); David Lodge (Cornell University); Jon Bossenbroek (U. Toledo); Hugh MacIsaac (U. Windsor); Anthony Ricciardi (McGill University)
- It would be beneficial to establish stakeholder groups around each of the Research Areas and/or projects – as it stands, the R&D plan is extremely broad and touches on a wide variety of topics, making it difficult for individual stakeholder group members to fully engage across every aspect of the plan. Focusing the plan on a smaller number of key research questions would also enable engagement across the plan by the stakeholder group.

2. Which stakeholder group member organizations should form the data working group? **(Obj. 2)**

- In addition to the groups currently listed in the plan (e.g., USCG R&D group and DFO), the GLP recommends mining the ballast water knowledge and expertise outside of the Great Lakes – any freshwater testing globally should be taken into consideration and built upon for specific Great Lakes issues
    - Further suggestions for data working group members should be solicited from the stakeholder advisory group

3. What is the process for mining, compiling, and sharing critical historic data that will inform project design? **(Obj. 2)**

- The data mining group will need to meet much more frequently than the stakeholder group and utilize full time data management staff to organize the literature search into an easily accessible directory searchable by relevant research area/priority and terms. It will be beneficial to have a smaller, unbiased expert panel to categorize references by relevance, scope, and practical application to project goals to draw attention to the best existing data for each project
- The 261 day timeline provided for the data mining group will be adequate ONLY if the group is set up to successfully network with a huge group of external experts
- We urge the development of a formal data management and reuse policy with standard operating procedures explicitly outlining and ensuring access to non-proprietary data and literature for projects and how/when this information would be shared with both the stakeholder group and the general public

4. Based upon published literature and data from the working group, what are the data gaps that must be addressed through the R&D Plan projects? **(Obj. 2)**

- Based on the R&D Plan Timeline, it appears literature review and data gathering is scheduled for completion by 1/2022. A thorough and extensive literature review is essential to ensure the work outlined in the plan identifies these data gaps and does not duplicate previous effort. The overlapping timelines of the literature review and the initial projects does not currently reflect the high priority nature of the review and is likely to

rush this process in an effort to get projects off the ground, leading to a less comprehensive review. Adequate time should be included in the R&D plan timeline for a literature review prior to undertaking any projects in order to inform their development

5. Is the ballast water R&D plan on track and are there any necessary updates based on the current state of affairs? **(Obj. 3)**

- The ballast water R&D plan is too broad and it is difficult to understand if the plan is on track, or to give detailed feedback without specific project details (e.g., hypotheses to be tested, methods, etc.). In order to elicit relevant and meaningful feedback on projects, we recommend an additional step in the review process where detailed project proposals are developed (after completion of the literature review) and distributed to the stakeholder group and other relevant parties for review and comment prior to moving forward with project designs

Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management

Objectives

1. Determination of Operational Characteristics of Commercial Vessels Trading within the Great Lakes System

- Past studies have been completed on this issue (STX, 2015; Choice Ballast Solutions, 2017); this is not a significant data/knowledge gap, although there would be some (limited) value in updating voyage patterns. The GWRC would be better served by identifying sources of error and gaps in these previous studies
- When considering the fleet as a whole, the list of limiting factors becomes very large, but any single vessel will have only a subset of those challenging factors. It is important not to get too weighed down by the minority or the extreme cases and instead focus on the average ship and the average operational characteristics. Testing a subset of vessels (e.g., 2-5 vessels) with features representative of the majority of the fleet (e.g., number and capacity of pumps, etc.) would be an efficient way of capturing the typical operational characteristics of the fleet
- There is no description of how the voyage patterns will be assessed. Network analysis from the Bossenbroek and Lodge labs (Saebi et al., 2020; Kvistad et al., 2019) needs to be taken into consideration. This analysis should not assume that ecoregion is the relevant spatial unit on which to evaluate ship movement, rather, should focus on movement between individual ports/port pairs and then scale-up to unit of interest based on specific spread questions

2. Land-Based Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

- It's not clear what the criteria for success are for this evaluation
- There is limited value in land-based testing at Duluth-Superior, particularly in duplicate testing between old (ETV standard) and new (Great Lakes ETV) protocols. Resources would be better used on barge testing or operational shipboard testing at regular ballast-source ports to achieve more test replicates of the systems most likely to be adopted by US and Canadian fleets. There is limited value in additional land-based testing; there are enough systems currently type approved by USCG for use in fresh water to focus on ship-based testing under this plan
- "Great Lakes conditions" are not defined; these conditions should be clearly defined, considering abiotic, biotic and ship operational factors. The range of such conditions should consider seasonality and voyage patterns, with a focus on the most-used ballast source and recipient port combinations during the shipping season. Water quality conditions to consider include:
    - Temperature
    - Salinity/specific conductivity
    - Dissolved oxygen
    - Turbidity
    - Total suspended solids
        - Particle size distribution
    - Dissolved organic carbon
        - Composition

    - Transmittance of ultraviolet light at 254 nm
    - Particulate organic matter
        - Particle size distribution
        - Composition
    - Mineral matter
- There needs to be a clear process for data availability (open and accessible data sharing) in this plan. To date, testing information for land-based and shipboard USCG type approval has been considered proprietary beyond pass/fail status, and as a result, natural resource managers have no way of understanding how well systems perform or if intermediate endpoints that are less than the IMO standard could be met. The consideration of intermediate endpoints needs to be included in testing design and data collection to ensure we can address these questions.
    - A written commitment should be included in this plan to address data availability (sharing) within a reasonable set timeframe. For the purpose of this research, final publication is not an acceptable timeframe to inform next steps and regulation. In addition, this work is intended to implement the GLLCISP. VIDA, under GLLCISP, includes a clause on data availability as part of the program

3. Shipboard Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

- The shipboard evaluation of more systems and more vessels should be a very high priority for the GWRC. Testing UV systems is the highest priority given its potential for use on the majority of lakers. Assisting with installation fees is a great way to get more BWMSs on more lakers, thus further expanding the pool of options for shipboard testing
    - Chemical/corrosive treatment systems have some relevance only to the Canadian fleet due a portion of Canadian vessels using lined ballast tanks
    - Mobile pasteurization systems should also be a priority for testing alongside UV-based systems; as other non-corrosive technologies become available that meet the needs of the Laker fleet, they should be reviewed for testing and inclusion in this program
- In addition to assisting installations (on a very few) Laker vessels that are most representative of the fleet, we recommend that GWRC coordinate with foreign vessels to sample treated ballast water from relevant systems that use UV treatment, which may add value to this work in the evaluation of foreign ship ballast systems operability in the Great Lakes
- It's not clear why the aim is to conduct repeated testing in the later years of the project on a very small number of ships/systems as opposed to testing a broader variety of (relevant) BWMSs, which would have much greater value in the near-term for laker ballast water management across a range of vessels and transits
    - The GLP suggests testing focused on at least the top three BWMSs most relevant to the Laker fleet, and that these systems be selected for testing in coordination with Laker industry representatives. Narrowing the scope of testing and doing a thorough job of testing the top 3-5 BWMSs across seasons and as many ballast source ports as possible is considered a top priority by the GLP

4. Evaluating the Effectiveness of Ballast Water Best Management Practices Including Hybrid Solutions

GLP Comments; Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management

- The recommendation of the GLP is that this research objective should not be pursued
    - The view of the GLP is that this is not a high priority research area and has limited value because the BMPs proposed are infeasible or have already been largely identified as being ineffective; resources would be better applied towards testing treatment systems or other research areas
    - Evaluation would need to be limited to conditions/time of year when the majority of the fleet are operational, making it more difficult to prioritize timely work
    - Open lake ballast water exchange will likely be infeasible for the lower lakes due to safety concerns and the possibility of a current pushing propagules onshore

5. Evaluating the Feasibility and Significant Impacts of Ballast Water Reception Facilities within the Great Lakes

- Previous studies have questioned viability of ballast water reception facilities (Jenkins, 2001; Dames & Moore, 2000; Soles et al., 2018; McMullin et al., 2018; Hull and Associates, 2017); infrastructure, volume, and scaling issues make it not an option for the Great Lakes and therefore not a priority for research

6. Assessing the Cost of Ballast Water Management Strategies on Commercial Vessels Operating Exclusively within the Great Lakes System

- This objective is redundant of information in recent research (STX, 2015; Choice Ballast Solutions, 2017) that is still relevant and adds very little value to ballast water management

Research Questions

1. What are the typical (and more challenging) ballasting operational characteristics of United States and Canadian-flag commercial vessels that trade within the Great Lakes? **(Obj. 1)**

- This has been extensively documented by the U.S. and Canadian fleets as well as by Choice Ballast and USCG. It is not clear what GWRC would be adding or discovering beyond what has been previously identified.

2. Are there existing BWMS available on the global market (either type-approved under the IMO Convention or by the U.S. Coast Guard) that can treat Great Lakes ballast water effectively to meet the current U.S. discharge standards using existing test methods (i.e., Generic Protocol for the Verification of Ballast Water Treatment Technology; U.S. EPA, 2010)? **(Obj. 2)**

- The focus should be on U.S. Coast Guard type-approved systems since under current requirements (the 2013 Vessel General Permit and the proposed Transport Canada regulations) ballast water management systems need to be type-approved for use in U.S. waters. Resources would be best spent understanding how existing systems can be modified or operated in a way that maximizes their potential in Great Lakes waters and lakers, rather than on finding new or different systems.

3. When evaluated at a land-based scale using the newly developed, Great Lakes-adapted protocol (see Protocol Development Project, Research Area 2 – Project 5), how do these BWMS perform? **(Obj. 2)**

   a. What is the level of ANS reduction that can be achieved in the Great Lakes based on land-based testing? **(Obj. 2)**

- The GLP sees little value in re-testing systems that have already achieved type-approval, and recommends using resources to pursue shipboard testing of systems already operating within the Great Lakes, including on foreign vessels, as an alternative to land-based testing of a Great Lakes-adapted protocol
  - A list of BWMS on vessels operating in the Great Lakes can be obtained from the NBIC database, as each ballast report includes the identity of the on-board BWMS
  - Great Lakes-specific criteria can be considered during shipboard testing and reported on regardless of inclusion in the current ETV protocol

4. Are there existing BWMS available on the global market (either type-approved under the IMO Convention or by the U.S. Coast Guard) that can treat Great Lakes ballast water effectively to meet the current discharge standards using existing test methods (i.e., ETV Protocol)? **(Obj. 3)**

- See comments on Research Question #3, above.

5. When evaluated at a shipboard scale using the newly developed, Great Lakes-adapted protocol (see Protocol Development Project, Research Area 2 – Project 5), how do these BWMS perform? **(Obj. 3)**
   a. What is the level of ANS reduction that can be achieved based on shipboard testing? **(Obj. 3)**
   b. Can filtration technologies and practices be improved for ballast water management in the Great Lakes? **(Obj. 4)**
   c. What are the efficacies of potential, promising BMPs in reducing the concentration of ANS in ballast water discharged within the Great Lakes? **(Obj. 4)**

6. What is the feasibility, economic, and environmental impact of reception facilities if utilized within the Great Lakes under certain scenarios or locations? **(Obj. 5)**

7. How do ballast water management strategies compare in terms of ANS reductions and cost for installation and operation? **(Obj. 6)**

- The term “strategies” needs to be clearly defined in order to answer this question

Research Area 2: Toward Development of a Great Lakes Relevant BWMS Testing Protocol

Objectives

1. Characterizing BWMS Challenge Conditions in the Great Lakes System
2. Evaluating Alternative/Emerging Sample Analysis Methods for Ballast Water Treatment Technology Testing
3. Development of a Great Lakes-Adapted Protocol for Verification of BWMS

- The value of adapting the ETV Protocol for Great Lakes water quality, biology, and the operational realities of the Great Lakes fleet has not been clarified. The view of the GLP is that resources are better spent testing existing systems at various locations within the Great Lakes.
    - There will be little motivation for BWMS vendors to retest under a new Great Lakes specific test plan since the Great Lakes market is so small
    - The timing of this new protocol isn't efficient; the new protocol should be established before testing is underway, not halfway through the R&D plan timeline
    - It is not clear a specific Great Lakes test protocol is needed as conditions in the Great Lakes are not so unique from other freshwater areas with global shipping

Research Questions

1. What are the ranges of living organism densities/composition and water quality parameters found within Great Lakes commercial ports where cargo off-loading/ballasting occurs? **(Obj. 1)**

- Laker trade patterns, ballast ports and volumes, and port connectedness have already been well characterized for the Great Lakes (e.g., Rup et al. 2010) and there is little value in redoing this work since trading patterns have remained stable for the past decades. Therefore, it would be more beneficial for GWRC to focus on research more directly applicable to the development and adoption of BWMS by the laker fleet, such as shipboard testing at a variety of major ballast source ports under a variety of conditions
- Building a matrix of port challenge conditions was initiated under previous Great Ships Initiative funding, but it is not clear what was accomplished previously and how this research question will build on that prior work.
    - It seems like a huge challenge to put together a meaningful matrix of challenge conditions across the seasons considering spatial and temporal variability.
    - This work should be narrowed to the top 5 or top 10 dominant Laker ballast-source ports.
- It is good to see there is a plan to reach out to organizations that may be collecting data in port locations (though some organizations such as GLOS may be missing from the stakeholder group).
- While this is a valid research question to ask, it would be a huge resource drain to examine each of the listed biological parameters of interest through the shipping season. Instead of extensive sampling, the GLP recommends measuring organism densities at uptake during shipboard testing to provide context to system efficacy and to identify the parameters under which systems fail
    - Once we know what systems fail at certain abundances, more focused sampling can identify when/how frequently those abundances occur

    - Coordinating with other agencies/institutions (e.g., EPA, DFO) to undertake port sampling during their regularly planned sampling season and share data with GWRC will also reduce the resource drain on GWRC
- We recommend that GWRC connect with other test facilities (e.g., through GloBal TestNet) to verify if a separate assessment of the <10 um organisms is truly a knowledge gap and to acquire data that may already be available.
    - Based on the preamble to this research area, it seems there will be a focus on the <10 um organisms and new indicator (fish) pathogens.
    - A strong case has been made that organisms <10 um can dominate the plankton community numerically, but there is no evidence that these are not being managed effectively by current BWMS technology. To date, it seems the >50 um organisms pose the greatest challenge for BWMS technology.
    - Some test facilities are already counting the <10 um organisms, though not necessarily reporting on that data
- For the water quality parameters, consider if data sondes can be placed in a few of the major ballast-source ports to collect data for a full season, if such monitoring is not already taking place.
- The objective of the eDNA marker work is unclear, and it may also be redundant of other initiatives – e.g., U.S. EPA has funded four GLRI projects to sequence Great Lakes species for this purpose, including zooplankton. USFWS have also been working on building sequence data for key species. Other initiatives within and outside the region are also already doing this work (e.g., SERC). As ballast water regulations are not species-specific, it is not clear how eDNA work would support the general objective to decrease environmental risk of Great Lakes vessels.

2. Given #1, are the minimum challenge condition requirements specified in the ETV Protocol appropriate (i.e., challenging, but not rare natural environmental conditions) for evaluating BWMS performance in the Great Lakes? **(Obj. 1)**

- Given the comments on Research Question 1, above, this is a low priority
    - Again, there will be little motivation for BWMS vendors to retest under a new Great Lakes specific test plan since the Great Lakes market is so small

3. What are potential emerging or alternative viability assessment methods for BWMS biological efficacy evaluation, and how effective are those methods? **(Obj. 2)**
    a. Are there viability assessment methods that can be utilized for the Great Lakes in order to evaluate treatment effects on planktonic organisms?
    b. Is it feasible to implement these methods during land-based evaluation of BWMS?
    c. Is it feasible to implement these methods during shipboard BWMS evaluation?

- The GLP supports the aim of this project to generate the data needed for USCG to accept Most Probable Number (MPN) method and low-dose UV BWMS on the Great Lakes, although it is not clear what proportion of UV-based BWMS are 'low-dose' systems for which this is relevant.
    - Many UV-based BWMS are high-dose and the standard FDA-CMFDA assessment method will be fine. Regardless, since UV-based BWMS are most desirable for the Great Lakes, having suitable methods for testing all systems can be of benefit.

- As the prior work conducted by GWRC does not seem to be publicly available, it is not possible to comment on the suitability of the proposed research. It is noted that extensive research has already been conducted on MPN methods (e.g., MacIntyre et al., 2019) which should be the basis for any additional research.
    - As suggested previously, it will be important to complete the literature review to developed detailed methodology and project plan, for further evaluation by the stakeholder group before extensive lab/field work is initiated.

4. Are there assessment methods for evaluating the mortality and/or viability of eggs and resting stages of organisms exposed to ballast water treatment? **(Obj. 2)**

- The GLP recommends focusing on other research areas first; resting eggs are important but given the challenges with these assessments, are a lower priority compared to other issues. Furthermore, because this issue is not specific to Great Lakes conditions, other research groups are looking at this globally, and the GLP prefers to see Great Lakes resources focus on addressing priority Great Lakes-specific issues.

5. Is there a method that can be used to accurately assess the environmental acceptability of treated and neutralized ballast water upon discharge? **(Obj. 2)**
    a. Is there an adequate benchmark value/environmental acceptability standard that can be used to ensure protectiveness to Great Lakes ports receiving ballast?
    b. Is it feasible to implement this method during shipboard BWMS evaluation?

- This question is bigger than the Great Lakes. Chemically treated ballast water can't be used on lakers due to corrosion, so there is little value in focusing on this issue for Lakers.
    - If this R&D plan is addressing the movement of Great Lakes water in the Great Lakes, the focus should be on UV and other non-chemical systems, making neutralization irrelevant.
    - Even considering salties, a significant majority of those coming into the lakes appear to have UV-based BWTS, so expending research effort on the few that might run a non-UV system is not a good use of resources.
- The IMO GESAMP BW Working Group has already established an extensive list of disinfection byproducts generated by each BWMS through G9 evaluation, and have conducted extensive modelling of chemical byproducts and discharge risk
- Water Quality Standards for the Great Lakes are already designed to be protective of aquatic life and drinking water, and there is known information about these types of wastewater and disinfection byproducts. The GLP does not consider additional work in this area to be a priority; further, this is a regulatory-focused decision (i.e., whether to use federal or more stringent state standards) that should not be addressed by this group
    - Technology is available to meet these standards, so that should be the benchmark for acute and chronic values.
    - Dilution should not be considered an appropriate mechanism, as that would be contrary to the Clean Water Act.

6. What changes to the existing ETV Protocol are appropriate for its use to evaluate BWMS effectiveness for Great Lakes vessels? **(Obj. 3)**

- As noted above, the value of adapting the ETV Protocol for Great Lakes water quality, biology, and the operational realities of the Great Lakes fleet has not been clarified. The

view of the GLP is that resources are better spent testing existing systems at various locations within the Great Lakes

- Should the stakeholder advisory group agree that there is significant value to updating the ETV protocol with Great Lakes-specific conditions, consider:
    - The greatest value to be gained through this research question is to generate additional, objective data regarding the Most Probably Number testing method proposed by industry. Information generated on this topic may inform USCG rule-making if completed within the next year. If this data is unable to be generated prior to the upcoming USCG rule-making, it may still hold value during the following five year cycle of rule-making review and updates

Research Area 3: Accelerating Development of Emerging Ballast Water Treatment Technologies

Objectives

1. Acceleration of Ballast Water Treatment Technology Development
2. Research and Development Testing for Emerging Ballast Water Treatment Technologies

Research Questions

1. What resources exist or can be provided to accelerate bringing Great Lakes-specific solutions to market? **(Obj. 1)**

- The role of this research plan should be to promote and expand research on testing relevant to Great Lakes conditions and ballast water management by lakers, and other research questions, rather than trying to answer resource/policy questions such as this one

2. Are there promising, emerging technologies for treating ballast water that may be candidates for undergoing Great Lakes-specific testing, including using the Great Lakes-adapted protocol? **(Obj. 2)**

- This is a long-term and lower priority compared to testing known systems now

3. Are there promising, emerging technologies capable of treating waters in addition to Great Lakes water? **(Obj. 2)**

- This is a lower priority research question, and effort and resources should be focused on Great Lakes water

Research Area 4: Development of Ballast Water Indicative Monitoring Methods

Objectives

1. Development of a Method to Collect Representative Ballast Water Discharge Samples Onboard Great Lakes Commercial Vessels
2. Great Lakes Verification of Ballast Water Indicative Monitoring Tools

Research Questions

1. What are the most practical indicative monitoring methods to determine effectiveness of a variety of ballast water management strategies used by Great Lakes vessels? **(Obj. 1)**

- Given existing research (e.g., SGS 2020 white paper; Sarah Bailey, Fisheries and Oceans Canada, personal communication) indicating that failures occur almost exclusive for the >50 µm size class, this work should focus on truly practical sampling methods for monitoring this size class, recognizing that what is ideal by research standards (e.g., 3 cubic meter water volume) may not be practical for monitoring
    - This is another issue that is not unique to the Great Lakes, and the focus of this plan may be better spent on unique Great Lakes issues

2. Are indicative monitoring devices sufficiently accurate, precise, and sensitive to assess Great Lakes ballast water? **(Obj. 2)**

- More emphasis should be placed on non-biological monitoring, including chemical/physical methods to measure compliance
- Note that ICES has published a protocol for verification of compliance monitoring devices, which is under discussion at IMO, and ISO is working on a separate standard for verification of compliance monitoring devices. So, if there is going to be any work on assessing devices, these should be the methods followed, at a minimum, or the results may not be upheld within the ballast water community
- Other organizations are engaged in and have funded this work, and indicative sampling devices are already in the marketplace with additional devices in development. This is another issue that is not unique to the Great Lakes, and the GLP continues to recommend that the GWRC focus this R&D plan on unique Great Lakes issues

Research Area 5: Assessing the Risk of Aquatic Nuisance Species Transfer From Ballast Water Discharge

Objectives

1. Establishment of Great Lakes Focal Ports to Determine Interlake Transfer
2. Using Semi-Field Methodologies to Determine the Impact of ANS Reduction in Managed Ballast Water

Research Questions

1. What is the risk of ANS interlake transfer via ballast water? **(Obj. 1)**

- The sampling of ANS at Great Lakes ports to assess risk is a huge research question that requires an immense amount of resources as well as lakes-wide coordination across research institutions, regulatory agencies, and industry. The GLP recommends that GWRC take a more active role in ballast (ship) sampling, allowing more data to be collected over the timeframe of this plan (in collaboration with SERC)
- Sentinel Port Monitoring/Greg Ruiz (SERC) have been funded to conduct port monitoring work in the Great Lakes and at Duluth-Superior, using similar methods to previous work in Chesapeake Bay and on the California coastline. There is value in this plan supporting the work of the Ruiz group and collecting samples to share with them, given the limited window for sampling across the Great Lakes
    - Surveillance port monitoring across all of the Great Lakes is outside the scope of capacity of the GWRC and may be achieved through other regional projects outside of this R&D plan, including ongoing surveillance efforts in the Great Lakes (e.g., U.S. Fish and Wildlife Service) that are undertaking similar work to understand ANS interlake transfer
- Numerous studies have already quantified interlake transfer risk through ballast water (e.g., Briski et al. 2012; Bailey et al. 2012)
    - The proposal here is completely undefined with no explanation of how risk would be determined
    - Additional effort is likely to have limited success and contribute little to the existing knowledge base; this is a question that would normally be addressed before establishing a research plan to solve the perceived problem

2. What is the relative ANS loading associated with various vessel voyage patterns within the Great Lakes, and are there significant differences that may warrant different technologies or practices for these different situations? **(Obj. 1)**

- The purpose of this question is unclear and project methods are undefined. Without understanding how this data will inform ballast water management, and recognizing that this would be another high-effort undertaking, this is a low priority to the GLP

3. Using existing semi-field methodologies and a variety of freshwater taxonomic groups, can the impact of ANS reduction in Great Lakes ballast water be determined under a variety of scenarios? **(Obj. 2)**

- The GLP recommends that GWRC focus on building on previous work on this research question by other agencies (notably DFO) in order to inform models that are already in use and filling data gaps needed to improve those models

GLP Comments; Research Area 5: Assessing the Risk of Aquatic Nuisance Species Transfer From Ballast Water Discharge

- There are many important risk-release studies not referenced here (including Bailey et al., 2009; National Resource Council, 2011; Lee et al., 2013; Leung et al., 2004) as well as recent government documents that incorporate the risk-release relationship within ballast-mediated invasion models (e.g., Drake et al. 2020)
- It is important that a full gradient of organism densities is explored during inoculation, from densities that would strongly exceed treatment, to densities that are non-zero but effectively undetectable during tank sampling.
- The choice of surrogate invader should be heavily scrutinized, especially in relation to the recipient community.
- The experiments should strive to incorporate as many invader identities, environmental conditions, biotic conditions, and timeframes as possible. This will allow the full set of possible risk-release relationships to be identified

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Comments on GLLCISP Plan v5
Transport Canada / Fisheries and Oceans Canada
June 2023

GENERAL COMMENTS:

Thank you for the opportunity to comment on and provide feedback for the ongoing R&D plan. In the following, we would like to provide general comments as well as feedback specific to certain research areas, and where applicable, objectives and their related projects.

As stated in the Great Lakes Ballast Water R&D Plan, Version 5, the mandate of the Great Lakes and Lake Champlain Invasive Species program (GLLCISP) is to "*assess the risk of ANS introduction and spread via ballast water as a vector within the Great Lakes System and identify and develop ballast water management practices for use by commercial vessels as necessary to prevent the spread of ANS within this system*." (p. 5). In this respect:

- We believe there is an opportunity to make stronger links between project plans and outcomes and the above objective at this stage of the program.

- There is an opportunity to focus more on ports of ballast water uptake in the Great Lakes system and explore a broader range of seasonality, with a consequent reduction in emphasis on studying uptakes at the port of Duluth where ballast water is normally discharged.

- The research could focus more on mitigation strategies and improvements at this stage as opposed to characterization of challenges.

Given the small size of the Great Lakes market for BWMS, and the presence of international ships in these waters, the goal of BWMS improvements is most likely to occur through improved U.S. and international rules regarding BWMS. Therefore, we recommend that each project in the R+D plan identify, and work towards influencing, a specific aspect of an international and/or U.S. regulatory provision (e.g. the BWMS Code or U.S. Type Approval requirements) in order to better align with the objective noted above of *"developing ballast water management practices."* In this respect, it should be noted that the International Maritime Organization is expected to amend the BWMS Code in the next 2-3 years to address challenging water quality. This could be a valuable opportunity for binational co-operation to ensure that type-approved BWMS increasingly address Great Lakes water quality challenges.

We recognize that year three is underway, and that the next version of the R+D plan will mostly influence year four and onwards. We suggest that further streamlining the plan can deliver more benefit for the substantial funds being invested. With this in mind, comments relevant to research areas and their respective projects are provided in the following:

Canada

Stakeholder Group Involvement
<u>Objective 1: Formation of the Ballast Water R+D Stakeholder Group and Kick-Off Meeting</u> Project: Form Stakeholder Group/Kick-off
<u>Objective 2: Formation of Data Working Group and Mining, Sharing, and Compiling Existing Data</u> Project: Form Data working Group/Data Mining and Sharing
<u>Objective 3: Engaging Stakeholders during R&D Plan Implementation</u> Project: Stakeholder Group Engagement
COMMENT(s): • In our view, thus far stakeholder meetings have not occurred with the optimal level of frequency. While a general overview of project progress has been presented at meetings, these have not consistently included a scientific discussion including clear objectives, methods, results, implications and next steps of each project. For this reason, many project discussions have been very general and less systematic and grounded in data, and this has limited opportunities for stakeholders to benefit from new knowledge being generated. As a result, meetings have not been optimal in terms of informing the science work going forward. • Project results have not yet been circulated in the form of reports or peer-reviewed scientific publications. Given the importance of the GLLCISP, it is crucial that results be reviewed by the broader scientific community if they are to provide a reliable basis for policy. We understand that some projects remain in progress, but interim publications should be considered where appropriate. • We recommend the creation of a specific science committee. Potential members with specific scientific expertise and experience on the Great Lakes could include: Greg Ruiz, Dave Reid, David Lodge, Rochelle Sturtevant, Sarah Bailey, and Hugh MacIsaac. We recommend regular science calls (e.g. bimonthly) that could include discussions on experimental design, adjusting to unforeseen impacts, and progress. Attendance at these calls should focus on scientific practitioners and technical project participants, and the agenda should be purely technical and operational. These meetings would be expected to provide mutual benefit to participants, including coordination and cooperation within and between field seasons, recognizing that other ongoing research programs in the region complement GLLCISP. • We note that the GLLCISP did undertake a data mining exercise, into which we did share data. We do not believe the “data mining and sharing” working group has been convened since year 1. We would welcome a better understanding of the GLLCISP plan for sharing the data it has accumulated and generated with this working group.

Research Area 1: Identification of Methods/Alternatives and Assessment of Cost for Great Lakes Ballast Water Management

Objective 1: Determination of Operational Characteristics of Commercial Vessels Trading within the Great Lakes System

Project: Determining Operational Characteristics of Great Lakes Vessels

COMMENT(s):

- We do not recall having seen any results on this project to date, and note that it was to be completed in year 1. It would be helpful to understand if this project still ongoing, and how its results will be conveyed and peer-reviewed.

Objective 2: Land-Based Evaluation of the Effectiveness of IMO Compliant and US Coast Guard Type Approved BWMS in Great Lakes Water

Project: Land-Based BWMS Evaluation

COMMENT(s):

- We do not see a compelling need for further land-based testing of BWMS given the data already collected and given BWMS type approvals. Continuing this work risks spreading research resources and priorities too thinly. Land-based testing offers conditions that are controlled but does not provide for samples that reflect shipboard and operational conditions.
- A further challenge with land-based testing at Duluth is that the water quality challenges there are not relevant to ports of uptake on the Great Lakes. We do not believe further land-based testing at a port that predominantly receives ballast water is necessary given the objective of the GLLCISP to "*develop ballast water management practices for use by commercial vessels as necessary to prevent the spread of ANS within this system."* This comment also informs our views on the projects below.
- Research into spread concerns reducing the transportation of organisms in ballast tanks, which implies working at ports of ballast water origin. Therefore, we recommend shifting to more systematic shipboard sampling of in-service BWMS at the primary ports where ballast water is loaded on the Great Lakes.

Objective 3: Shipboard Evaluation of the Effectiveness of IMO Compliant and U.S. Coast Guard Type Approved BWMS in Great Lakes Water

Projects: Shipboard BWMS Evaluation

COMMENT(s):

- Our primary observation regarding shipboard testing is that the number of samples to date appears to be small and conducted over a short period of each year that may introduce a seasonal bias into the results.
- We recommend GLLCISP expand the number of annual samples in a targeted way to assemble a dataset that is representative of primary ports of ballast water uptake and seasonal ballasting patterns. We recommend caution in focusing on "worst case" ports and conditions; while some of this data is helpful to inform revisions of global IMO/U.S. BWMS type approval procedures, oversampling can introduce bias into a dataset intended to inform policy, and systematic data is desired over anecdotal results.
    - We suggest at least 10 paired samples per year that compare harbour (uptake/before treatment) and discharge (treated) water at major ballast loading ports.

- We also recommend the expansion of the type of ship-board testing that is done in partnership with the Smithsonian Environmental Research Centre. Consideration could also be given to expanding sampling through the use of experienced, reputable contractors, such as SGS, that have experience in detailed ballast water sampling and analysis to complement work already underway.

- Our experience is that newly-installed BWMS present a learning curve for ships and crews. We have observed that the GLLCISP project to date has focused on sampling of new BWMS installations, which have been affected by initial installation, operation and maintenance problems that impact BWMS reliability and efficacy. Caution should be used in interpreting results collected during the 'learning curve'. We recommend focusing on ships where BWMS have been in regular use for a few seasons. For context, Canadian shipowners using BWMS have conveyed that operational challenges are easing with experience, and that remaining challenges are location-specific and operations-specific (e.g. differences between docking aft-end in vs. forward-in).
- We caution drawing conclusions based on the use of BWMS that are undersized compared to vessel needs, which we understand to underlie some of the challenges reported to the GLLISCP so far. Properly selecting a suitable and adequately-sized BWMS is a crucial and cost-effective step to reducing installation, operation and maintenance challenges once the BWMS enters into service. BWMS sizing is a commercial decision that should take into account expected in-service flow rates vs. vessel needs. It would be valuable for GLLCISP to consider system sizing in allowing commercial vessels to more easily "*prevent the spread of ANS within this system."*
- We recommend using sampling and analysis methods consistent with Fisheries and Oceans Canada (DFO) (which align with the globally-accepted ICES Standard Operating Procedure) in order to facilitate later pooling of data. Taxa should be identified to the species level to inform BWMS performance and standards. We recommend reducing reliance on ship self-reports and BWMS logs that, while clearly well-intentioned, may not provide enough systematic data to answer research questions with reliability.
- Finding ships may be facilitated by sampling U.S, Canadian or foreign vessels and in this respect we continue to support "key question" 1b under objective 3 of research area 1 in v5 of the plan. In our view, doing so may also help to increase the number and representativeness of sampling at major ports/seasons of ballast water uptake. It may also address the issue of sampling new installations.

Objective 4: Evaluating the Effectiveness of Ballast Water Best Management Practices Including Hybrid Solutions

Projects: Ballast Water Filter Performance
Project: Ballast Water BMP Effectiveness

COMMENT(s):

- With respect to the planned winter filtration project presented at the last stakeholder meeting, we note it is framed as a search for challenges. We would suggest including a mitigation component into this type of project, which in this case could include varying the depth of sea suction and simulating the recirculation of waste heat.
- High sediment rates are known to cause problems for filtration-based BWMS in global ports as well as on the Great Lakes. In improving filter performance, it may be helpful to study systems in which the filter is oversized relative to the TRC of the BWMS, where multiple filtration units are installed in parallel, or where a pre-filter is fitted before the type-approved BWMS.
- There was discussion of assessing filtration alone as a ballast water management practice at the stakeholder meeting. There has been significant work undertaken on this already, so the utility of

further study should be considered. It is our understanding that filtration alone would not resolve the filtration challenges associated with BWMS, nor would it reliably achieve the D-2 standard.
- Further study of the VGP BMPs may provide only diminishing returns.

Objective 5: Evaluating the Feasibility and Significant Impacts of Ballast Water Reception Facilities within the Great Lakes

Projects: Feasibility Study of Reception Facility Treatment

COMMENT(s):

- While there has been long-standing discussion on this issue it has never been demonstrated to be feasible or cost-effective. Based on discussions at the stakeholder meeting, industry does not see this as a viable approach for its ships.

Objective 6: Assessing the Cost of Ballast Water Management Strategies on Commercial Vessels Operating Exclusively within the Great Lakes System

Project: Management Strategy Cost

COMMENT(s):

- There are independent cost estimates available from the U.S. Coast Guard study and Transport Canada's *Transactions on Ballast Water Treatment Systems for the Great Lakes.* Given that the GLLCISP is science-based, this objective doesn't clearly align with the rest of the program. We recommend that consideration be given to removing further costing work from the plan and undertaking it in an economic/policy context instead.

Research Area 2: Toward Development of Great Lakes Relevant BWMS Testing Protocol

Objective 1: Characterizing BWMS Challenge Conditions in the Great Lakes System

Project: Characterize BWMS Challenge Conditions

COMMENT(s):

- We recommend merging this project into an expanded and more representative shipboard testing program.
- The work to date at Duluth can be considered as proof of concept, and it would now be helpful to expand the effort to the main ballast water loading ports on the Great Lakes, as well as different seasons (throughout the shipping season). Doing so would provide more operationally relevant results.
- Linking the challenge conditions to BWMS performance and operational impacts (through the paired harbour/uptake and discharge sampling, as mentioned in Research Area 1-3) would be more informative than assessing water quality parameters in isolation.

Objective 2: Evaluating Alternative/Emerging Sample Analysis Methods for Ballast Water Treatment Technology Testing

Project 2: Viability Assessment Method Development
Project 3: Eggs/Resting Stages Method Development
Project: 4: Ballast Discharge Toxicity Method Development

COMMENT(s):

- Viability assessment methods focus on the 10-50 µm size class, which does not pose much challenge to existing approved BWMS (near 100% pass rate in Canadian and global sampling

programs using live/dead stain method). We believe devoting further resources to project 2 might provide only diminishing returns.

- With respect to assessing the viability of eggs and resting stages in project 3, we do not believe there is evidence linking this issue primarily to the Great Lakes. We believe work on this broader issue could divert focus from the GLLCISP emphasis on solution-finding relating to the reduction of the spread of organisms in Great Lakes ballast water.
- We are interested in any results that have been achieved to date in these projects, and look forward to final publications. However, as we continue to be unclear on the benefit of this broader work relative to the more specific goals of the GLLCISP, we suggest consideration be given to winding this work down after year 3.

Objective 3: Development of a Great Lakes Adapted Protocol for Verification of BWMS

Project 5: Protocol Development

COMMENT(s):

- While we do want to see the globally-applicable IMO and USCG type-approval standards strengthened to account for challenge conditions on the Great Lakes, this is served by Objective 1 of Research Area 2. That work to characterizing water quality for the lakes (at ports of substantial ballast water uptake) will help to improve IMO and USCG type-approval challenge conditions and thereby improve the performance of BWMS in challenging seasons and locations on the Great Lakes.
- However, we continue to be concerned by the concept of going further to create a 'Great Lakes-specific protocol' for assessing BWMS. We are concerned that any efforts to develop a new regional protocol that would require development of new equipment could extend technology-development beyond the timeframe of the current GLLCISP. It could also have the unintended consequence of reinforcing the challenges of sourcing BWMS for a small Great Lakes market. We believe the GLLCISP should focus on existing equipment, which provides a substantial risk reduction as demonstrated by Canadian science.

Research Area 5: Assessing the Risk of Aquatic Nuisance Species Transfer from Ballast Water Discharge

Objective 1: Establishment of Great Lakes Focal Ports to Determine Interlake Transfer

Project: Quantifying ANS Transfer

COMMENT(s):

- Significant data exists regarding the organism populations transported in the ballast water tanks of Canadian, U.S. and international ships following uptake in the Great Lakes basin. Any further efforts along these lines should focus on closing specific gaps in this data, and building representativeness concerning the seasons and locations of ballast water uptake on the Great Lakes.
- With respect to the sentinel sites, monitoring efforts are valuable, especially when they collect data systematically, use methods comparable to vessel sampling, identify taxa to the species level, and are representative of the seasonal and spatial distribution of discharges.
- It should be noted, however, that species invasions can be rare, high impact events. The absence of a new species detection over the short period of this R+D program at a small number of locations may not be material to future risk assessments. Caution is therefore indicated in interpreting the results.

Objective 2: Using Semi-Field Methodologies to Determine the Impact of ANS Reduction in Managed Ballast Water

Project: 2: Determining Impact of ANS Reduction

COMMENT(s):

- We appreciate the work undertaken on this project to date, and look forward to seeing how the results compare with the existing body of work along these lines that has already been undertaken, including in the Great Lakes.
- We note the challenges in trying to quantify the risk-release relationship, as noted in the National Research Council's 2011 study (*Assessing the Relationship Between Propagule Pressure and Invasion Risk in Ballast Water*), which concluded that such efforts would require multiple lines of evidence over long timescales. The NRC study concluded that the best approach is to implement a ballast water standard (such as D-2) and carry out a long-term assessment of the benefits.
- We concur with the NRC conclusion and suggest taking stock of the current work to determine if there may be diminishing returns to continuing the work beyond this year, given the short remaining timeframe of the GLLCISP.