Great Lakes Panel
ANS
on Aquatic Nuisance Species

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Dr. Matt TenEyck, Director, Great Waters Research Collaborative
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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

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

- 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

- 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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