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Update on Ballast Water Research in Canada

Sarah Bailey

Fisheries and Oceans Canada

Canada

Current/Recent Projects

- Preparing to Implement the Convention
  - Tools for rapid compliance checks
  - Risk-based decision support tool for Inspectors
  - How to collect a “representative” sample
  - Factoring uncertainty into decision-making
- Arctic Shipping Vectors
  - Ballast Water vs. Biofouling
  - Commercial vs. Military Ships
  - Coldwater treatment testing

Tools for Indicative Analysis

- Previously reported on RV METEOR voyage comparing different tools/methods for ballast water analysis
- Special issue(s) in Journal of Sea Research was organized to publish findings from the cruise and more broadly on Recent Advances in Ballast Water Research
- See ‘Recent Articles’ online at https://www.journals.elsevier.com/journal-of-sea-research/recent-articles

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Optimizing methods to estimate zooplankton concentration based on generalized patterns of patchiness inside ballast tanks and ballast water discharges

Sarah Bailey and Harshana Rajakaruna

(submitted to J. Applied Ecology)

Canada

Research Problem

- Zooplankton populations can be spatially heterogeneous and stratified/trended inside ship ballast tanks and in ballast discharge
- sampling protocols to monitor compliance with Regulation D-2 “should result in samples that are representative of the whole discharge of ballast water from any single tank or any combination of tanks being discharged”
- Sampling methods should therefore take heterogeneity and trends into account, for accurate estimation of tank average

Background Info

- Very limited data on spatial structure of plankton inside ballast tanks – some evidence for trends by depth (at least for some taxa – Murphy et al. 2002)
- Recent inline sampling studies report that zooplankton concentration can vary widely depending on the timing (sequence) of sample collection - Gollasch & David 2013

- If there are trends and patchiness in-tank and inline discharge, estimates disregarding depth and sequence of volume discharged can lead to large errors (uncertainty) in decisions on compliance

Research Objectives

- to examine the spatial heterogeneity of zooplankton within ballast water
- to model and estimate the average concentration of zooplankton across the entire ballast tank
- to determine under which contexts different sampling methods are most representative (yielding the most accurate estimate of the tank average)

Sampling methods

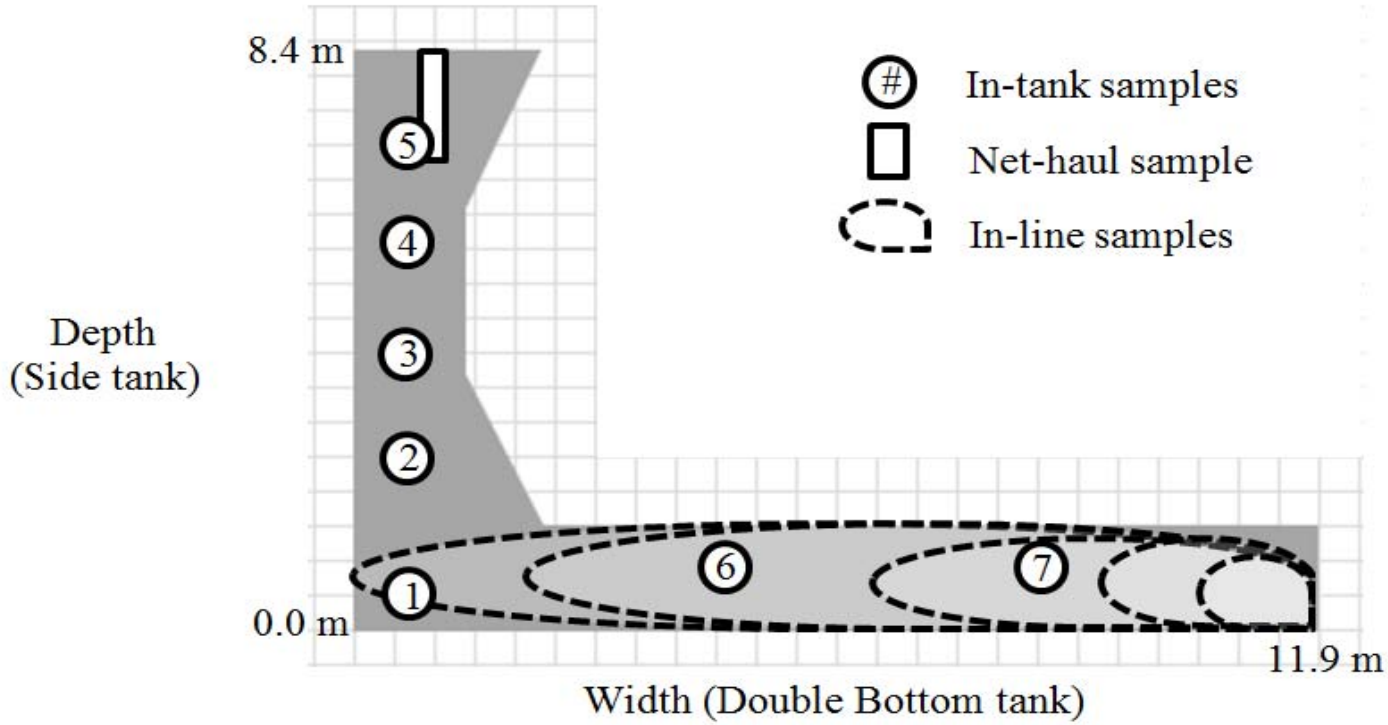


Fig. 1. Cross-sectional diagram of studied ballast tank (view from forward, in grey) showing the location and estimated coverage of the three sampling methods (drawn to scale). Sample points 1 through 5 were used for first four trips; sample points 1, 3, 5-7 were used for final trip. Spatial extent of in-line samples is estimated assuming little tank mixing.

Analytical Methods

- Data from 5 trips (different ballast sources, age, etc.)
- Modeled data to look for trends by volume-discharged & tank depth
- Combined data across methods (net, pump, inline) to generate tank average
- Modeled standardized errors in each sample estimate w.r.t. tank averages
- Estimated bias, variance of errors and their MSE.
- bias - over or underestimations;
- variance - variability;
- MSE - accuracy (the lower the MSE the more likely a random sample estimate approximates the tank average)

Trends by depth / sequence

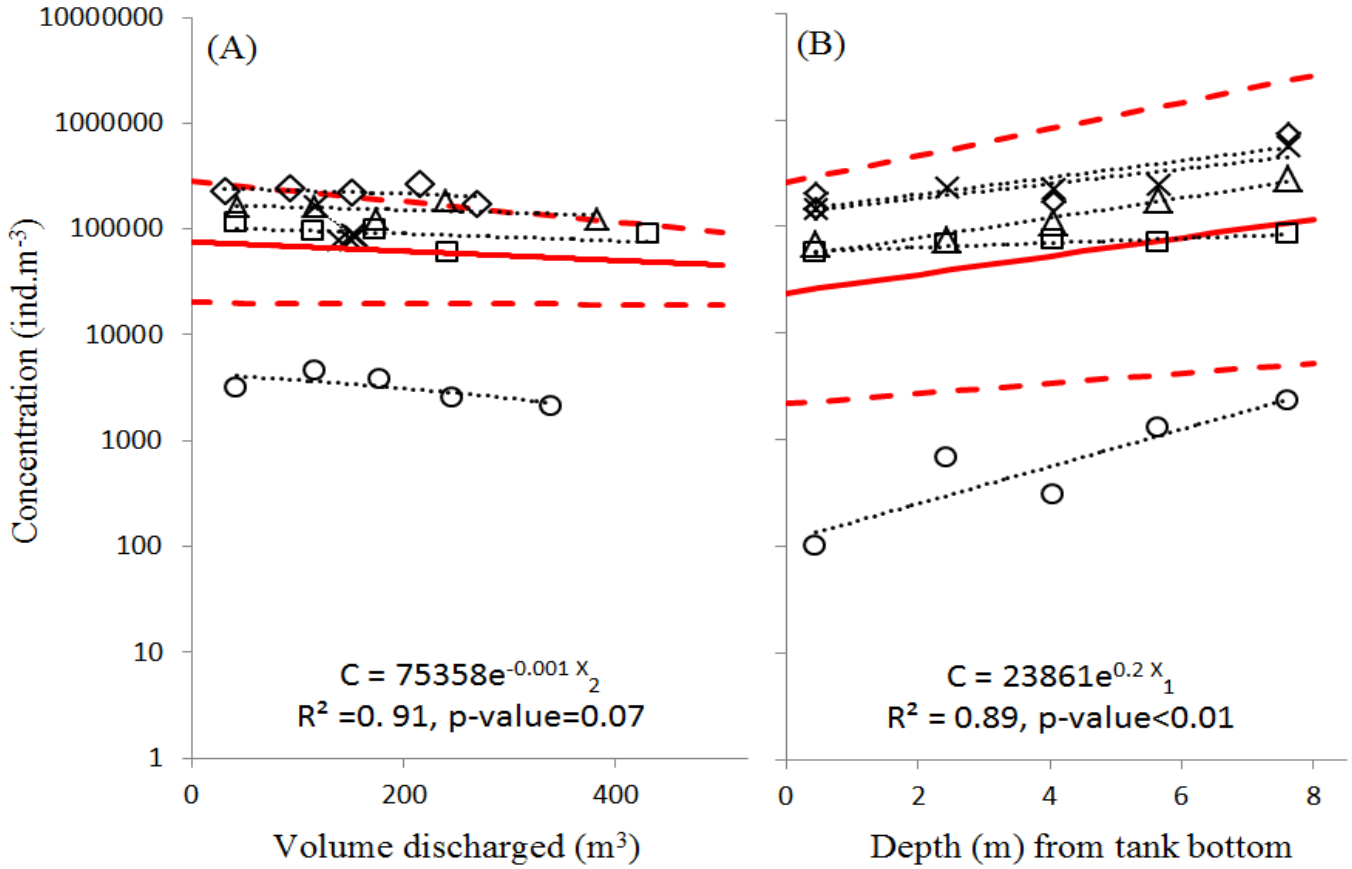
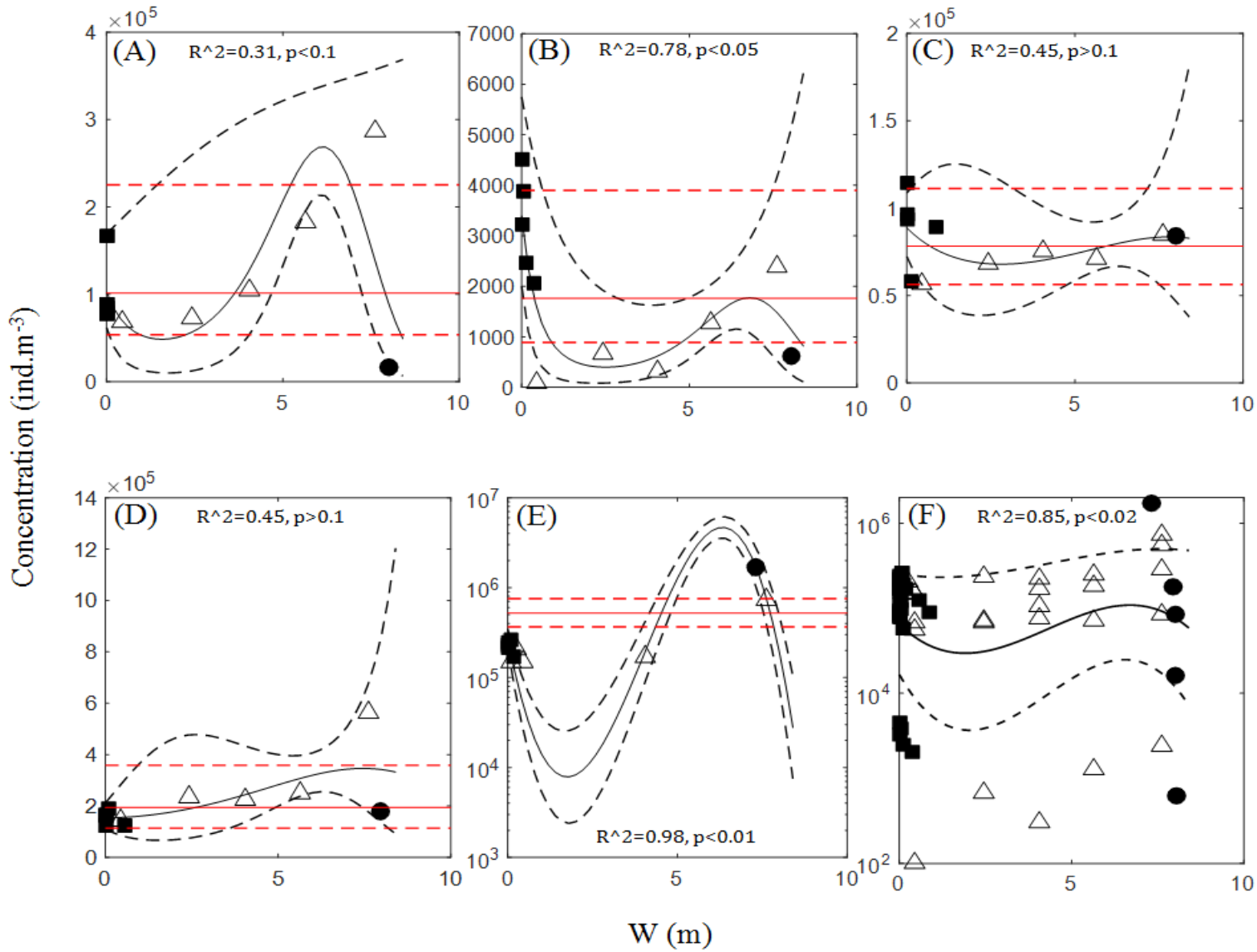
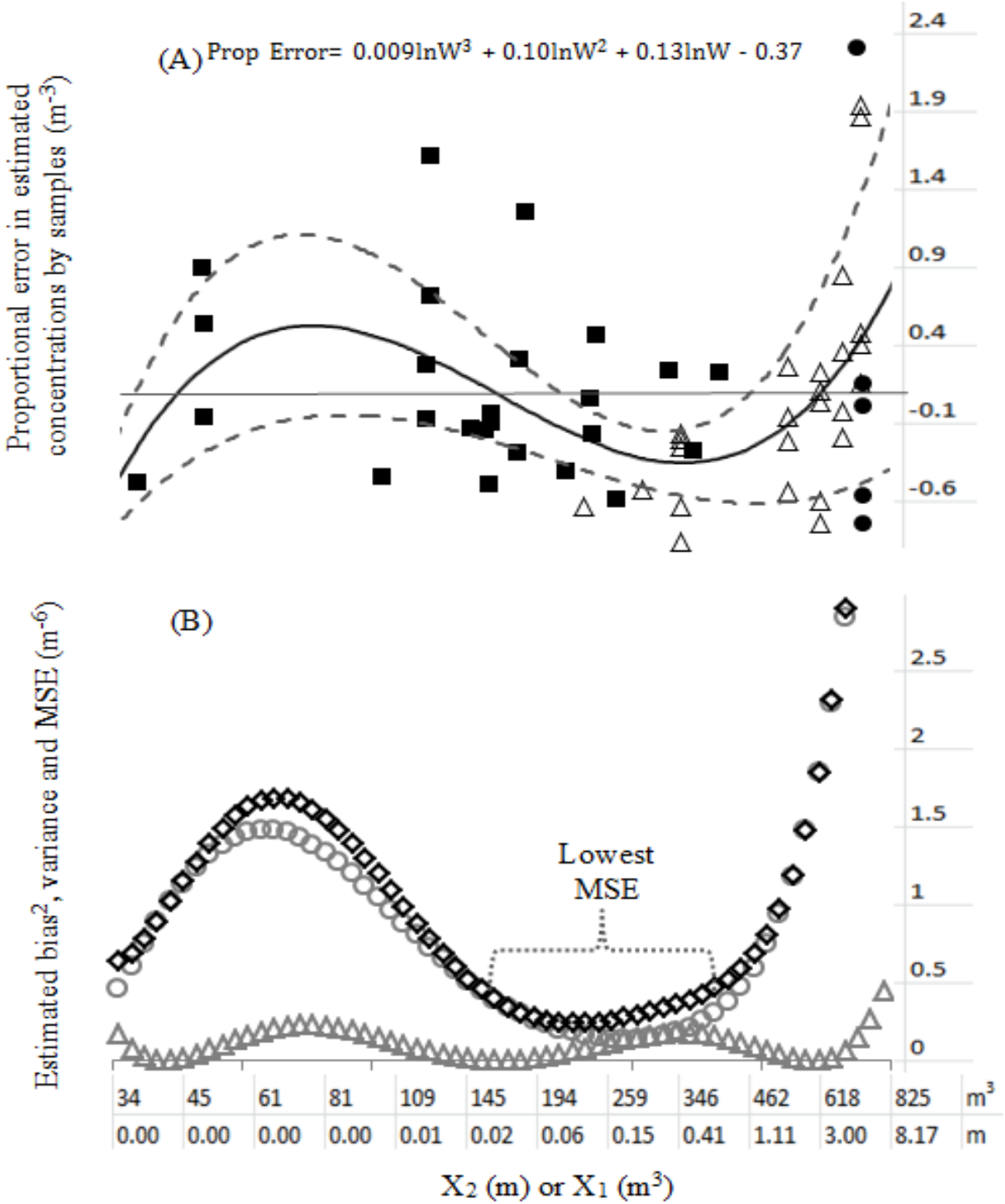


Fig. 2. Point estimates of zooplankton concentration collected by (A) in-line discharge samples and (B) in-tank pump samples across five trips. Black dotted lines denote trends within trips, solid red lines denote the generalized trend across trips, with dotted red lines indicating 95% confidence intervals.

Pooling data to generate tank average



■ inline
△ pump
● Net haul



Sampling Error (Bias,variance and MSE)

Conclusions

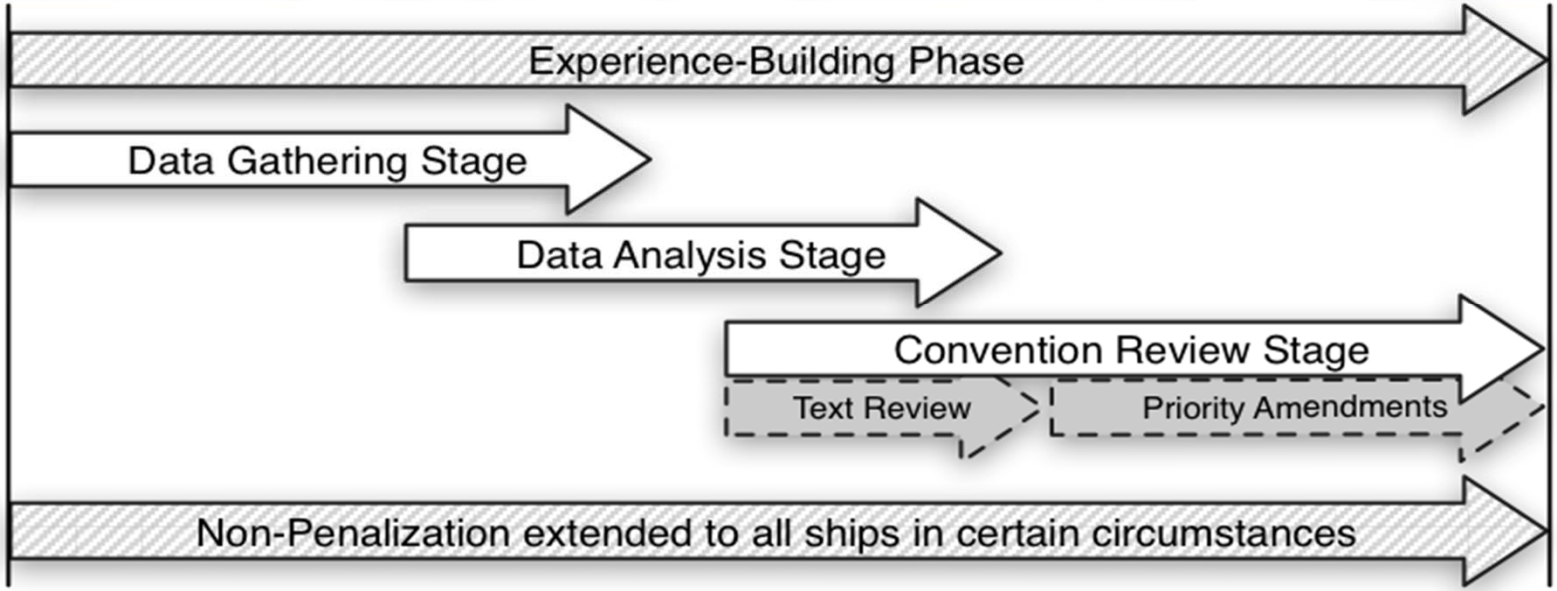
- Sample representativeness, as compared to the tank average, varied depending on the depth or tank volume discharged
- In-line discharge samples provided the least biased and most precise estimate of average tank abundance (having lowest MSE) when collected during the time frame of 20-60% of the tank volume being discharged
- As net-haul estimates show positive bias, a net-haul estimate indicating discharge standard has been met appears to be a robust "pass", while a failure to meet the standard would be uncertain

Caveats

- Results were consistent across trips despite differences in ballast water source, season, and age…
- Additional research examining sample representativeness across
  - different types of ballast tanks
  - different sizes of ships
  - a broader selection of zooplankton communities
  - treated ballast water

  would be beneficial to confirm that the trends we observed are more generally applicable

Experience Building Phase



- Goal: to monitor and identify aspects of the Convention that are working well / to identify issues requiring further attention
- Three stages: data gathering, data analysis, Convention text review
- Non-penalization for non-compliance with D-2 standard when Ballast Water Management System used with best intentions/effort; may take actions to protect the environment

Science Plans 2017-18

- DFO will be trialing sampling and analysis methods to determine feasibility for use by Inspectors
- Will conduct both indicative and detailed sample analysis to examine reliability/precision of indicative methods
- Will gain information about new BWMS and how well they are working
- Aiming for 10-day monthly rotations in major ports receiving ships with BWMS (e.g. Vancouver, Saint John, and Great Lakes)
- Secondary goals: gather more data regarding plankton patchiness inside tanks; harbour sampling (?)

Acknowledgements

Thanks to lab members, academic / gov't collaborators, and industry partners!

J Adams, A Adebayo, J Bradie, E Briski, O Casas-Monroy, F Chan, M Deneau, A Drake, S Ellis, J Kydd, R Linley, H Rajakaruna, M Rup, J Vanden Byllaardt, T Wang

C Henein, P Mudroch, C Wiley

Funding Partners:

Transport Canada Transports Canada

Fisheries and Oceans Canada Pêchés et Oceans Canada

NSERC CRSNG

Canada