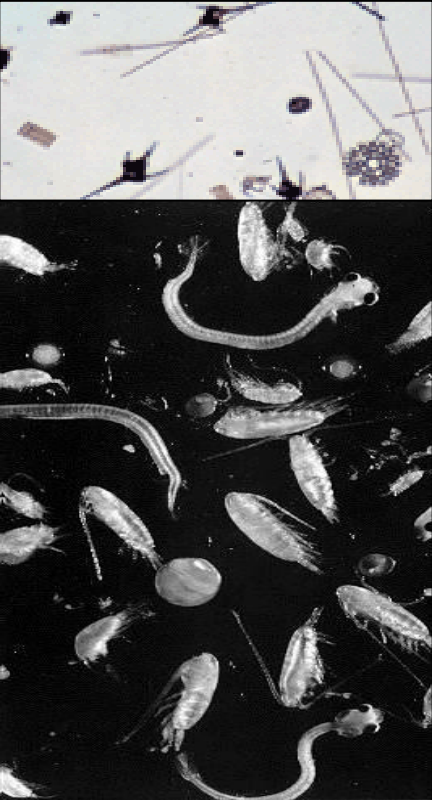




Optimizing methods to estimate zooplankton concentration based on generalized patterns of patchiness inside ballast tanks and ballast water discharges

Sarah Bailey and Harshana Rajakaruna

Research Problem



- Zooplankton populations can be spatially heterogeneous and stratified in ship ballast tanks and ballast discharge
- Sampling protocols for monitoring Regulation D-2 should be “representative of the whole discharge of ballast water from any single/combination of tanks being discharged”
- Sampling methods should therefore take heterogeneity into account, for accurate estimation of tank average

Background Info



- Very limited data on spatial structure of plankton in ballast tanks – some evidence for trends by depth for some taxa ([Murphy et al. 2002](#))
- Recent inline sampling studies report zooplankton concentration varies depending on timing/sequence of sample collection ([Gollasch & David 2013](#))
- If there are trends and patchiness in-tank and during inline discharge, estimates ignoring depth/sequence may lead to large errors (uncertainty)

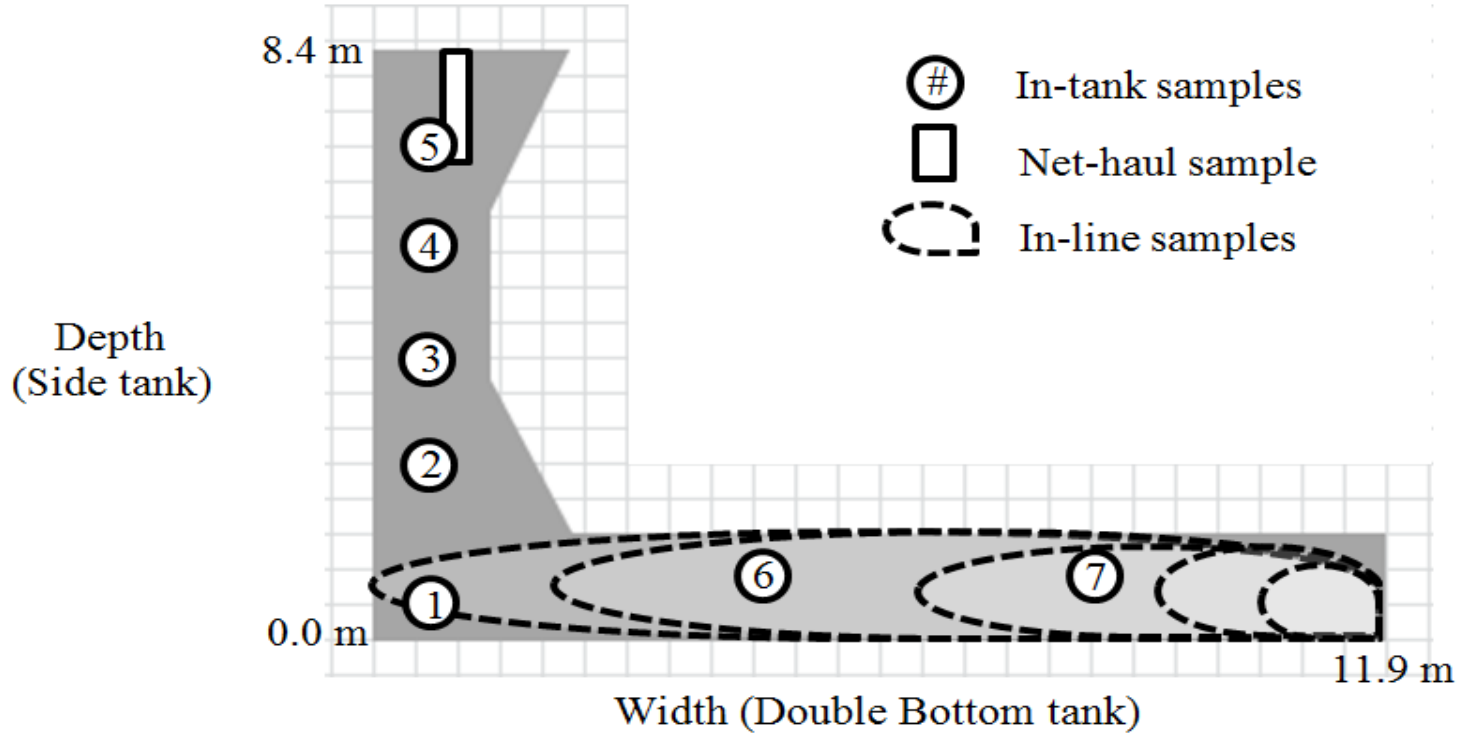
Research Objectives



- to examine spatial heterogeneity of zooplankton in 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 (yield the most accurate estimate of the tank average)



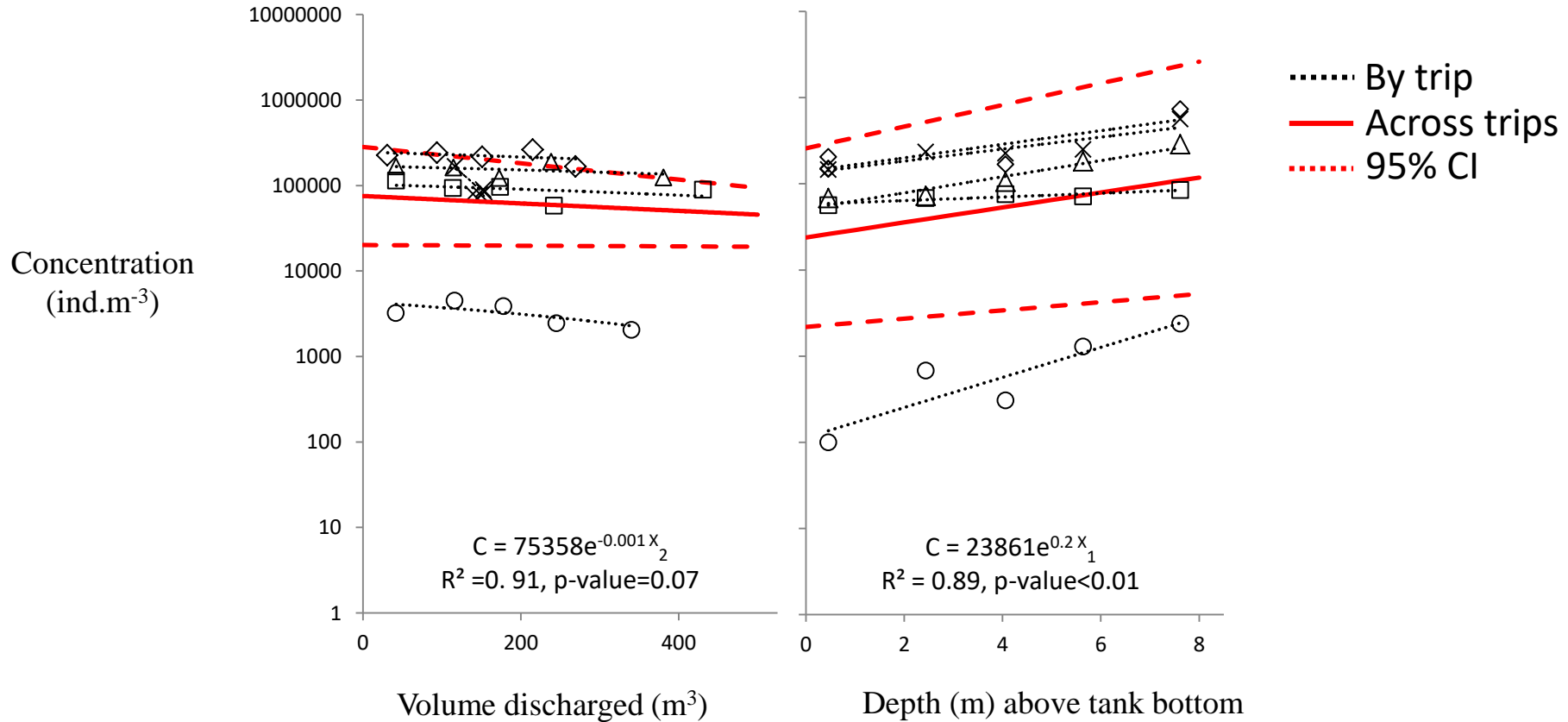
Sampling Locations – M/V Tim S Dool



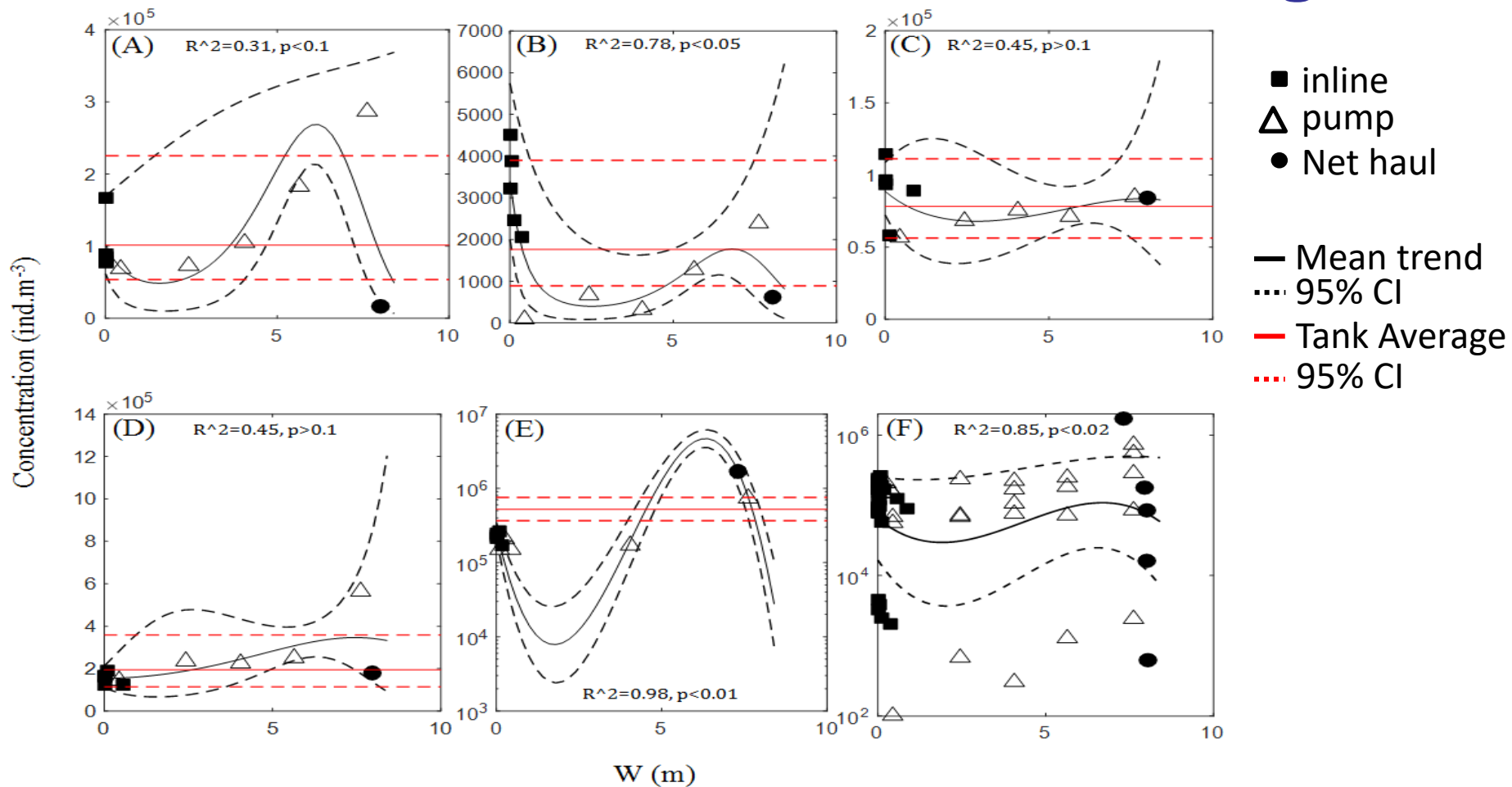
Analytical Methods

- Data from 5 trips (different ballast sources, age, season, etc.)
- Modeled data to look for trends by volume-discharged and tank depth
- Combined all data (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 (lower MSE = better estimate of tank average)

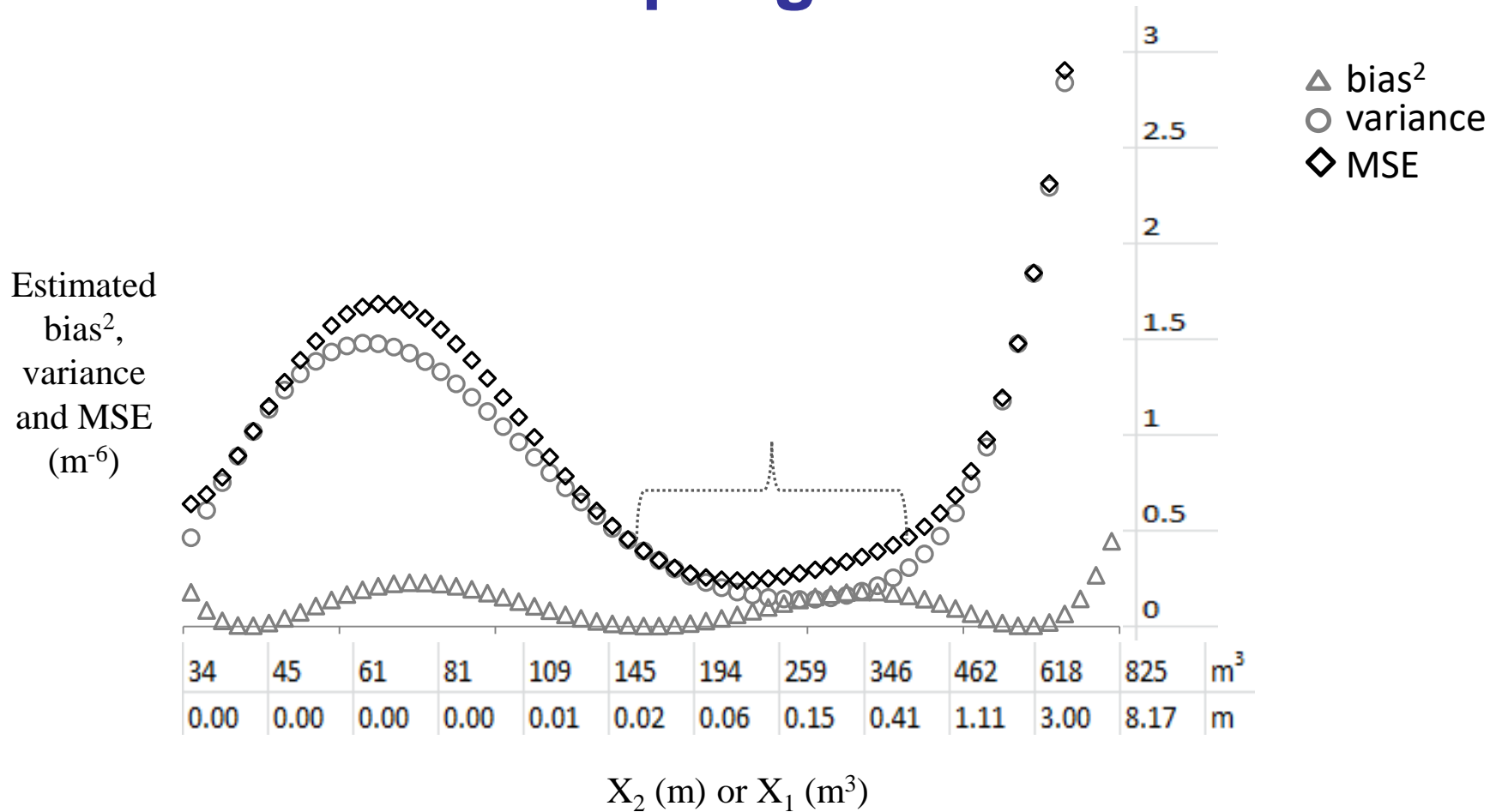
Trends by sequence / depth



Pooling data to generate tank average



Sampling Error



Conclusions

- Sample representativeness, as compared to the tank average, varied depending on the depth or sequence sampled
- 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 meeting D-2 standard appears to be a robust “pass”, while a failure would be uncertain

Next Steps

- Results were consistent across trips despite differences in ballast water source, season, and age...
- Additional research examining sample representativeness would be beneficial to confirm the trends we observed are generally applicable across
 - different types of ballast tanks
 - different sizes of ships
 - a broader selection of zooplankton communities
 - treated ballast water



Acknowledgements

Algoma Central Corporation; crew M/V TIM S. DOOL;
R.D. Linley, J. Kydd, and J. Vanden Byllaardt

Read the full publication in *Ecology and Evolution*; DOI: 10.1002/ece3.3498

Funding



Fisheries and Oceans
Canada

Pêchés et Océans
Canada

Partners:



Transport
Canada

Transports
Canada

