Fisheries and Oceans Canada | Pêches et Océans Canada

Research Update: Canadian Ballast Water Research

Sarah Bailey

Canada

Recent/Current Great Lakes Projects

- National Ballast Water Risk Assessment
- BWE + BWMS Shipboard Testing
- Cold-water treatment testing (Arctic focus)
- Utility of FlowCAM & LOPC for early detection
- Utility of FDA staining & Hach kits for freshwater

National RA: Objectives

- To conduct an analysis of the relative risk among different ballast water pathways in Canada
- Consider the potential for arrival and survival of zooplankton and phytoplankton NIS (microbes are not considered) as well as the magnitude of consequences of these aquatic NIS
- Consider risk posed by ballast water from commercial ships under current regulatory requirements, as well as future requirements for International Maritime Organization (IMO) D-2 performance standards

Anchoring Risk

- There is currently insufficient data to confidently identify p(invasion) for a particular inoculum density (U.S. N.A.S. 2011)
- Invasions are a stochastic process
- Rare, high risk events may be more important than general trends
- Releases spread out over space and/or time may be more important than single, large release events
- Used the GLSLR International transoceanic vessels as a bench mark for relative risk - No ballast-mediated NIS reported in the GLSLR since 2006 (Bailey et al. 2011).

Peer Review Process

- Canadian Science Advisory Secretariat: coordinates the peer review of scientific issues for DFO, fostering national standards of excellence.
- Centre of Expertise for Aquatic Risk Assessment: provides guidance on scientifically defensible biological risk assessment
- Two meetings held to review scientific rigour of methods – more than 15 external shipping, aquatic ecology and invasive species experts participated in peer review
- Monte Carlo simulation recommended to account for high variability, allowing better decision making under uncertainty

Shipping Pathways in Canada

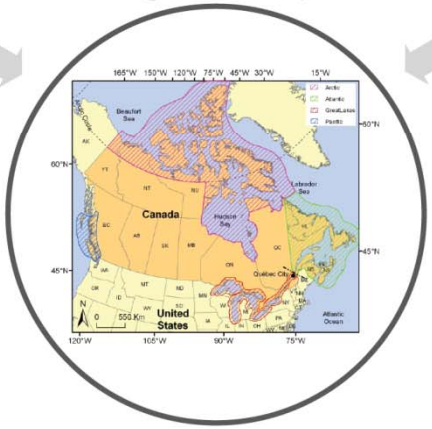
International Exempt vessels
Vessels operating outside the Canadian EEZ, but within the exchange exemption zone

Coastal Domestic vessels
Vessels operating between Great Lakes, Canadian Atlantic & Arctic ports

International Coastal U.S. vessels
Vessels operating outside the Canadian EEZ and the exchange exemption zone on a coastal U.S. route

Atlantic vessels
Vessels that operated exclusively between Atlantic ports inside the Canadian EEZ

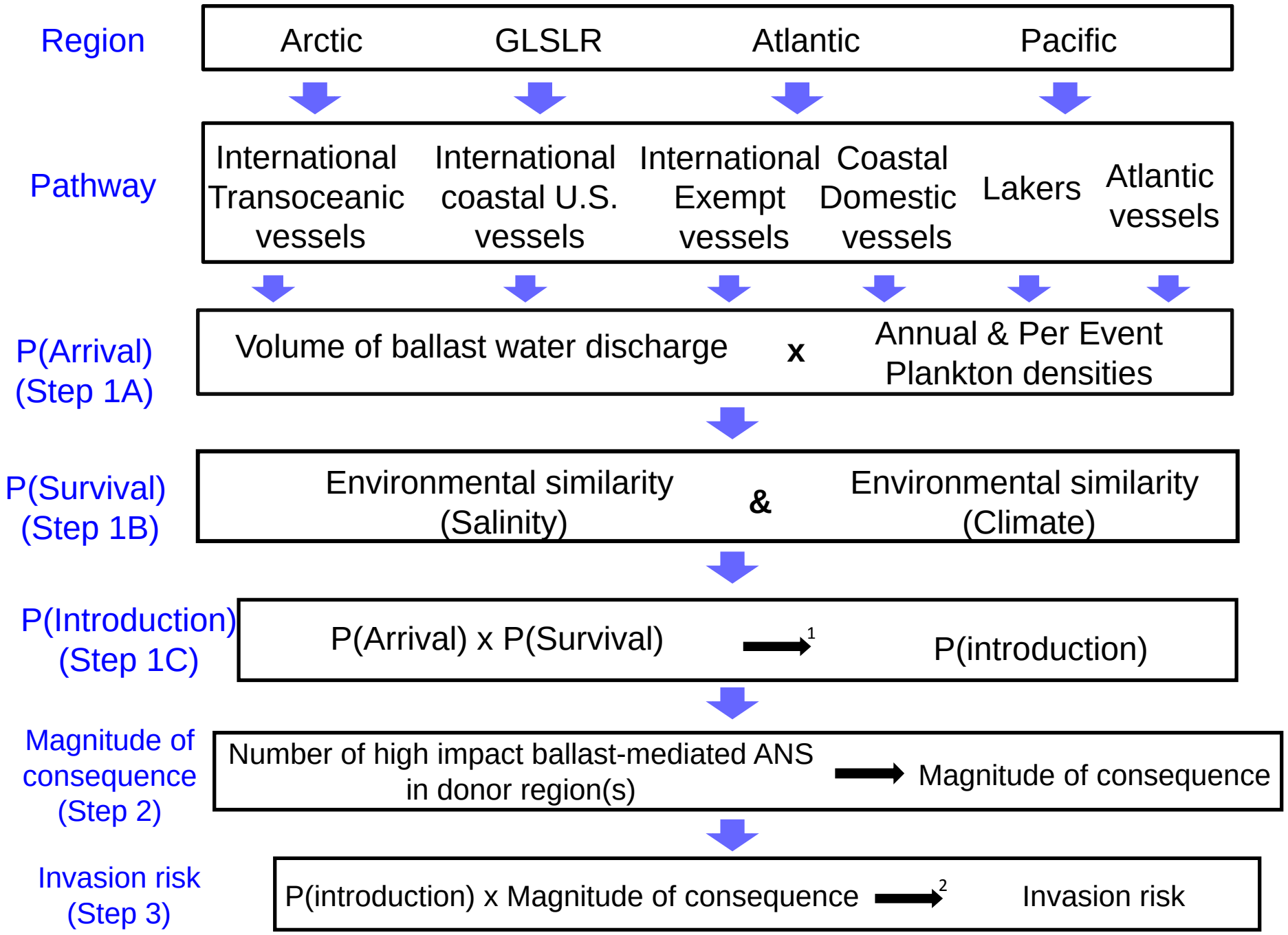
International Transoceanic vessels
Vessels operating outside the Canadian Exclusive Economic Zone (EEZ) on a transoceanic route



Lakers
Vessels that operated exclusively within the Great Lakes and the St. Lawrence Estuary

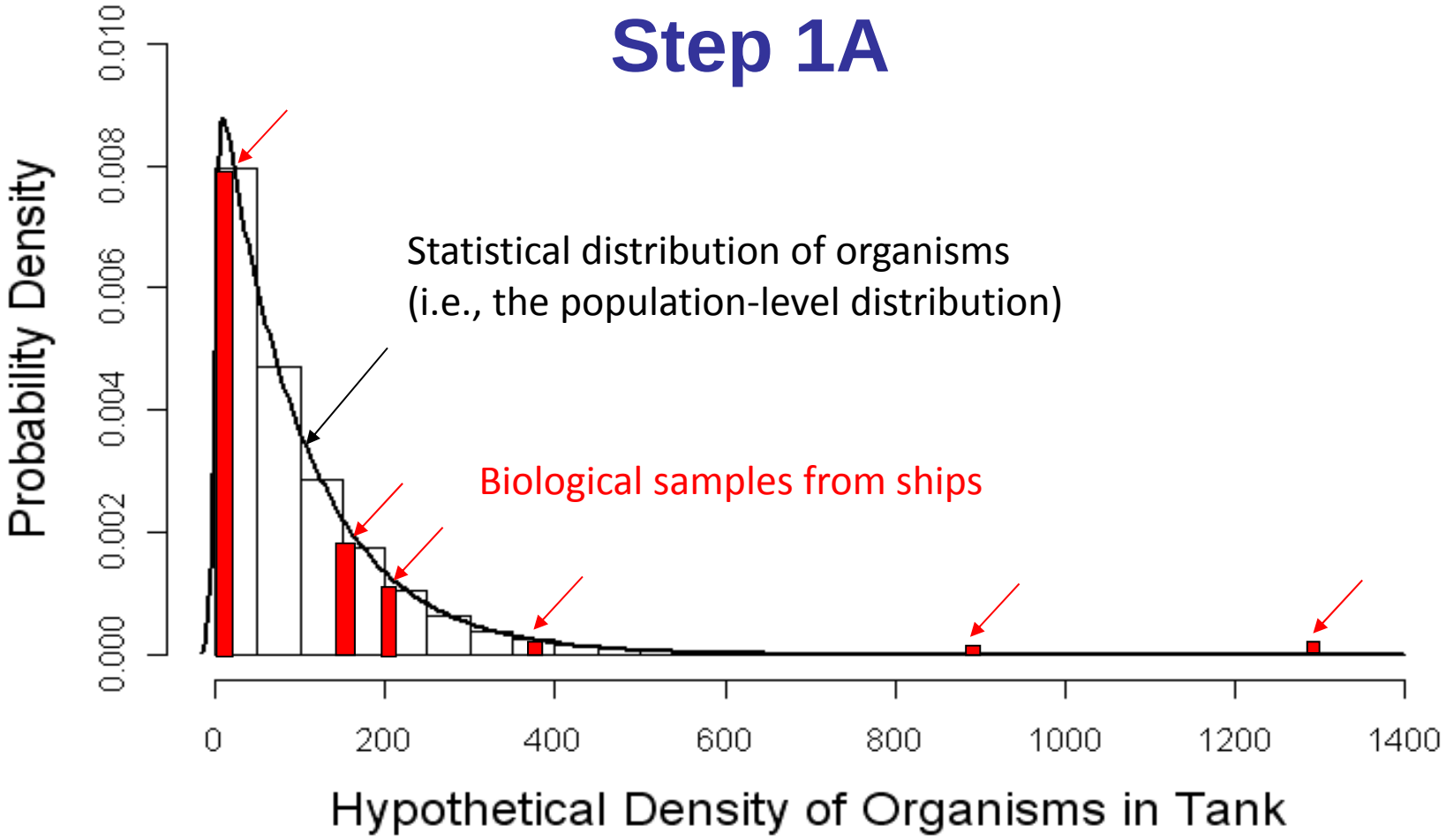
Biological Risk Assessment for NIS

- Likelihood of an NIS introduction
  - probabilities of arrival & survival
- Magnitude of consequences (ecological impacts)
- Uncertainty
  - considers quality and quantity of data available to rank likelihood and magnitude
  - provides risk managers with indication of the inherent strengths and weaknesses in the risk assessment

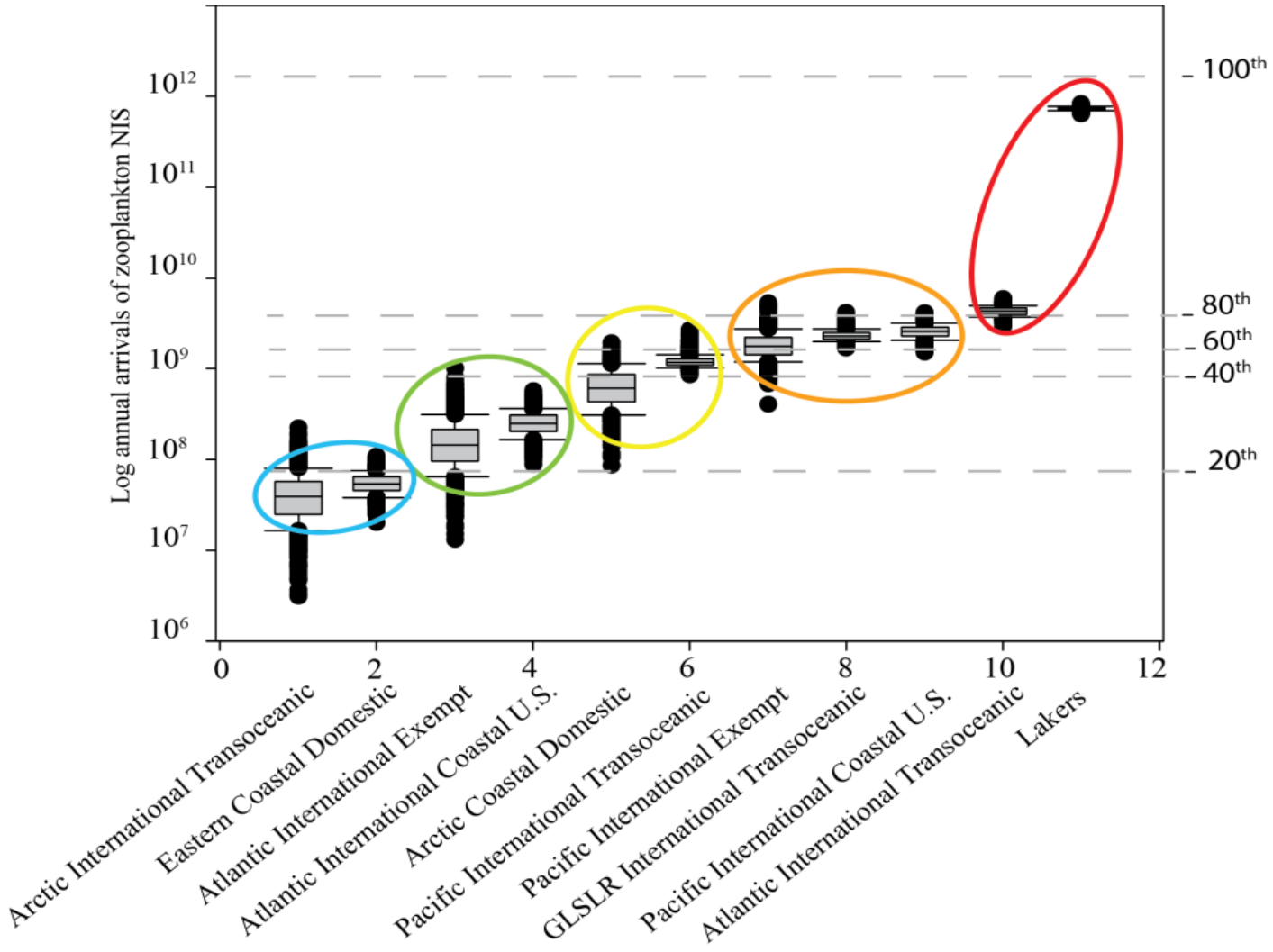


[1]Minimum probability approach; [2]Mixed rounding matrix approach

Step 1A


Probability Density
0.000
0.002
0.004
0.006
0.008
0.010
Statistical distribution of organisms
(i.e., the population-level distribution)
Biological samples from ships
0
200
400
600
800
1000
1200
1400
Hypothetical Density of Organisms in Tank

Step 1A - Results



Risk Permutations

The risk assessment was repeated to examine risk for different taxa and timescales:

- Zooplankton vs. phytoplankton
- Single discharge event vs. annual cumulative risk
- Current risk (ballast water exchange) vs. future risk (IMO standards)

Results: Current Risk

	Current Risk	
Pathway	Annual	Per Discharge Event
Arctic Coastal Domestic	Lowest	Lowest
Arctic International Transoceanic	Lowest/Intermediate	Highest
Eastern Coastal Domestic	Lowest/Intermediate	Highest
GLSLR International Transoceanic	Lowest	Lowest
Lakers	Highest/Lowest	Highest/Lowest
Atlantic International Coastal U.S.	Intermediate/Highest	Highest
Atlantic International Exempt	Intermediate/Highest	Highest
Atlantic International Transoceanic	Highest	Highest
Pacific International Coastal U.S.	Highest	Highest
Pacific International Exempt	Highest	Highest
Pacific International Transoceanic	Highest	Highest

Note that risk differed for some pathways depending on taxonomic group being considered (reported as zooplankton/phytoplankton)

Results: Future Risk

Pathway	Future Risk under IMO D-2	
	Annual	Per Discharge Event
Arctic Coastal Domestic	Lowest	Lowest
Arctic International Transoceanic	Lowest/Intermediate	Lowest/Highest
Eastern Coastal Domestic	Lowest	Lowest
GLSLR International Transoceanic	Lowest	Lowest
Lakers	Lowest	Lowest
Atlantic International Coastal U.S.	Lowest/Highest	Lowest/Highest
Atlantic International Exempt	Lowest/Highest	Lowest/Highest
Atlantic International Transoceanic	Lowest/Highest	Lowest/Highest
Pacific International Coastal U.S.	Lowest/Highest	Lowest/Highest
Pacific International Exempt	Lowest/Highest	Lowest/Highest
Pacific International Transoceanic	Lowest/Highest	Lowest/Highest

Note that risk differed for some pathways depending on taxonomic group being considered (reported as zooplankton/phytoplankton)

Science Advice

- Current requirements for BWE by transoceanic vessels reduce risk of invasions to freshwater ecosystems (e.g., Great Lakes), but are less effective in reducing risk to marine ecosystems
- Lakers pose highest invasion risk for zooplankton NIS but lowest for phytoplankton NIS. for both annual and per-event temporal scales
- The abundance of zooplankton NIS would be reduced for all pathways if managed to IMO D-2 standard, while the abundance of phytoplankton NIS would be reduced only for half of the pathways.\

BWE + BWMS
Shipboard testing

><((((°> GoConsult

Stephan Gollasch
GoConsult, Hamburg, Germany

David Consult

Matej David
David Consult, Korte, Slovenia

Fisheries and Oceans Canada | Pêchés et Océans Canada

Elizabeta Briski
Sarah Bailey
Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington

Study objectives

- Evaluate efficacy of saltwater exchange plus treatment through shipboard trials with freshwater ballast water
- Combination management strategy was contrasted against those of exchange alone, treatment alone and no management (= control experiment)

Voyage details

- Hamburg, Germany:
  Uptake sampling in freshwater

- Bay of Biscay:
  BWE in >200m & >50 nautical miles

- Discharge sampling:
  Algeciras, Spain

Trip 1 (March 2013)

- BWMS: Filtration + electrochlorination
- salt water injected to reach minimum salinity for treatment

Trips 2,3 (Nov 2013; Feb 2014)

- BWMS: Filtration + UV

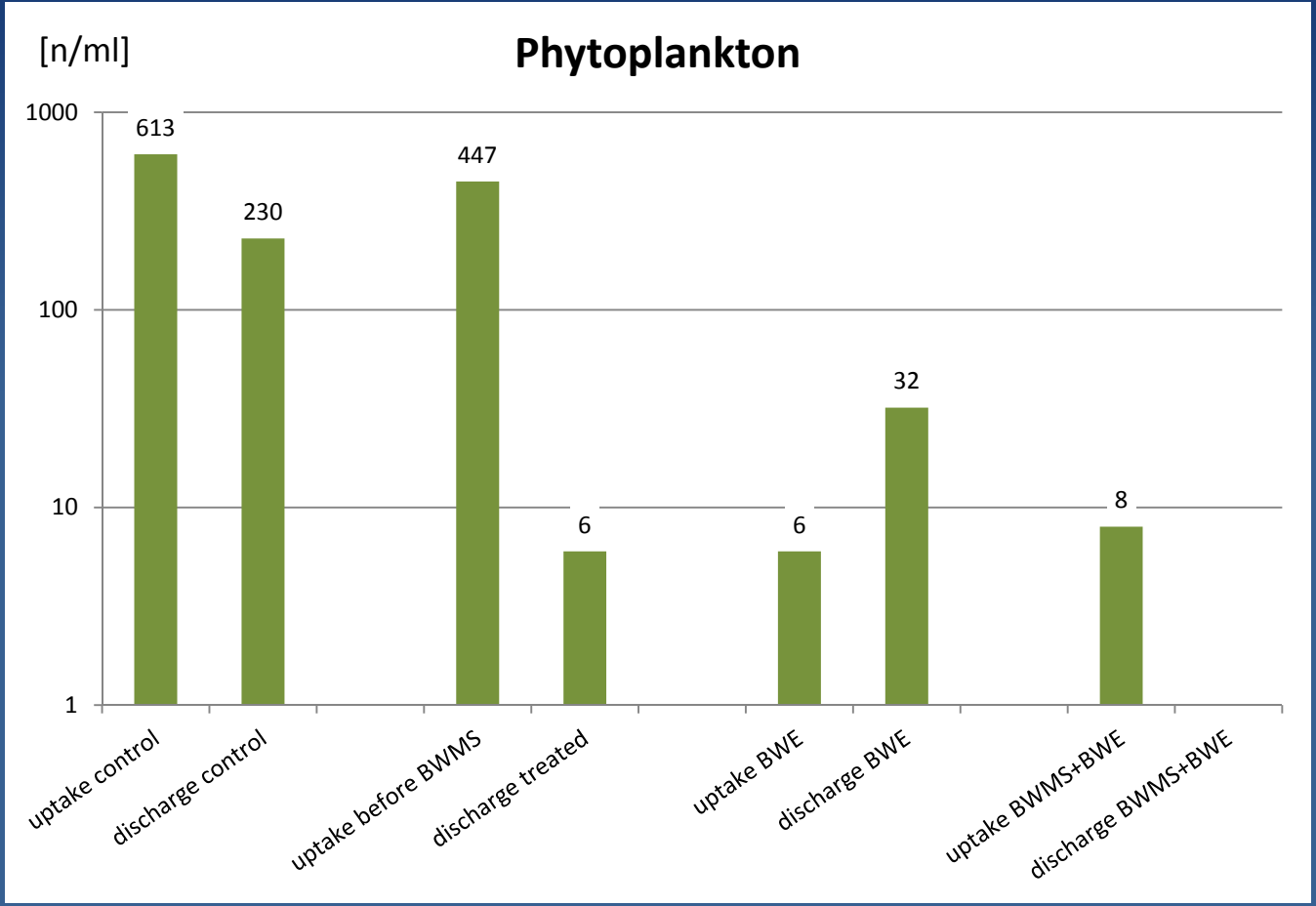
Sampling approach

- In the engine room
- Isokinetic sampling points
- Phytoplankton
  - Continuous drip sample over entire pumping event
  - Sample volume ca. 5 L
- Zooplankton
  - Samples taken over the entire pumping time in sequences
  - Each sequence between 6 and 18 minutes
  - Volumes between 210 and 645 L

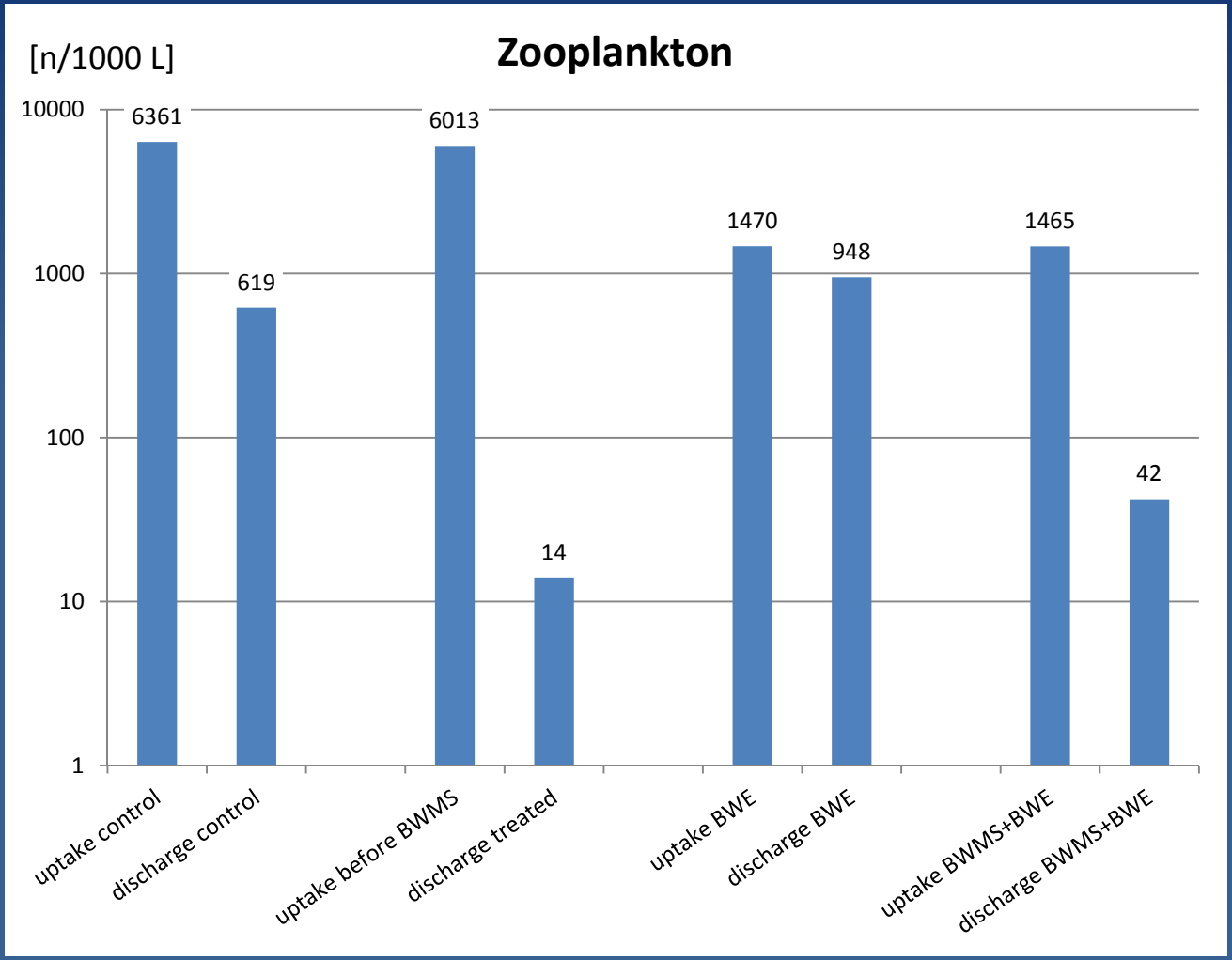
Analytical methods

- Phytoplankton
  - PAM (viability)
  - Flow cytometry (NIOZ)
  - Epifluorescence method using FDA (on board)
- Zooplankton
  - Stereomicroscope (on board)

Preliminary Results (Trip 1)



Preliminary Results (Trip 1)



Preliminary Findings

- BWE can result in an increase (refresh) of plankton in tank
- BUT total counts likely do not equal risk
- work is ongoing to look at taxonomic composition (freshwater vs. marine)

Acknowledgements

Transport Canada / Transports Canada

Fisheries and Oceans Canada / Pêchés et Oceans Canada

NSERC CRSNG

CAISN Canadian Aquatic Invasive Species Network

- Ship crew for support during sampling
- Ship management
- Treatment system manufacturers