Research to inform Canadian ballast water regulations

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Canada

Outline

- Efficacy of Exchange Plus Treatment for Canadian Freshwater Ports
- Efficacy of Ballast Water Treatment for the Great Lakes

Summary of the Model

- We used a multi-stage model to estimate the establishment rate of nonindigenous (NIS) zooplankton species under various ballast water management scenarios.
- The model includes three main components of the invasion process:

Arrival

- Estimating the number and concentration of NIS species discharged to Canadian ecosystems

Survival

- Calculating the survival probability of NIS based on the environmental match between ballast source and recipient locations

Establishment

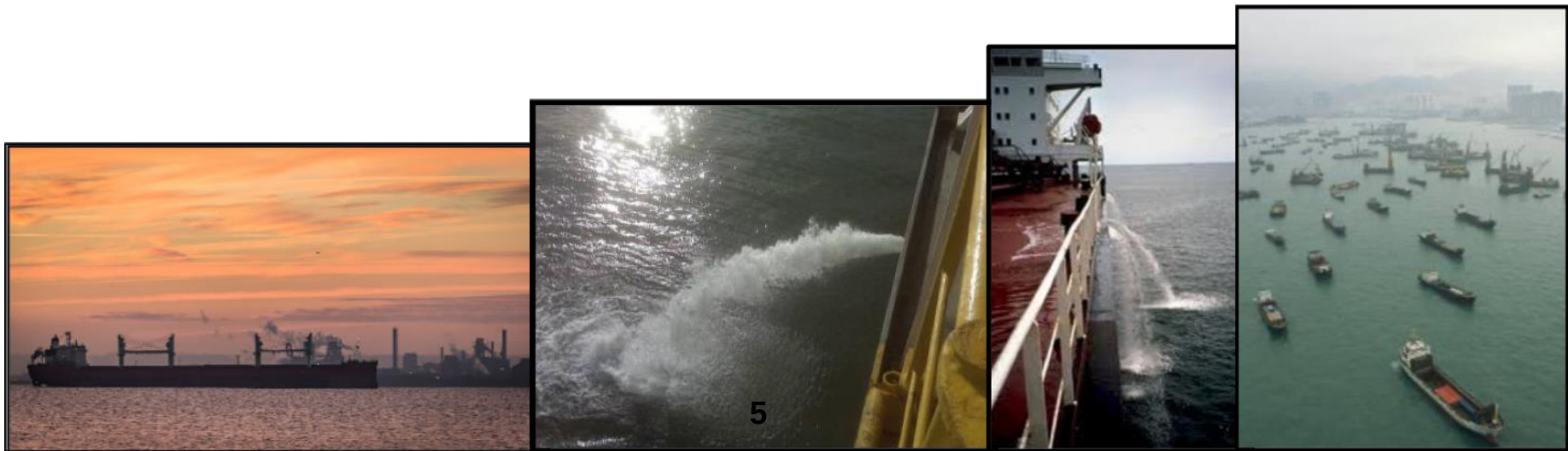
- Estimating NIS establishments based on their initial concentration and per-capita establishment probability

Modelling the Management Scenarios

- **Modelled effect of ballast water exchange** as a change in survival and establishment probabilities reflective of the environmental match between the locations of exchange (at 2000 meter depth) and recipient ports
- **Modelled effect of ballast water treatment** as a change in organism concentration to levels observed during field studies
- **Two treatment scenario types**
  1. 100% efficacy: ballast meets D-2 standard on 100% of transits
  2. 50% efficacy: 50% of transits meet D-2 and 50% did not meet D-2
     - Based on 2017-2019 ship sampling (not presented today)

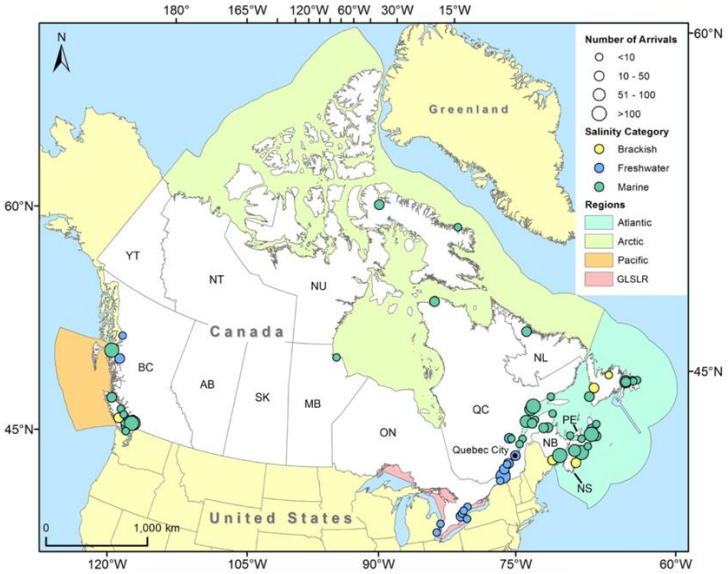
Two Establishment Risk Metrics

- Mean number of establishments per year
  - Tallies all establishment events
  - Accounts for spread of introduced species across Canadian ports
- Number of trips until ≥ 1 species establishes



Part 1: Efficacy of Exchange Plus Treatment in Canadian Freshwater Ports

- Canada-wide establishment rates were modelled for NIS zooplankton (and harmful phytoplankton).
- Scenarios include international ship traffic arriving to Canadian ports and domestic ship traffic to Canadian ports in the Arctic.
- The scenarios examined different applications of exchange plus treatment for ships travelling to freshwater ports, at a national scale (ships travelling to brackish and marine ports used treatment only)

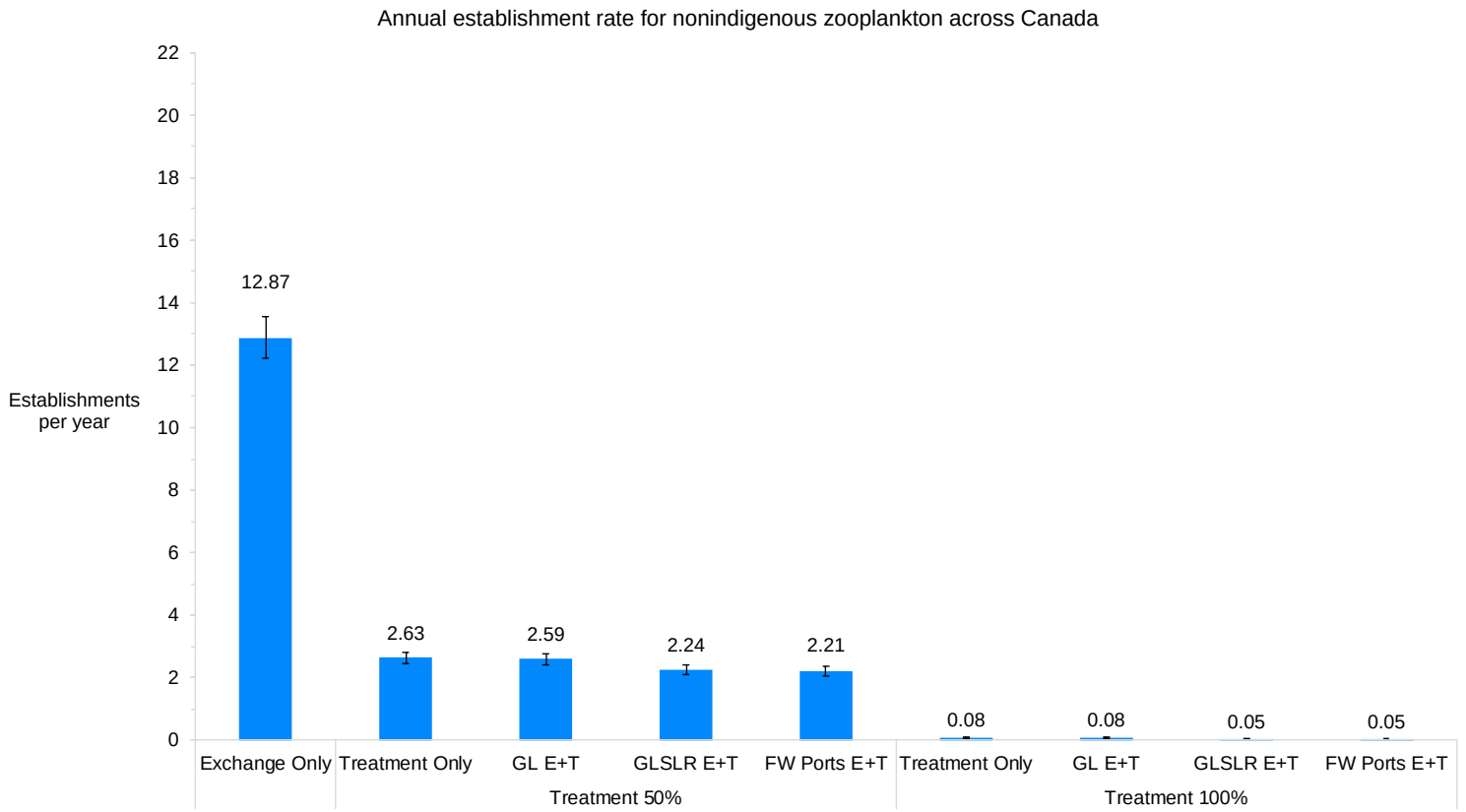


Canada

Exchange Plus Treatment Scenarios

Scenarios	Description
All ports, exchange	Ballast water exchange for all ports in Canada.
All ports, treatment	Ballast water treatment for all ports in Canada.
Great Lakes, exchange plus treatment; other ports, treatment	Exchange plus treatment for the Great Lakes only (ports upstream of the Saint-Lambert Lock). Treatment alone for all other ports in Canada.
Great Lakes-St. Lawrence River (GLSLR), exchange plus treatment; other ports, treatment	Exchange plus treatment for the GLSLR only (ports upstream of and including Quebec City). Treatment alone for all other ports in Canada.
Freshwater ports, exchange plus treatment; other ports, treatment	Exchange plus treatment for all freshwater ports in Canada, including Kitimat, BC, Stewart, BC, ports on the Fraser and Saguenay Rivers, and ports in the GLSLR. Treatment alone for all other ports in Canada.

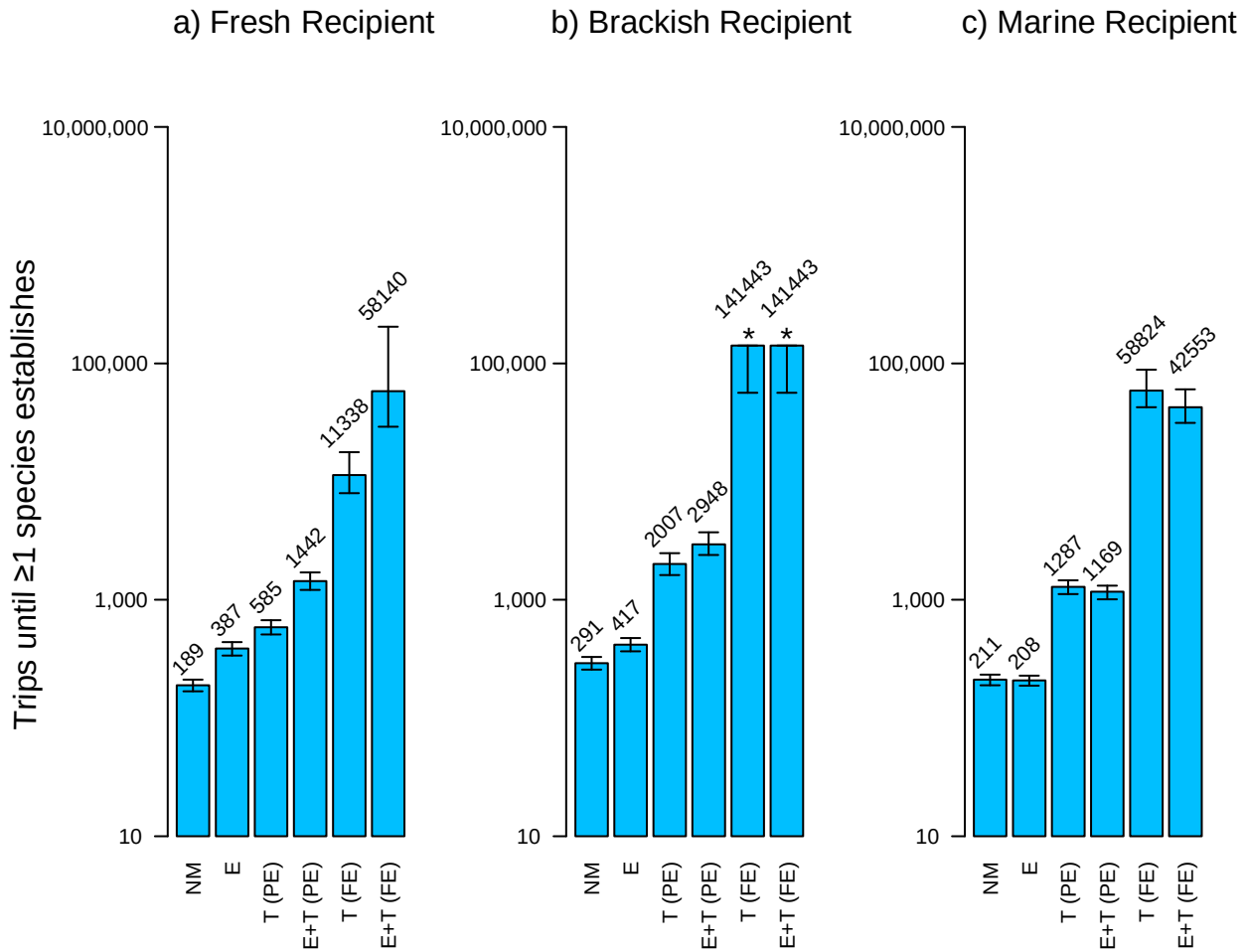
Estimated NIS Zooplankton Establishment Rate Across Canada



- Exchange plus treatment (50% efficacy) resulted in fewest zooplankton establishments when applied to all freshwater ports.
- All scenarios with treatment (100% efficacy) reduced establishments >99%.
- The effect of exchange plus treatment in freshwater ports is ‘muted’ in the Canada-wide context by the inclusion of brackish and marine recipient ports.

DFO (2020)

Estimated NIS Zooplankton Establishment Rate Across Canada by Recipient Port Salinity



- Exchange plus treatment produced substantial benefit (5x reduction) compared to treatment alone at freshwater recipient ports, even when treatment systems had full efficacy.

Bradie et al. (2021)

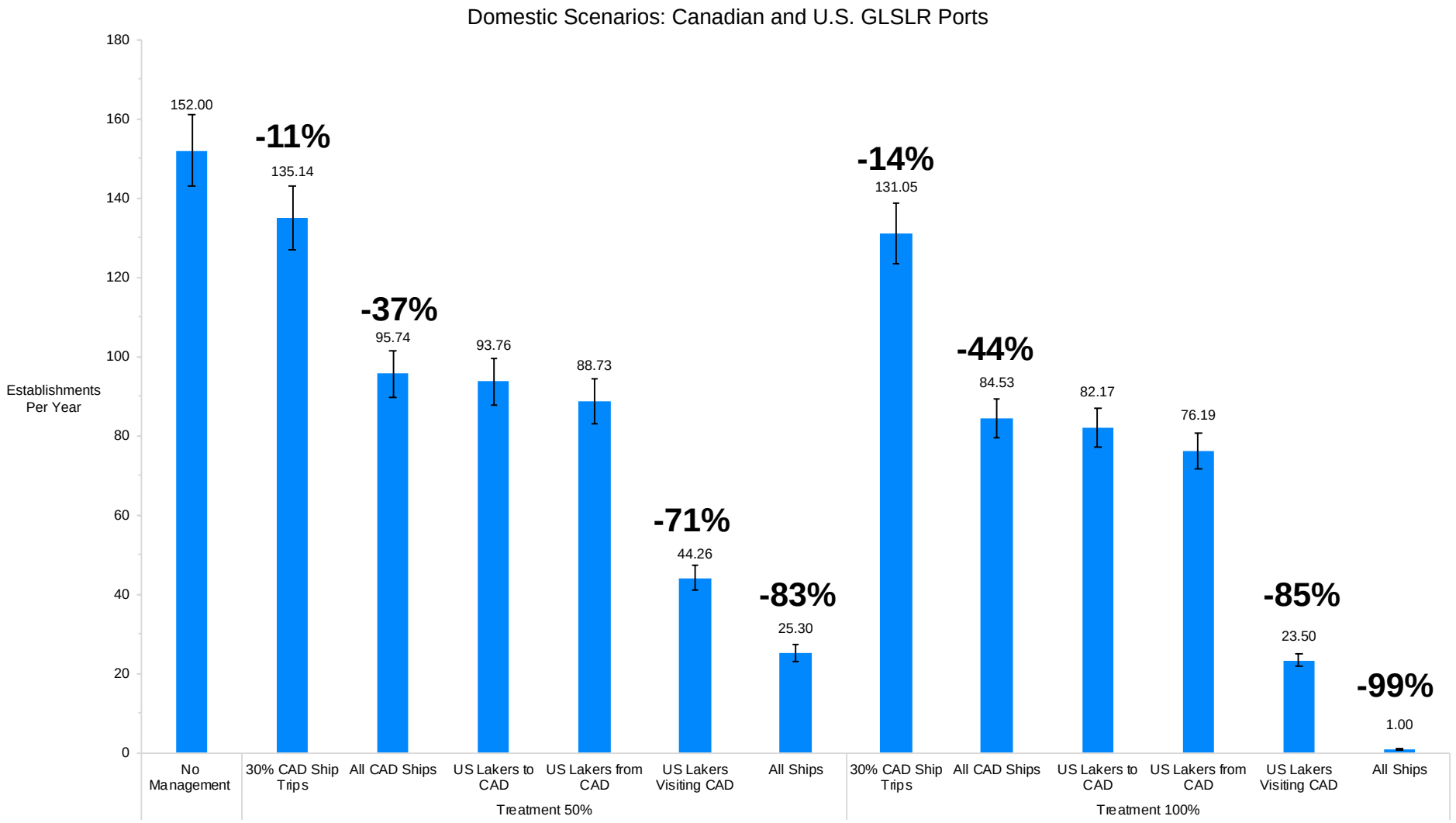
Part 2: Efficacy of Ballast Water Treatment on Domestic Transits

- The establishment rate of NIS zooplankton was modelled for various domestic scenarios.
- Establishment rates were estimated for the following regions:
  1. Canadian GLSLR ports;
  2. Canadian and U.S. GLSLR ports; and,
  3. (Canadian ports in the GLSLR, Atlantic, and Arctic combined.)
- Scenarios include domestic transits for Canadian ships, U.S. Lakers, and international ships.

Domestic Shipping Scenarios: Canadian and U.S. GLSLR Ports

Domestic Shipping Scenarios	Canadian Ships	U.S. Lakers	International Ships
Domestic ships, no management	No management	No management	All ships, treatment
30% of Canadian ship trips, treatment	30% of trips, treatment	No management	All ships, treatment
All Canadian ships, treatment	All ships, treatment	No management	All ships, treatment
U.S. Lakers on trips to Canada, treatment	All ships, treatment	U.S. Lakers on trips to Canadian GLSLR ports, treatment	All ships, treatment
U.S. Lakers on trips from Canada, treatment	All ships, treatment	U.S. Lakers travelling from Canadian GLSLR ports to the U.S., treatment	All ships, treatment
U.S. Lakers visiting Canada at least once in a given year, treatment on all transits	All ships, treatment	U.S. Lakers visiting Canada at least once in a given year, treatment on all transits	All ships, treatment
All ships, treatment	All ships, treatment	All ships, treatment	All ships, treatment

Estimated NIS Zooplankton Establishment Rate at Canadian and U.S. GLSLR Ports



- Treating all ballast water discharged by Canadian ships and U.S. Lakers produced the lowest establishment rate in the Great Lakes region.

DFO (2020)

Conclusions

Part 1: Efficacy of Exchange Plus Treatment for Canadian Freshwater Ports

- Exchange plus treatment produced substantial benefit (5x reduction) compared to treatment alone across all Canadian freshwater recipient ports, even when treatment systems had full efficacy.

Part 2: Efficacy of Ballast Water Treatment for the Great Lakes

- Treating discharges by ships that visit Canada at least annually reduced NIS zooplankton establishments by 71-85% (depending on treatment efficacy)
- Treating all discharges by Canadian ships and U.S. Lakers reduced NIS zooplankton establishments by 83% - 99% (depending on treatment efficacy)

Acknowledgements

Funding:

Transport Canada | Transports Canada

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Relevant Publications

- DFO. 2020. Additional Analyses of Ballast Water Management Scenarios to Reduce the Establishment of Harmful Aquatic Species Across Canada and the Great Lakes. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/053.
- Drake, D.A.R., Bradie, J.N., Ogilvie, D., Casas-Monroy, O., and Bailey, S.A. 2020. Effectiveness of Ballast Water Exchange plus Treatment as a Mechanism to Reduce the Introduction and Establishment of Aquatic Invasive Species in Canadian Ports. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/003.
- Bradie JN, DAR Drake, D Ogilvie, O Casas-Monroy and S Bailey. 2021. Ballast water exchange plus treatment lowers species invasion rate in freshwater ecosystems. Environmental Science & Technology 55:82-89.