Vessel Biofouling as a Vector for Nonindigenous Species Introductions in Canada

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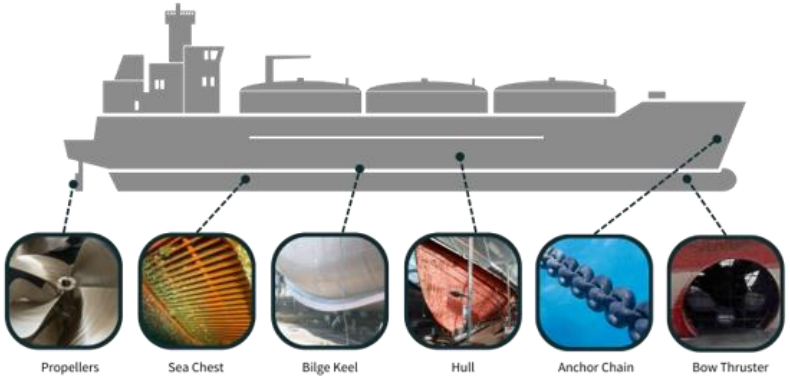
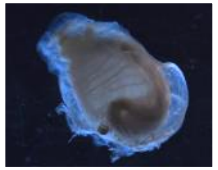
Objectives

- Create an up-to-date comprehensive national biofouling assessment using best available data and models (building on previous DFO regional assessments)
- Determine probabilities of arrival, survival, and establishment of biofouling non-indigenous species (NIS) via international commercial vessels at ports in Canada
  - Differences in regions, vessel type
- Determine the impacts of forecasted changes (temperature, shipping activity) on the probability of establishment of NIS in Canadian ecosystems

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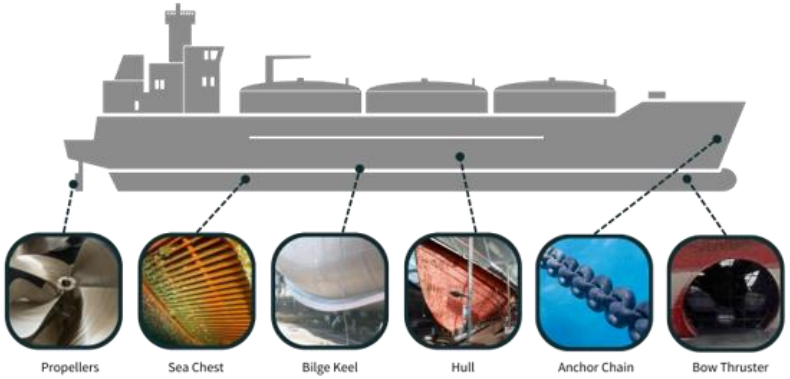


Methods – Study Area

- Canada-wide assessment
- Separated by four regions:
  - Pacific (ports in BC)
  - Atlantic (ports in QC*, NB, NS, PE, NL**)
  - Great Lakes-St. Lawrence River (freshwater ports in QC*, ON)
  - Arctic (ports in NT, NU, MB, QC*, NL**)

*QC – Atlantic includes ports east of Quebec City, GLSLR includes ports west of and including Quebec City, Arctic includes ports in Northern QC

**NL – Atlantic includes ports in the island of Newfoundland, Arctic includes ports in Labrador

Canada

Methods – Data

Shipping Data

- First arrivals to Canada in 2018 (commercial vessels)
  - Updated Arctic region arrivals for increasing operations at Baffinland iron mine
  - Total: 8103 vessels arriving
- Hull wetted surface area calculated based on gross tonnage

Biological Data

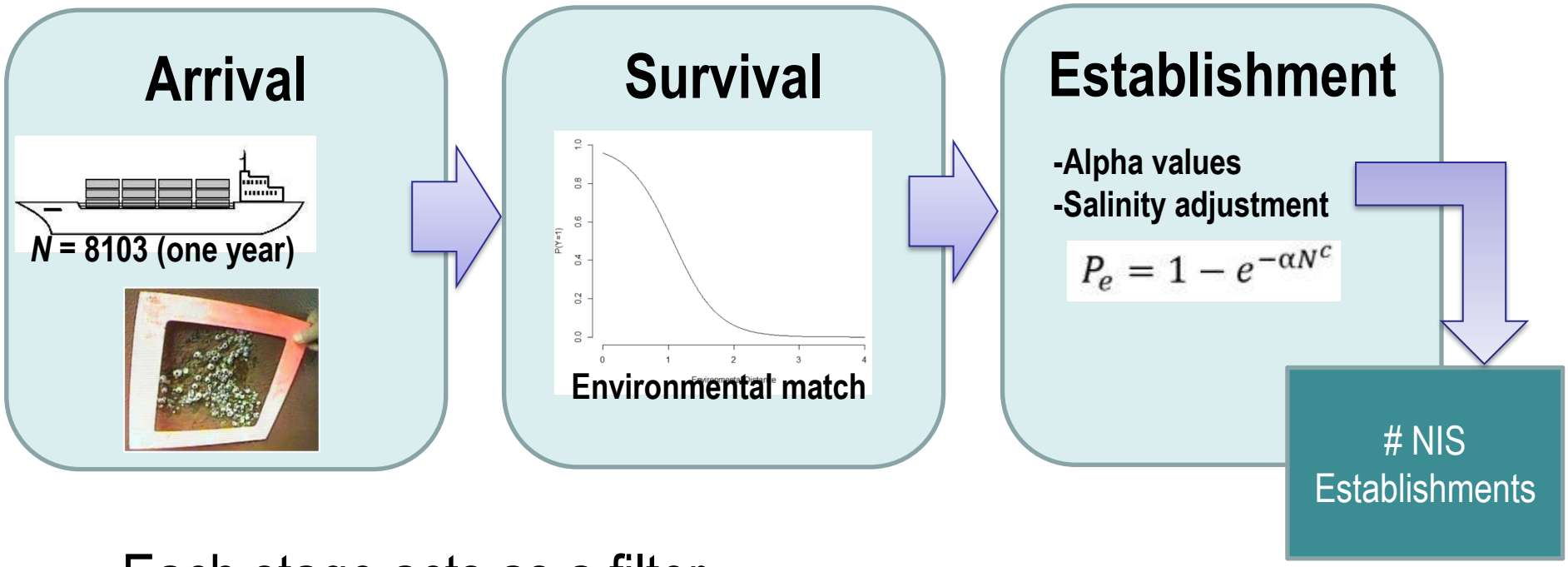
- Canadian Aquatic Invasive Species Network (CAISN) biological surveys from vessels in Atlantic, Pacific, GLSLR, and Arctic (*N* = 71 vessels)
- Seachest data in Pacific, Atlantic (*N* = 8 vessels)
- Percent cover, abundance, species richness

Environmental Data

- Global port environmental data (salinity, temperature)

Methods – Modelling Approach

- Multistage model based on invasion process in biofouling:



- Each stage acts as a filter
- Total # NIS establishments

Methods – Arrival Step

1) Vessel arrival data (2018 vessel traffic)

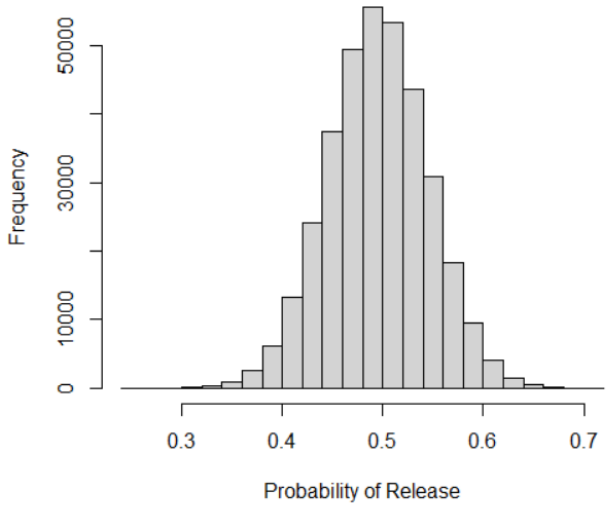
Region	Number of vessel arrivals	Number of ports
Pacific	3447	24
Atlantic	3138	54
Great Lakes-St. Lawrence River	1421	22
Arctic	97	10

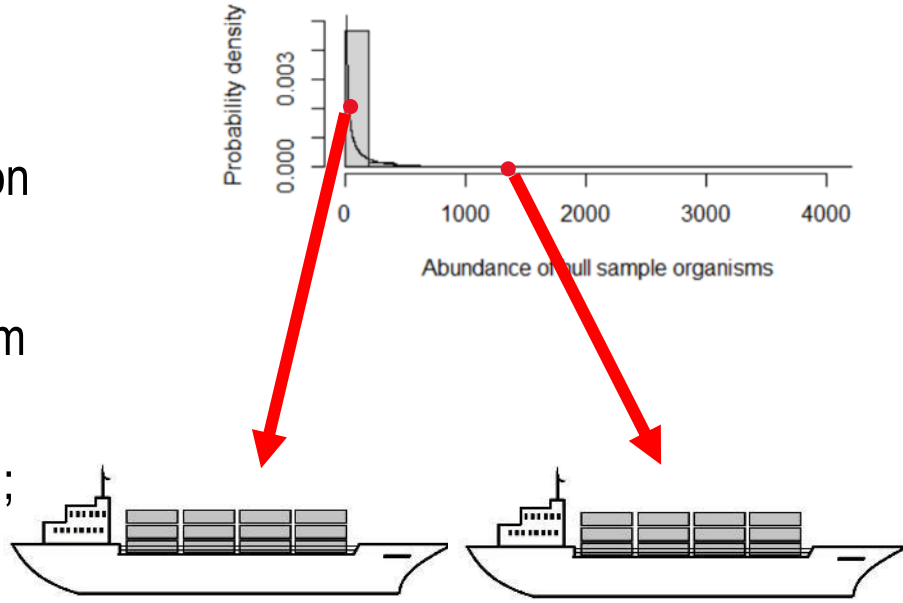
Vessel types:
Bulkers, Containerships, Tankers, LNG/LPG, Passenger ships, Tugs

Methods – Arrival Step

2) Biological arrival data

A. Fouling abundance – Probability distribution
B. Proportion of NIS – Probability distribution
C. Species abundance distributions – Random draw from CAISN data
D. Probability of release (binomial distribution; p = 0.5)

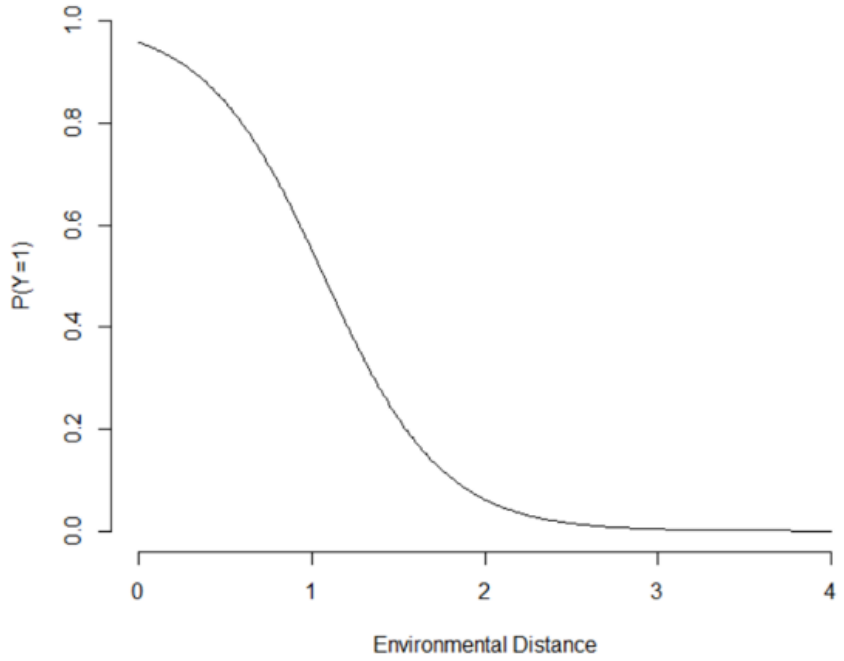




Random draws made for each vessel (vessel traffic data 2018)

Methods – Survival Step

1) Calculate associated probabilities of survival
   - Based on survival curve using port environmental distance (temperature-based) (Bradie et al. 2021)



2) Random draw made to determine if individual NIS survive or not by comparing to uniform distribution between 0 and 1

Methods – Establishment Step

1) Generate alpha values for species that arrive and survive

2) Adjust alpha values based on salinity match:

		LPOC		
		Marine	**Brackish**	**Freshwater**
DP	**Marine**	*α*	*α/2*	*α/10*
	Brackish	*α/2*	*α*	*α/2*
	Freshwater	*α/10*	*α/2*	*α*

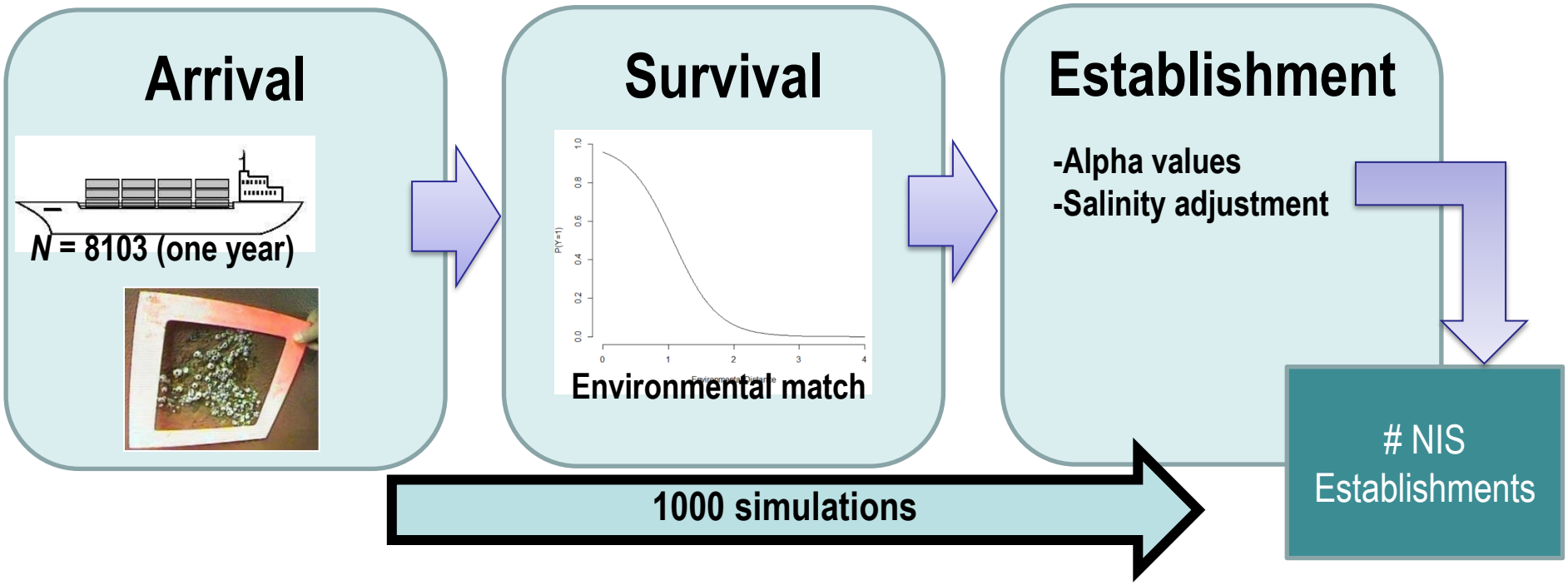
3) Calculate estimated establishment of species using:

$$P_e = 1 - e^{-\alpha N^c}$$

(Leung et al. 2004)

Methods – Final Probability of Establishment

- Repeat model process for 1000 simulations:

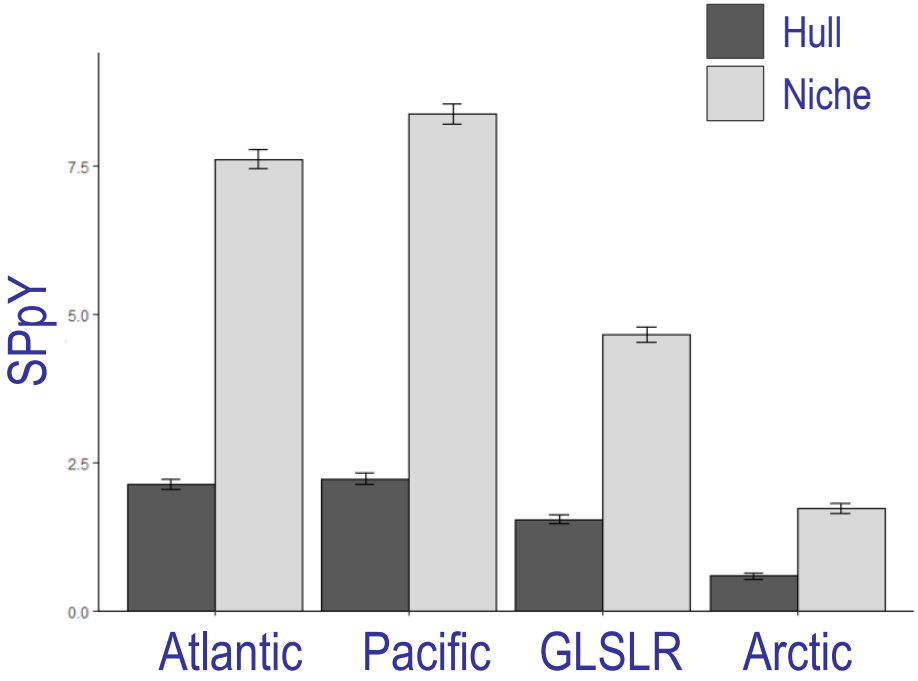


-Calculate metrics of interest (based on mean of 1000 iterations)

-Comparison of Hull vs. Niche areas on ships, ship types, regions

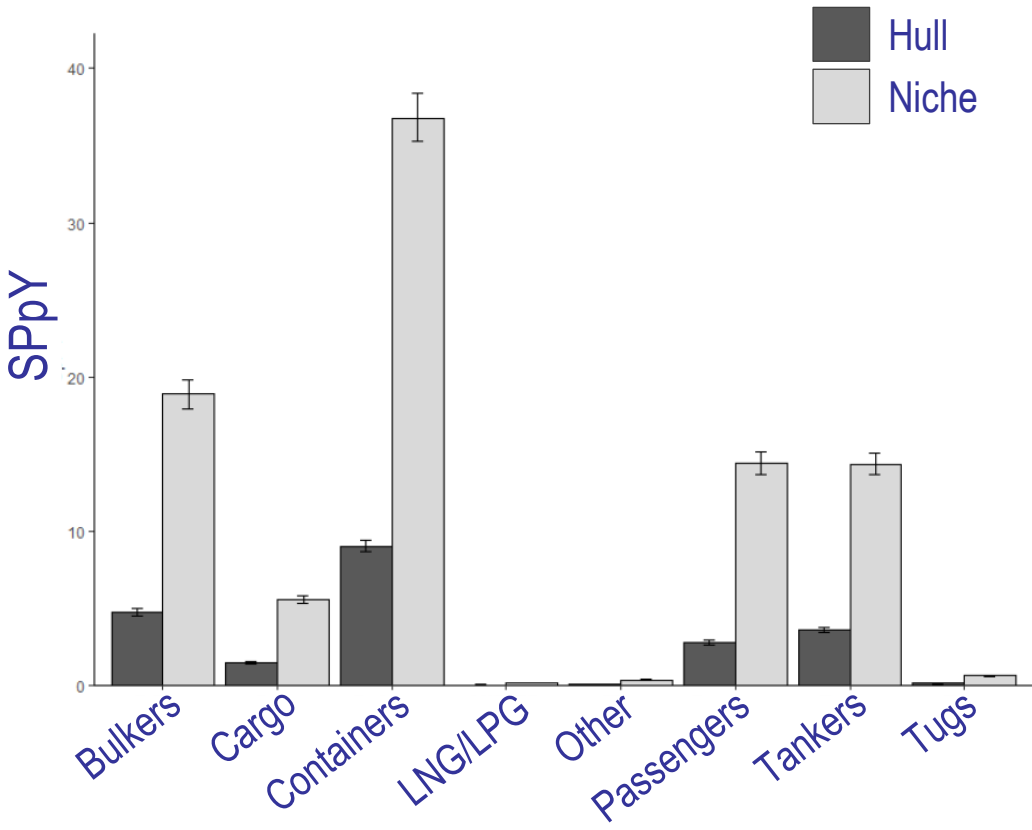
Results and Discussion – Species per Year

- Number of species per year (SpPY) per region
  - Main hull = dark bars
    Niche areas = light bars
- Niche areas of ship are highest risk for NIS establishment
  - Higher concentration of organisms in niche areas
- Both Pacific and Atlantic are at highest risk
  - Highest shipping traffic



Results and Discussion – Vessel Types

- Number of species per year (SpPY) by vessel type (across all regions)
  - Main hull = dark bars
    Niche areas = light bars
- Containerships and bulkers are most associated with NIS establishment by biofouling



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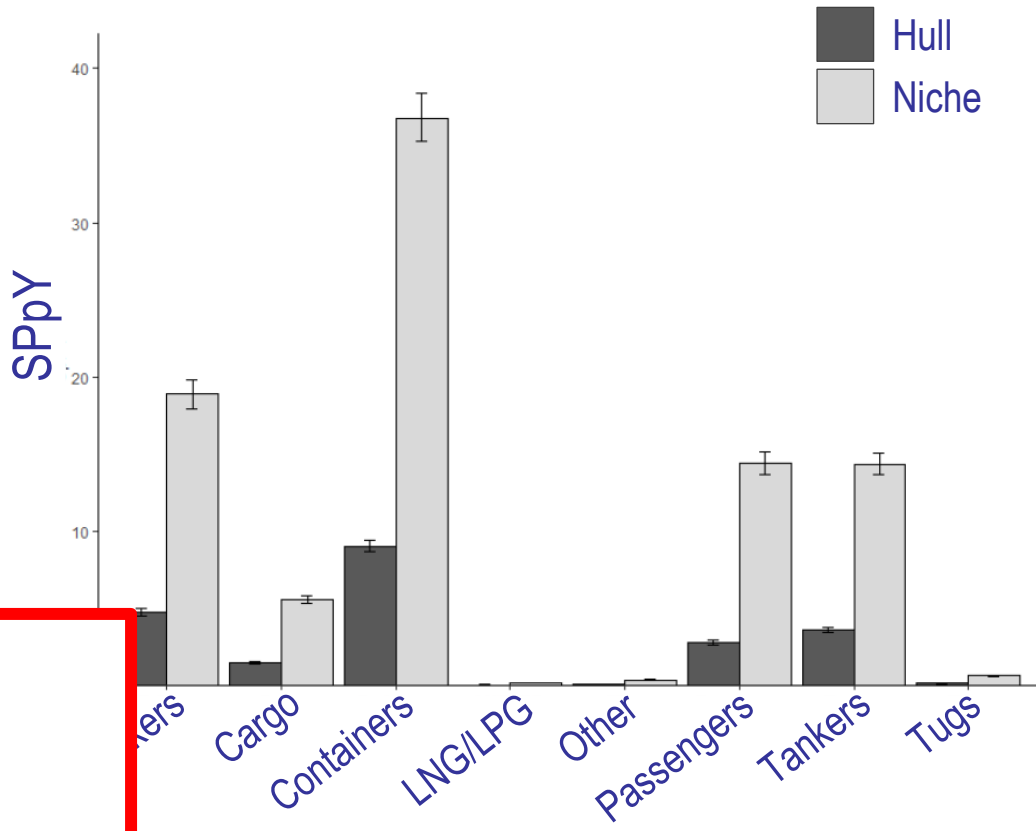
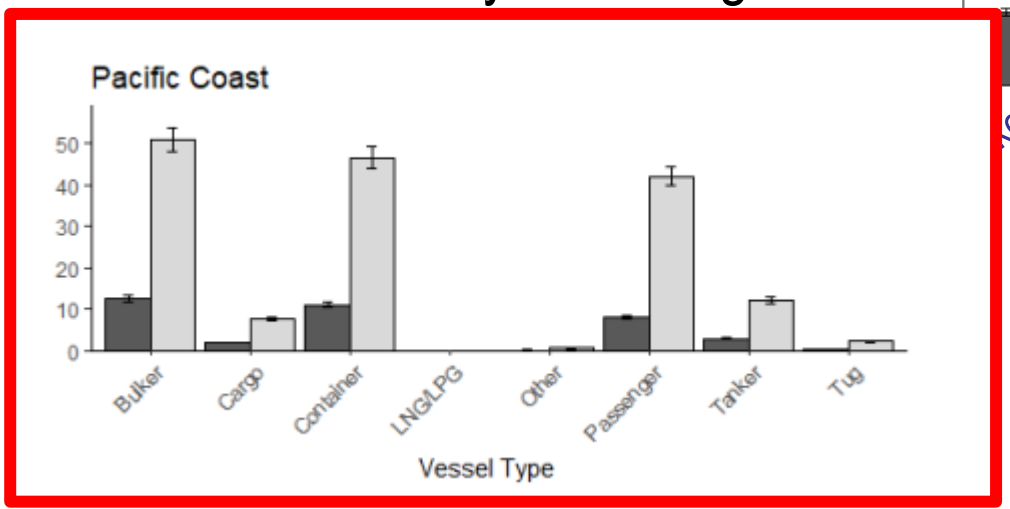
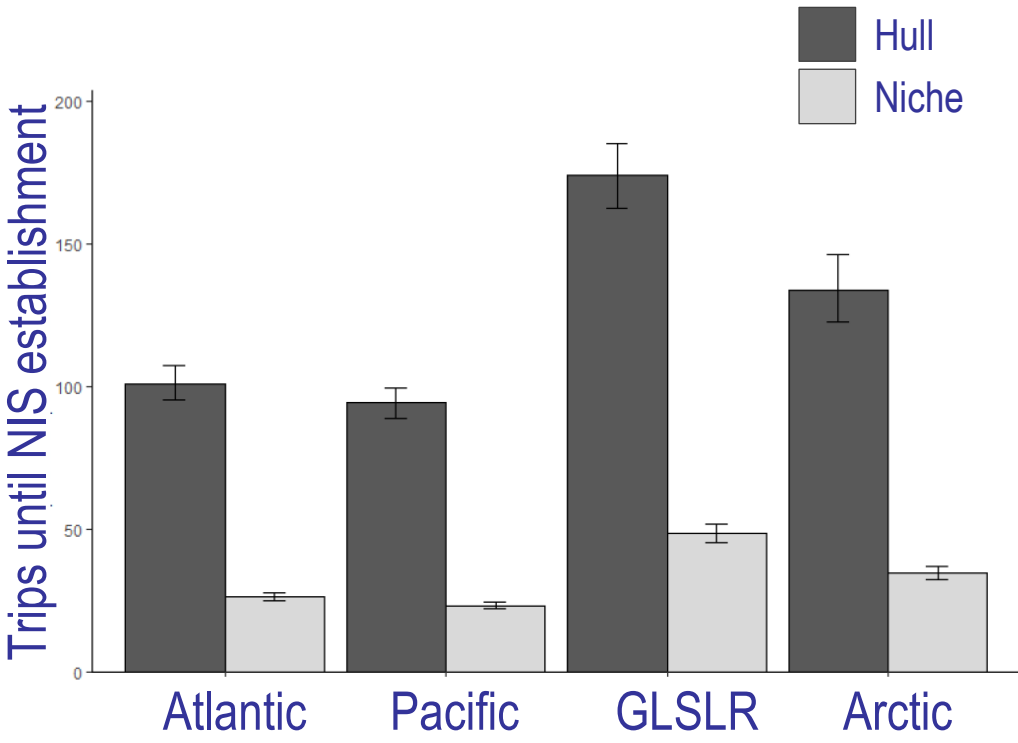




Results and Discussion – Trips until establishment

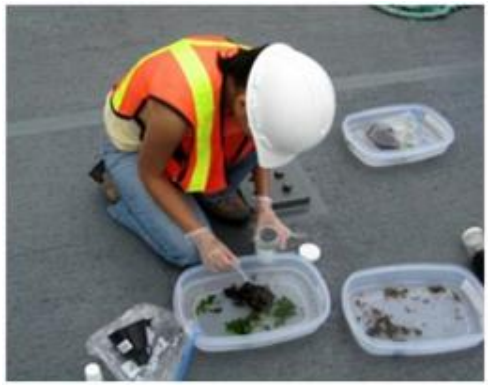
- Number of trips until one NIS establishment occurs via either hull or niche areas
  - Main hull = dark bars
    Niche areas = light bars
- "Per trip" estimate
- Both Pacific and Atlantic have low number of arrivals until an NIS establishment
  - Pacific had fewest trips (greatest risk): 94 trips until NIS establishment via hull, 23 trips until NIS establishment via niche areas



Conclusions

- Both coasts (Pacific and Atlantic) are highest risk areas for potential NIS establishment via biofouling
- Niche areas are much higher risk compared to main hull
- Vessel traffic is a main driver of likelihood of NIS establishment (although not the only factor)

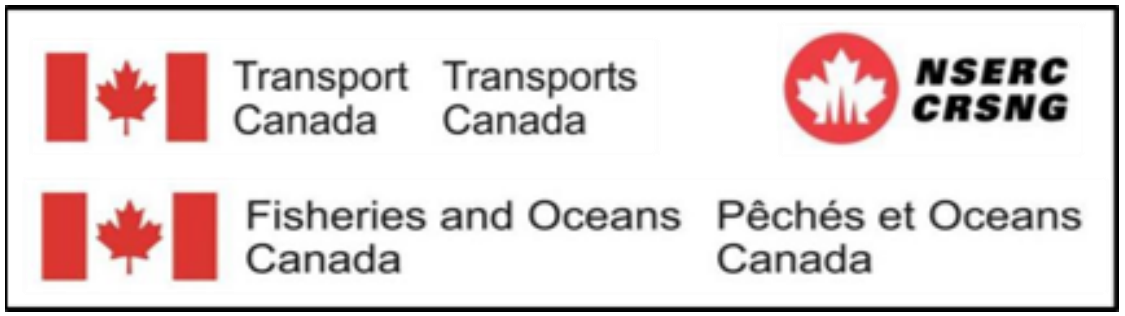
Next Steps



- Sampling planned for 2023-2025 to update biological data and fill in knowledge gaps
  - Pacific (Vancouver, BC), Atlantic (Halifax, NS), Great Lakes (Hamilton, ON)
- Attempt to cover greater range of vessels and anti-fouling coatings, increased sample size
- New technologies for methods (ROV, Automation of biofouling image processing)

Acknowledgements

Funding partners:



Publications

Research Doc: Brinklow, T.R., Chan, F.T., Etemad, M., Deb, J.C., and Bailey, S.A. 2022. Vessel Biofouling as a Vector for Nonindigenous Species Introductions in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/072. iv + 49 p.

SAR: DFO. 2022. Science Advice on Vessel Biofouling as a Vector for Nonindigenous Species Introductions in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/048.

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