

Aquatic Nuisance Species

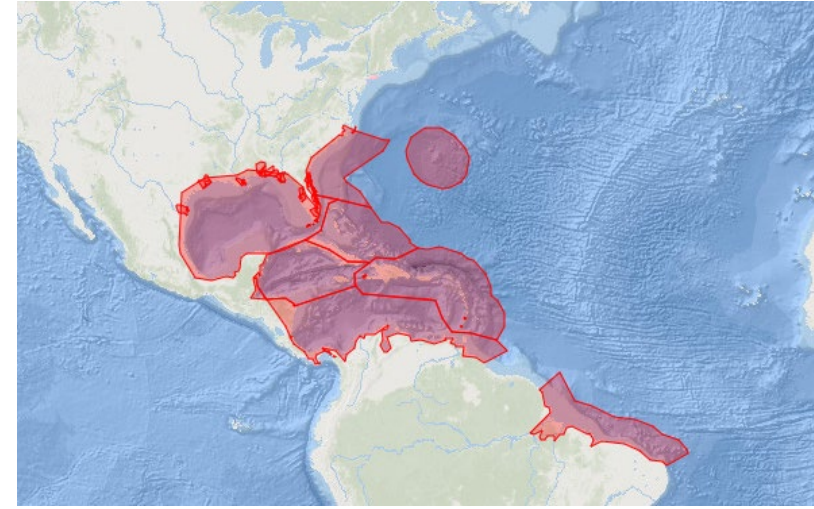
Aquatic Nuisance Species can cost millions of dollars in mitigation and management every year

Successful Invader needs 3 things:

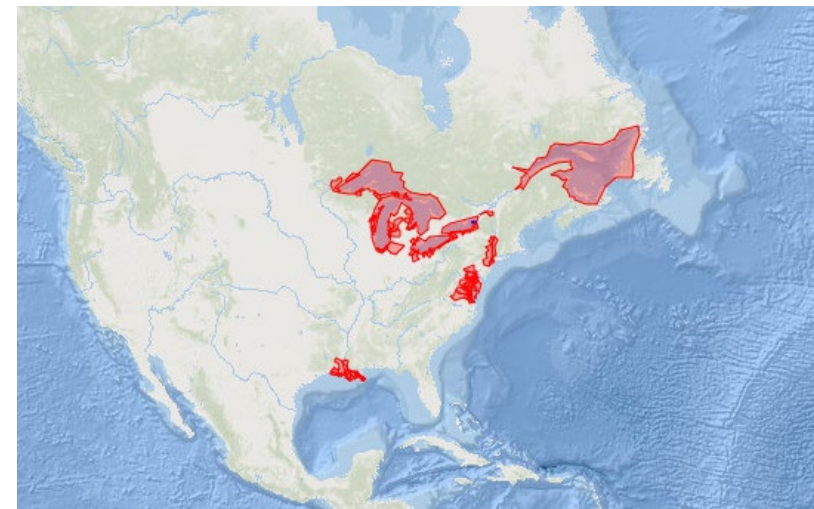
- Rapid growth and reproduction
- Adaptability
- No predators



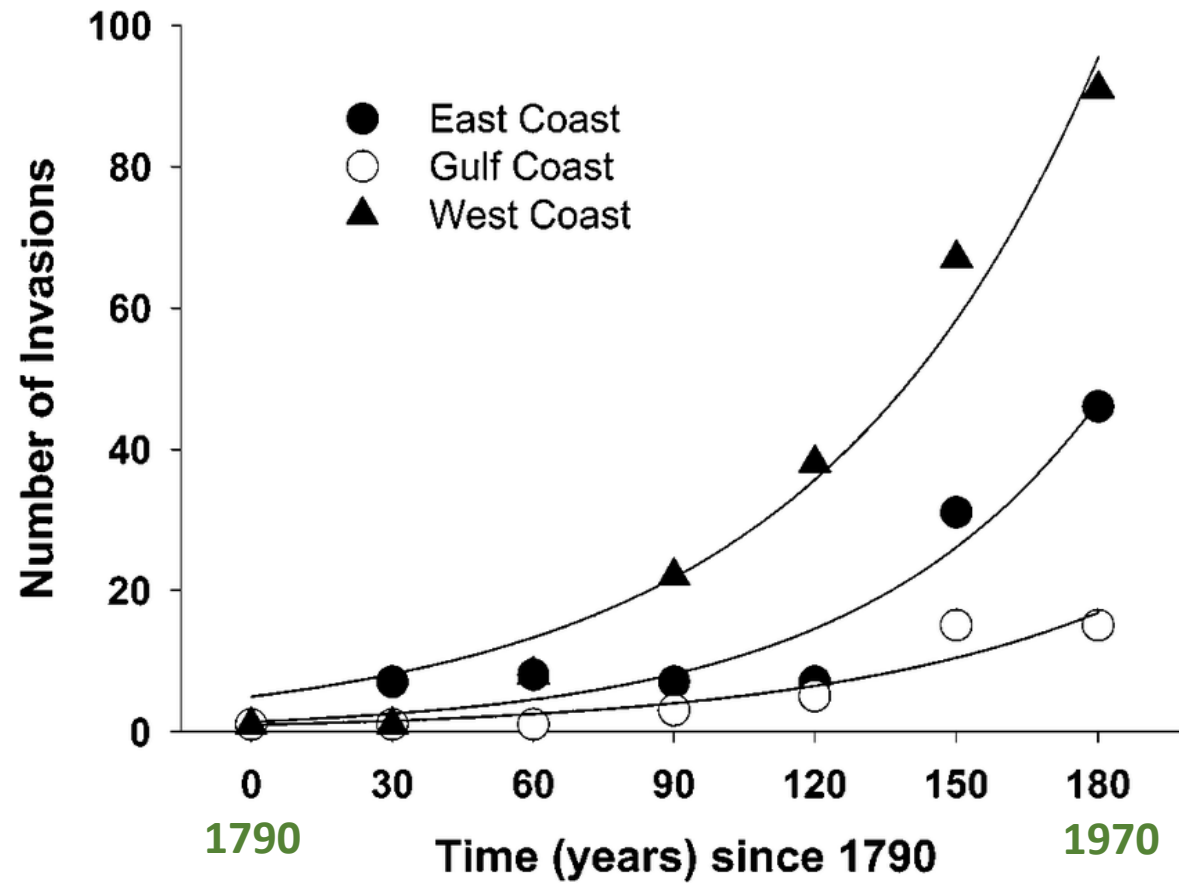
Lionfish
(*Pterois volitans*)



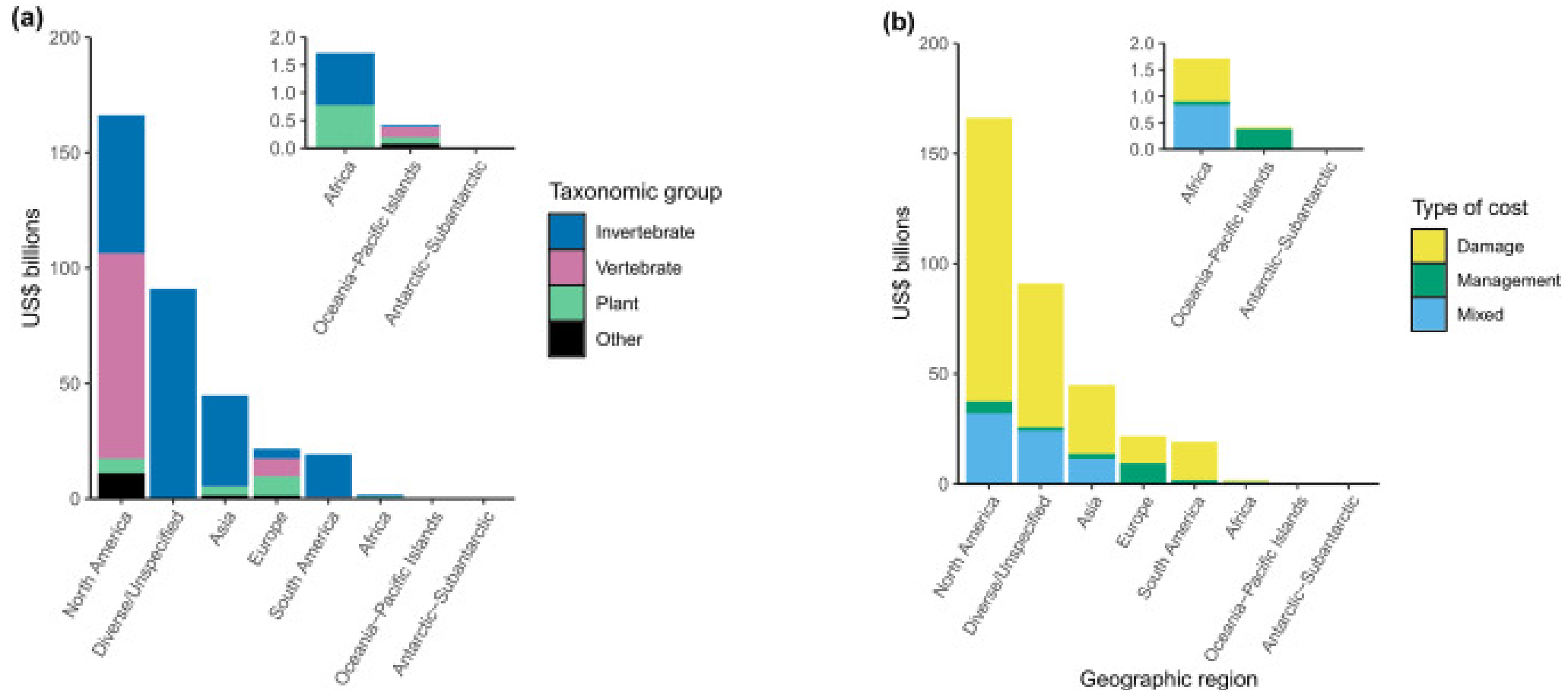
Zebra mussel
(*Dreissena polymorpha*)



Marine Nuisance Species Patterns

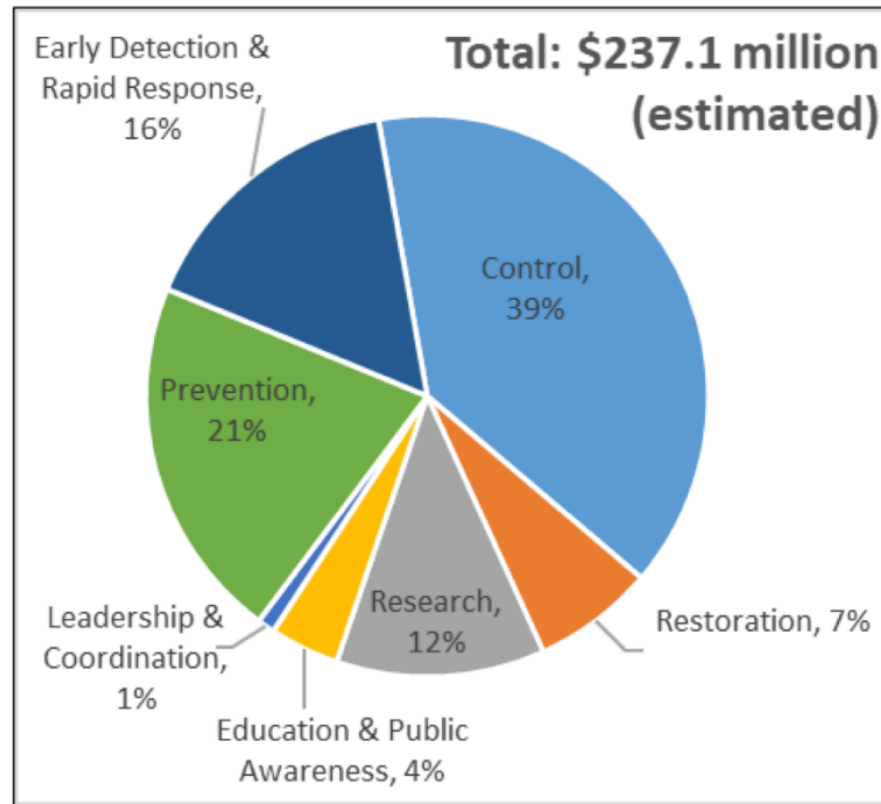


Aquatic Nuisance Species Costs

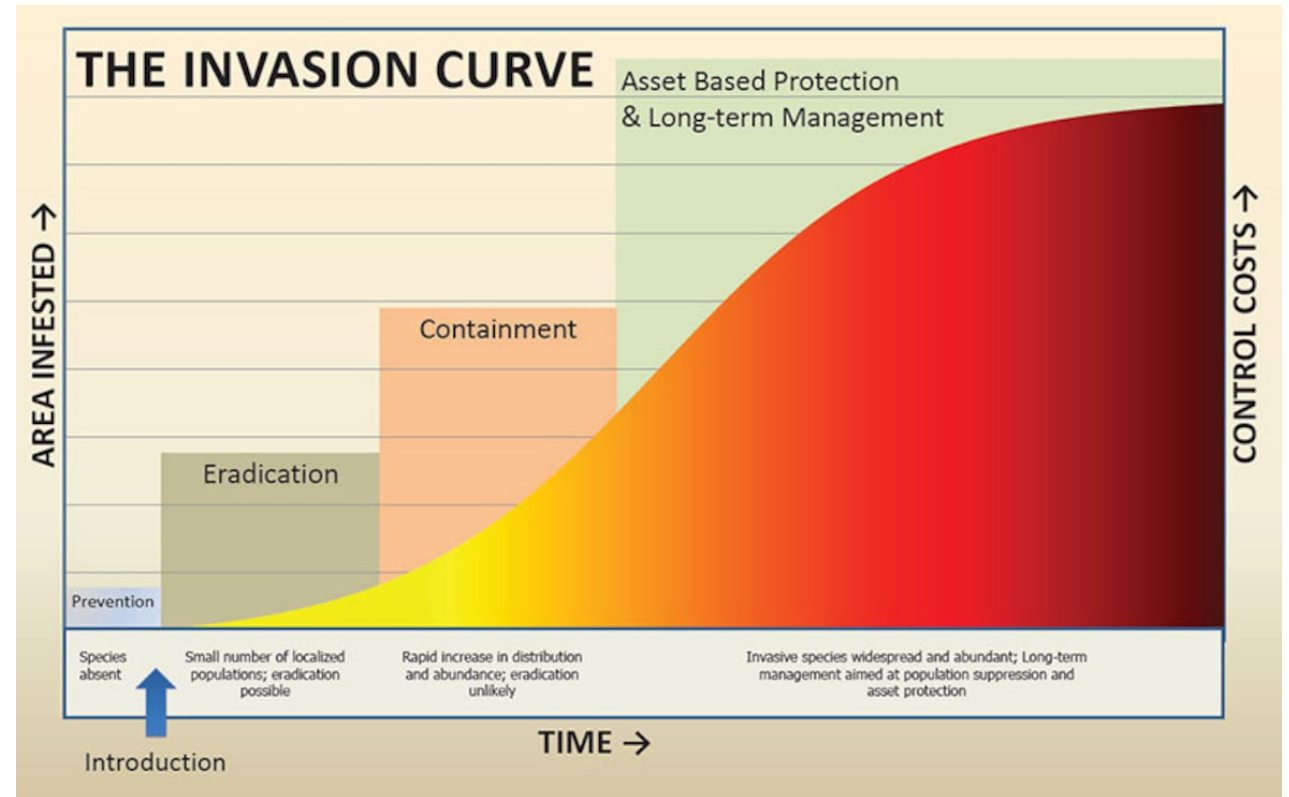


USACE Costs

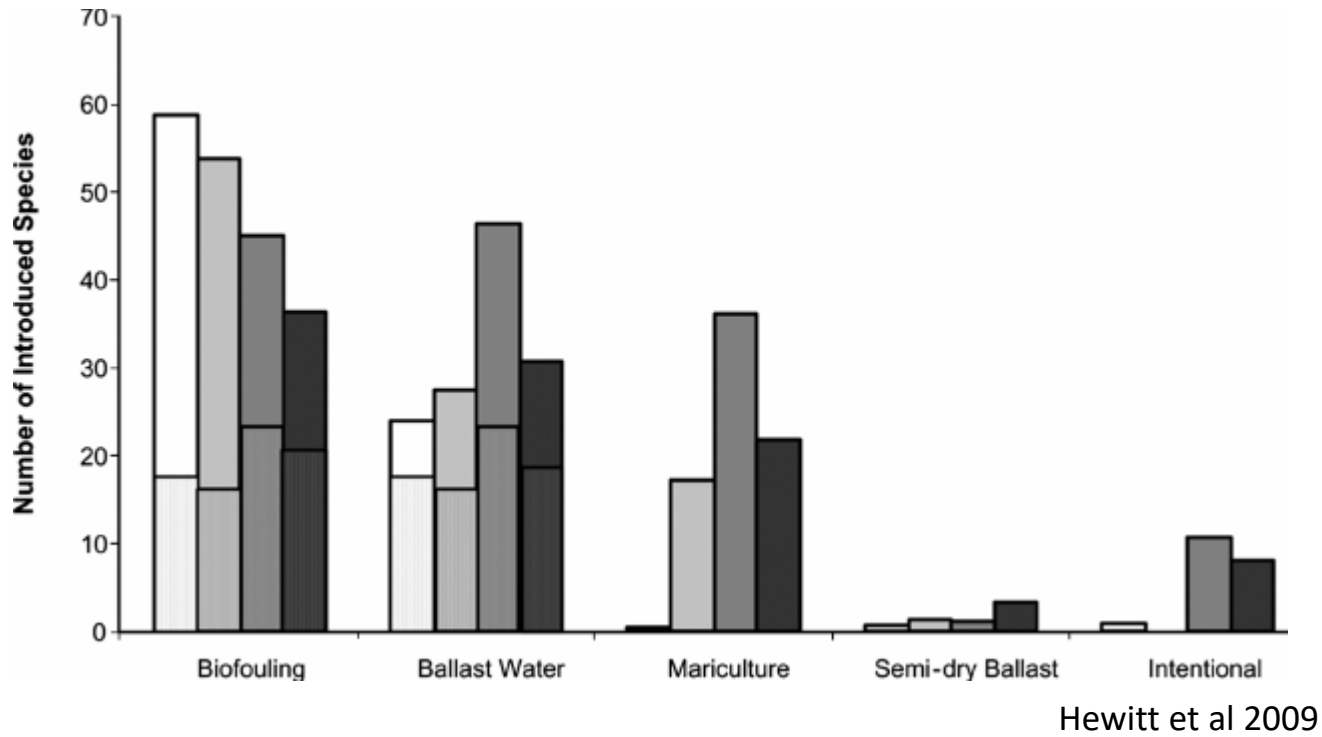
Figure 1. USACE Estimated Spending on Nuisance Species Efforts by Response Activity, FY2022



Source: CRS, using *FY2022 National Invasive Species Council Crosscut Budget*, at <https://www.doi.gov/invasivespecies/crosscut-budget>.

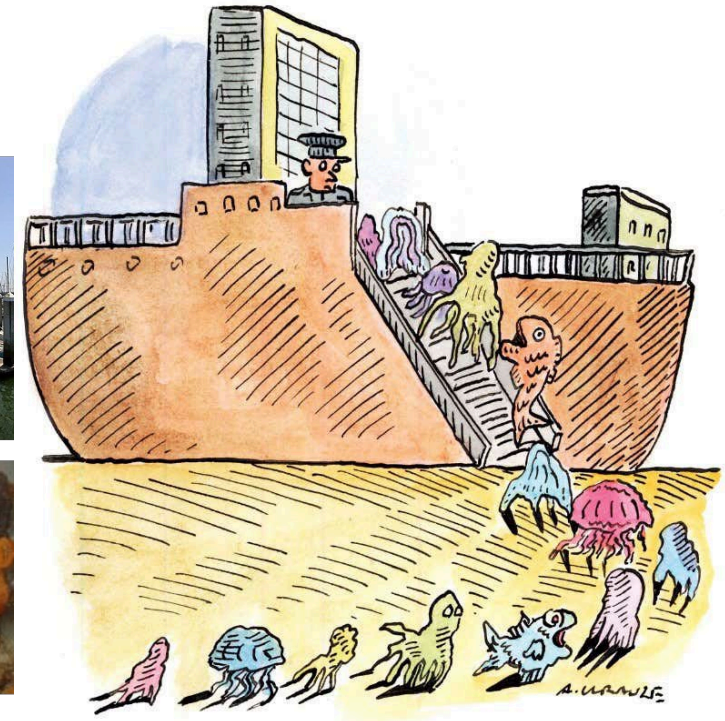


Invasion Vectors



Invaders spread beyond regional range:

- In Ships
- On Ships
- Aquaculture/Aquarium Trade
- Intentionally



(New Scientist, Illustration: Andrzej Krauze)

Review of Current Ecological Models

ERDC SR-23-DRAFT



US Army Corps
of Engineers®
Engineer Research and
Development Center



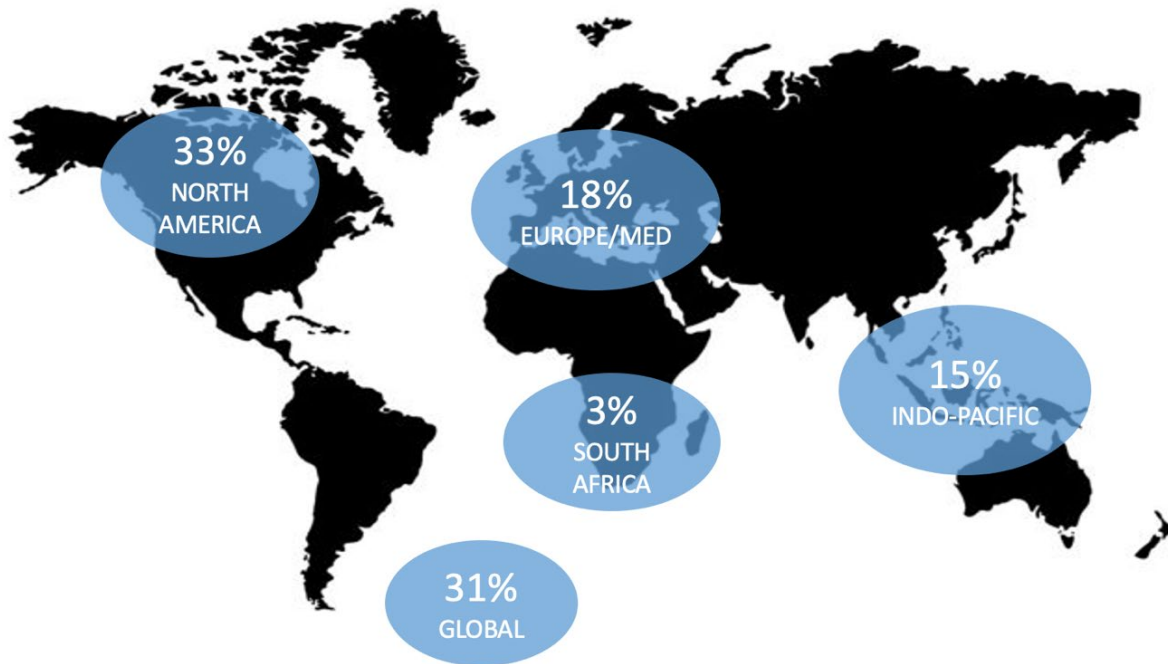
Aquatic Nuisance Research Program (ANSRP)

Marine Bioinvasion Risk

Review of Current Ecological Models

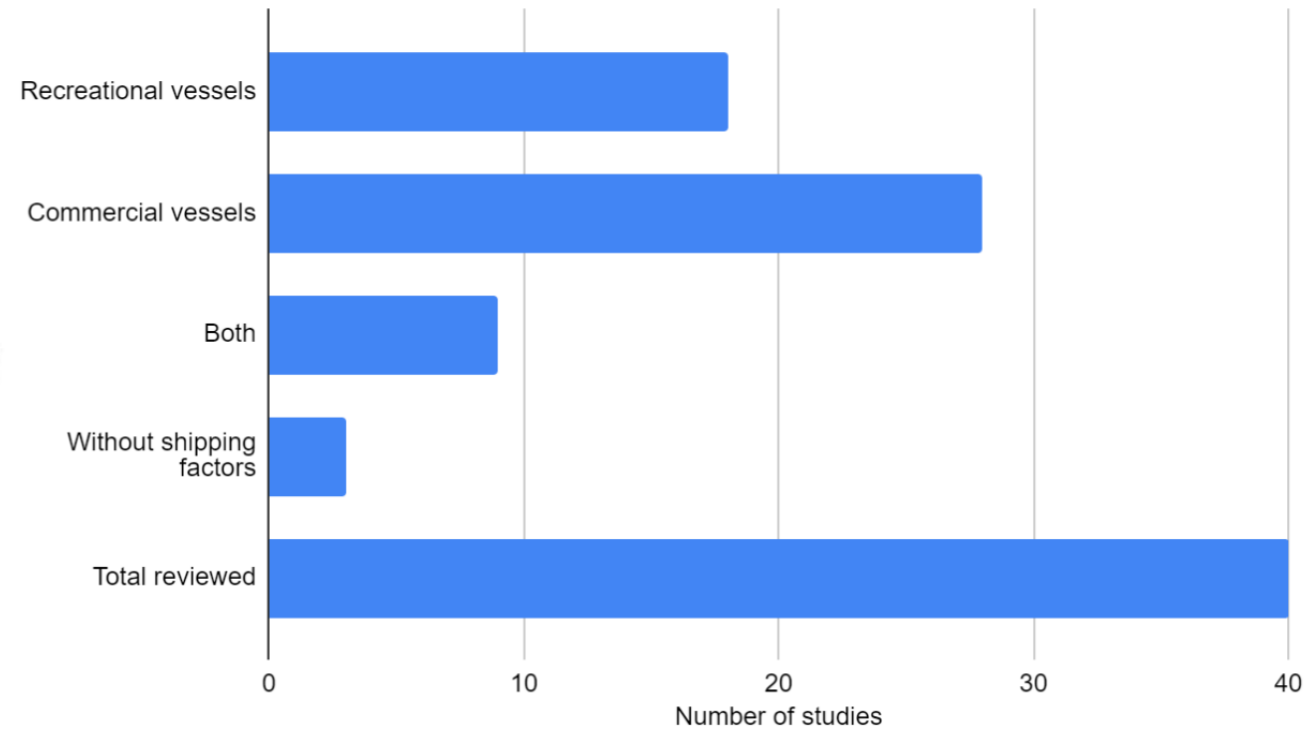
Safra Altman, Krystyna Powell, and Marin M. Kress

May 2023



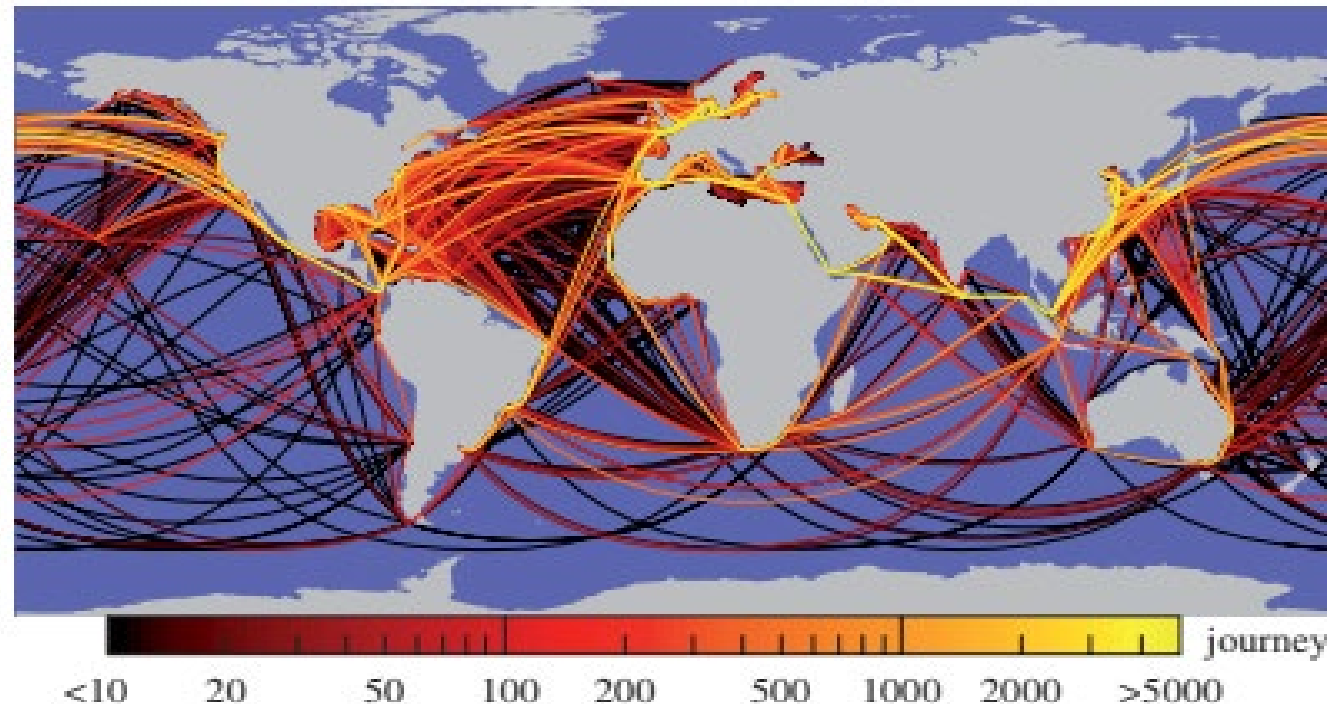
Distribution of literature reviewed

Summary of studies



Research Questions

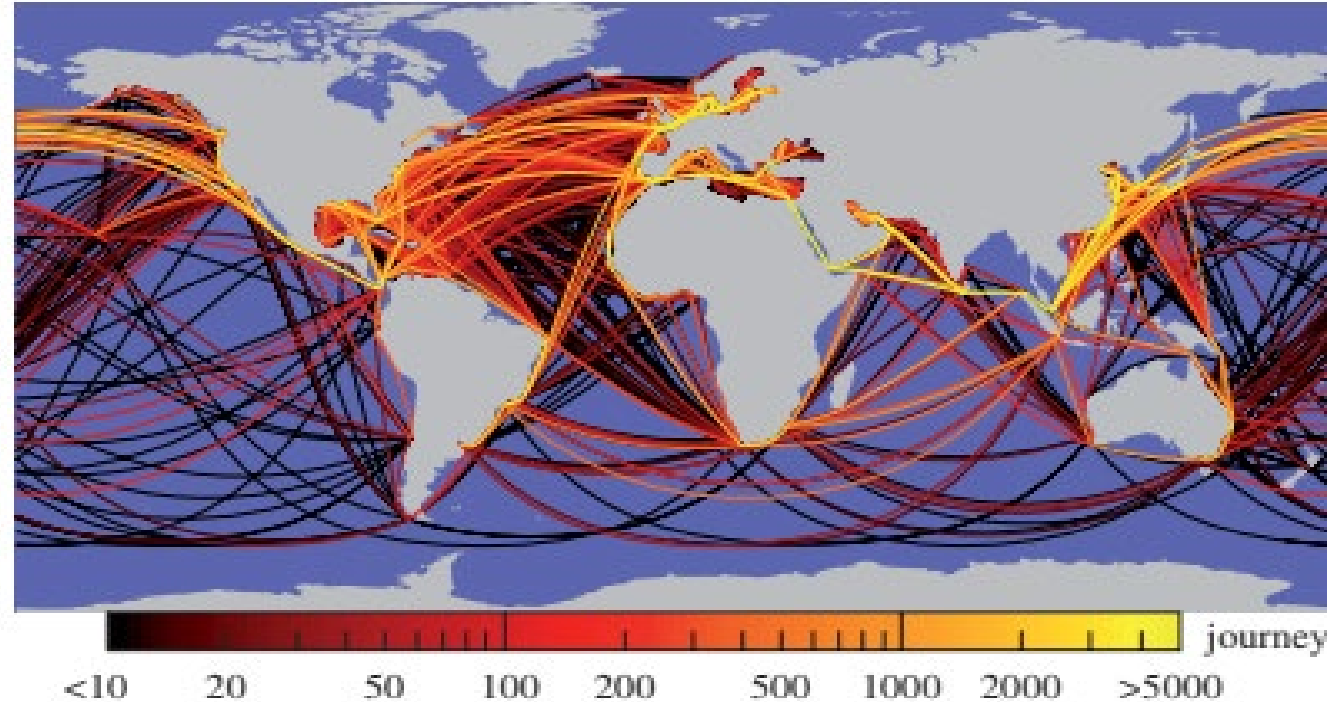
- What is the potential impact of commercial ships and recreational vessels on aquatic invasion risk?
- How do the patterns of commercial ships and recreational vessels differ in space and time?
- How does this potential impact differ across species?



Kaluza et al 2010

Model Framework

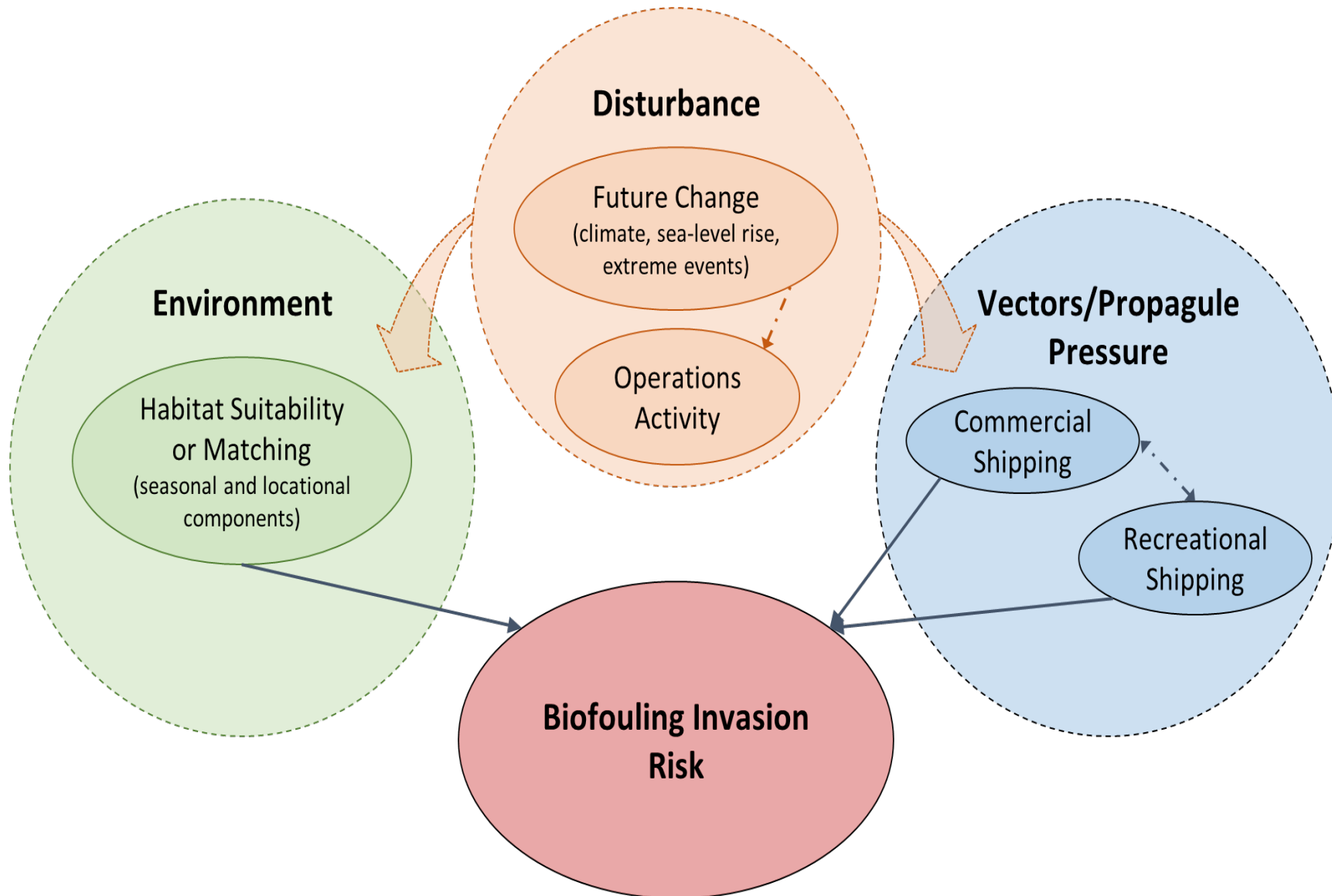
- What is the potential impact of commercial ships and recreational vessels on aquatic invasion risk?
- How do the patterns of commercial ships and recreational vessels differ in space and time?
- And does this potential impact differ across species?



Kaluza et al 2010

This project focuses on **developing a model that couples Automatic Information System (AIS) data describing global ship movement with species distribution models to identify high-risk areas for marine bioinvasion.**

Conceptual Model Framework



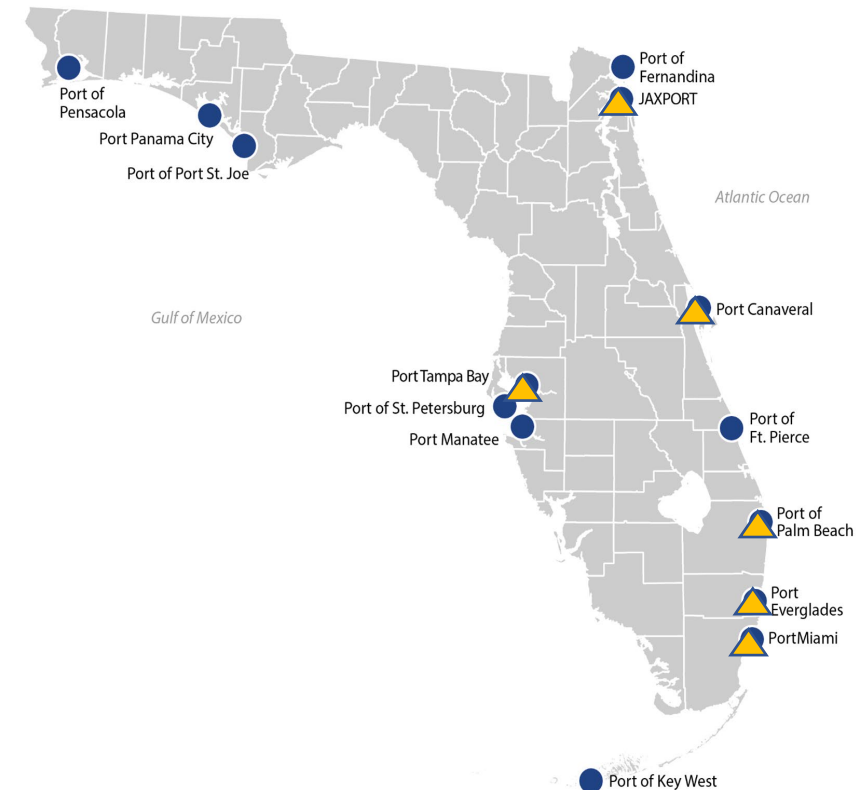
Environment

Habitat Suitability
or Matching
(seasonal and locational
components)

Model Development: Environmental Data

- 6 Major commercial ports and various recreational zones
- 10 non-native marine species identified to include in model
 - Five phyla (tunicate, bivalves, polychaete, crustaceans, hydrozoans)
 - Multiple functional groups (mobile, sessile, burrowing, planktonic, filter feeders, predators)
- Environmental drivers and thresholds identified for each species (NEMESIS Database)
 - Water Temperature
 - Salinity
- Habitat suitability curves derived for each species and environmental parameters

Target Ports

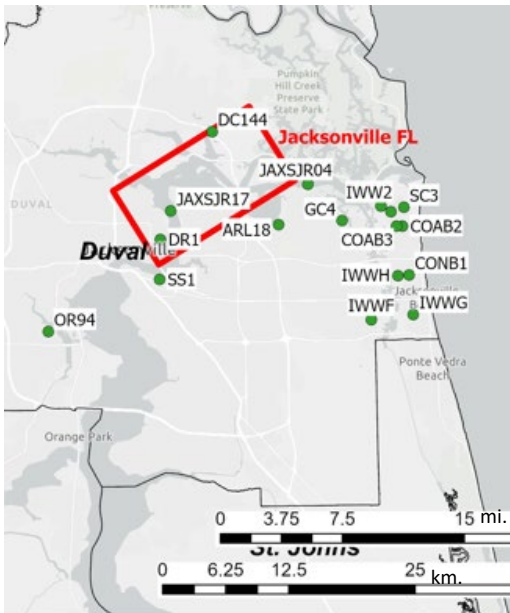


Environment

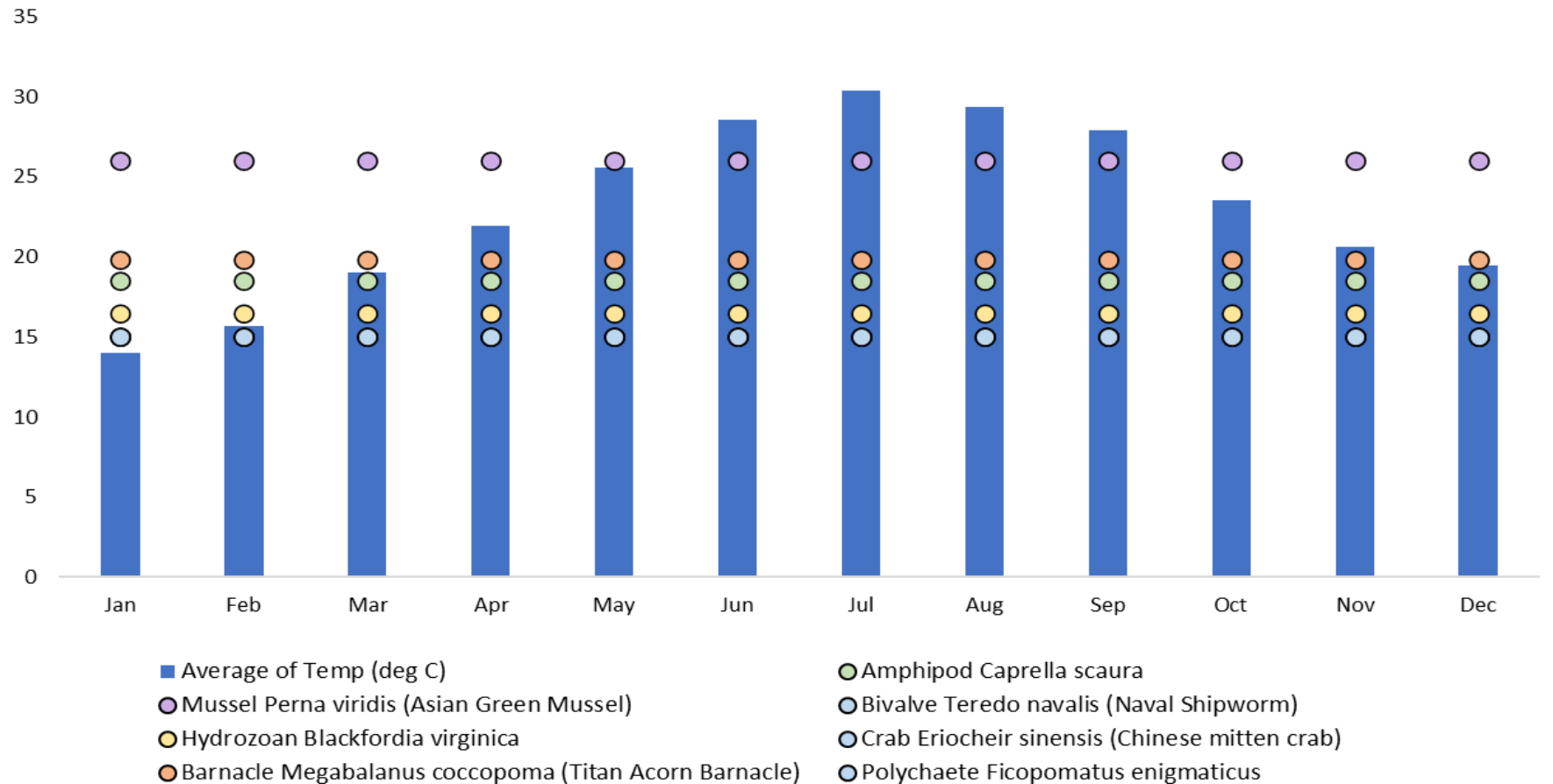
Habitat Suitability
or Matching
(seasonal and locational
components)

Model Development: Environmental Data

Water Quality data
acquired for all FL
coastal counties (STORET
data warehouse, FL DEP)



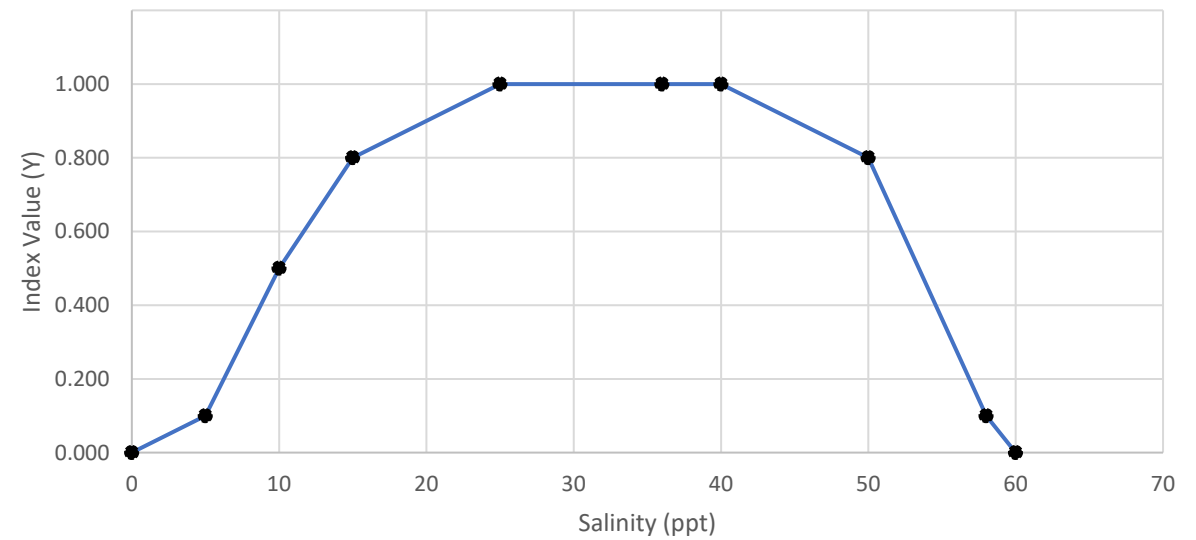
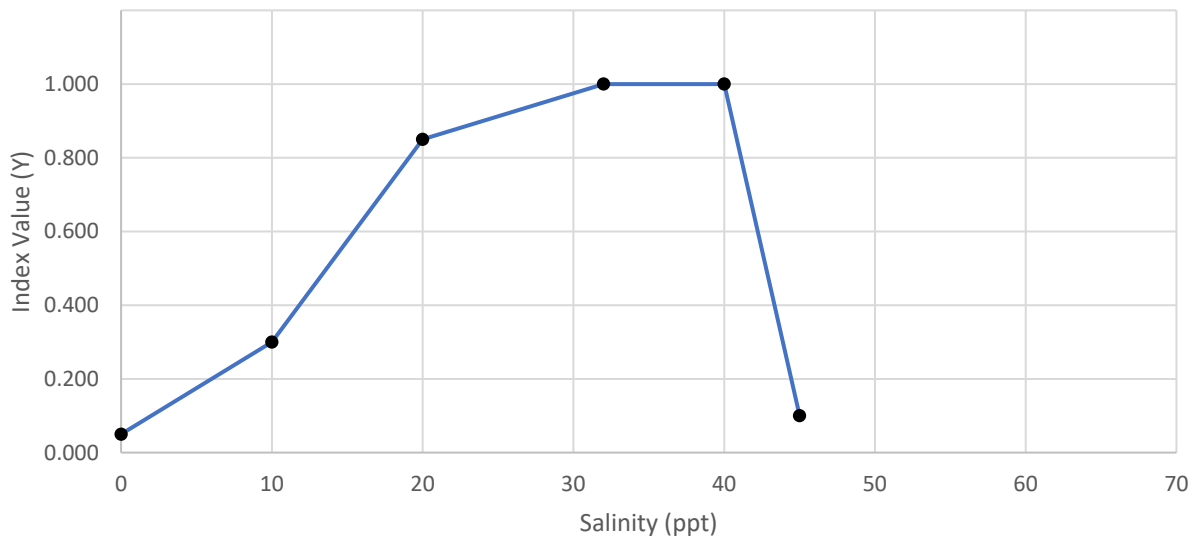
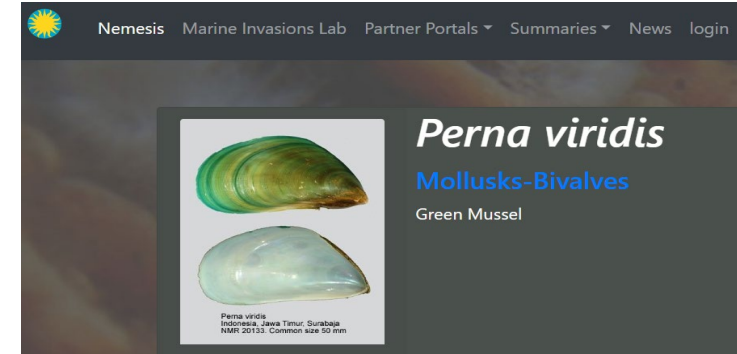
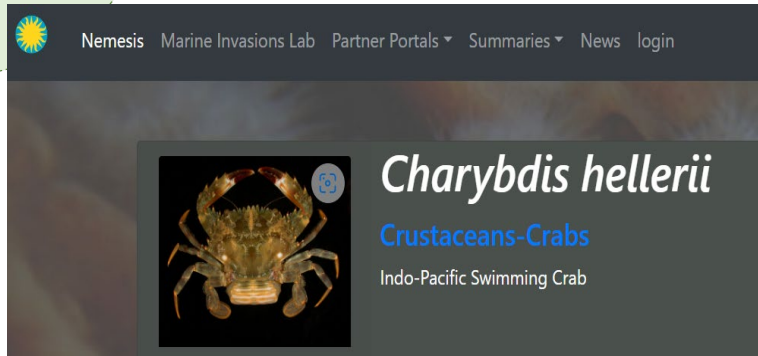
Monthly Average Temperature (C) by Species in Jacksonville, FL



Environment

Habitat Suitability
or Matching
(seasonal and locational
components)

Model Development: Habitat Suitability

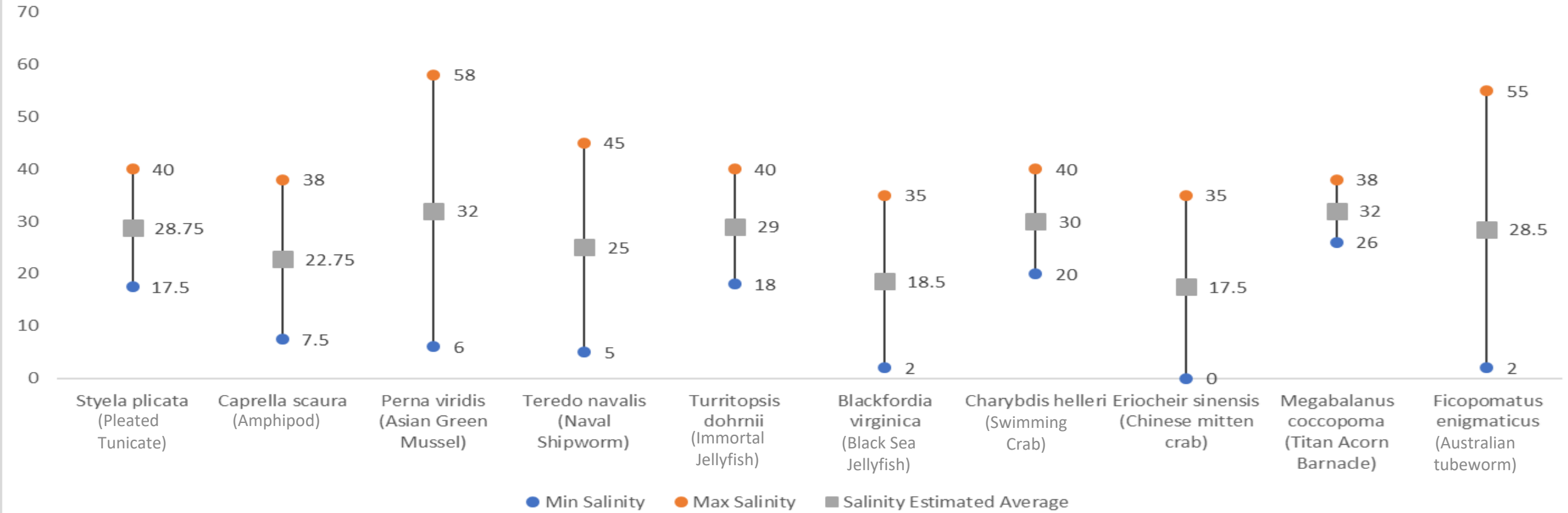


Environment

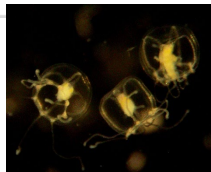
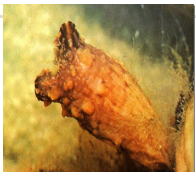
Habitat Suitability or Matching
(seasonal and locational components)

Model Development: Biological Thresholds

Species Salinity Thresholds



● Min Salinity ● Max Salinity ■ Salinity Estimated Average



Vectors/Propagule Pressure

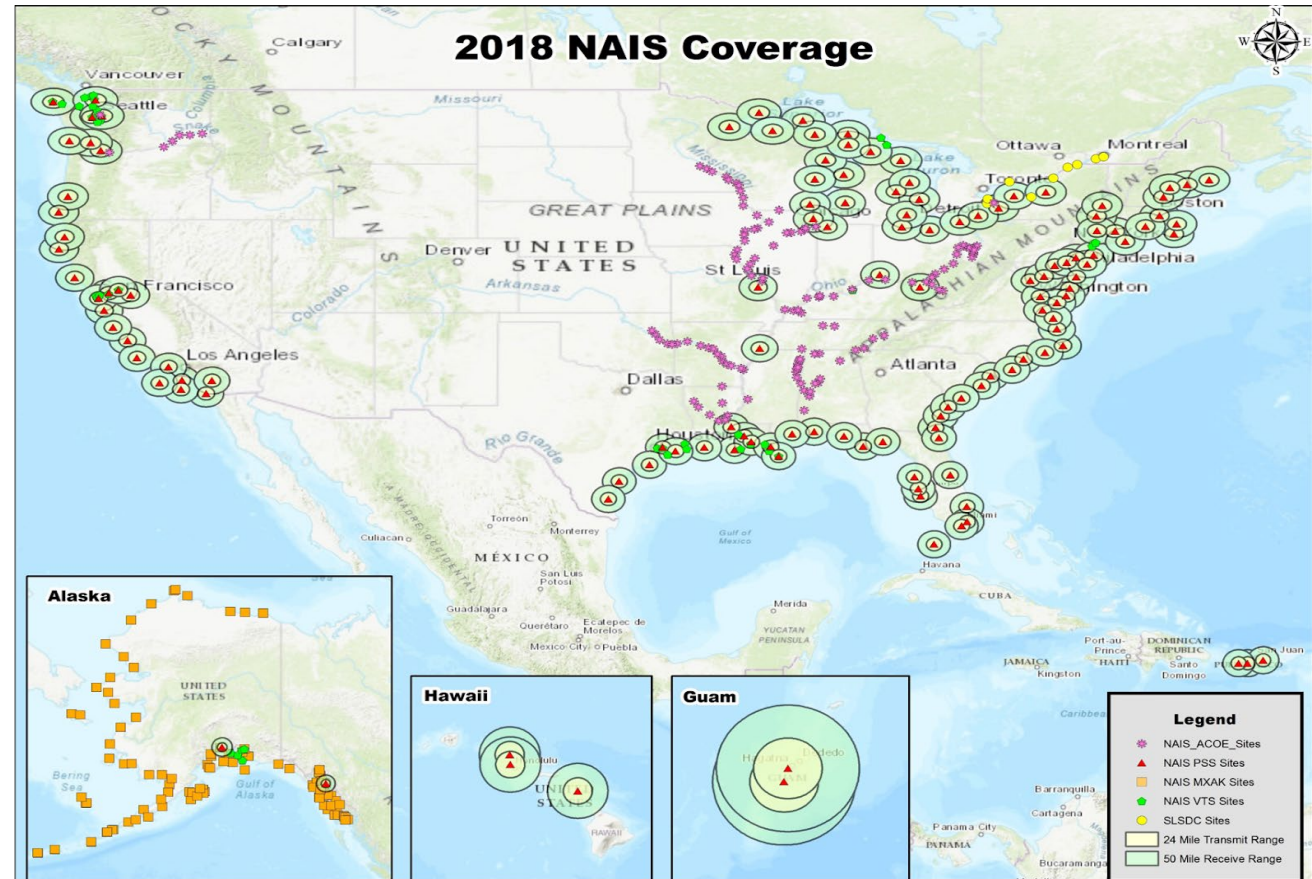
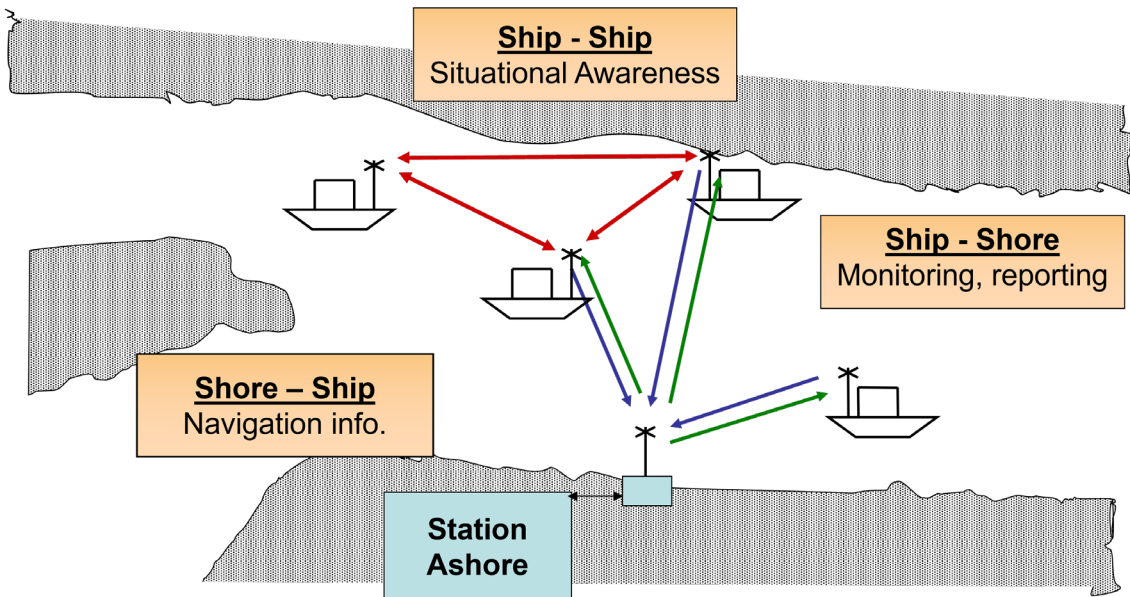
Commercial Shipping

Recreational Shipping

Model Development: Vectors of Invasion

- AIS – Automatic Identification System is a shipboard broadcast system that acts like a transponder

Automatic Identification System (AIS)



Abbreviations used in map: NAIS = Nationwide Automatic Identification System; ACOE = Army Corps of Engineers; PSS = Primary Shoreside (USCG); MXAK = Marine Exchange of Alaska; VTS = Vessel Traffic Service; SLSDC = St. Lawrence Seaway Development Corporation. Credit: USCG

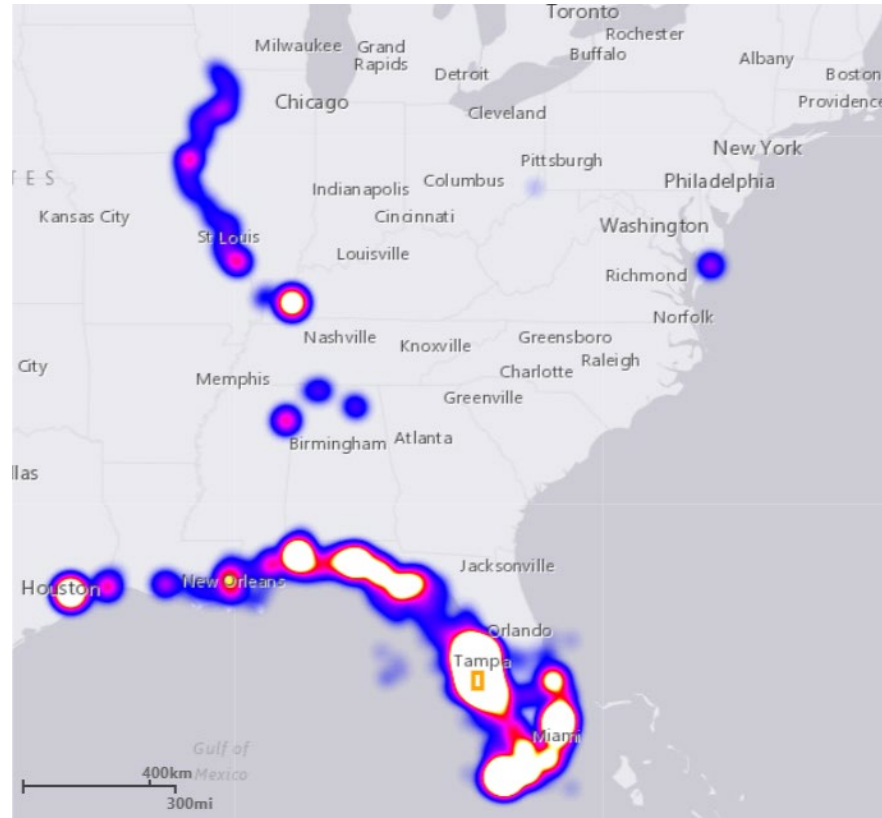
Vectors/Propagule Pressure

Commercial Shipping

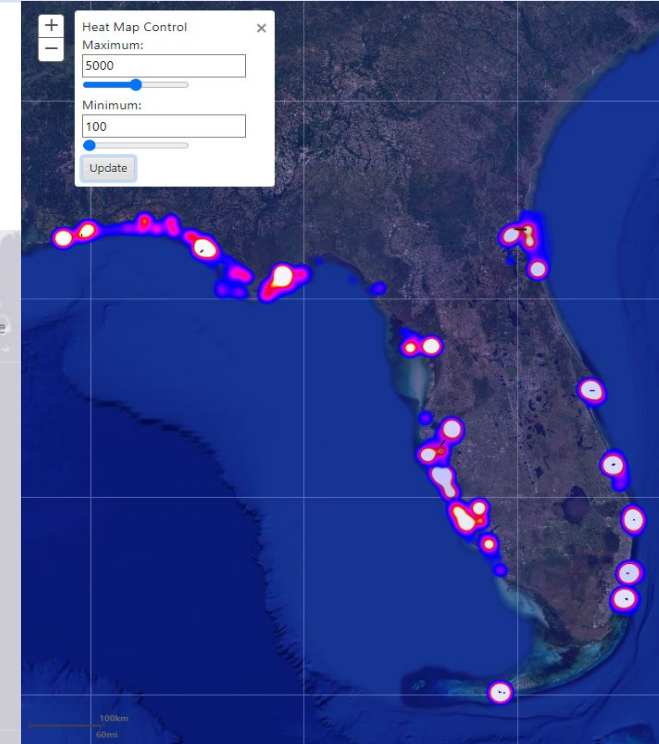
Recreational Shipping

Model Development: AIS Data

Customs data and AIS data used in combination to determine route patterns of commercial and recreational vessels in and around FL
Used to develop weighting and connectivity distributions



AIS Signal density plot of Pleasure Craft vessels that were identified in the Sarasota FL region (orange box) in 2020 and then tracked for 1-month.



Heatmap of vessel traffic inside our regional “watch areas” with minimum (blue tones) at 100 position reports, and max (white) at 5,000+ reports for 2020.

Model Development: Quantifying Shared Vessel Traffic

Vectors/Propagule
Pressure

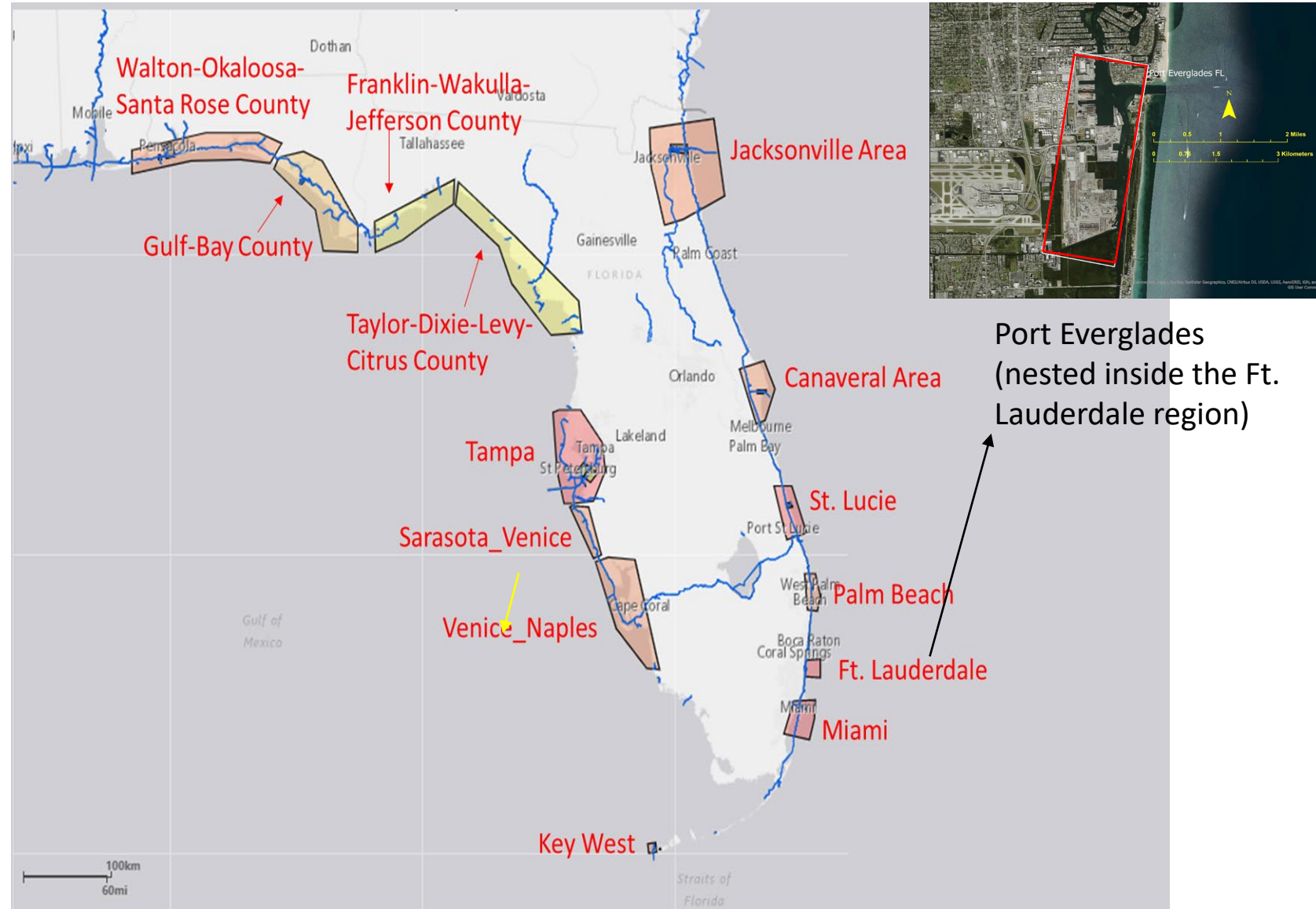
Commercial
Shipping

Recreational
Shipping

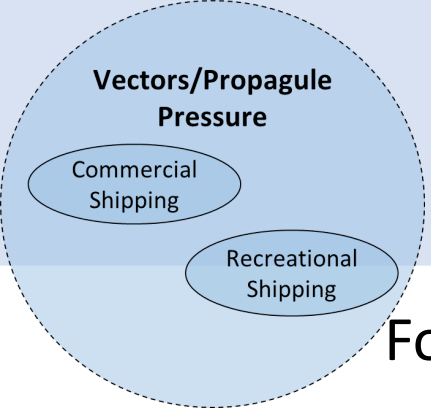
Segmented FL into different “watch areas” to understand movements happening within the state.

Allows us to look at connectivity within specific watch areas.

Approach was to not treat all of FL as one singular area since there are key differences within spatial resolution.



Port Everglades
(nested inside the Ft.
Lauderdale region)

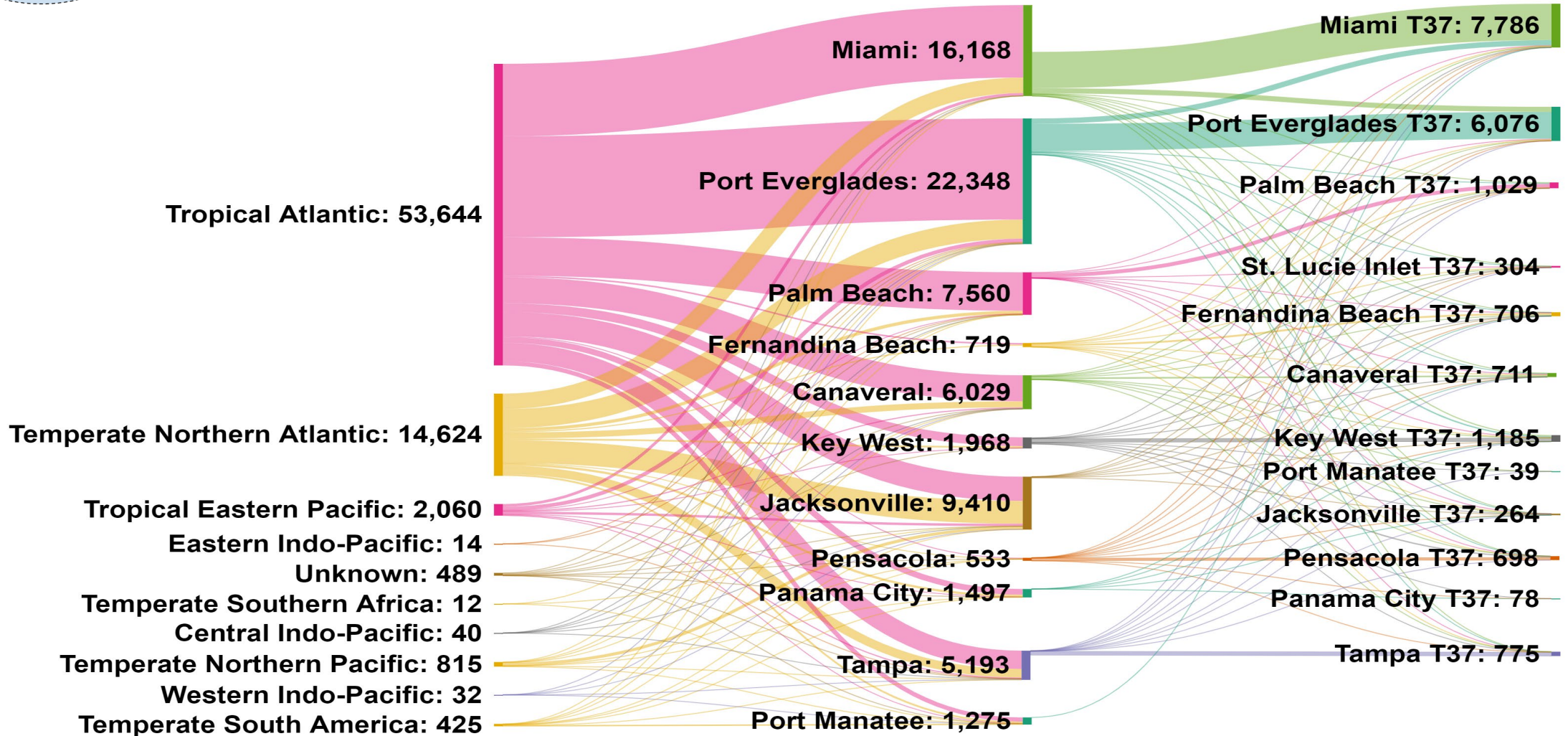


Model Development: Quantifying Connectivity

Foreign Vessels inbound to Florida

Outbound Recreational Vessels within Florida

Marine Ecoregions



Model Approach

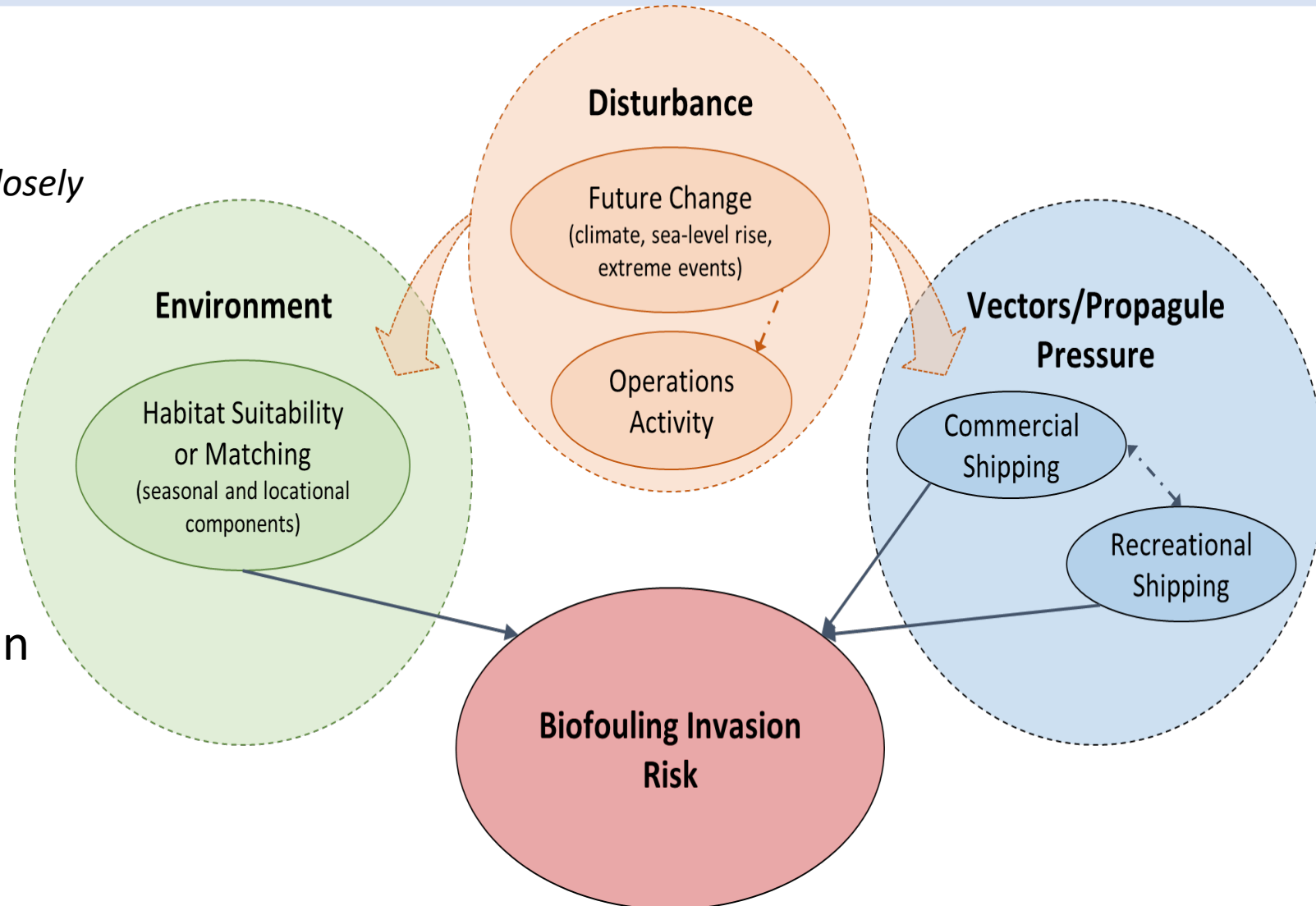
Probability species of interest associated with vessel route
(ensures that the invasion risks between two closely located ports are negligible)

Probability of introduction
(survival on route, in and on vessel)

Probability of establishment
(donor and recipient port matching and HSI)

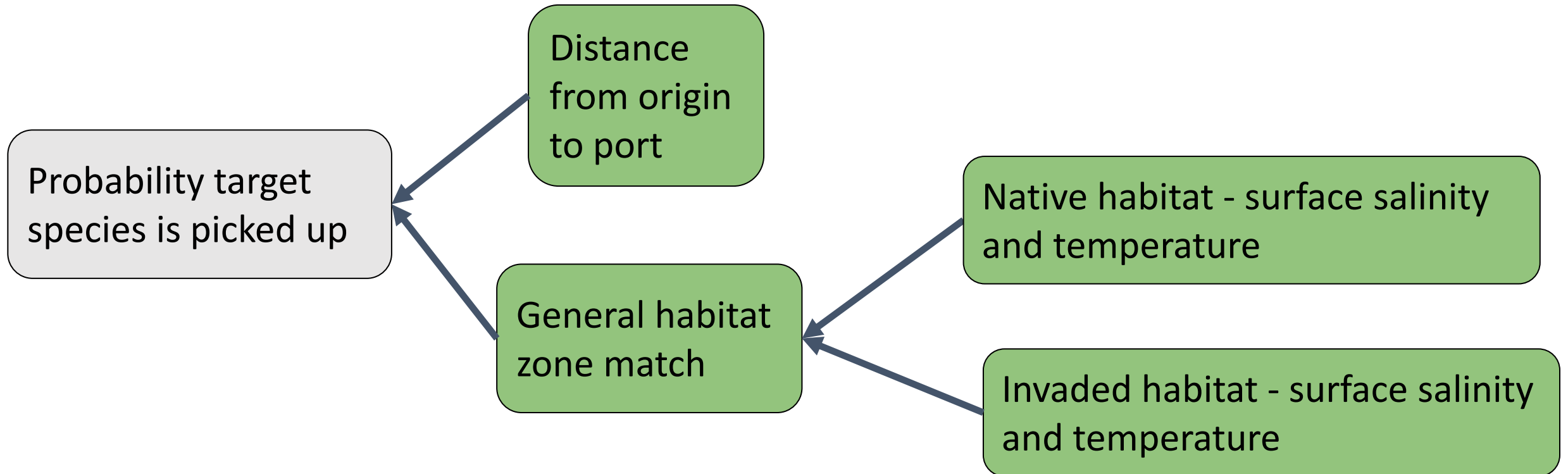
Calculation of invasion risk based on probability of introduction and establishment

Reminiscent of Seebens et al. 2013



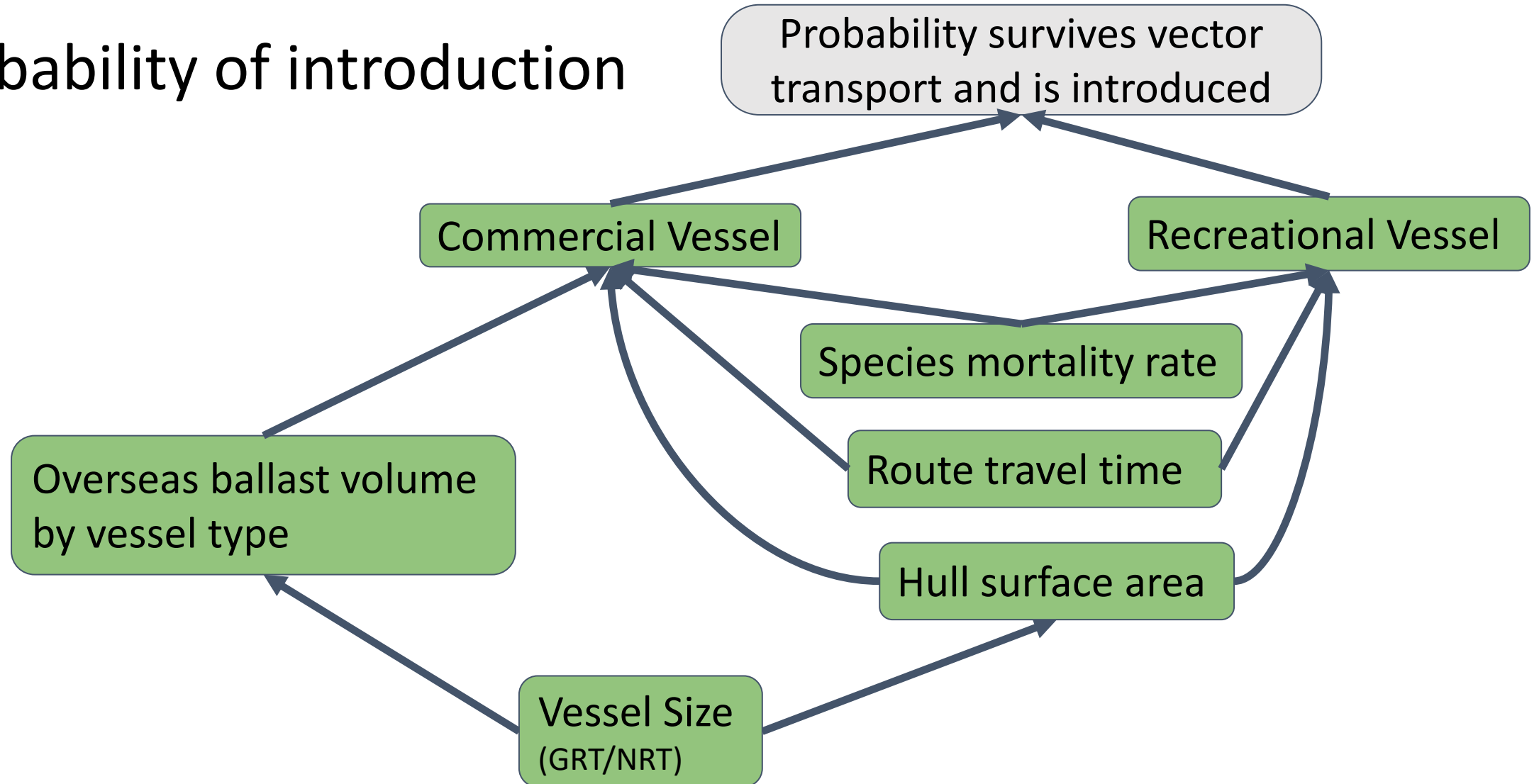
Model Components

Probability of association



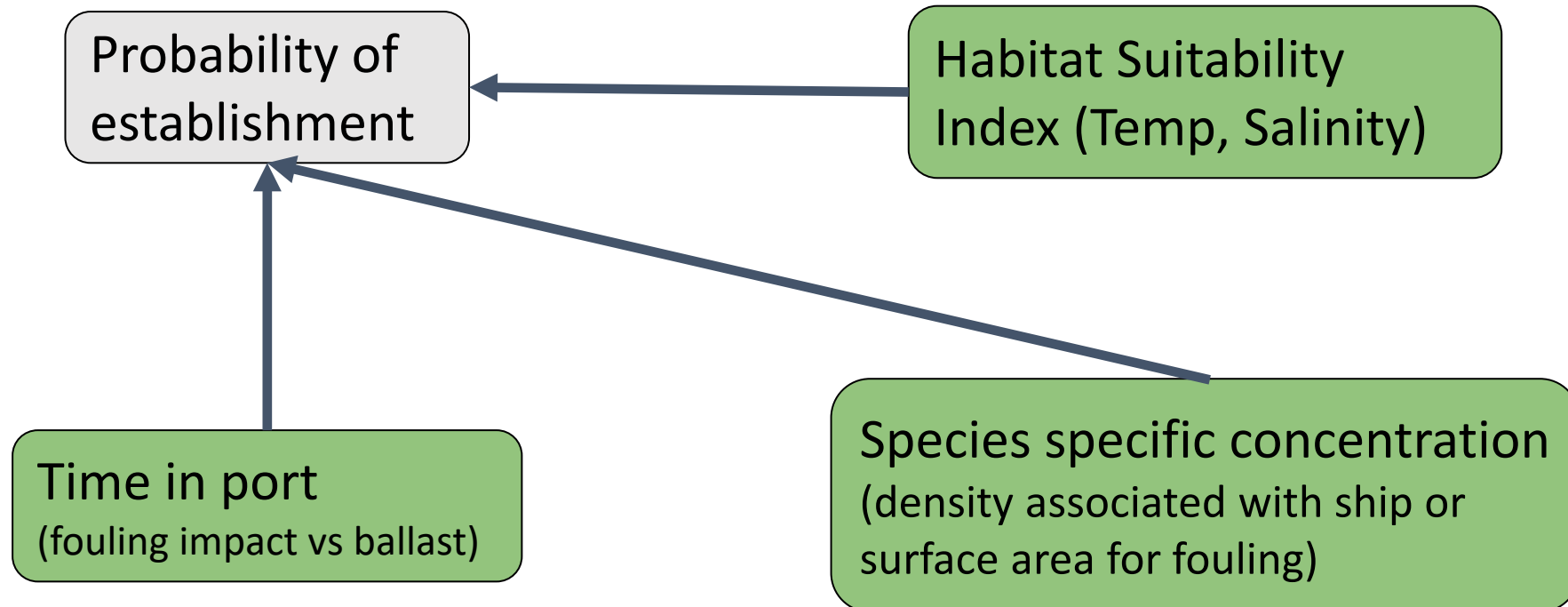
Model Components

Probability of introduction



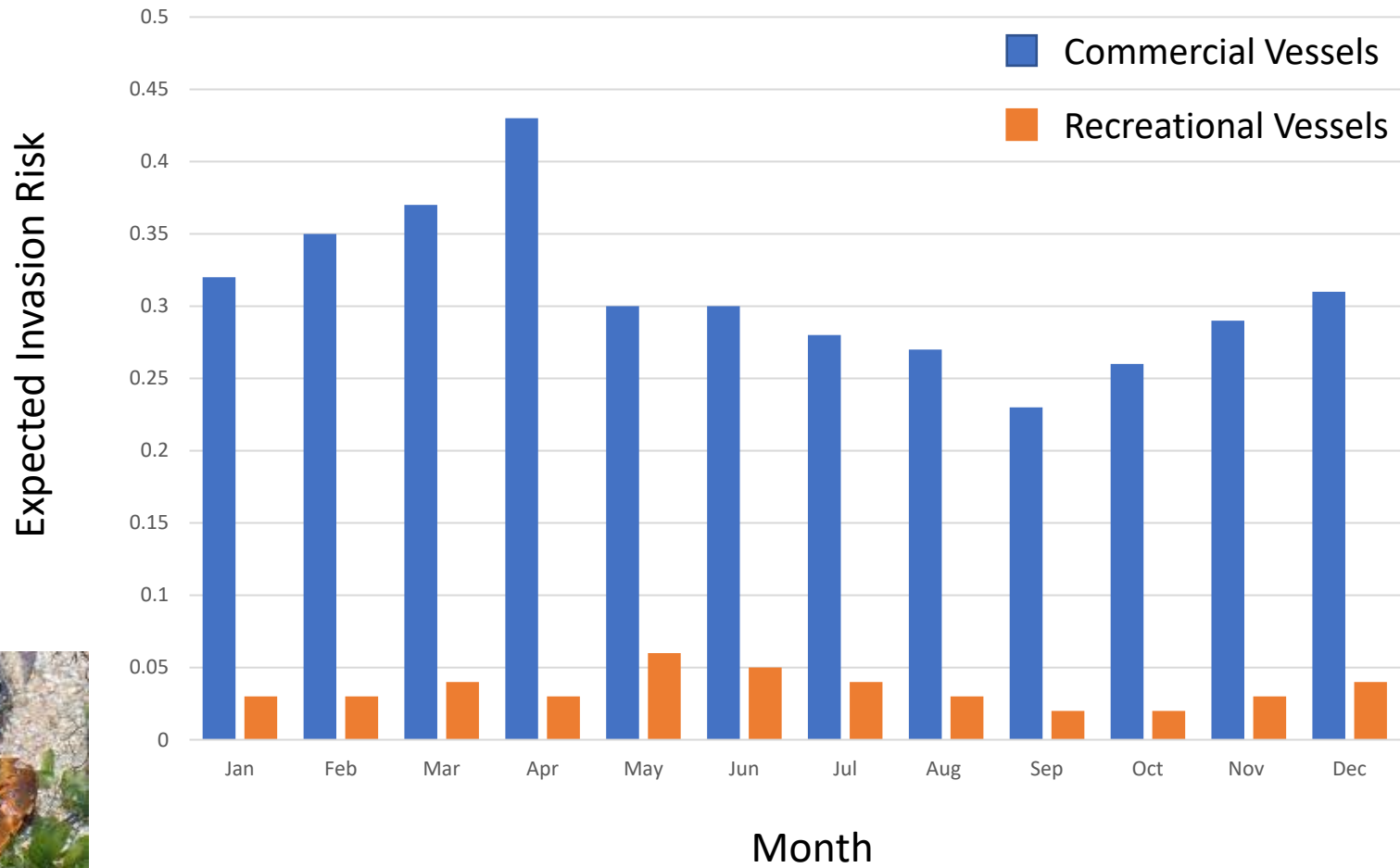
Model Components

Probability of establishment



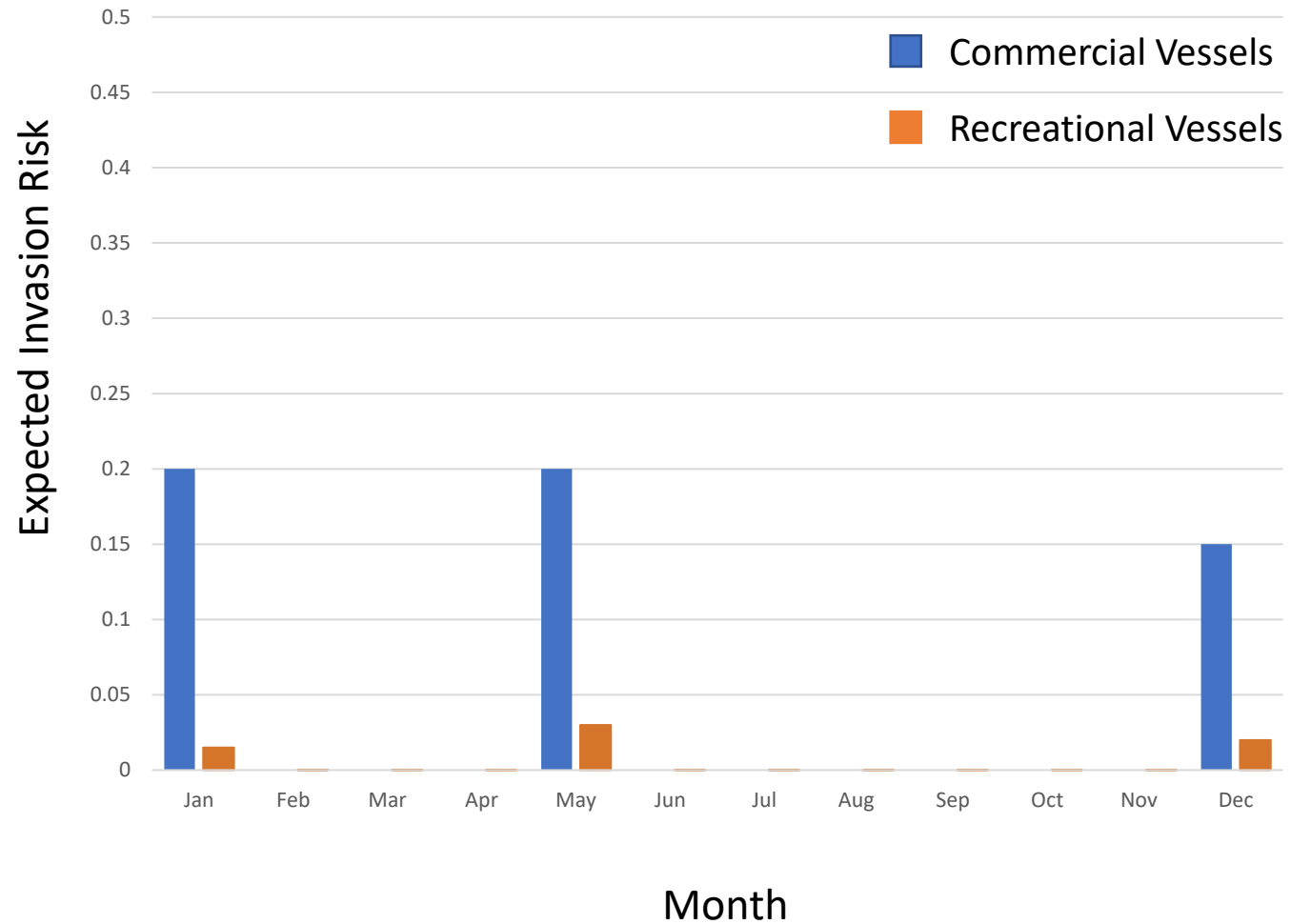
Model Results

Tampa, *Charybdis hellerii*



Model Results

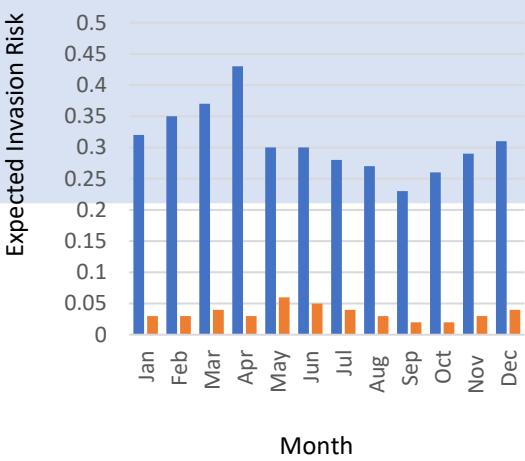
Tampa, *Megabalanus coccopoma*



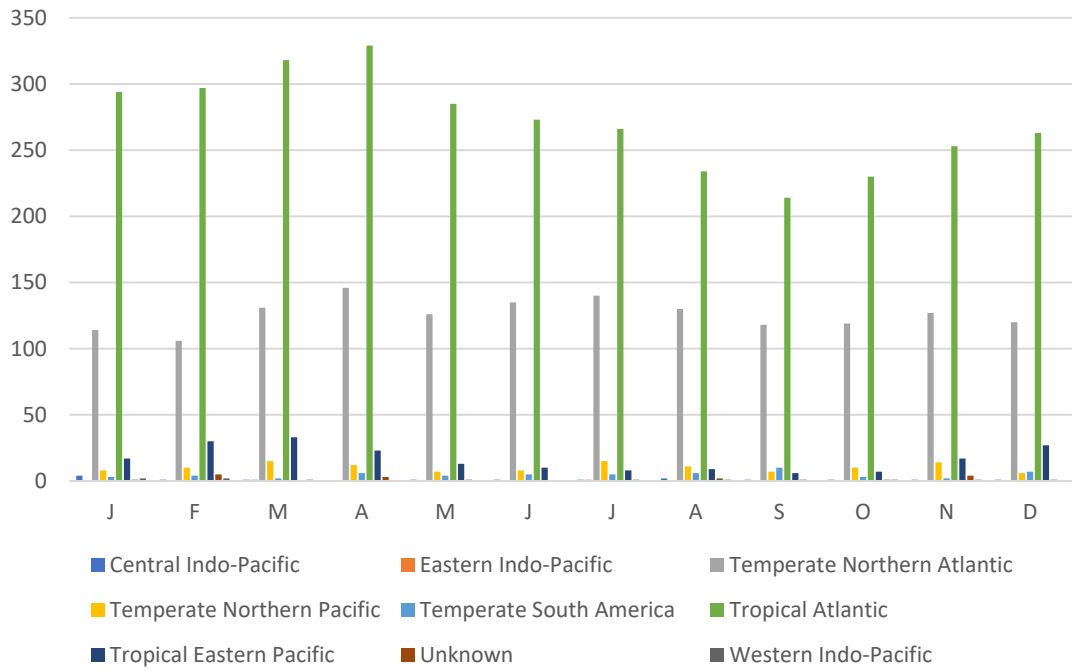
Jaxshells.org

Model Results

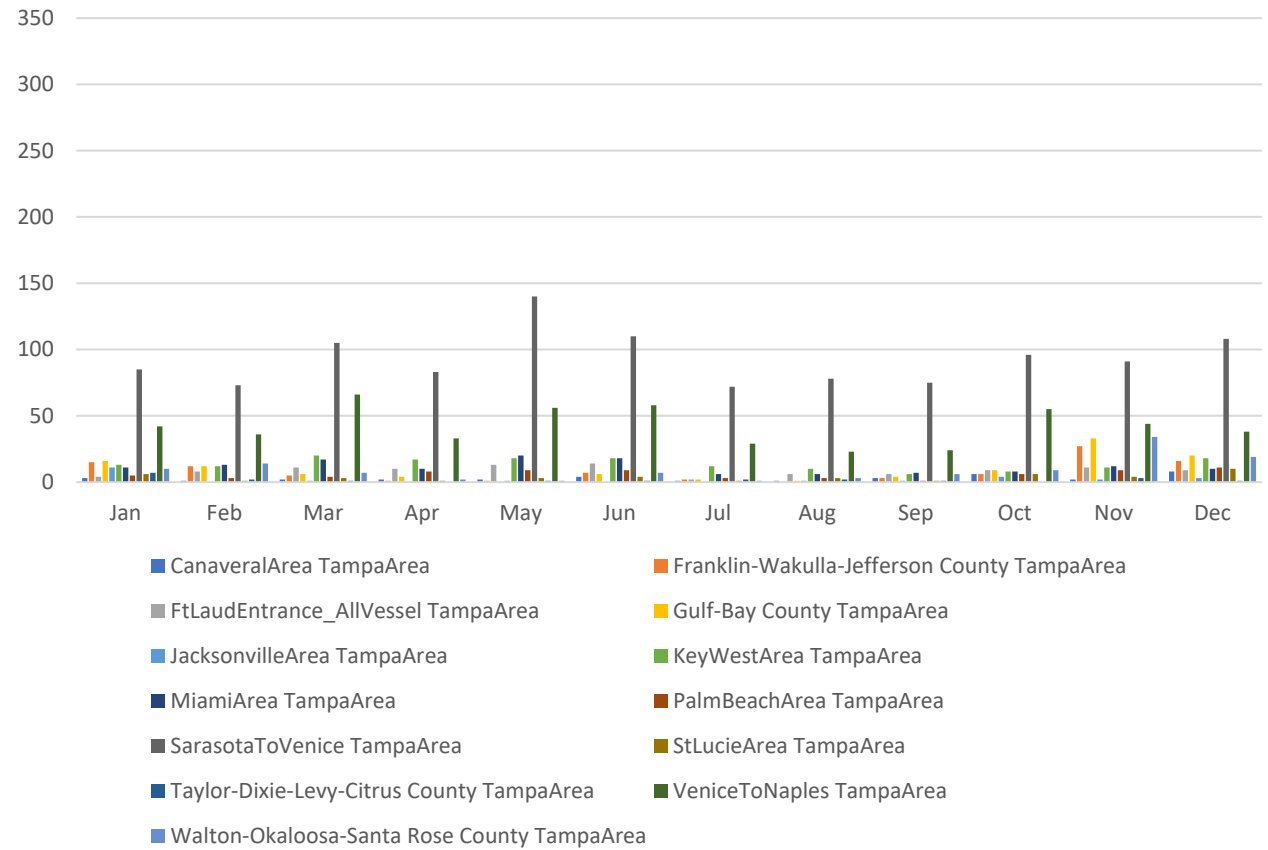
Tampa - Drivers



Commercial Vessels Entering Tampa

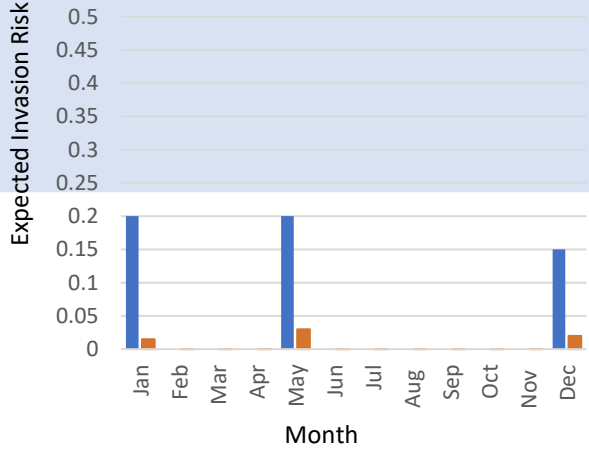


Recreational Vessels Entering Tampa

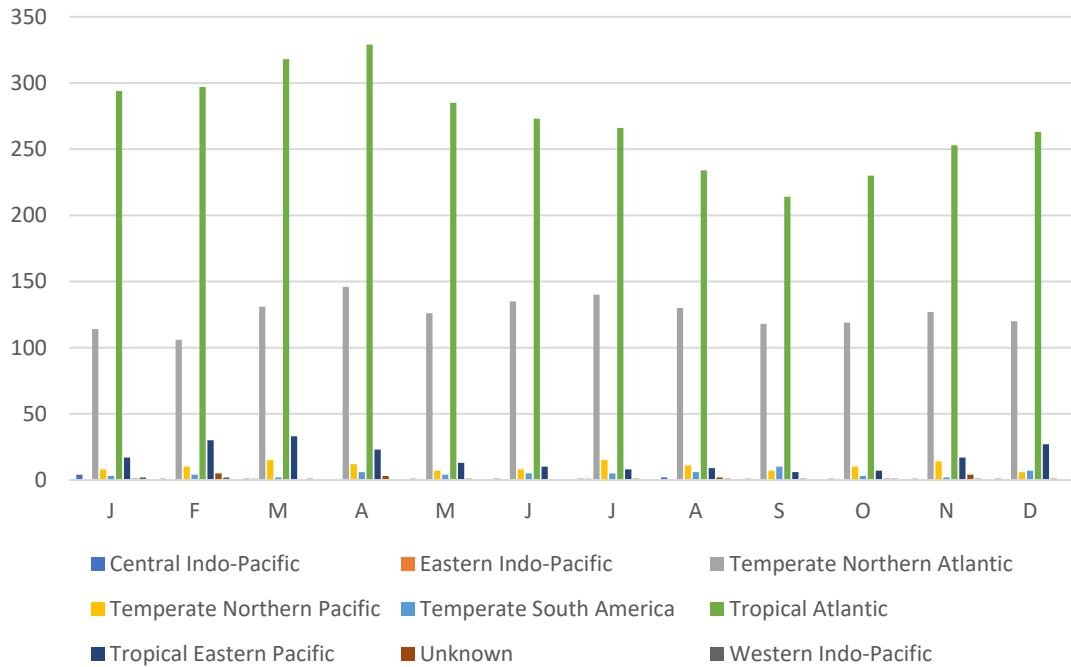


Model Results

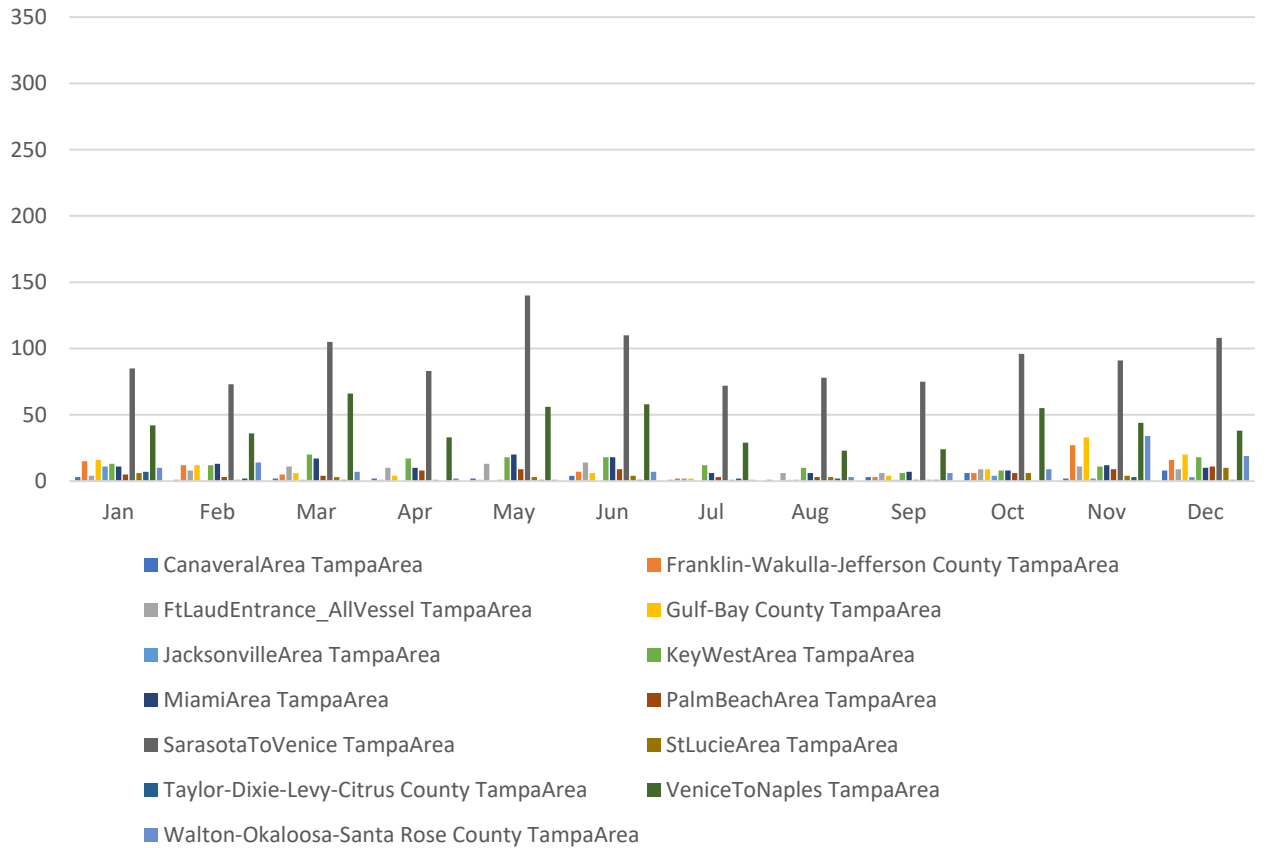
Tampa - Drivers



Commercial Vessels Entering Tampa



Recreational Vessels Entering Tampa



Summary

- 2 species show different monthly patterns of Expected Invasion Risk, both are influenced more by commercial traffic than recreational traffic
- Vectors seem to be drivers for crab
- Habitat suitability seems to be driver for barnacle

- But – this is only one site!
- Variation in environmental conditions as well as traffic patterns will highlight complexity
- More target ports, more species results to evaluate

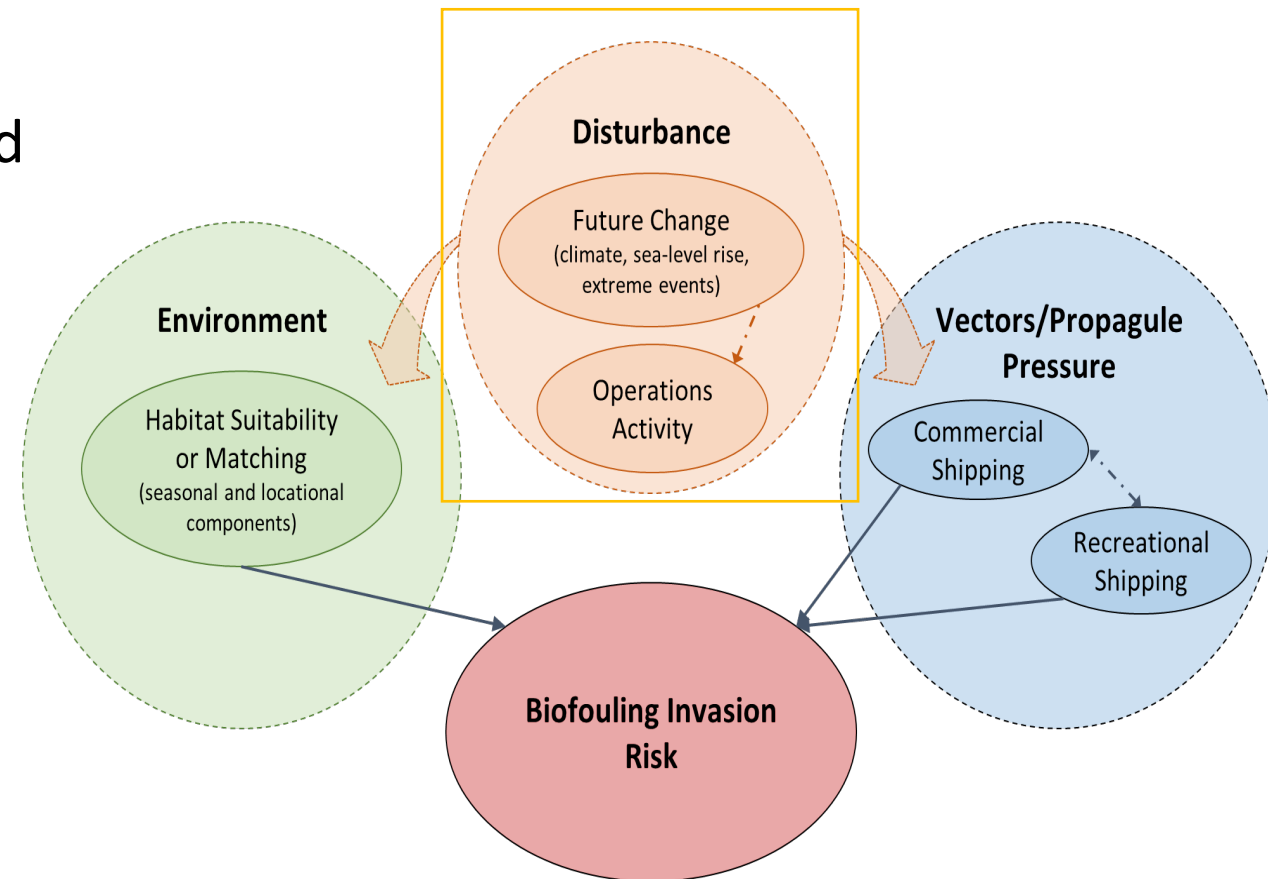
Summary

Overall goal is to identify high-risk areas for marine bioinvasion to inform planning, operations and mitigation strategies.

- ✓ Performed extensive literature review and data mining
- ✓ Created conceptual model
- ✓ Identified probability equations and data components
- ✓ Developed parameterized model

Next Steps...

- Evaluate additional results
- Scenario analysis
- Include dredging maintenance/operations activity and future environmental change



Aquatic Invasive Species and Shipping-Modeling Risk



Questions &
Discussion

Thank you for your attention!



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Krystyna.T.Powell@usace.army.mil