Ecological Sustainability and the Challenge of Managing Risks Posed by Invasive Species

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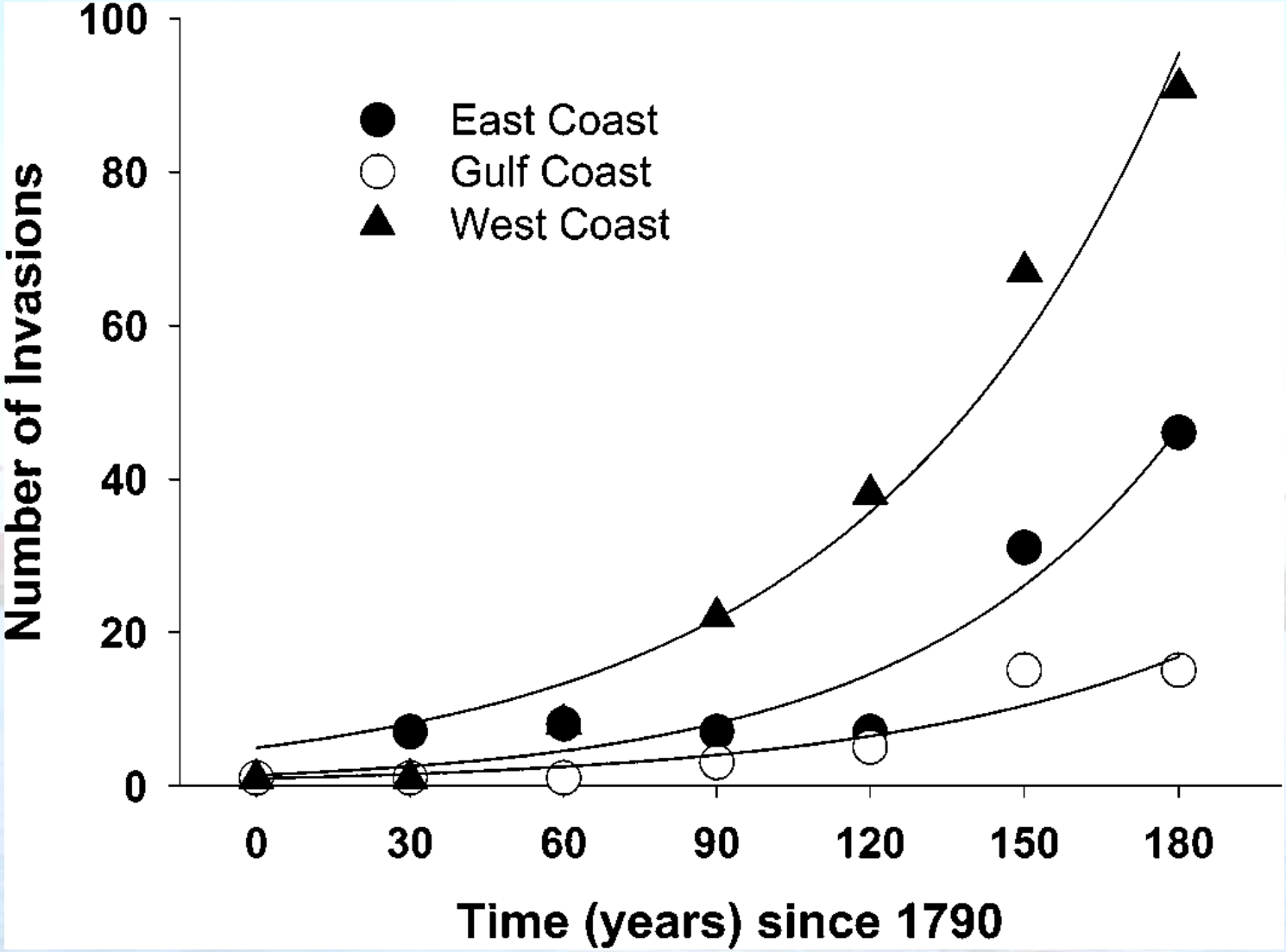
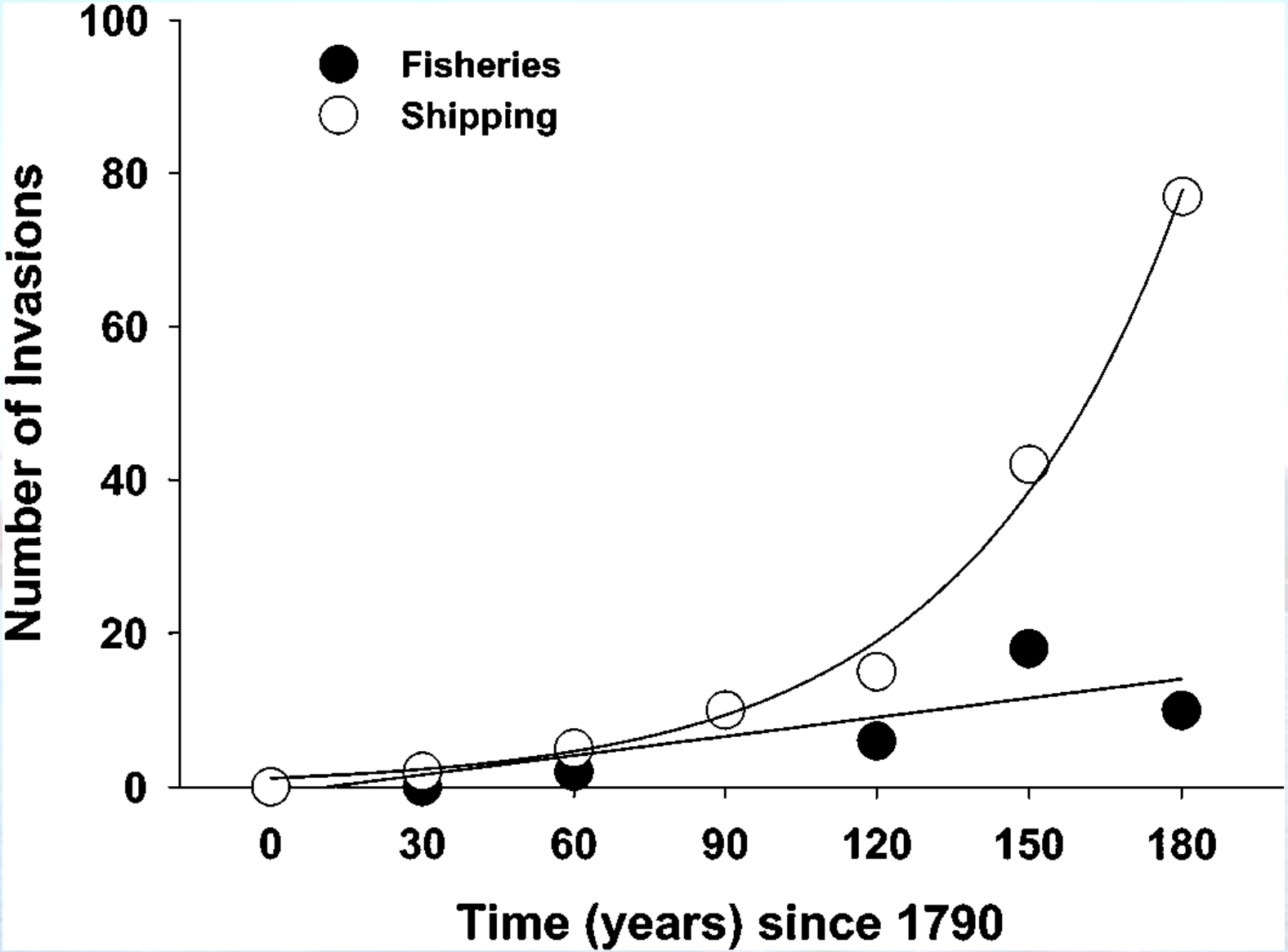
Aquatic Invasive Species

- Invasions by nonindigenous species (NIS) result in significant ecological, economic, and human health impacts
- Economic cost in U.S. of aquatic invasions >$10 billion / year (Pimentel 2003)
- Transfers of NIS by human activities have increased dramatically over the past century
- Pathways
  - Aquaculture
  - Aquarium Trade
  - Shipping



(Ruiz et al, 2000)

Invasion Process



(Ruiz et al,2000)

MTS Related Invasive Species Pathways

- Ballast

- Hull Fouling
  - Ship Decommissioning

Ballast Mediated Introductions

~110,000 Arrivals to U.S. Annually (Overseas + Domestic)

Zebra Mussels, Lake Erie

(Great Lakes Environmental Research Laboratory)

Native to SE Russia

U.S. Great Lakes (1988)

Spread to Mississippi, Hudson, St. Lawrence, Ohio, Cumberland, Missouri, Tennessee, Colorado, and Arkansas Rivers

Massachusetts and Minnesota (2009)

California (2010)

Ballast Mediated Introductions

Mnemiopsis leidyi

Introduced from Western Atlantic

Black Sea (1980's)

Caspian Sea (1999)

North and Baltic Seas (2006)

Ballast Regulations

- National Ballast Information Clearinghouse
  (Smithsonian Environmental Research Center & U.S. Coast Guard)

  - Established (1997)
  - Voluntary Management (1998)
  - Mandatory Management (2004)

Mid-ocean Ballast Water Exchange
Empty / Refill (100%) or Flow-Through (300%)

- California State Lands Commission Marine Invasive Species Program

Ballast Regulations

- Ballast Water Discharge Standard Notice of Proposed Rulemaking (USCG-2001-10486, 2009)
  - Phase I (2012) – Ballast released in port if meets IMO standards
  - Phase II (2016) – Standards 1000x more stringent
- US EPA Draft Environmental Technology Verification Ballast Water Protocol (2010)

Need for rigorous testing process

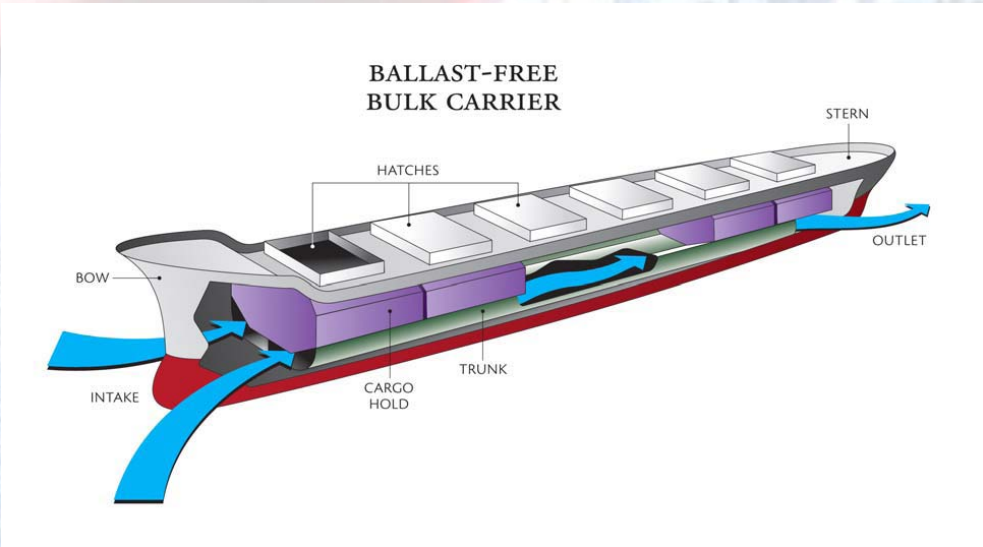
Need for new methodology and approach

Ballast Research

- Ballast water patterns
- Ballast exchange developments and studies
- Exchange verification studies
- Filtration/separation of ballast water
- Sterilization of ballast water by ozone, UV light, electric currents, or heat treatments
- Chemical treatments (biocides)
- Asphyxiation (removing oxygen)

Ballast

- Ballast water discharge protocols center on mid-ocean water exchange
- New treatment technologies will allow for a shift in regulations
    - ocean exchange to in-port discharge standards
- Engineering solution
    - Ballast free ship design



Michael Parsons, University of Michigan, Great Lakes Maritime Research Institute

Hull Fouling

- Without anti-fouling systems, vessels may gather up to150 kg of fouling per m^2 in less than six months at sea.
- On a Crude Carrier with 40,000 m^2 wetted surface area, equivalent to 6,000 tons
- A small amount of fouling can lead to an increase of fuel consumption of up to 40-50%

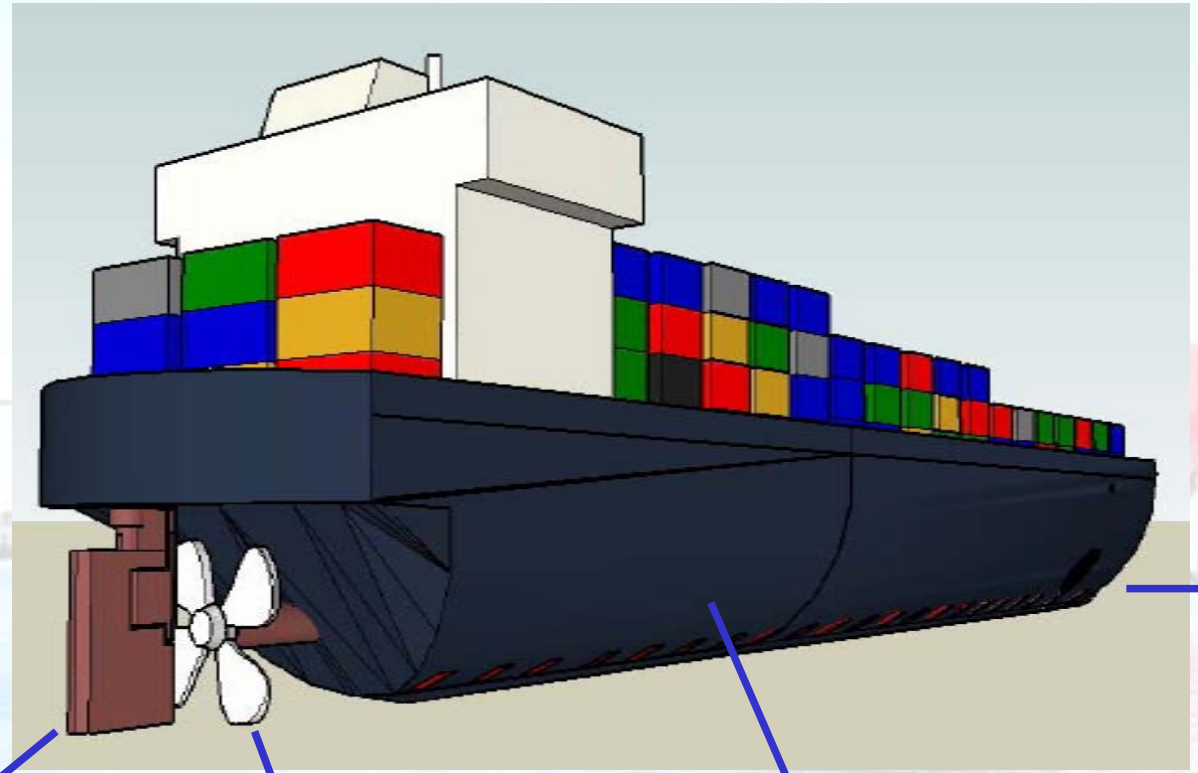
Hull Fouling

- 45% of introductions are unambiguously linked to ship fouling (Davidson, 2009)
- Historic problem
- Current problem:
  - Larger, faster ships
  - Tributyltin (TBT) phase out
- No current regulations in place to inhibit bioinvasion through ship fouling

Hull Fouling - Regulations

- U.S. H.R. 3618 Clean Hull Act of 2009
  - Comply with International Convention on the Control of Harmful Anti-fouling Systems on Ships
  - Directs EPA to serve a regulatory role
  - Authorizes EPA and NOAA to undertake related research
- California State Lands Commission,
  Marine Invasive Species Program

Differential Fouling



> 80% **~10%** **~ 50%** **~ 50%**

Coutts et al (2003), Davidson et al (2009), SERC and PSU

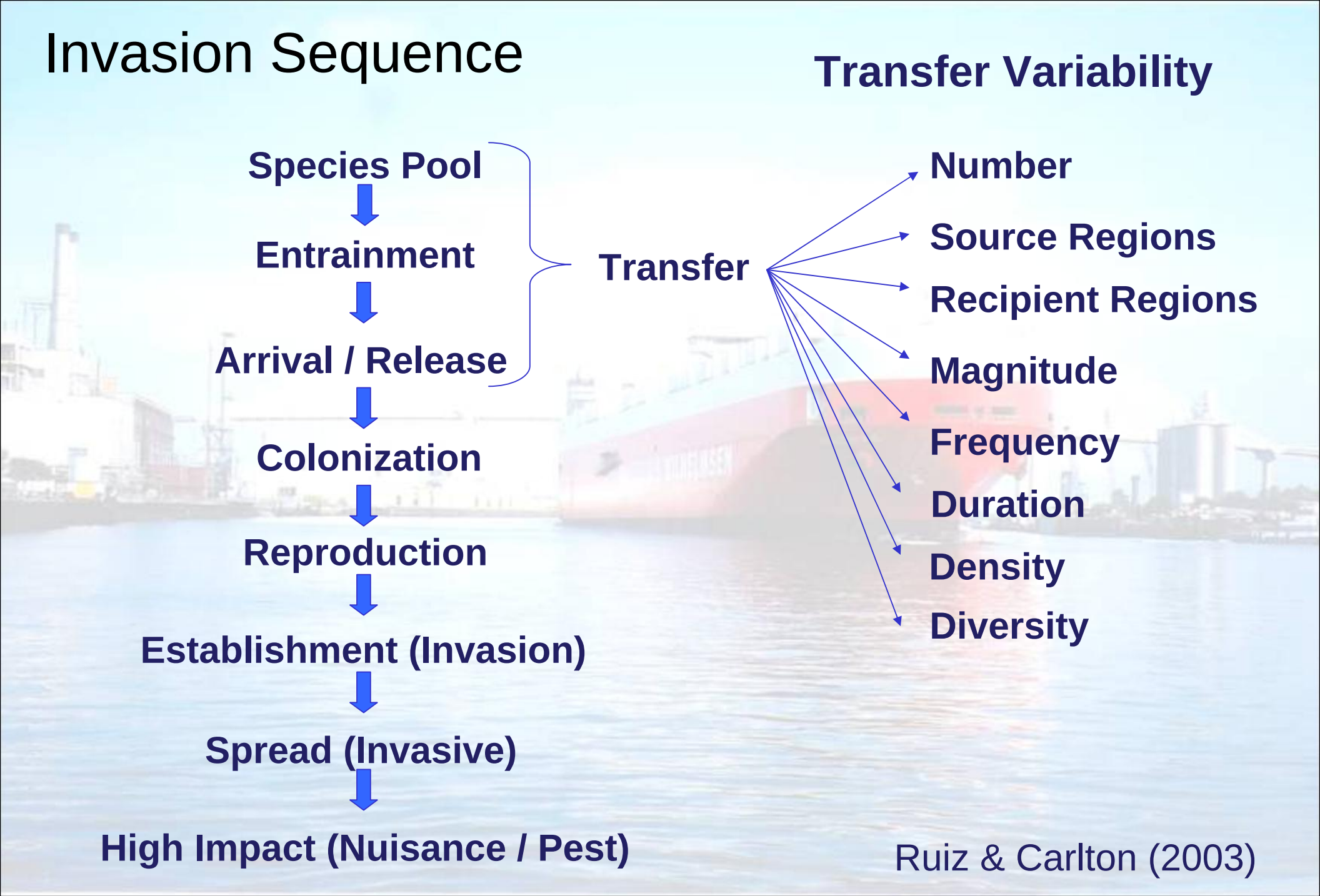
Hull Fouling
Research Needs

- Traffic flux measures for recreational, fishing, & barge traffic
- Extent and composition of biofouling assemblages on commercial ships (& other vessel types)
- Effect of vessel behavior (route, husbandry, etc) & ship type on biota
- How does hull assemblage relate to probability of NIS establishment?

Vector Management

- Management to reduce impacts of AIS
  - Costly
  - Does not usually result in eradication
  - Population control
- Vector Management
  - Prevent introductions in the first place
  - Cost effective (economically, ecologically)

Invasion Sequence



Ruiz & Carlton (2003)

Ballast Water Vector Management

Research Priorities and Information Needs

- Need for rigorous testing process
- Need for new methodology and approach
- Engineering solutions

Hull Fouling Vector Management

Research Priorities and Information Needs

- Determine the frequencies of dry dock, cleaning, coating for commercial vessels – and their ports of origin
- Determine movement of recreational vessels
- Conduct cost-benefit studies for the timing of cleaning in relation to performance, fuel efficiency.

(Maryland SeaGrant Vector Management Workshop, 2009)

Questions?

What additional research is needed to support vector management?

Thanks

SERC Marine Invasions Research Lab

NOAA USCG MD Sea Grant

Anti-Fouling Alternatives

- **Copper-based antifouling paints**
- **Tin-free anti-fouling paints**
- **Non-stick coatings**
- **Cleaning**
- **Natural resistance, natural biocides**
- **Electricity**
- **Prickly coatings**