



Smithsonian Environmental  
Research Center

# Biological Invasions of Marine Ecosystems

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## **INVASIONS – what are they?**

- Invasions result from the establishment of self-sustaining populations of species beyond their historical range.
- Most invasions result from human activities, creating many mechanisms (or vectors) for the intentional or unintentional transfer of species across oceans and continents --- and breaching historical barriers to dispersal.



## **EFFECTS OF INVASIONS**

### **(why do we care?)**

- Invasions by NIS are a major force of global change, resulting in significant ecological, economic, and human health impacts.
- Invasions are considered second only to habitat destruction as a threat to biodiversity and cause of extinction.
- For the U.S. alone, the economic cost of invasions was recently estimated at > \$137 billion per year.
- Available evidence indicates the transfer and introduction of NIS by human activities has increased dramatically over the past century and continues to do so.

# Examples of U.S. Marine Invasive Species

*Rapana venosa* – rapana welk



*Phragmites* – marsh reed



*Carcinus maenas* –  
European green crab



*Eriocheir sinensis* –  
Chinese mitten crab



*Loxothylacus panopei* –  
parasitic barnacle





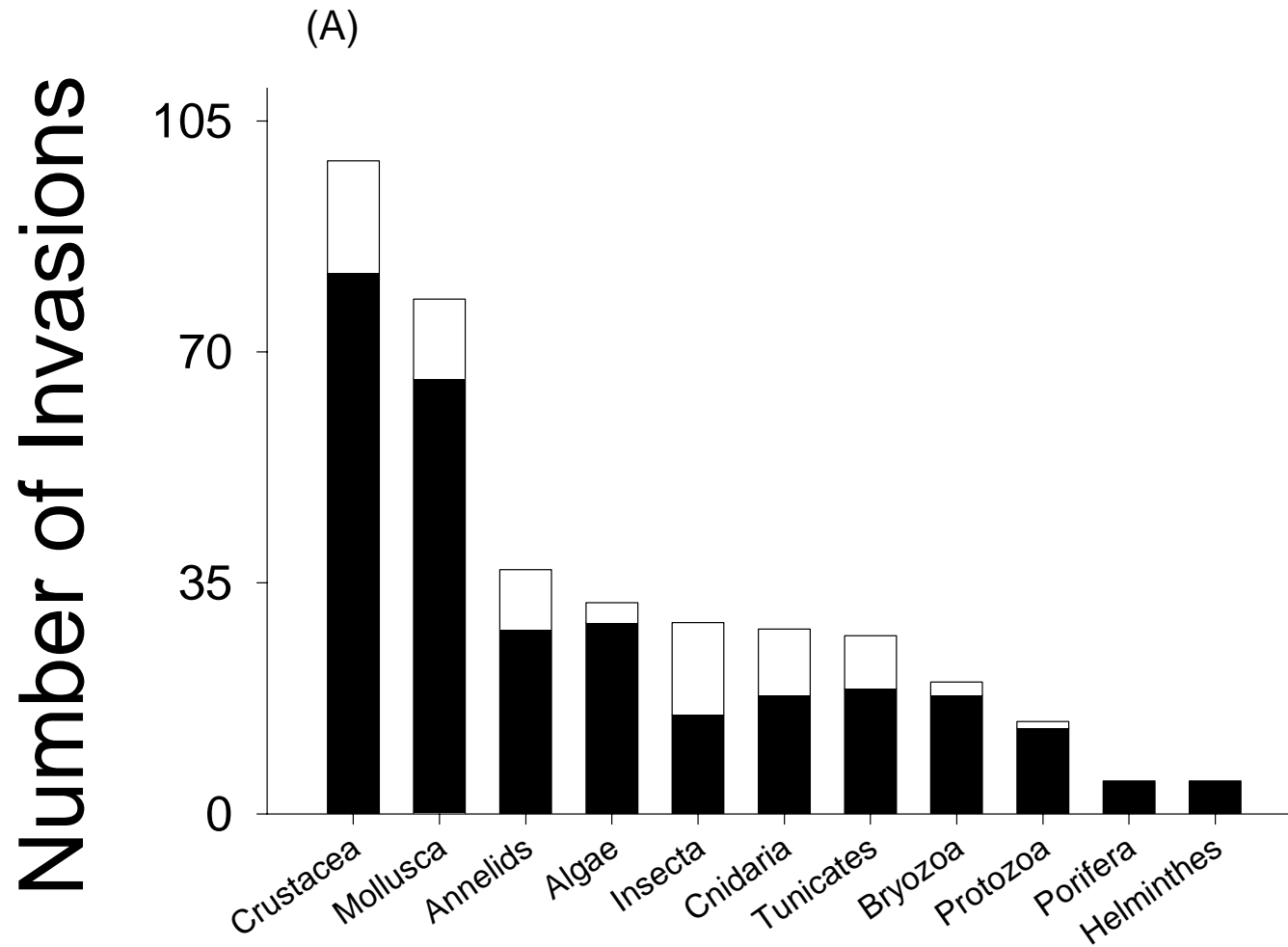
## COASTAL INVASIONS

- Most information and historical management effort for NIS have been in terrestrial and freshwater ecosystems.
- In the past decade, it's become increasingly clear that coastal marine invasions are abundant, increasing, and cause significant impacts.
- However, for most bays and estuaries in the U.S., the extent of invasions remains unknown.



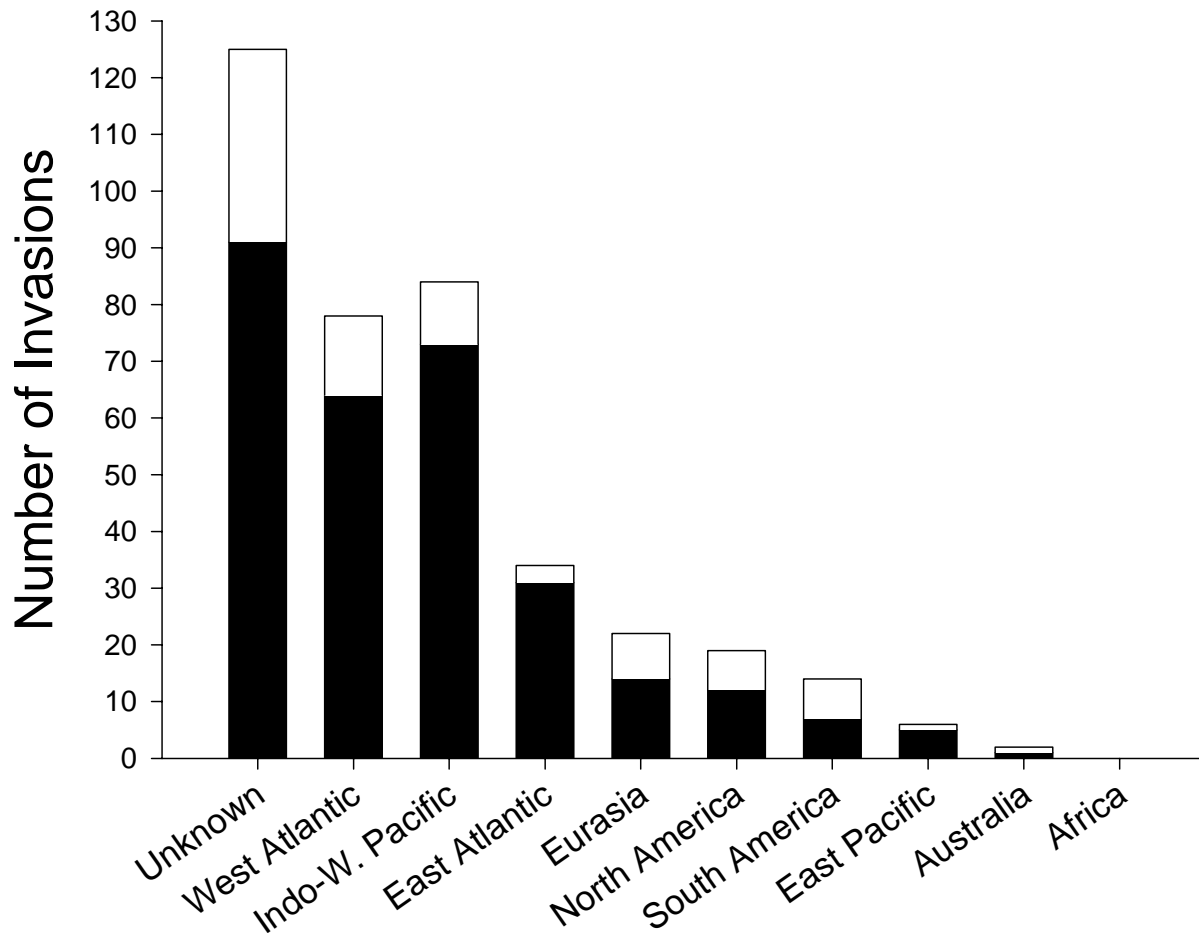
## COASTAL INVASIONS (Cont.)

- Even where data exist on numbers of NIS, the information is often incomplete, resulting from “by-catch” and haphazard surveys that may be decades old.
- Importantly, because existing data were not collected in a consistent fashion among sites (e.g., using standard methods), we presently have extremely uneven and incomplete knowledge about patterns and effects of marine invasions.
- Furthermore, much of the existing information on marine NIS remains inaccessible in obscure reports and publications, which have not been synthesized.



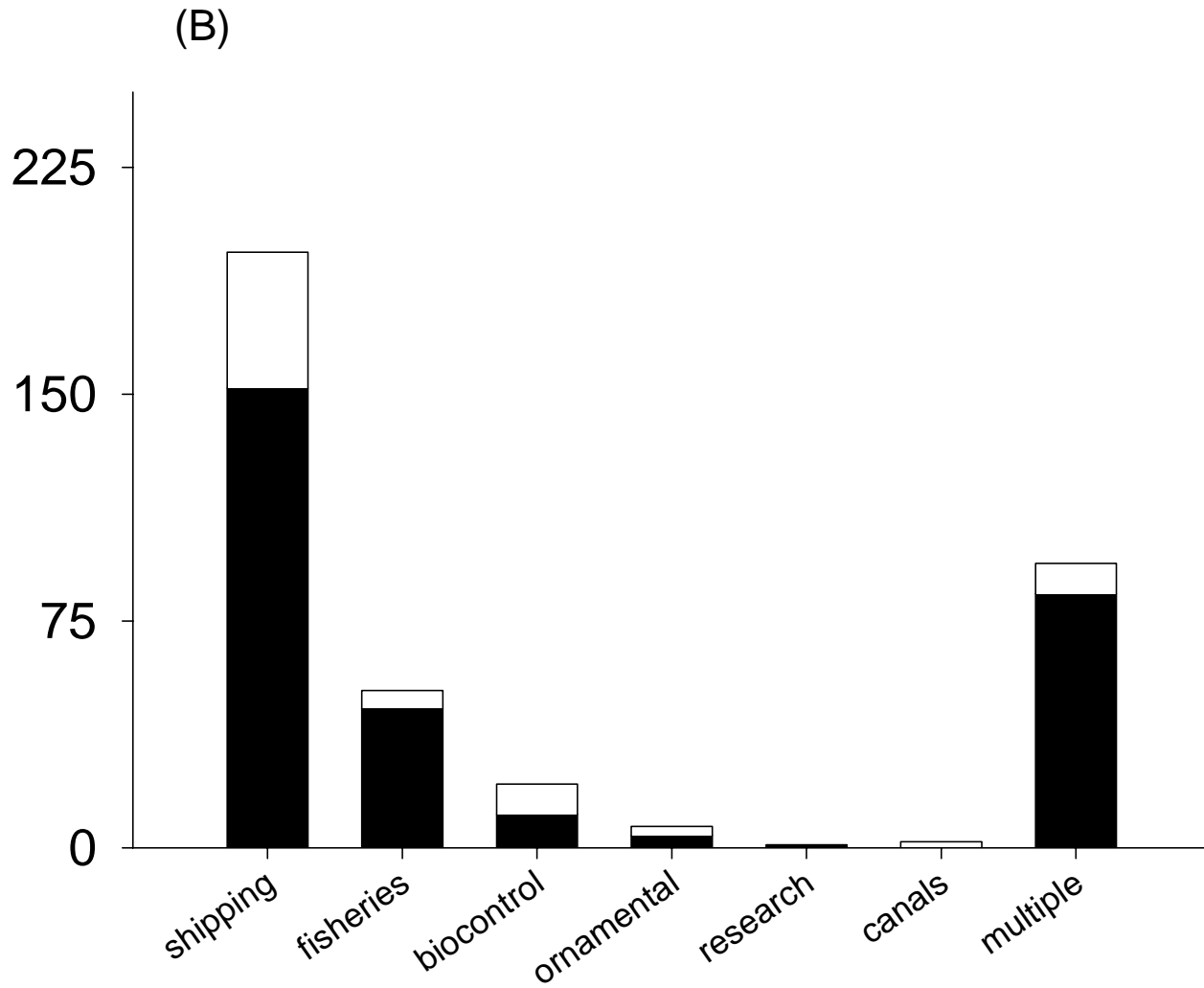


## Number of Marine and Estuarine Invasions in the Continental United States by Source Region



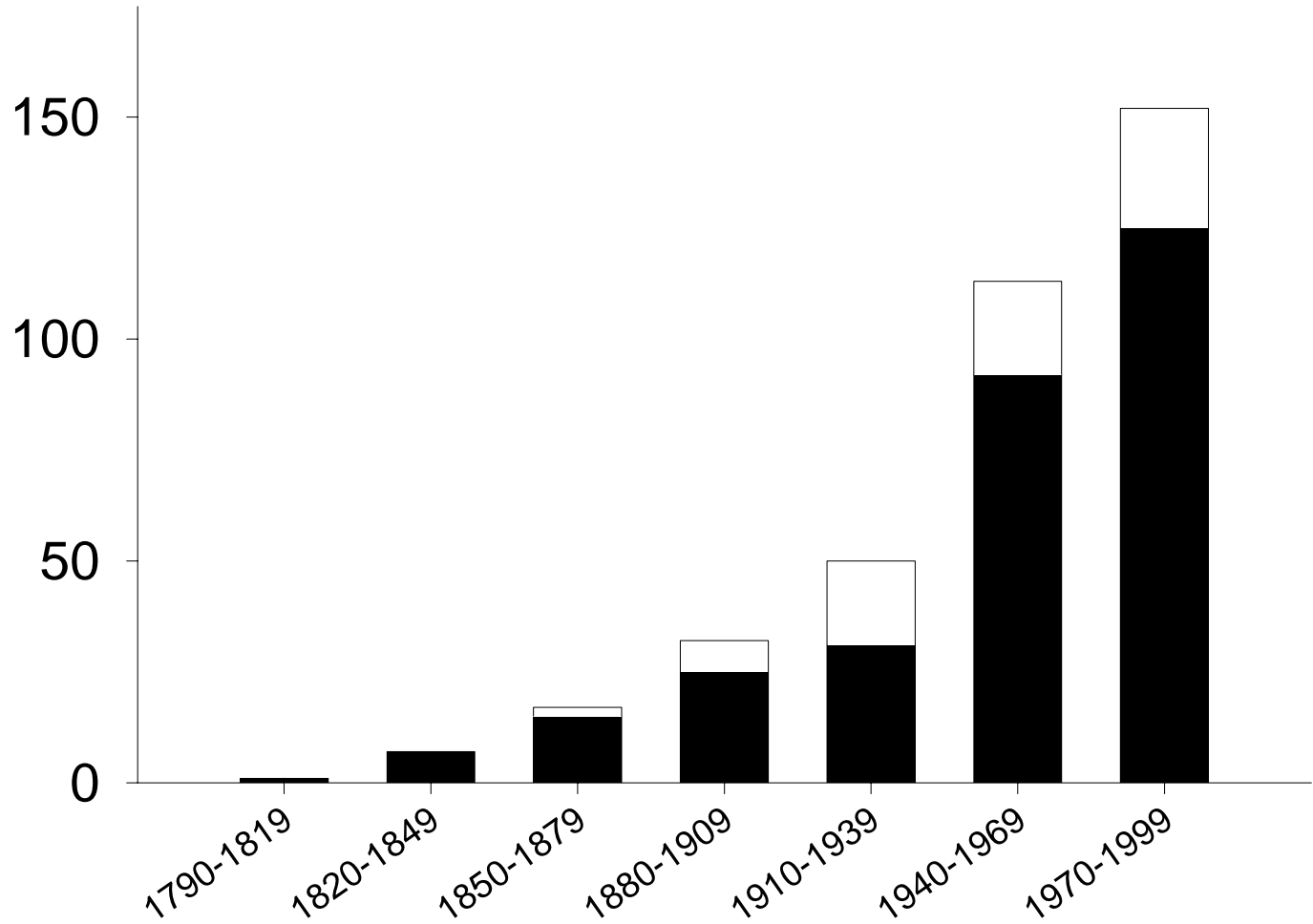


# Number of Invasions



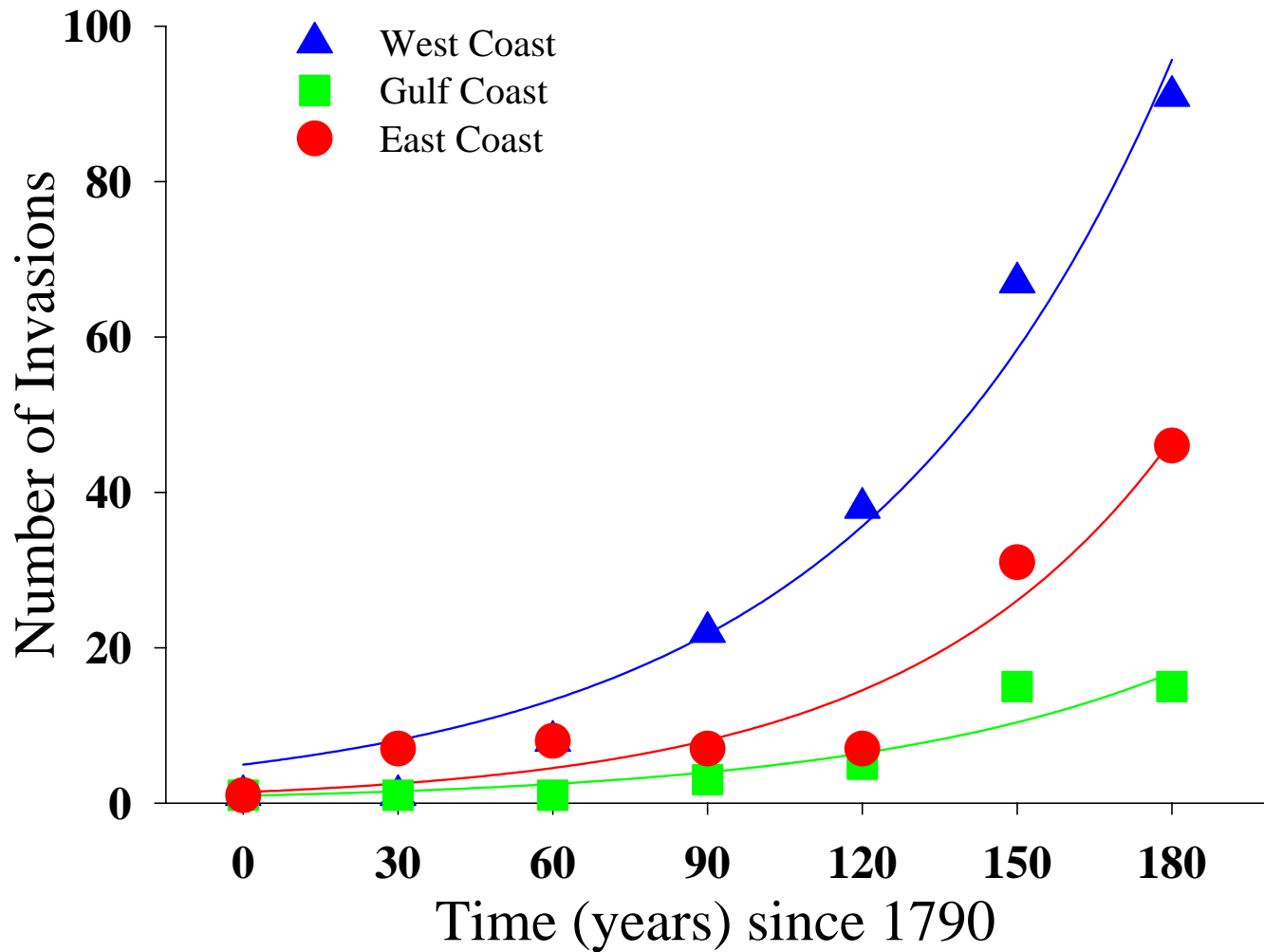


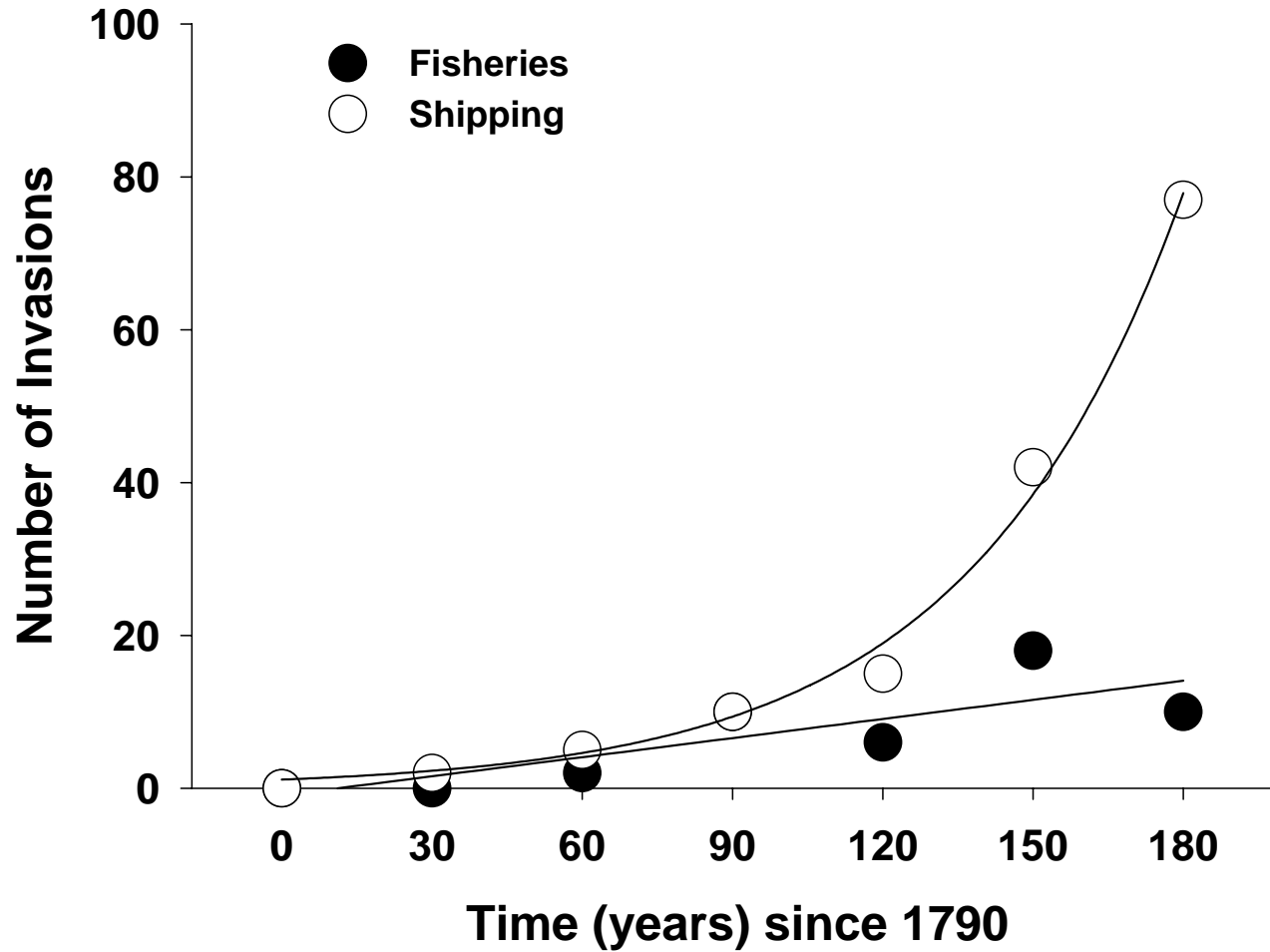
# Number of Invasions





## Coastal Invasions of the United States







## **SIGNIFICANT GAPS IN MARINE INVASION SCIENCE**

- We lack the data needed to (1) characterize patterns of invasion, (2) test relative effects (roles) of particular species traits, inoculation characteristics, source regions, and recipient region traits (e.g., biodiversity, disturbance) on invasion establishment and dynamics.
- Without these data, we cannot (a) develop and test predictions or (b) assess the efficacy of any management strategy on invasion patterns.
- What data exists is not readily available to resource managers, scientists, and the public.
- There exists no program in the U.S. to implement standardized surveys and information management needed to address these gaps.



## OVERALL GOALS

- Measure contemporary extent, patterns, and effects of NIS in coastal bays of the U.S.
- Provide synthesis of key data on known marine invasions of the U.S., making information readily available to multiple users
- Implement standardized surveys to develop national baseline of data, which is needed track changes in NIS and native species composition
- Create species inventory for NIS and native biota

# SERC Marine Invasion Research Sites

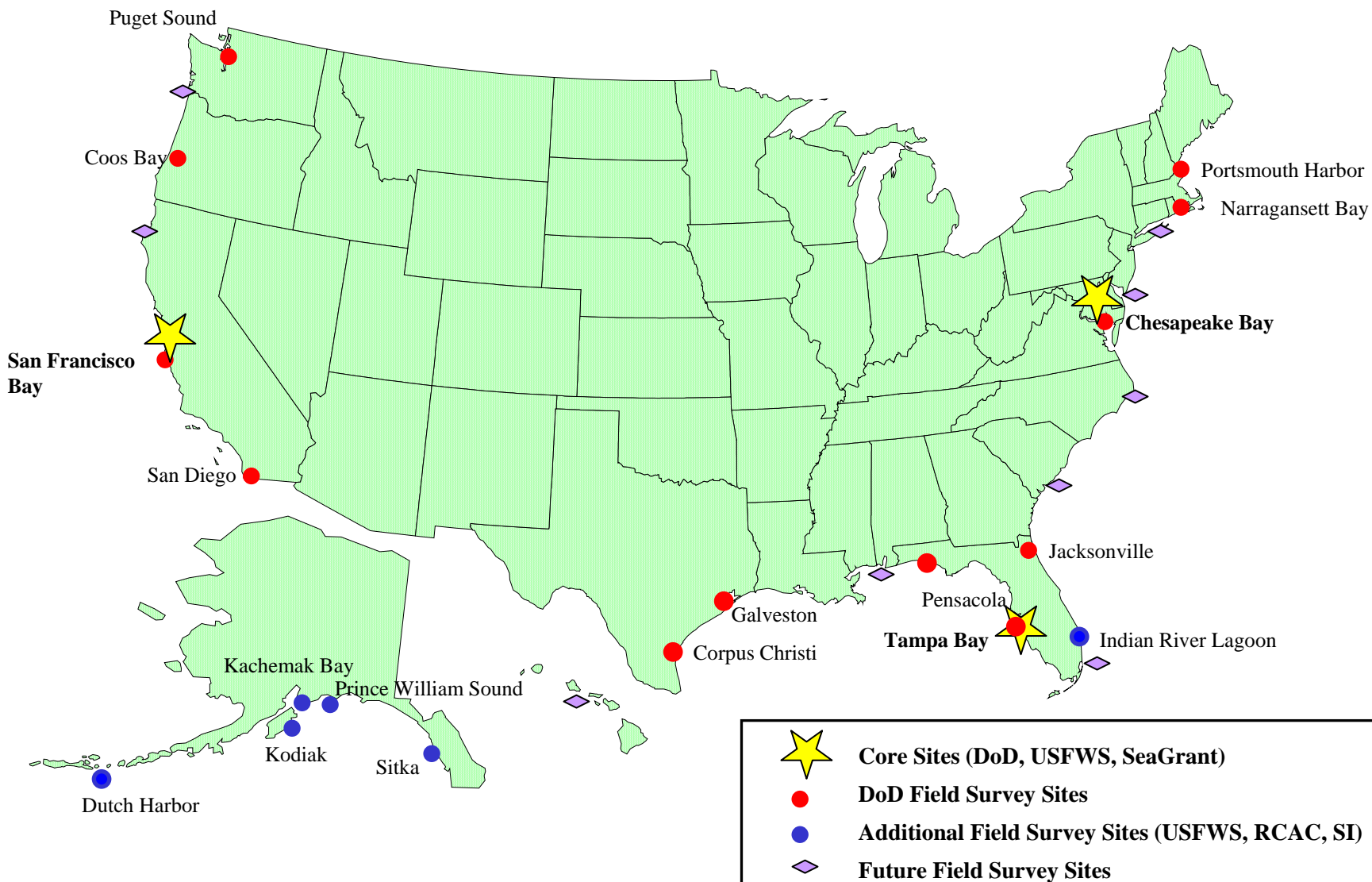
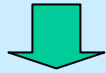




Plate Retrieval



On-Site Analysis



Voucher Collection  
/ Preservation



Synoptic Collection  
/ Archive



Taxonomic Identification  
/ Verification



Data Analysis





## **SPECIFIC OBJECTIVES**

- Measure number of NIS and native species at each site, using standard methods.
- Estimate relative importance of NIS in terms of species diversity, within and among sites.
- Test for differences in relative importance of NIS among East, West, & Gulf coasts and as a function of latitude.
- Measure effects of NIS in reducing biodiversity, through homogenization, among sites.
- Provide species inventory for each site, based upon surveys and literature



## MANAGEMENT ACTIONS: PREVENTION

- To limit the transfer and impact of new invasions, U.S. Congress has passed two laws (1990, 1996), which have focused largely on shipping
- In 1999, President Clinton signed an Executive Order, instructing federal agencies to develop strategies to minimize the transfer and risks associated with NIS.
- Many states (e.g., California, Washington, Oregon, Maryland, Virginia, Michigan) have now passed their own legislation, including regulations, to reduce the number and impacts of new invasions.
- Although current federal and state laws exclude military activities, the transfer of NIS by DoD vessels is being managed under the UNDS process, and U.S. Navy has implemented OPNAVINST 5090.1B.
- NAISA: National Aquatic Invasive Species Act



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# Mid-Ocean Exchange





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## **Ballast Water Exchange:**

- **Empty-Refill**
- **Flow-Through**
- **How many exchange cycles?**
- **Stratification; enhancement?**



## RECOMMENDATIONS

- National network of surveys/monitoring of invasive species using standardized methods.
- Synthesis of key information on invasive species using shared, online database.
- Assess vectors and minimize transfer mechanisms, e.g., mid-ocean exchange of ballast water, prevent fishery releases.



## **PARTNERS**

- DoD Legacy Program
- U.S. Fish & Wildlife Service
- Regional Citizens' Advisory Council of Prince William Sound
- National Sea Grant Program (NOAA)
- Smithsonian Institution
- U.S. Coast Guard

# Valdez Marine Terminal

