BALLAST-BORNE MARINE INVASIVE SPECIES: EXPLORING THE RISK TO COASTAL ALASKA

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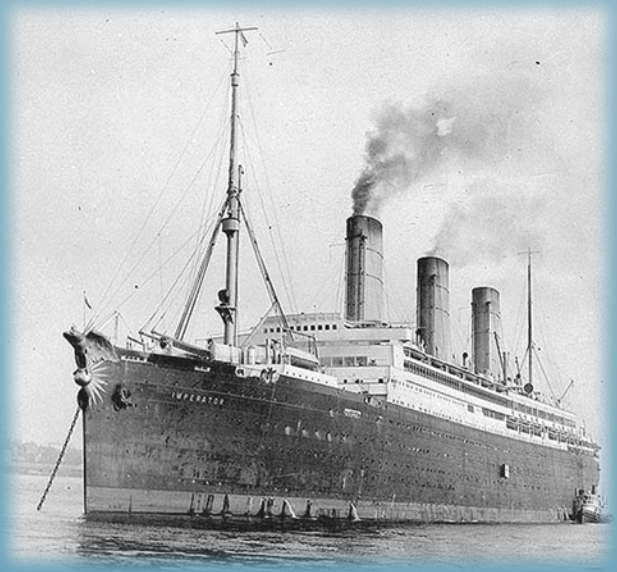
PHASES OF BIOLOGICAL INTRODUCTIONS

1) 1500 AD - end of the Middle Ages, beginning of global exploration

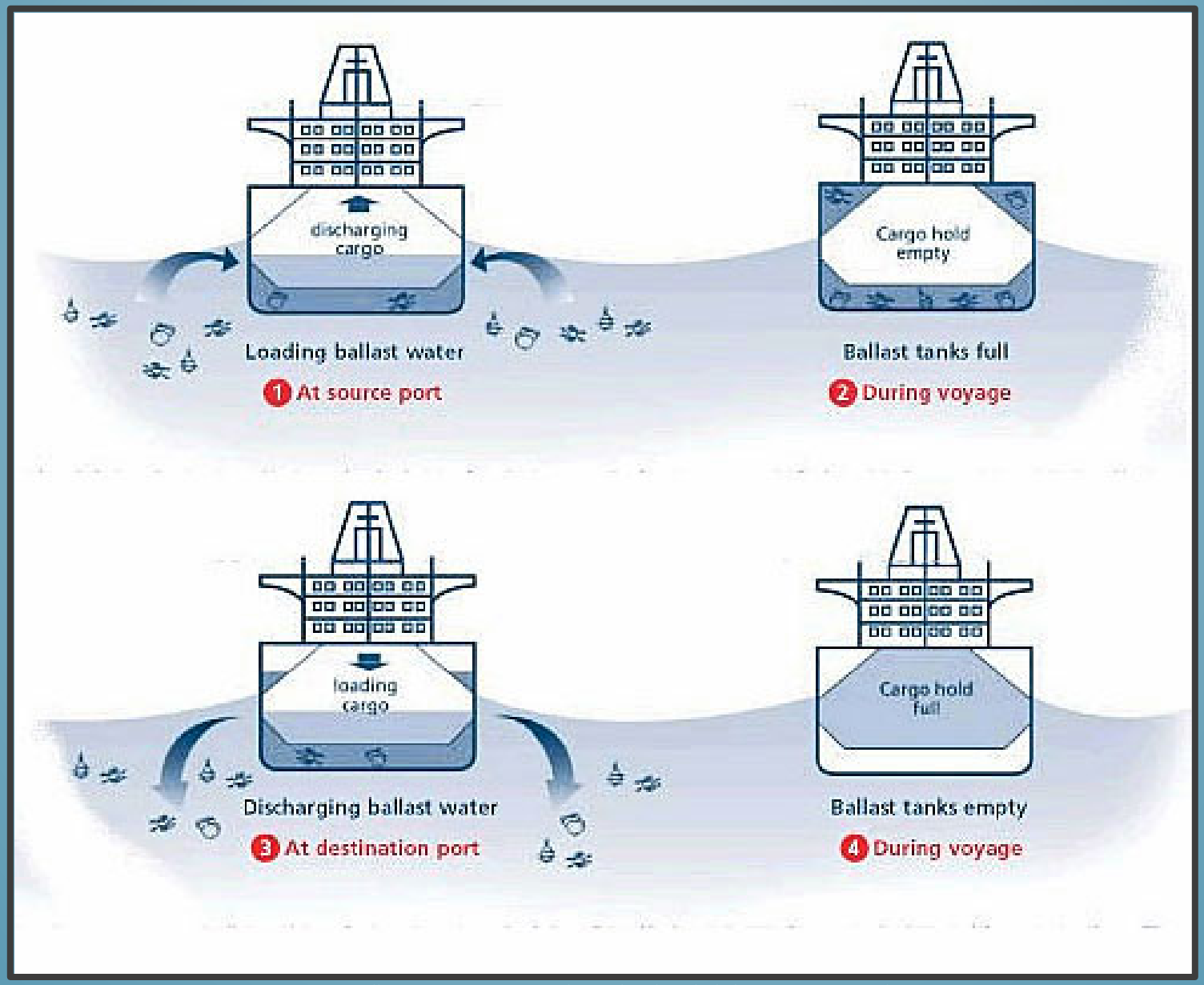
2) 1800 AD - Industrial Revolution and mass European emigration

3) Present - "Era of Globalization"



Hulme, 2009

BALLAST WATER



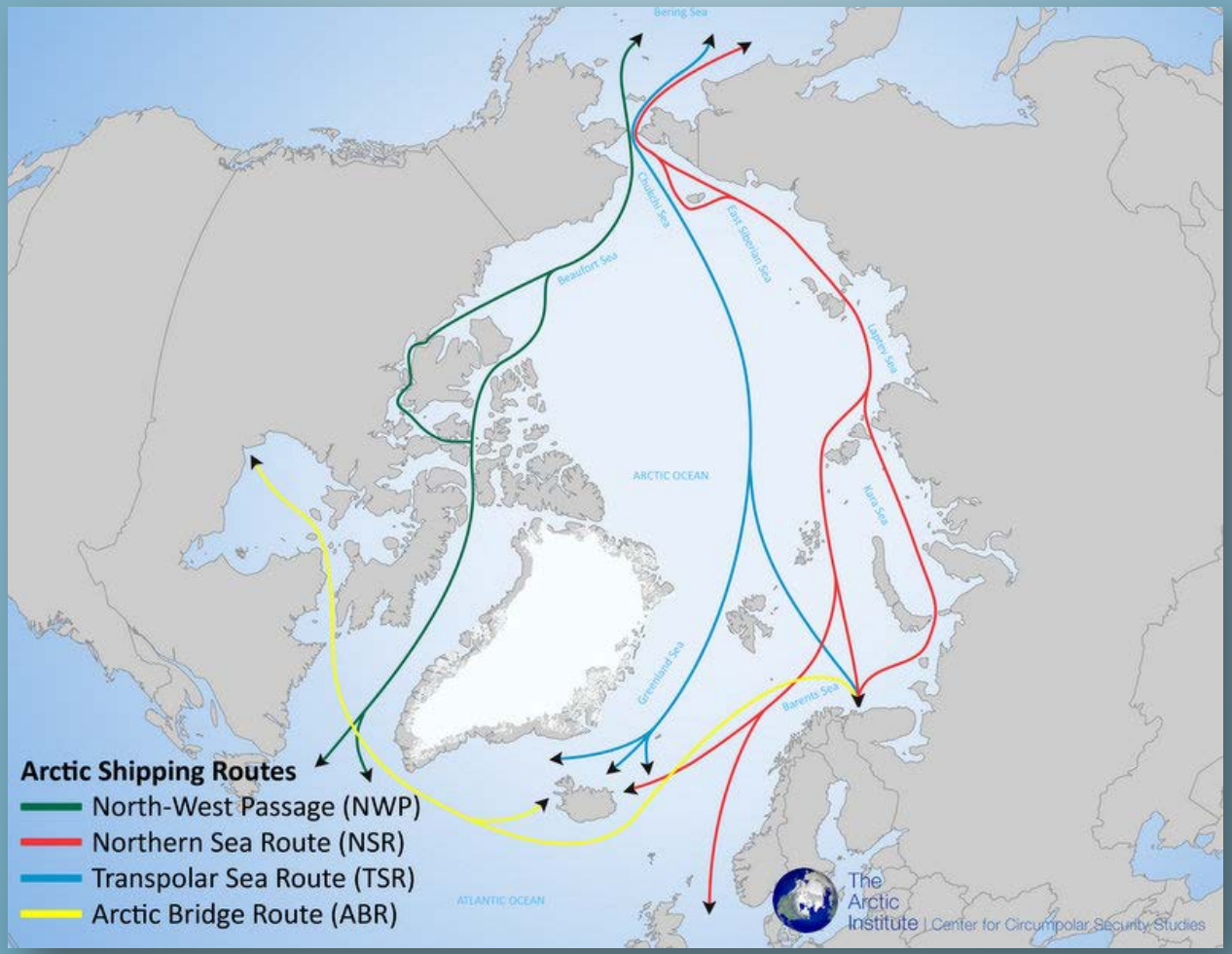
http://minnesota.publicradio.org/display/web/2009/05/13/ballast_water_battle/

WHY BALLAST WATER?

- Ships are the largest contributor of marine invasive species[1]
- The international shipping industry transports ~3-5 billion MT of ballast annually[2]
- Short voyage duration = greater organism survival[3]
- Responsible for marine invasions around the globe

1 Ruiz et al. 2000, 2 Endresen et al. 2004, 3 Lavoie et al. 1999

WHY BALLAST WATER?



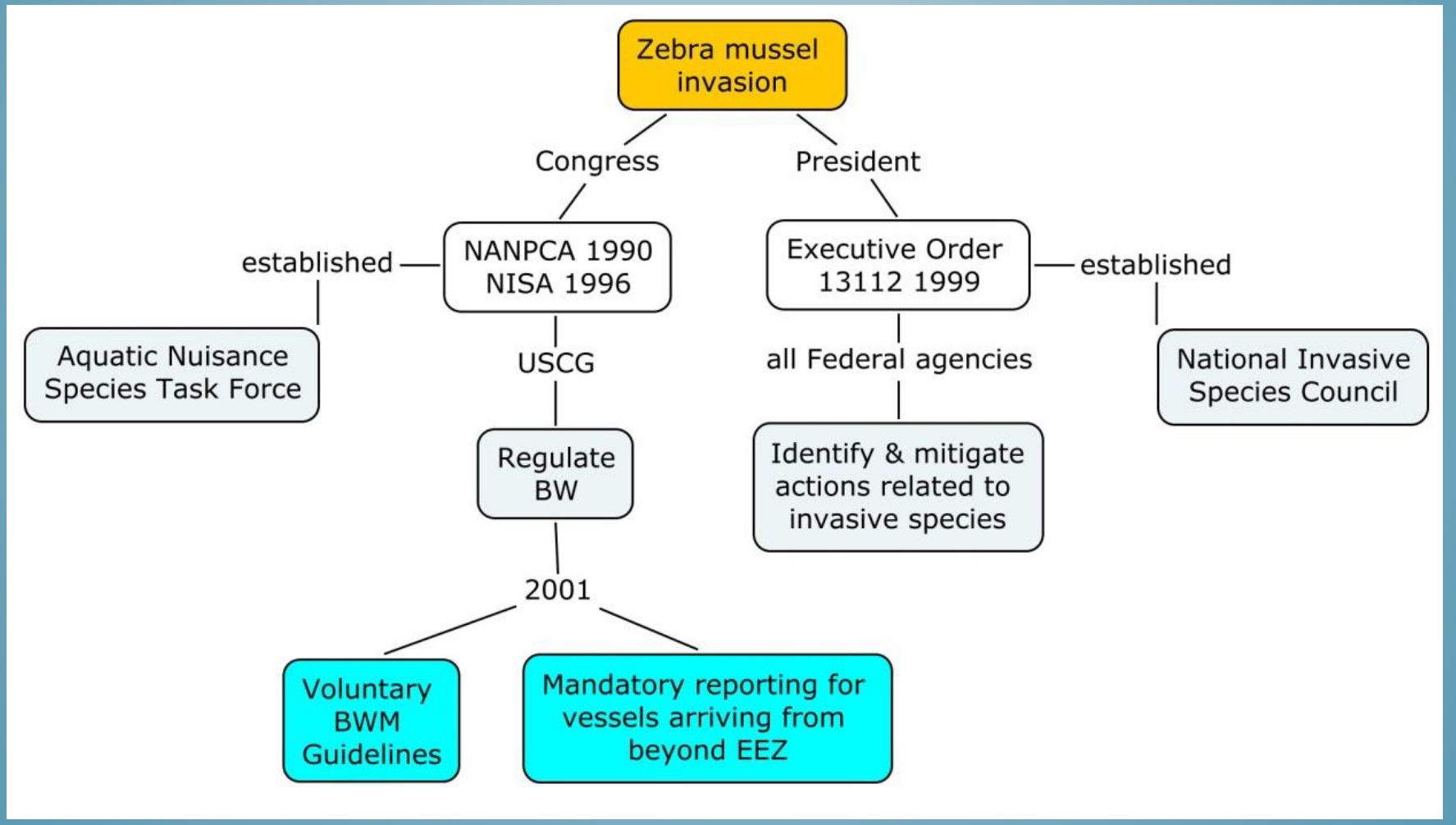
Changing environmental conditions have already resulted in increased vessel traffic in the Arctic & Bering Strait

STUDY DESIGN

- *Policy Review*
  - *Objectives:*
    - *Document changes in policy and identify drivers*
    - *Assess implications for BWM*

- *Risk Assessment for Coastal Alaska*
  - *Objectives:*
    - *Assess ballast water discharge in Alaska, 2005 – 2012*
    - *Develop risk assessment framework*
    - *Model risk for coastal Alaska*

MAJOR POLICY SHIFTS IN BWM



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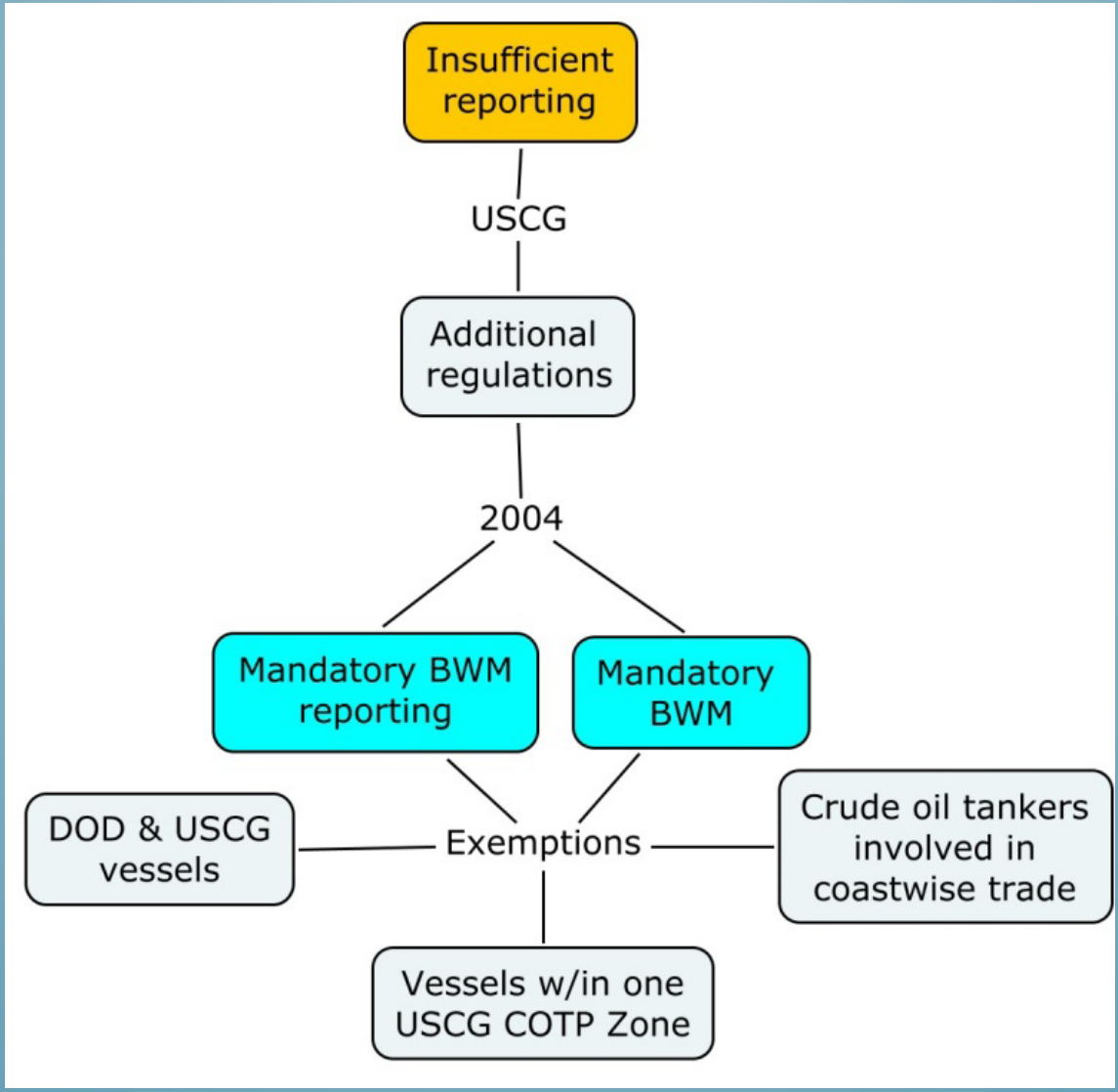

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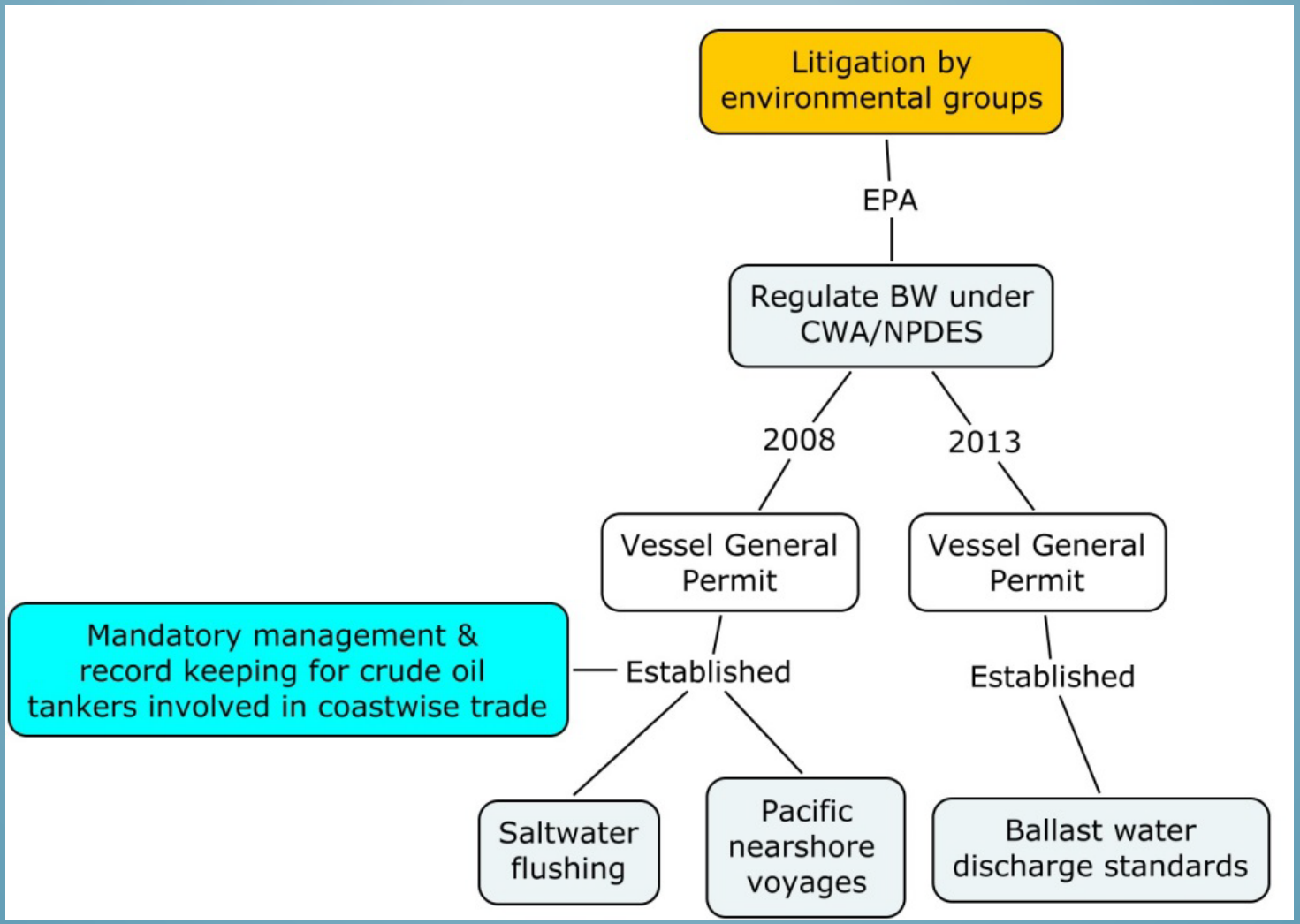


BALLAST WATER MANAGEMENT

- The globally accepted form is ballast water exchange:

  Empty – Refill Method
  Flow Through Method

  > 200 nm from shore

- Management practices are reported to the National Ballast Information Clearinghouse

http://invasions.si.edu/nbic/managementpract.html

Coastwise: ballast water does not transit beyond combined US & Canadian EEZs

Overseas: ballast water does transit beyond combined US & Canadian EEZs

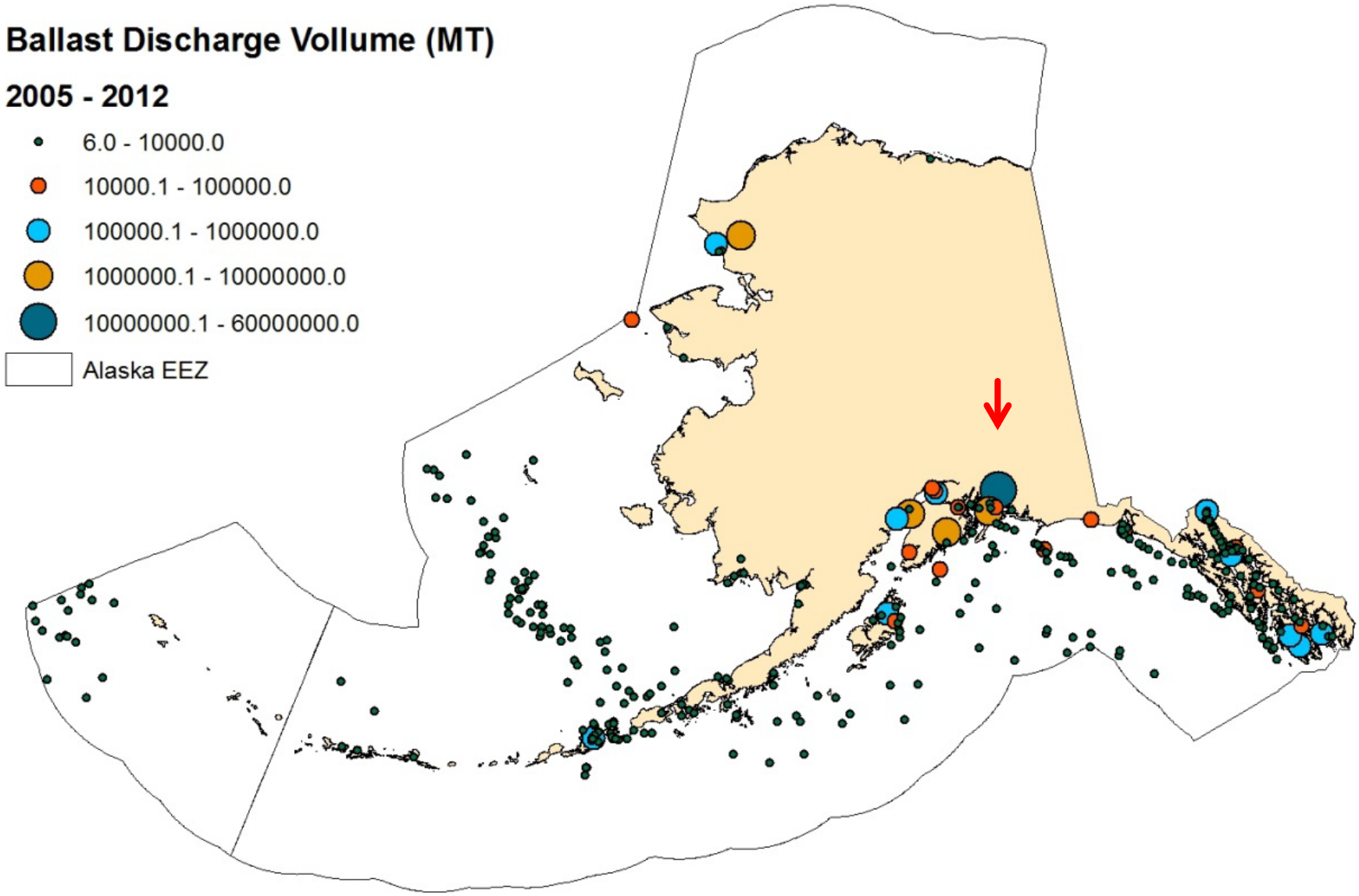
BALLAST IN ALASKA, 2005 - 2012

National Ballast Information Clearinghouse NBIC

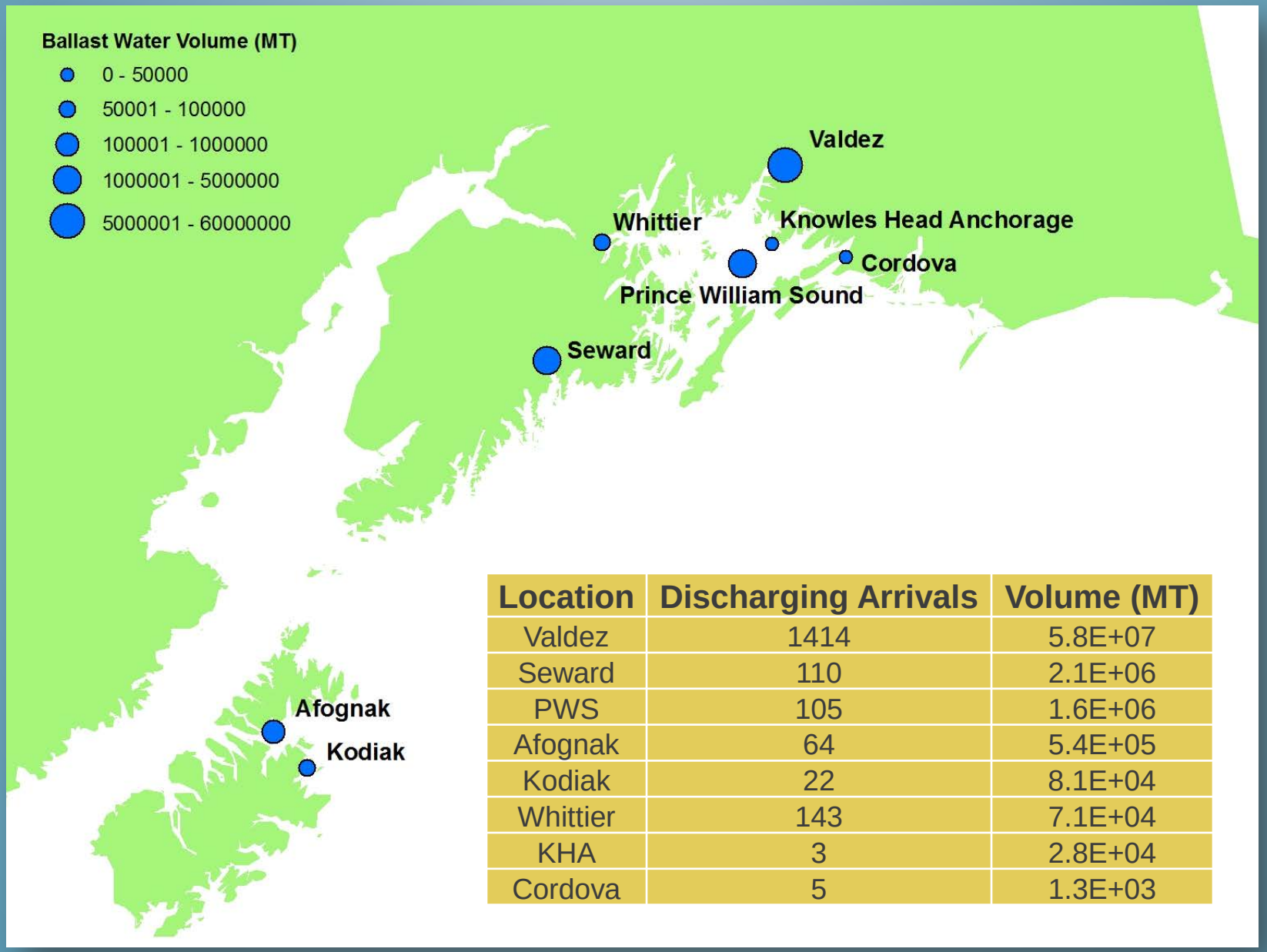
- 3,773 vessels
- 27,303 ballast tanks
- 7.5 x10^7 MT of ballast
- 67 named locations
- 910 geographic coordinates

- *~72% of ballast discharge was sourced on the US west coast or BC*
- *Tankers discharge ~88% of all ballast*
- *Only 33% of reported ballast is managed (BWE)*

TOTAL AK BALLAST WATER DISCHARGE: 2005 - 2012

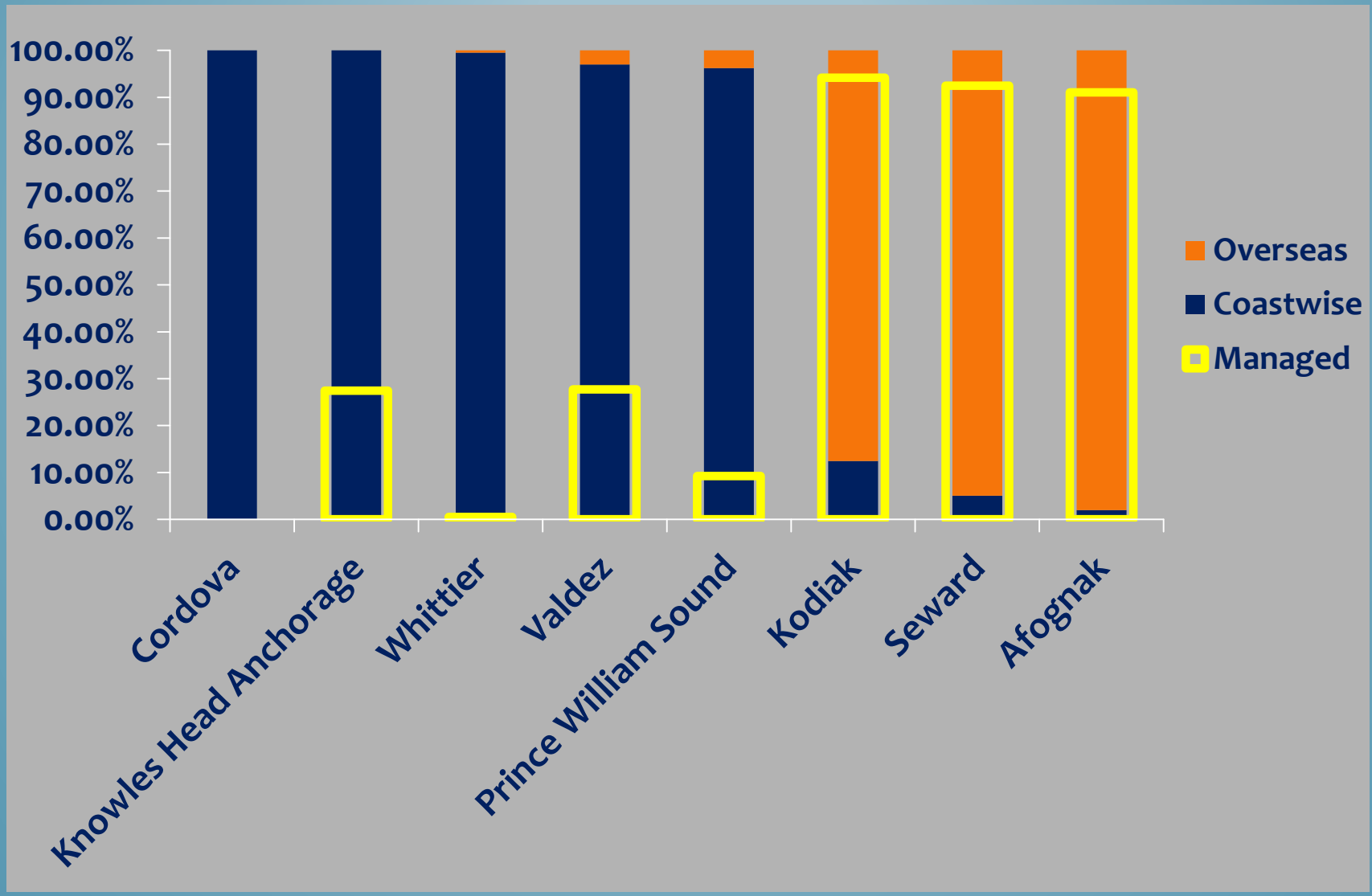


Ballast Water Discharge in Prince William Sound: 2005 - 2012



Location	Discharging Arrivals	Volume (MT)
Valdez	1414	5.8E+07
Seward	110	2.1E+06
PWS	105	1.6E+06
Afognak	64	5.4E+05
Kodiak	22	8.1E+04
Whittier	143	7.1E+04
KHA	3	2.8E+04
Cordova	5	1.3E+03

Ballast Water Discharge in Prince William Sound: 2005 - 2012



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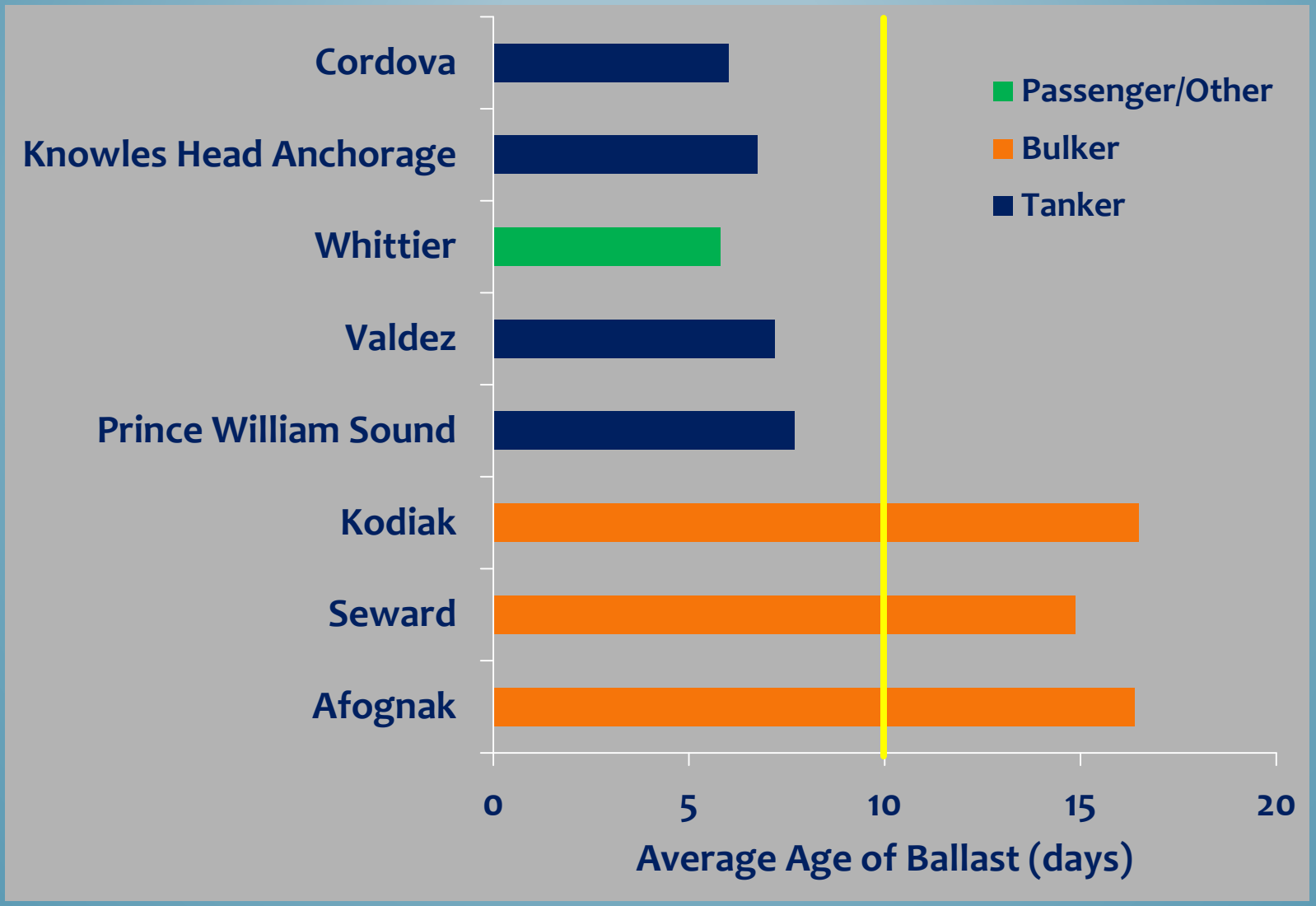


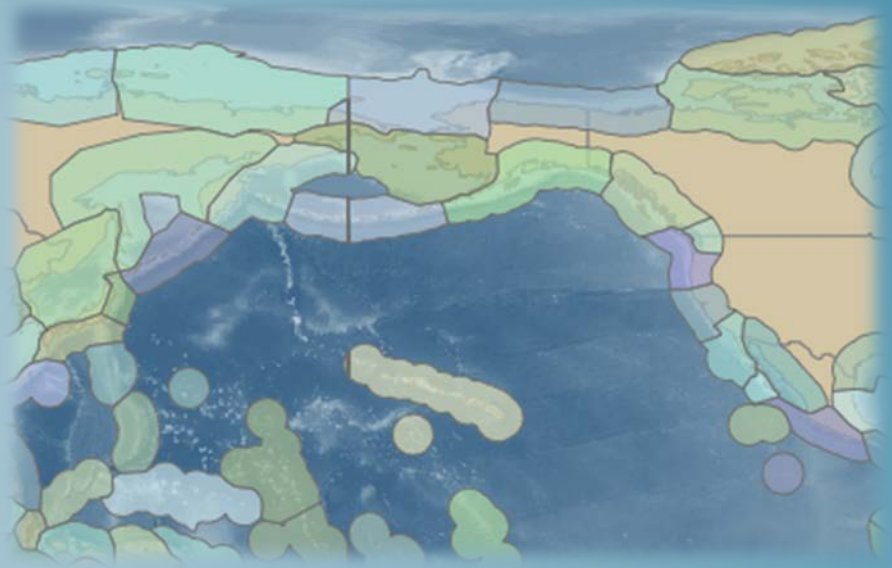
RISK ASSESSMENT 2009 – 2012

1. *Model risk as a function of environmental similarity, ballast water age and volume*
   - *Between source and discharge regions*
   - *Between source region and ports >50,000 MT*

Following other high-latitude risk assessments:

Leppäkoski & Gollasch 2006
Chan et al. 2013
Ware et al. 2013

RISK FRAMEWORK



Spalding et al. 2007

- *Environmental Similarity*
  - *(positively correlated with risk)*

1) Low risk → non-adjacent ecoregion

2) Medium risk → adjacent ecoregion

3) High risk → same ecoregion

– *A weighted average was applied to the proximity ranking based on the volume per source ecoregion*

RISK FRAMEWORK

- *Ballast water age*
  - *(negatively correlated with risk)*

    – *Number of days between source and discharge date*

RISK FRAMEWORK

- *Ballast water volume*
  - *(positively correlated with risk)*
    - *Serves as a proxy for propagule pressure*
    - *0.1 correction factor applied to managed ballast to represent 90% efficacy rate of BWE (Ruiz & Reid 2007)*

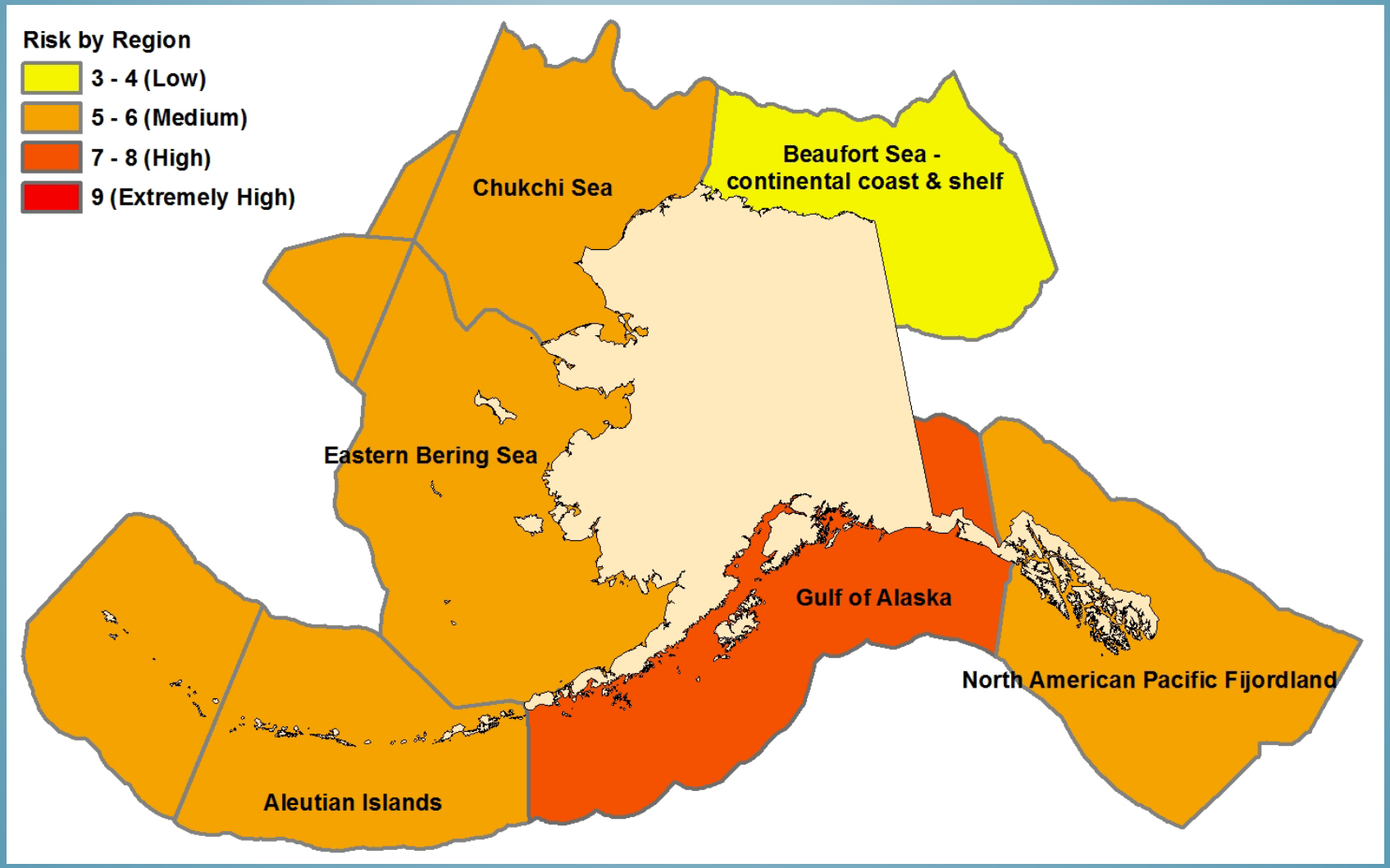
ADDITIVE RISK SCALE

	Environmental Similarity	Age (days)	Corrected mean volume of BW discharge: ecoregions & ports (log_{10}MT)
(1) Low	< 1	> 10	< 2.6
(2) Medium	1 – 2	6 – 10	2.6 – 5.1
(3) High	> 2	< 6	> 5.1

Total Risk = sum of factors

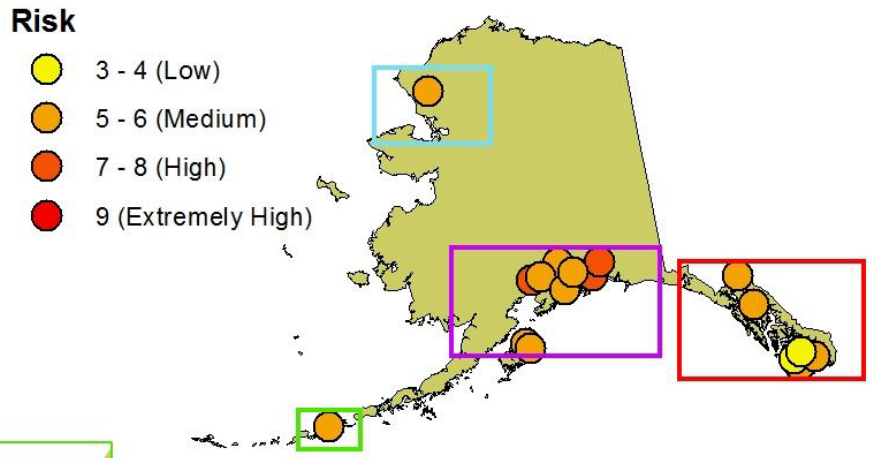
Total	Risk
9	Extremely High
7 – 8	High
5 – 6	Medium
3 – 4	Low

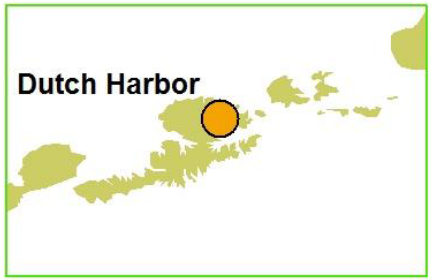
RISK BY ECOREGION

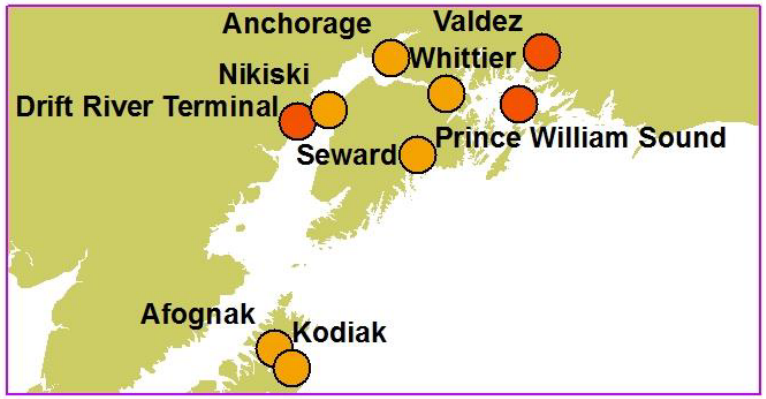


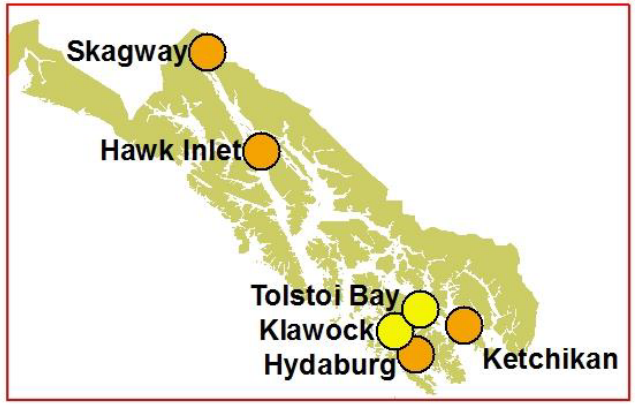
Marine Ecoregions of the World
Spalding et al. 2007

RISK BY PORT



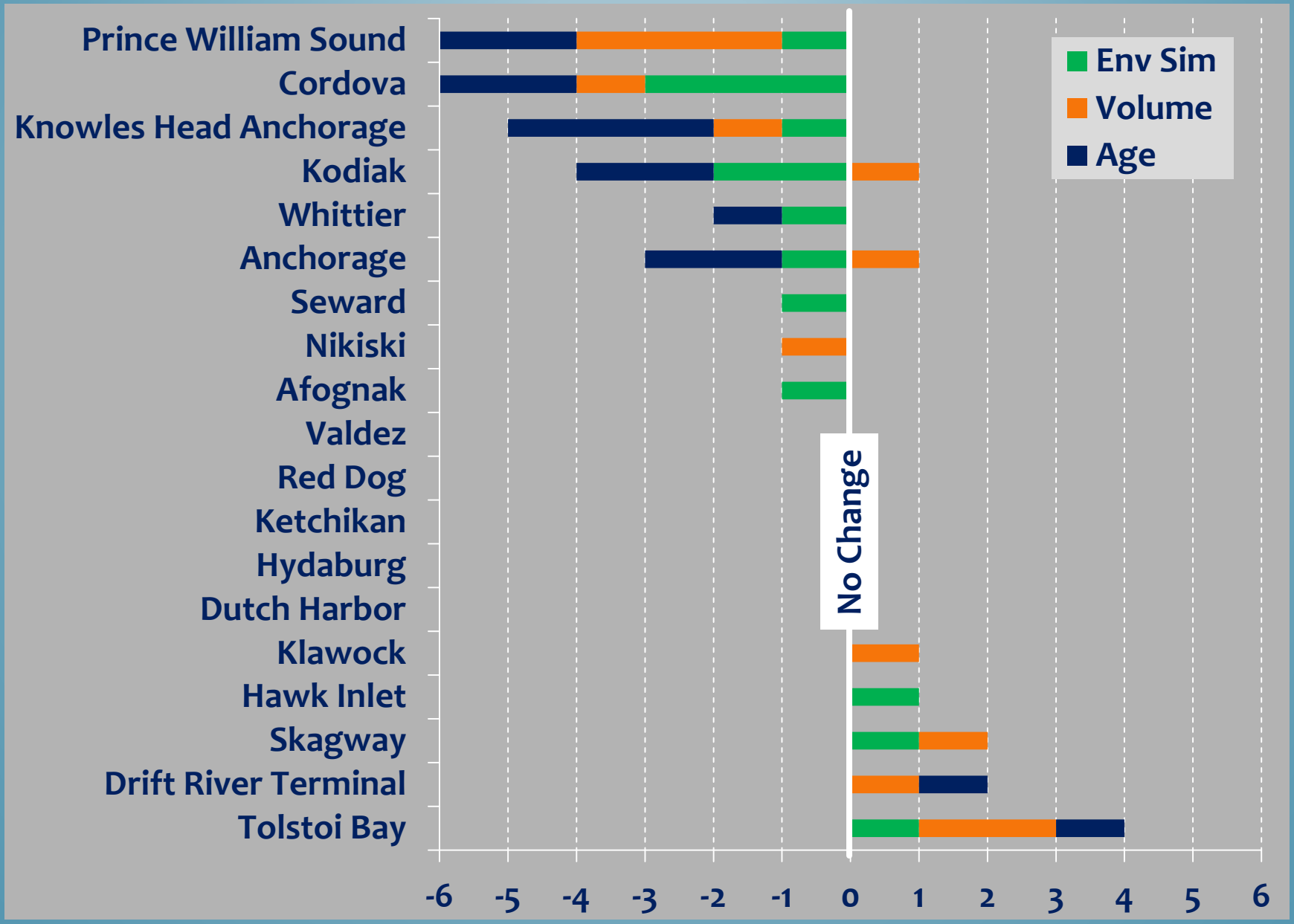






Ports that received
> 50,000 MT of ballast

CHANGING RISK BY PORT (2012 – 2009)



CONCLUSIONS

- *Southcentral AK receives the greatest volume of ballast discharge*
- *Tankers pose the greatest risk due to ballast volume and age*
- *Policy exemptions elevate risk and hinder monitoring*
- *Recent and expected changes in BW discharge may be predictive of new areas of high risk*

Didemnum vexillum

Carcinus maenas

Acknowledgements

Smithsonian Environmental Research Center

National Ballast Information Clearinghouse NBIC

At-sea Processors Association
Partners for Healthy Fisheries

Questions?