



Regulatory and Engineering Approaches to Stopping Ballast Water Invasive Species

Mario Tamburri

Maritime Environmental Resource Center

Chesapeake Biological Laboratory

University of Maryland Center for Environmental Science



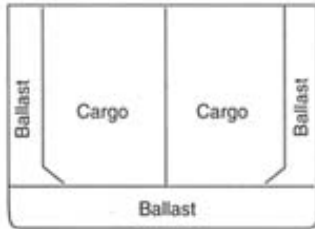


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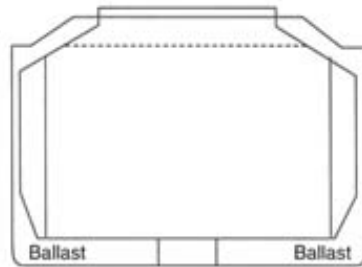
- **Ship Ballast Water**
- **Changing Regulatory Environment**
- **Ballast Water Treatments**
- **Conclusions**
- **Maritime Environmental Resource Center**



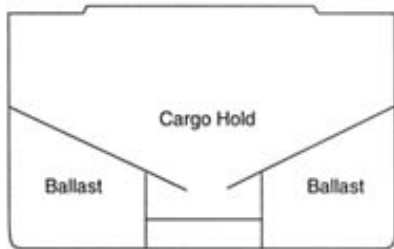
Ship Ballast Water



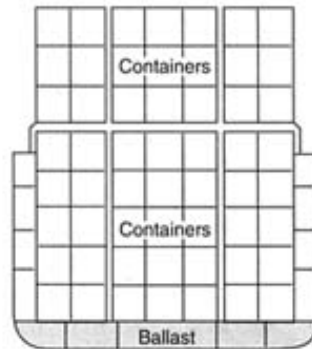
Tanker



Panamax size oil bulk ore carrier



Great Lakes bulk vessel,
intermediate class



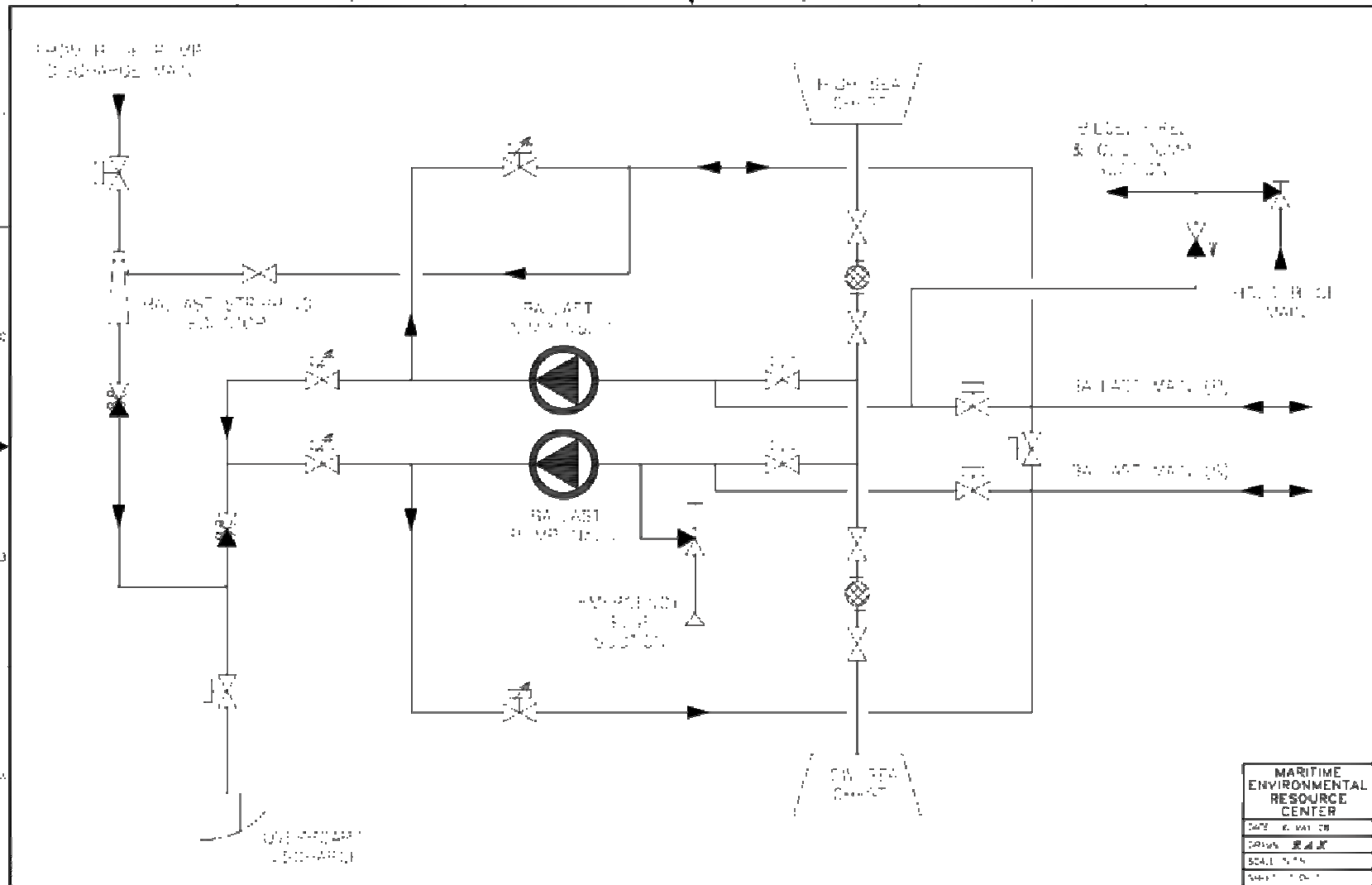
Container ship

- Adjust trim and draft
- Rates 100 - 12,000 m³/hr
- Volumes 10,000 - 100,000 m³
- System capacity depends on rate of draft or trim adjustment
- Tankers and Containerships required rate depends on cargo loading/unloading times, min/max drafts and equipment tolerances

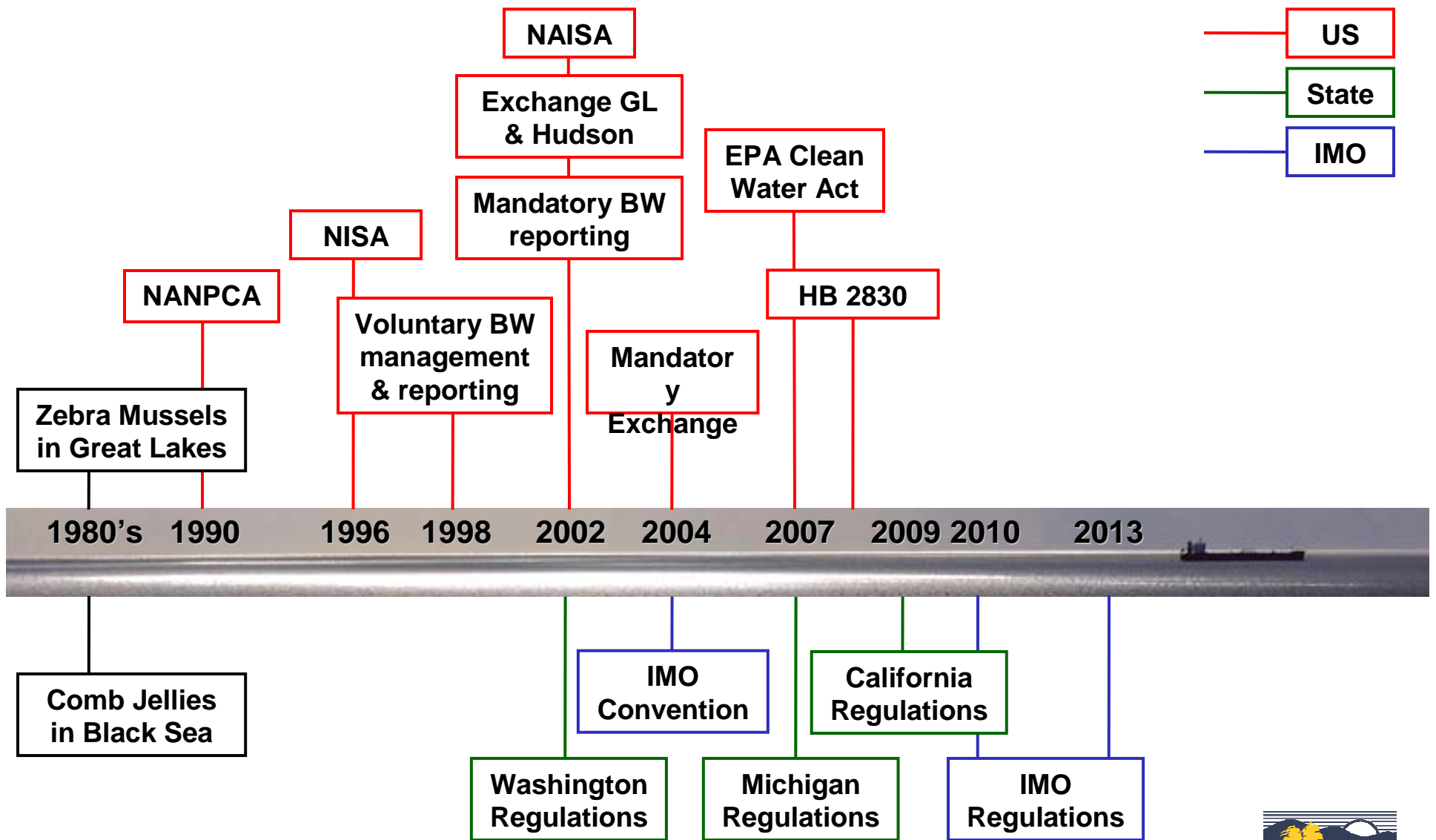
- Total Capacity of tanker ballast pumps typically sufficient to fill/discharge in 15 hours
- Common practice (except tankers) loaded with full cargo to carry no ballast



Typical Ballast System



Ballast Water Regulations Timeline



Current Ballast Water Regulations

- US (and others) have mandatory exchange
- Interim solution with limitations



- Michigan – Treatment based
- Washington – Percent reduction and treatment based





Future Ballast Water Regulations

- **California (2009)**
- **Minnesota and Wisconsin (pending)**
- **US House Bill 2830**
- **USCG and EPA standards/regulations**
- **IMO Convention (D2 Standards and G8 & G9 Guidelines)**



Range of Discharge Standards



Organism Size Class	IMO	California	Washington
Organisms greater than 50 µm in minimum dimension	< 10 viable organisms / m ³	No detectable living organisms	Technology to inactivate or remove: 95% zooplankton 99% bacteria and phytoplankton
Organisms 10 – 50 µm in minimum dimension	< 10 viable organisms / ml	< 0.01 living organisms / ml	
Organisms less than 10 µm in minimum dimension		< 10 ³ bacteria/100 ml < 10 ⁴ viruses/100 ml	
<i>Escherichia coli</i>	< 250 cfu/100 ml	< 126 cfu/100 ml	
<i>Intestinal enterococci</i>	< 100 cfu/100 ml	< 33 cfu/100 ml	
Toxicogenic <i>Vibrio cholerae</i> (01 & 0139)	< 1 cfu/100 ml or < 1 cfu/gram wet weight zooplankton samples	< 1 cfu/100 ml or < 1 cfu/gram wet weight zoological samples	



Ballast Water Treatments

- **Shore-based**
- **Shipboard**
 - **Effective at killing/removing invaders**
 - **Safe for ship crew**
 - **Environmentally benign**
 - **Feasible and affordable**





Shipboard Ballast Water Treatments

- **Mechanical**
 - Filtration
 - Hydrocyclone
- **Chemical (Biocides)**
 - Oxidizing - chlorine, chlorine dioxide, ozone, bromine, hydrogen peroxide, peroxyacetic acid
 - Non-oxidizing – gluteraldehyde, menadione, acrolein
- **Physical**
 - Cavitation
 - Deoxygenation
 - Flocculation
 - Heat
 - Ultrasound
 - Ultraviolet Radiation
- **Several Combinations**



Recent Reviews

- **Lloyd's Register (June 2007)**
- **California State Land Commission (Dec 2007)**
 - **28 Treatment Systems (9 countries)**
 - **17 combination of 2 or more**
 - **21 chemical (18 oxidizing, 3 non-oxidizing)**
 - **10 have been tested onboard active vessels**



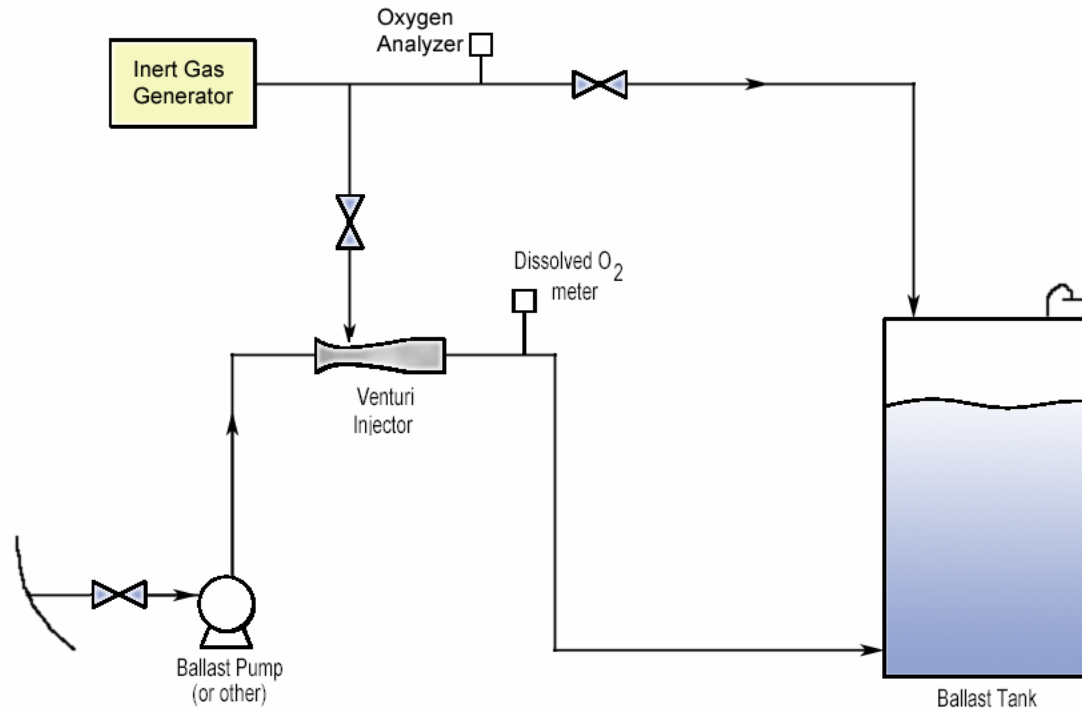


Status of Ballast Water Treatments

- **IMO Certified:**
 - **NEI (USA) Venturi Oxygen Stripping (VOS), deoxygenation**
- **Nearing Certification:**
 - **Alfa Laval (Sweden) PureBallast, filtration + advanced oxidation**
 - **Hamann (Germany) SEDNA, hydrocyclone + filtration + Peraclean**



NEI Venturi Oxygen Stripping



- **Utilizes inert gas to deoxygenate ballast water**
- **No flow-rate restrictions**
- **IMO compliant testing and meets D2 Standards**
- **Certification by Liberian Register, with technical review by ABS**
- **Significantly reduced tank corrosion**



Status of Ballast Water Treatments

- **Other Promising Treatments:**
 - Ecochlor, chlorine dioxide
 - Greenship, hydrocyclone + electrochlorination
 - Hitachi, filtration + flocculation
 - Hyde Marine, filtration + UV
 - Japan Assoc. Of Marine Safety, Special Pipe mechanical treatment + ozone
 - MSI and Dow, filtration + UV or chemical
 - Nutech 03, ozone
 - OceanSaver, filtration + N₂ saturation + cavitation
 - OptiMar, hydrocyclone + UV
 - Resource Ballast Technologies, cavitation + ozone + sodium hypochlorite
 - RWO, filtration + advanced electrolysis
 - Severn Trent DeNora, filtration + sodium hypochlorite
 - Techcross, electrochemical oxidation



A Few Thoughts

- **Technologies are available to meeting IMO Regulations.**
- **Multiple regulations and standards greatly complicate the issue.**
- **Treatment testing is challenging and some standards are currently beyond measure.**
- **Compliance monitoring and enforcement remains unclear.**
- **Regulations/treatments will reduce invasions but ballast water is not the only source.**



Maritime Environmental Resource Center

A Maryland Ballast Water Initiative



www.maritime-enviro.org

- Provide facilities and expertise for testing of treatment systems
- Provide information and decision tools to select the most appropriate treatment options
- Remove as much uncertainty as possible from emerging markets to accelerate the adoption of treatment technologies
- Initial focus on ballast water but will address various maritime environmental issues



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