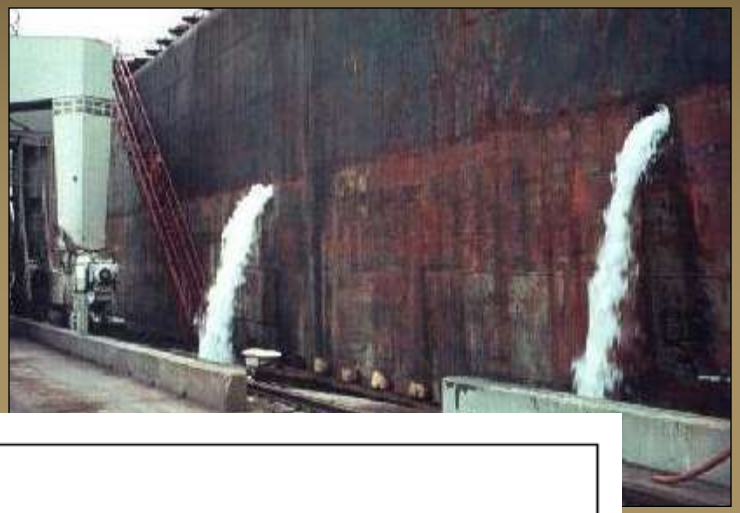
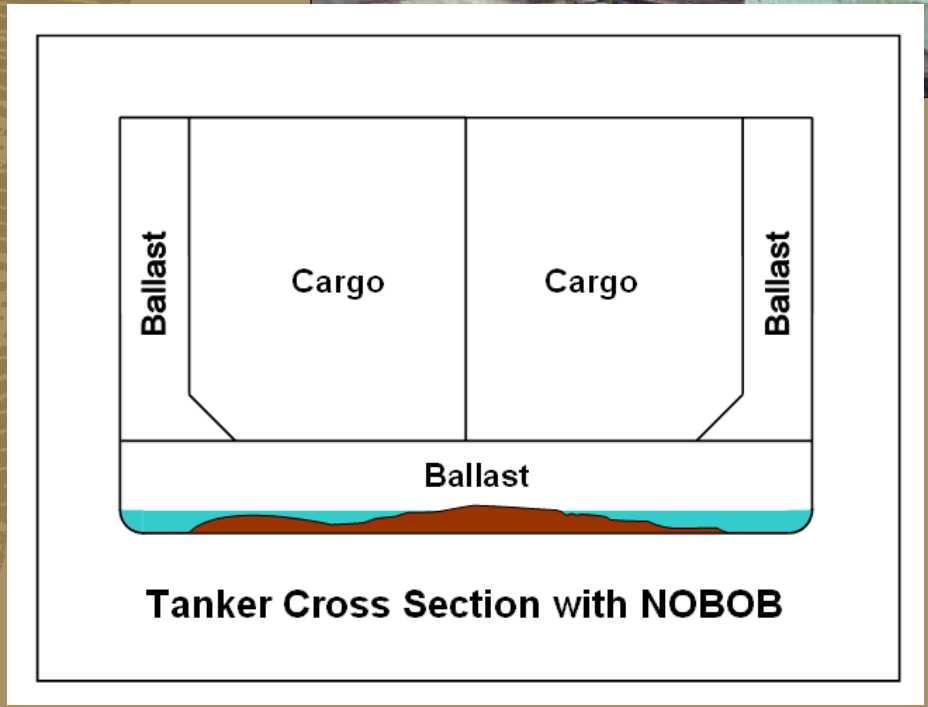
Protecting Biosphere Reserves

- Defining the Problem
- Assembling Research Partners
  Outreach to affected industries
- Collaboration and Innovations

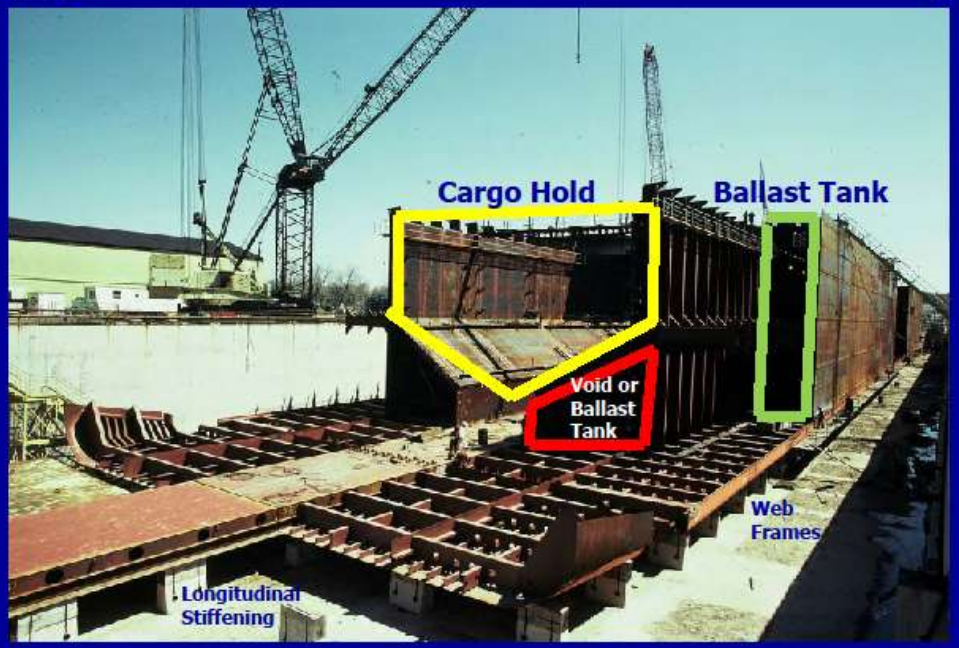
Ballast Water and Marine Invasions



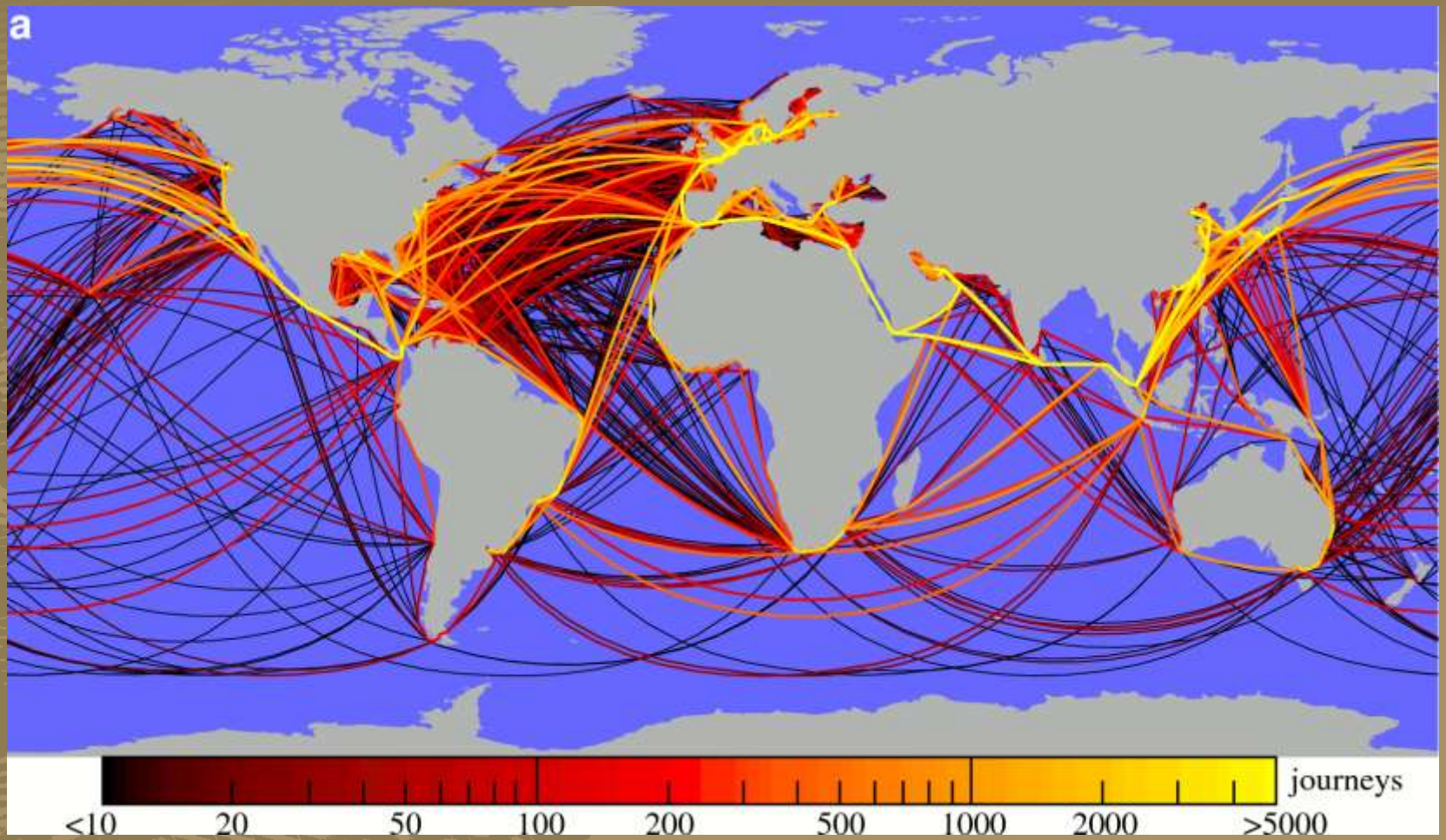
- 40,000 ships operating worldwide
- Ballast pumping rates of 5000 to 15,000 m^3/hr
- Tank volumes up to 25,000 m^3



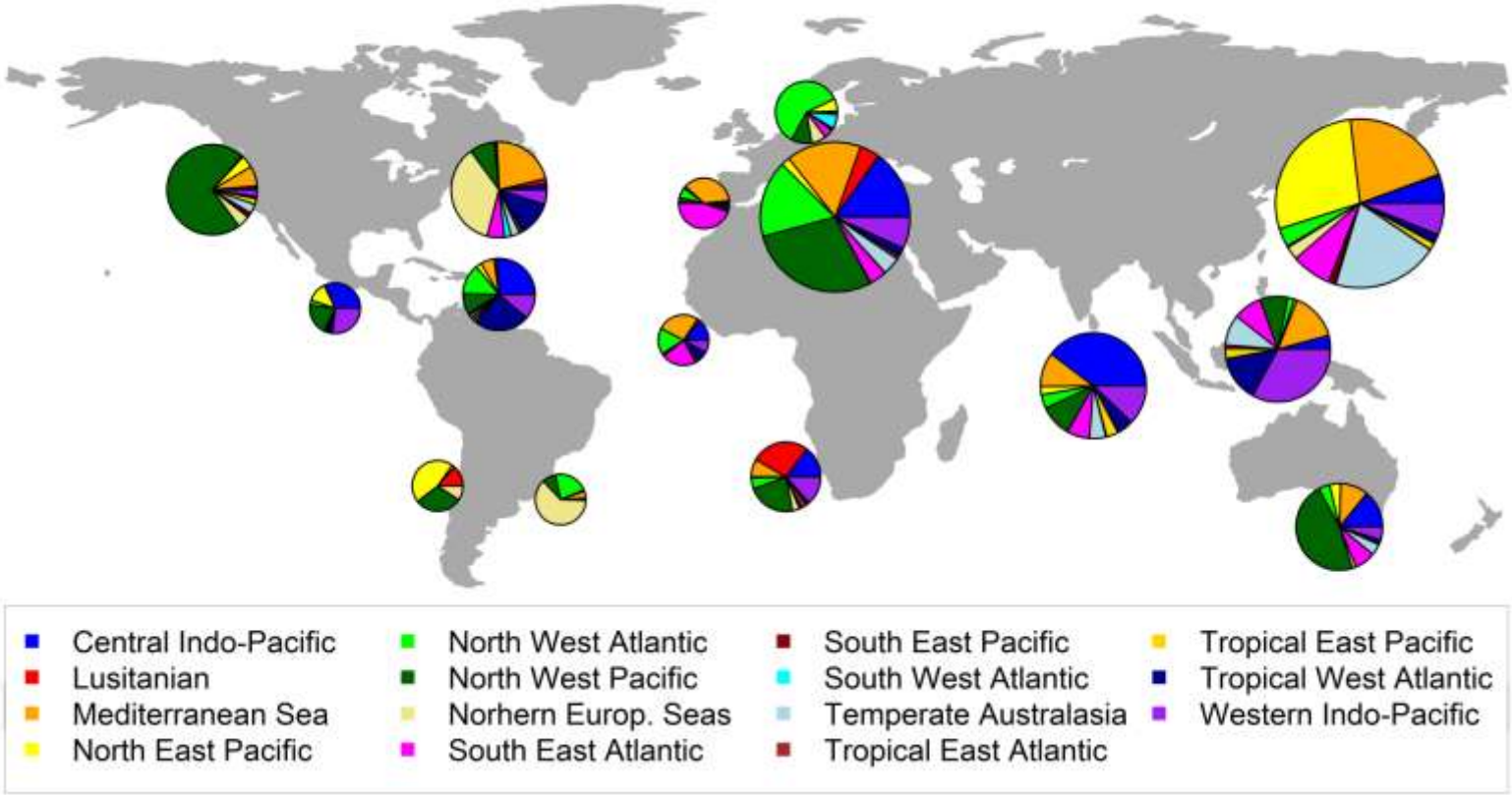
Internal structure of 1000 foot Laker
(1,000' Edwin H. Gott Under Construction)



Global cargo ship network
Kaluza et al. 2010: The complex network of global cargo ship movements, J. R. Soc. Interface

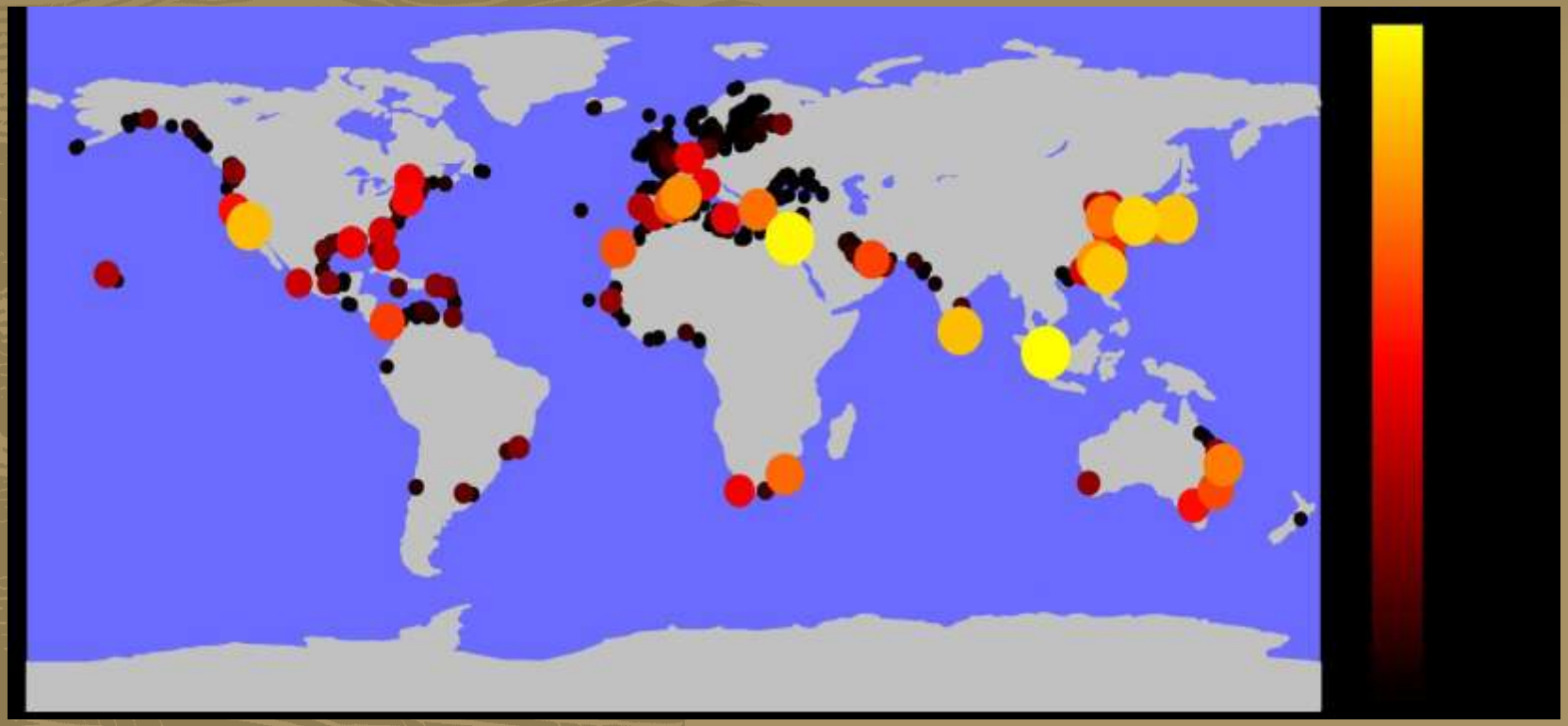


Source Regions for Marine Invasions



Bioinvasion Hotspots

Color coding and point size indicate the probability to get invaded Yellow has the highest probablity.



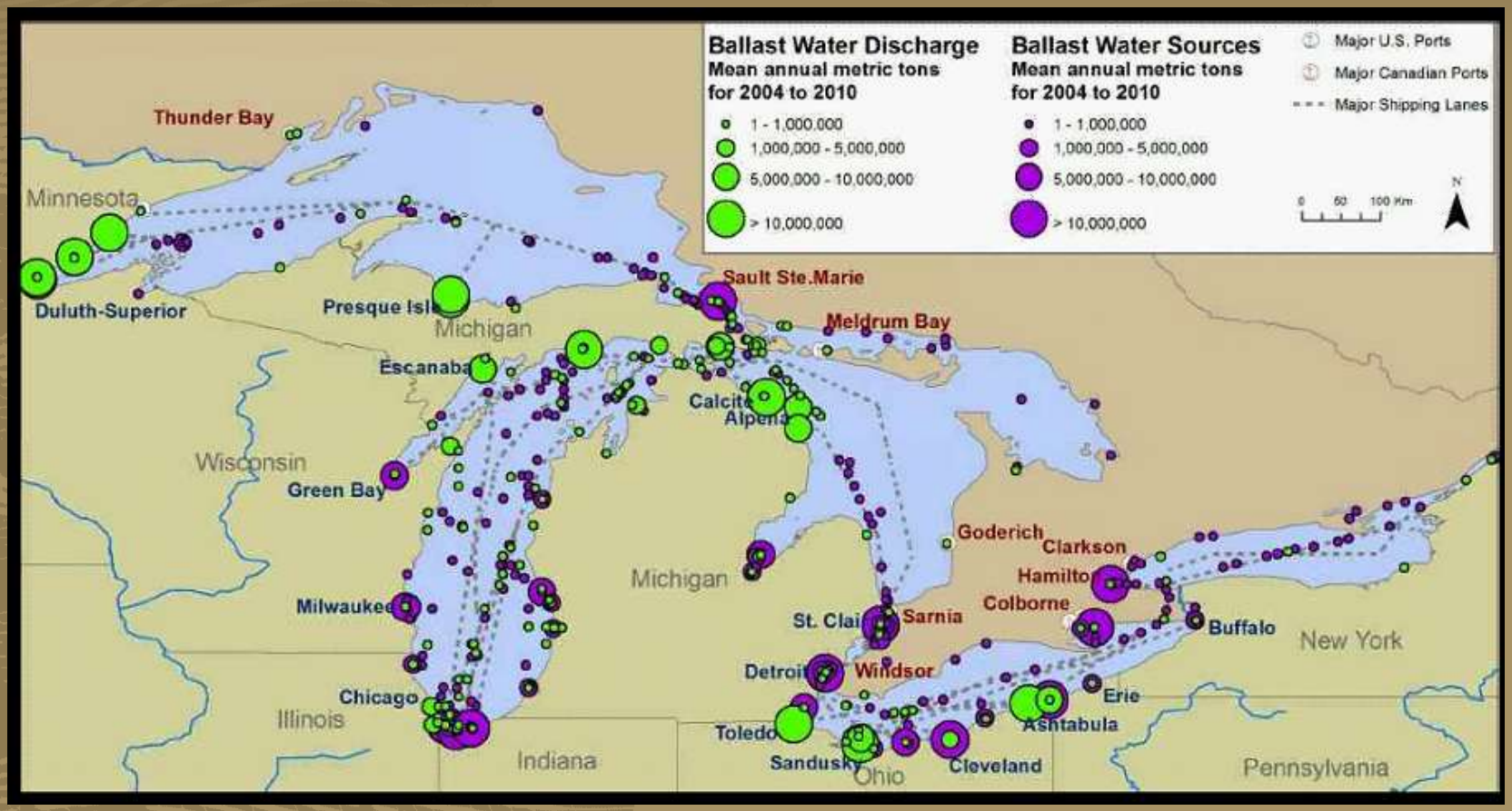
Ballast Responder – Mobile Treatment

MOTIVATION – NATIONAL PARK SERVICE

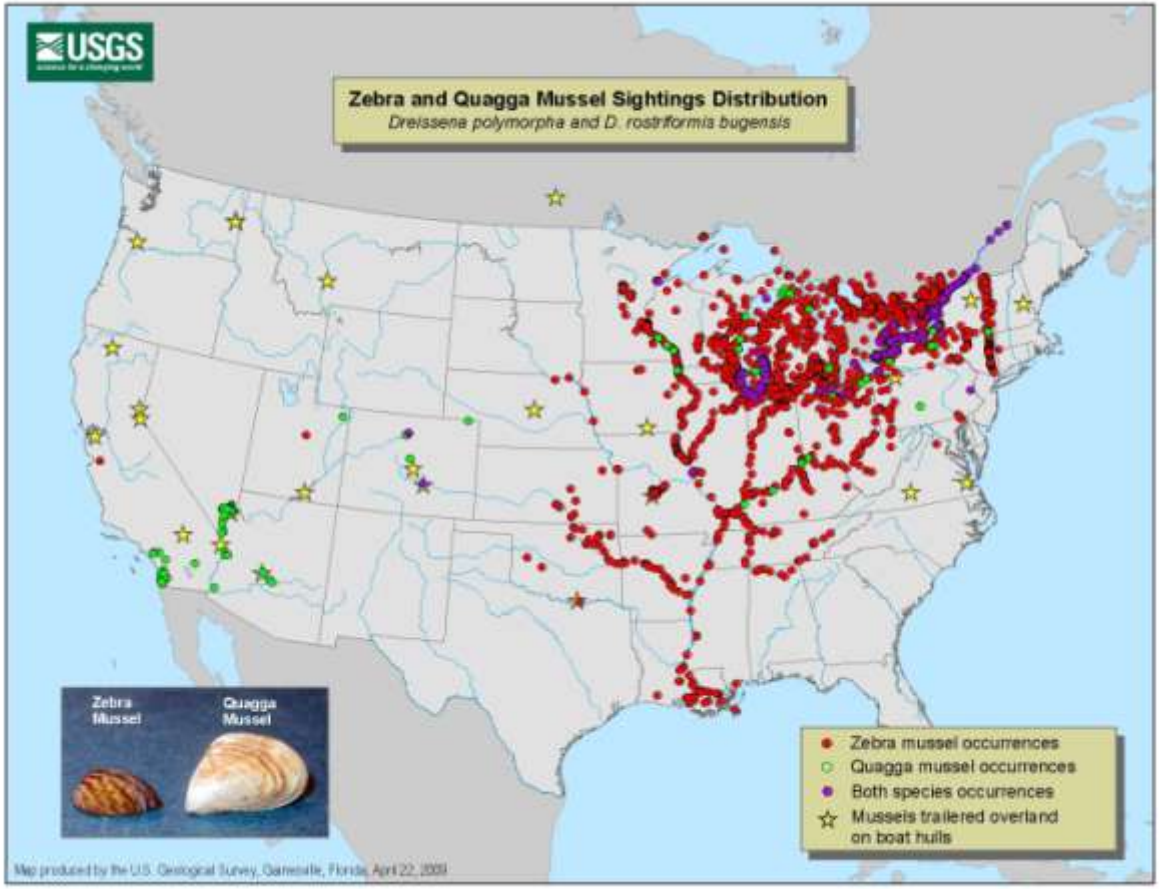
MT Igloo Moon Grounded 1996 on Biscayne Bay National Park. Before discharge of 'high risk' ballast water, treated ~4,200 tons with calcium hypochlorite. Bulk dose into full tanks.

Protecting the Great Lakes from Ballast borne Aquatic Invasive Species

How to prevent the next invasion?


Ballast Water Discharge
Mean annual metric tons
for 2004 to 2010
1 - 1,000,000
1,000,000 - 5,000,000
5,000,000 - 10,000,000
> 10,000,000
Ballast Water Sources
Mean annual metric tons
for 2004 to 2010
1 - 1,000,000
1,000,000 - 5,000,000
5,000,000 - 10,000,000
> 10,000,000
Major U.S. Ports
Major Canadian Ports
Major Shipping Lanes
0 50 100 Km
N
Thunder Bay
Minnesota
Duluth-Superior
Presque Isle
Michigan
Escanaba
Sault Ste.Marie
Meldrum Bay
Calcite
Alpena
Wisconsin
Green Bay
Milwaukee
Chicago
Illinois
Indiana
Michigan
Goderich
Clarkson
Hamilto
Colborne
St. Clai
Sarnia
Buffalo
New York
Detroit
Windsor
Erie
Ashtabula
Toledo
Sandusky
Ohio
Cleveland
Pennsylvania

National Park Service
U.S. Department of the Interior



Isle Royale National Park

Manual Dosing of Ballast

Assuring discharge standards are met.

Ranger III demonstrated both emergency and permanent treatment on a small vessel.

But could it be scaled up?

NPS Ballast Program Goals

- **Goal 1) Prevent Aquatic Invasive Species transfers to, or from, Isle Royale National Park via commercial vessels and the NPS vessel Ranger III.**

  Results: 1) first initiated emergency treatment on the ship and Purchased and installed a U/V system in 2012. Technology transfer of the process for install for small ships on-going.

- **Goal 2) Prevent new AIS arrivals from salt water vessels releasing near or grounding within a NPS boundaries or live AIS releases within the great lakes to float into NPS boundaries via the development of the emergency ballast treatment**

- **Goal 3) Prevent inter-basin transfers of AIS via the freshwater fleet by developing and demonstrating treatment technology to meet their needs.**

- **Goal 4) Develop a path through the regulatory maze by initiating projects that support treatment approvals for fresh and salt water applications for large and small ships.**

Industry Partners

- American Steamship Company
- Clorox Inc
- Dow Chemical
- Glosten


INDIANA HARBOR

Ballast Responder – Mobile Treatment

DEVELOPMENT TRIALS (LABORATORY AND *MV INDIANA HARBOR*

Field Trials on Great Lakes Bulker
April 2009 and May 2010

Vessel Name:	**M/V Indiana Harbor**
Owner:	**American Steamship Company**
Built:	**Bay Shipbuilding, 1979**
Particulars:	**Great Lakes Bulk Carrier, U.S. Flag** **Iron ore pellets and western coal transport** **1,000'-0" length overall** **105'-0" beam, 56'-0" depth, 34'-3/4" midsummer draft** **80,900 gross tons deadweight capacity at MS draft** **10,000 tons/hour cargo unloading capacity** **14,000 shaft horsepower, twin screw**
Ballast System:	**Four (4) main pumps at 13,000 gpm each** **30" header and 14" branch lines** **Two (2) stripping pumps at 4,000 gpm each** **10" header and branch lines**
Ballast Tanks:	**Fourteen (14) deep ballast tanks typical capacity of 1,259,000 gallons (4,808 long tons) each** **Two (2) double bottom, one (1) forepeak, (1) aftpeak**

Finding the Right Researchers

- Expertise in pumps and diversion systems
- Knowledge of aquatic invasive species
- Knowledge of ballast tanks

Find the right researchers

DRAFT 4/6/2010

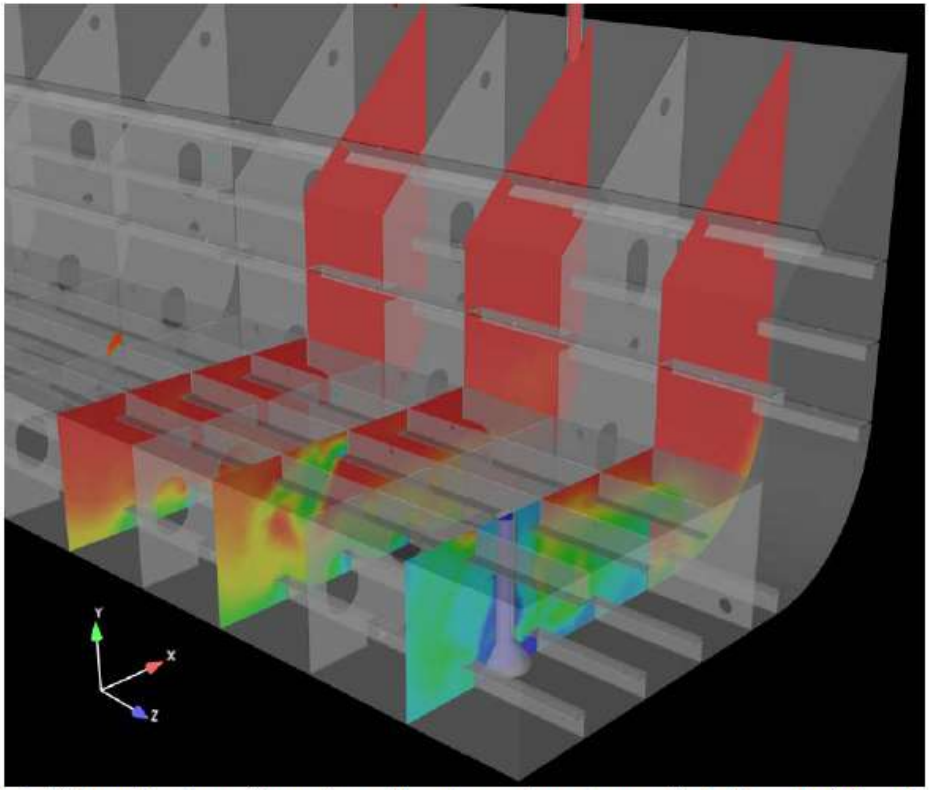
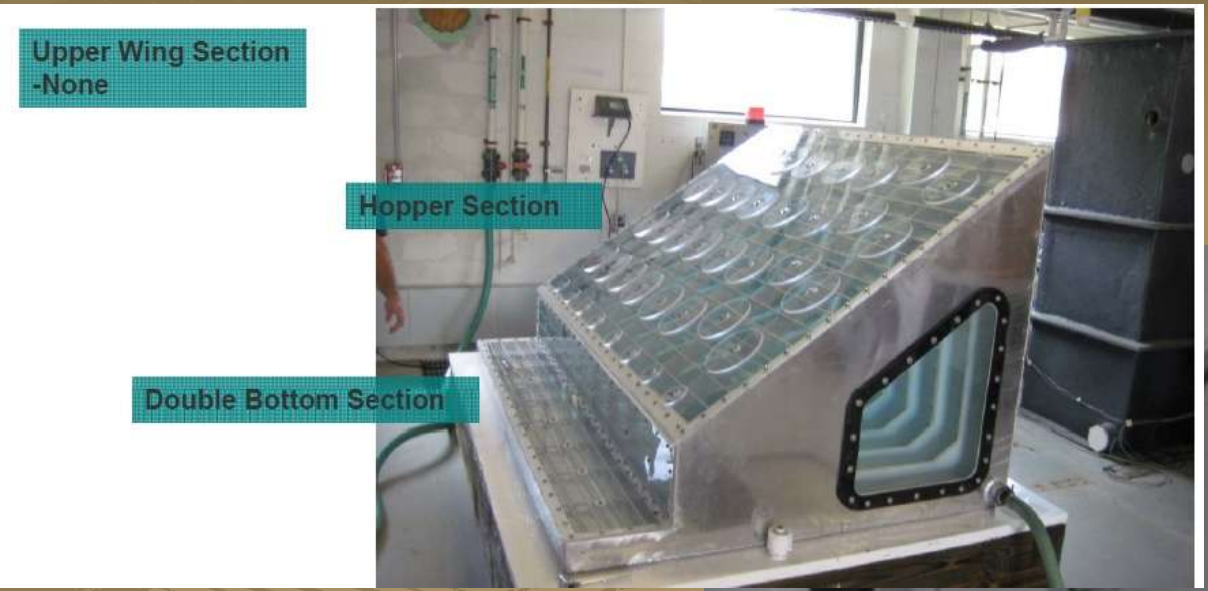


Figure 2: Volume fraction of incoming salt water contours in specified planes in full-scale ballast tank (red = pure resident fresh water, blue = incoming salt water).

U

USGS Scientists Dr. Watten, Dr. Smith and Dr. Adams

1/10th scale model



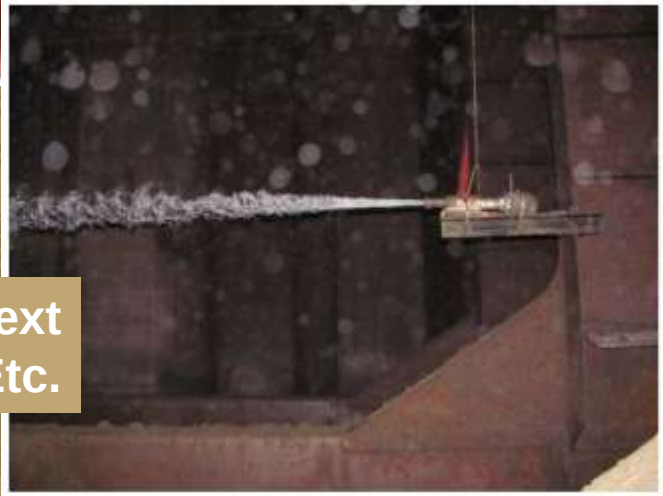
1/10th Scale
Ballast Tank

Ballast Responder – Mobile Treatment

DEVELOPMENT TRIALS (LABORATORY AND *MV INDIANA HARBOR*

Step 1 – Prepare Chemicals for FULL Ballast Tanks

Step 2 – Dose One Method

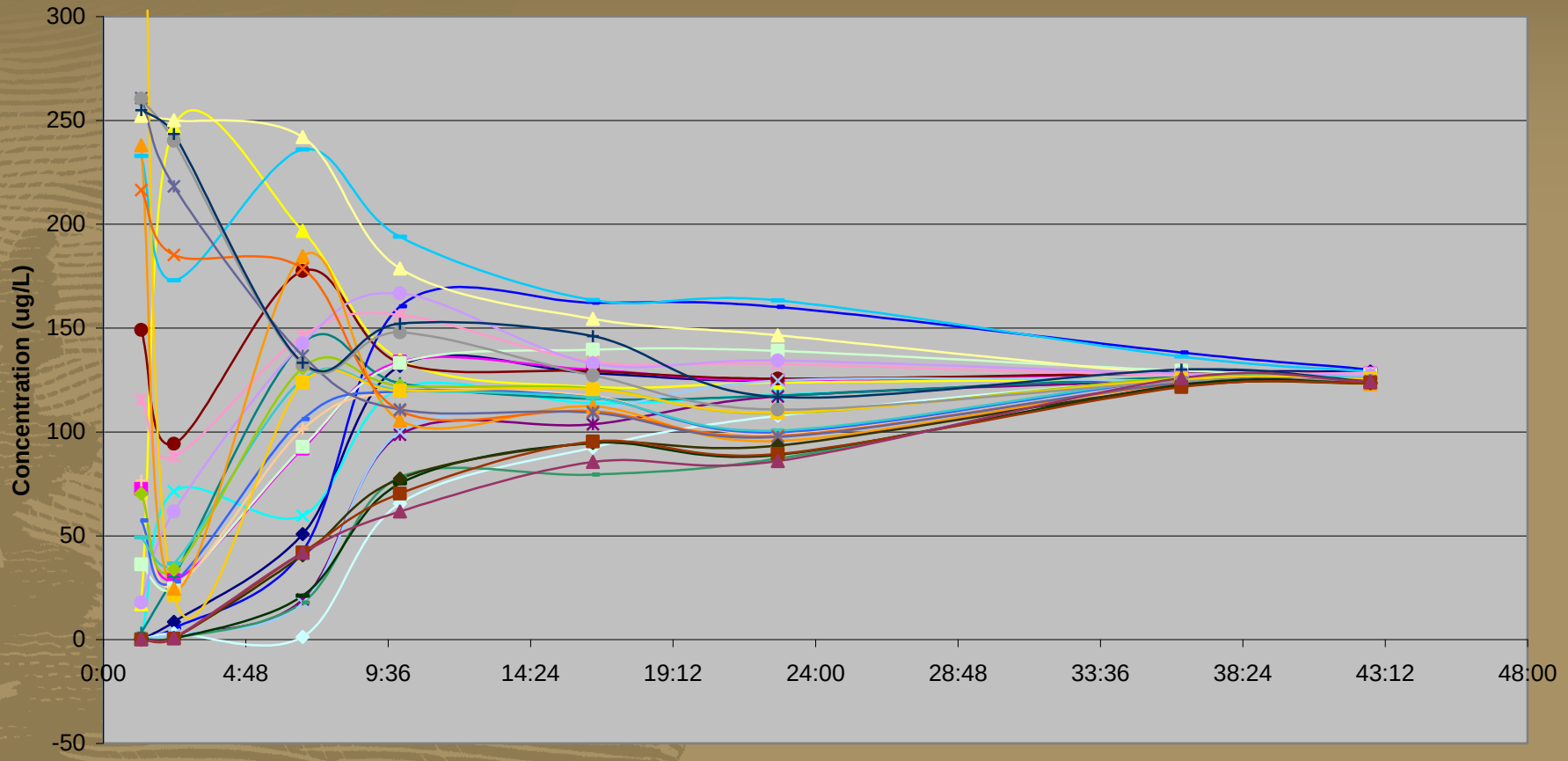


Steps 3 through x – Dose Next Method, Next Method, Etc.

Ballast Responder – Mobile Treatment

DEVELOPMENT TRIALS (LABORATORY AND *MV INDIANA HARBOR*

Field Trials on Great Lakes Bulker – Dye Concentration Measurements



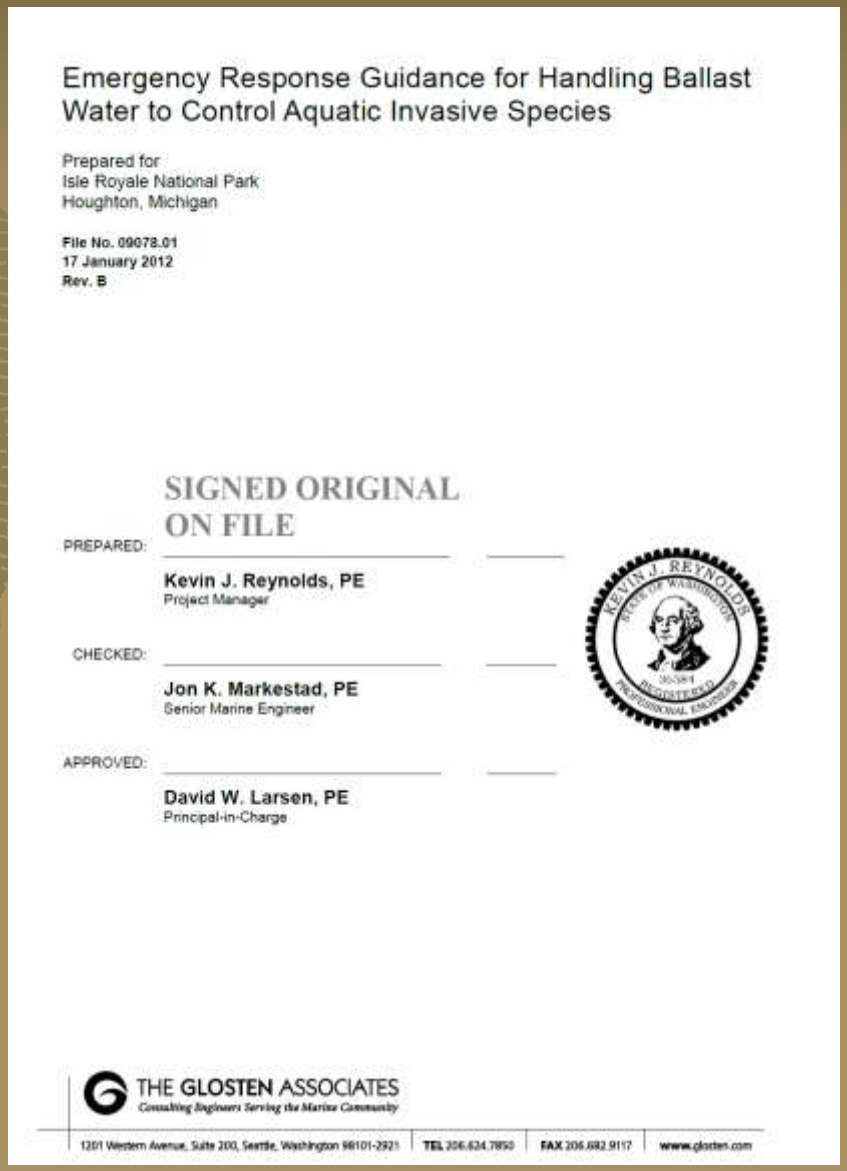
Dye Concentration vs. Time (Example Method)

Ballast Responder – Mobile Treatment
EMERGENCY RESPONSE GUIDE

Emergency Response Guide for Handling Ballast Water,

Initial Release January 2010
Updated January 2012

http://www.nps.gov/isro/



Emergency Response Guidance for Handling Ballast Water to Control Aquatic Invasive Species

Prepared for
Isle Royale National Park
Houghton, Michigan

File No. 09078.01
17 January 2012
Rev. B

SIGNED ORIGINAL ON FILE

PREPARED:
Kevin J. Reynolds, PE
Project Manager

CHECKED:
Jon K. Markestad, PE
Senior Marine Engineer

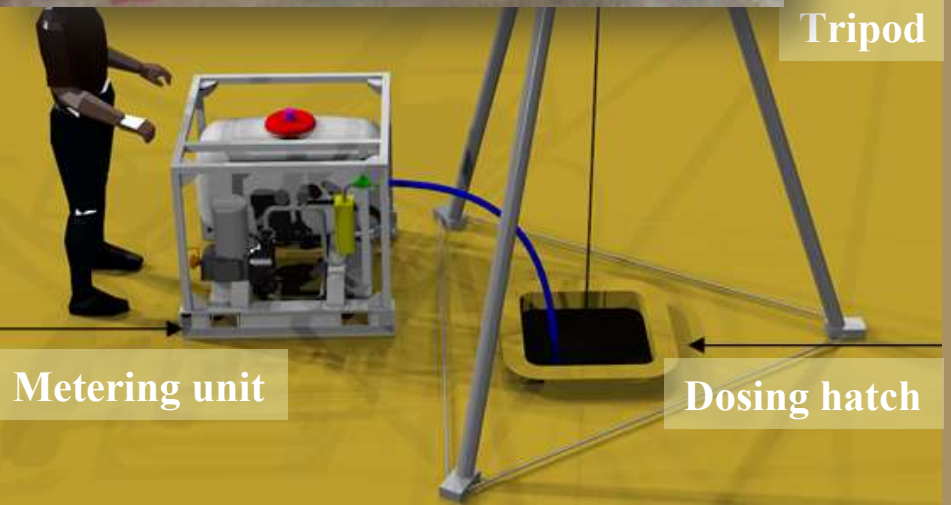
APPROVED:
David W. Larsen, PE
Principal-in-Charge

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

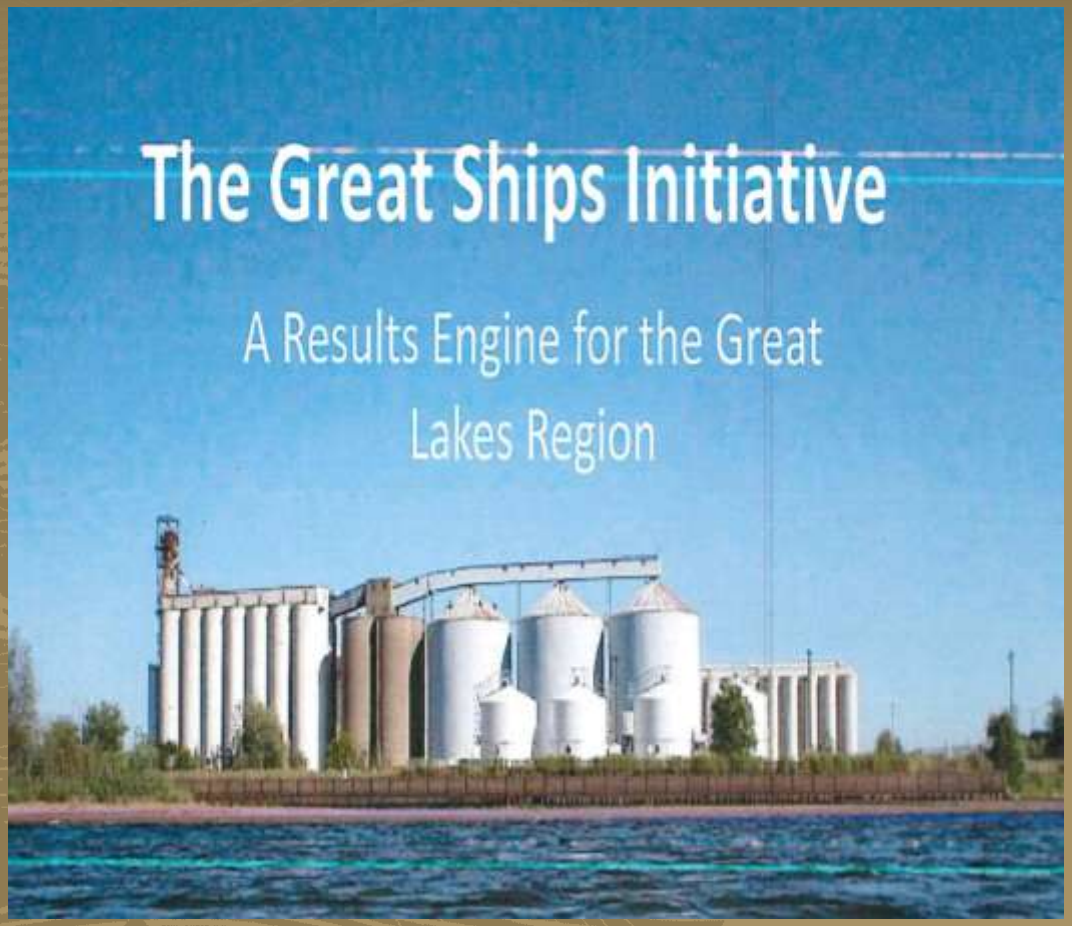
1201 Western Avenue, Suite 200, Seattle, Washington 98101-2921 | TEL 206.624.7850 | FAX 206.682.9117 | www.glosten.com

Ballast Responder – Mobile Treatment

PROTOTYPE DEMONSTRATION – *TS GOLDEN BEAR*

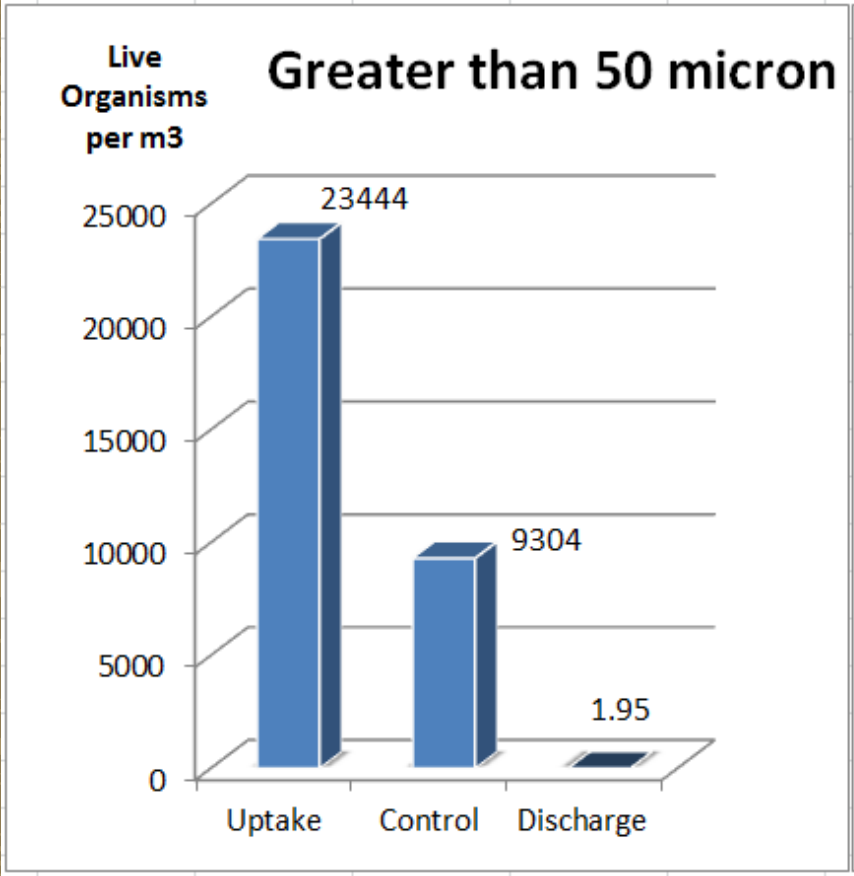


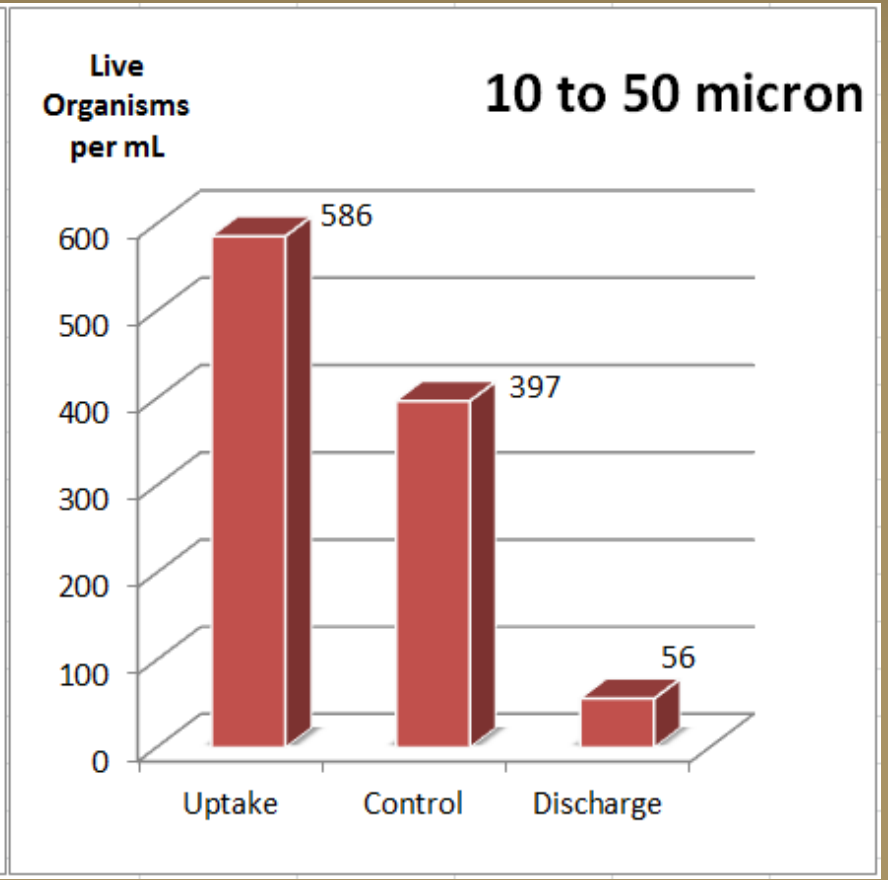
National Park Service
U.S. Department of the Interior



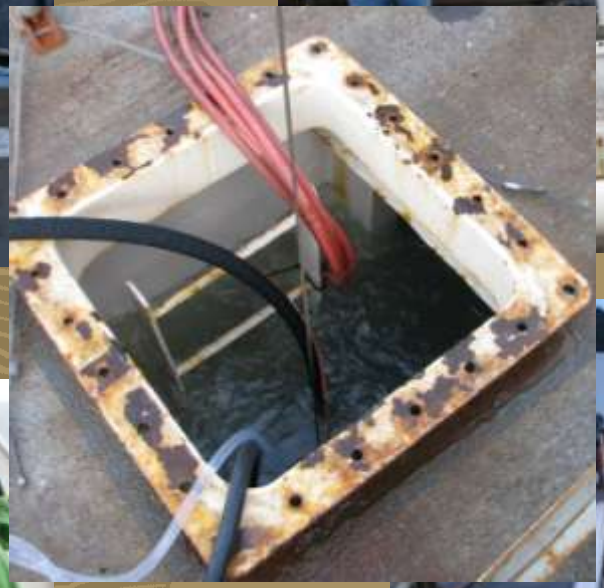
EXPERIENCE YOUR AMERICA

Ranger III Results



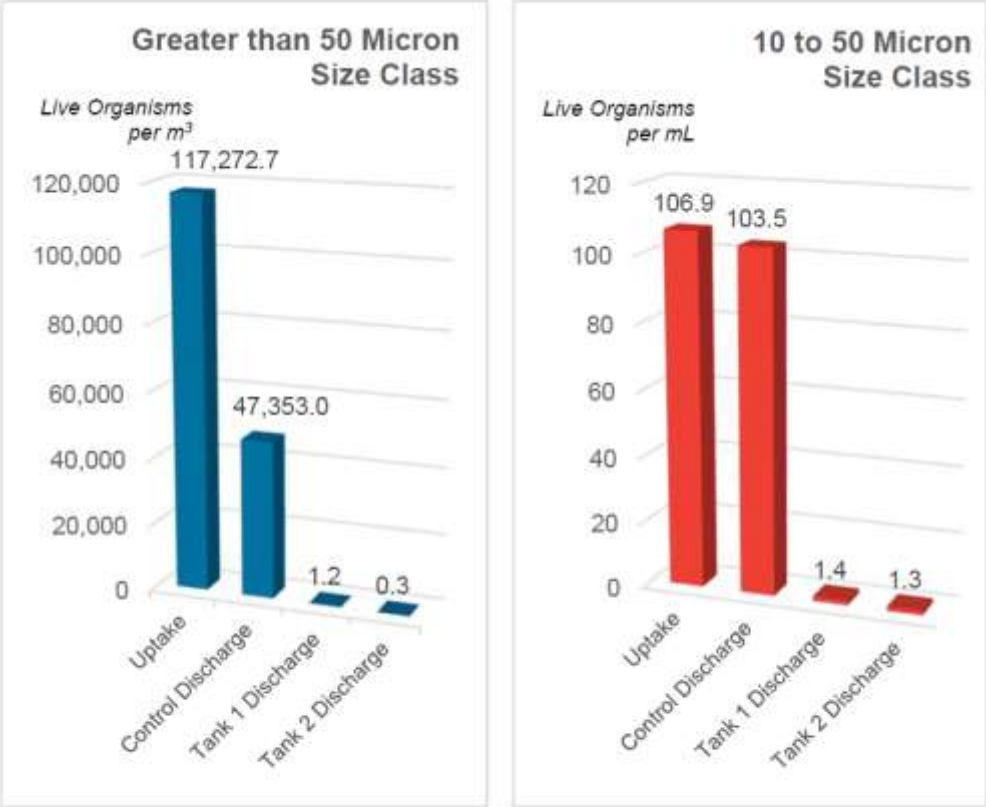


Golden Bear California



EXPERIENCE YOUR AMERICA

Golden Bear Results



Results from in-tank treatment testing of Ballast Responder at Golden Bear Facility. Live organism concentrations are shown for Uptake (where ballast water enters tank), Control (tank without treatment), and Tank 1 and Tank 2 (treated tanks). Concentrations in Tank 1 and Tank 2 discharge concentrations indicate compliance with the IMO/USCG/EPA standards of less than 10 organisms per m³ for the larger than 50 micron size class, and 10 organisms per milliliter for the 10 to 50 micron size class.

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

USGS
science for a changing world

National Park Service
U.S. Department of the Interior

Ballast Responder – Mobile Treatment

Emergency Response and Interim Ballast Water Treatment Development, Test Results, and Path Ahead

Presented to:
Workshop on Port-based Ballast Water Management Measures
12 November 2012, Singapore

Presented by: Kevin J. Reynolds, PE, The Glosten Associates

A Framework for contingency treatment is moving through IMO

Igloo Moon Biscayne National Park

GIA Global Industry Alliance

gef

UNDP Empowered lives. Resilient nations.

IMO INTERNATIONAL MARITIME ORGANIZATION

GloBallast Partnerships

IMO Global Industry Alliance (GIA)
2nd EXPERT WORKSHOP ON PORT-BASED BWM CONTINGENCY MEASURES
Thursday 24 October 2013
BEXCO Centre, Busan, Republic of Korea

Spring of 2017 IMO Meeting

- Will put forth a contingency treatment framework.
- Current contingency treatments have no standards for discharges (developers are targeting IMO and USCG standards)
- Framework would provide guidance to the industry, including port State control officers, marine vessel operators, and technology providers.
- Will consider
  - Level of risk reduction required
  - Potential liability of the various parties
  - Responsibility of the service providers

Tests on Ranger III

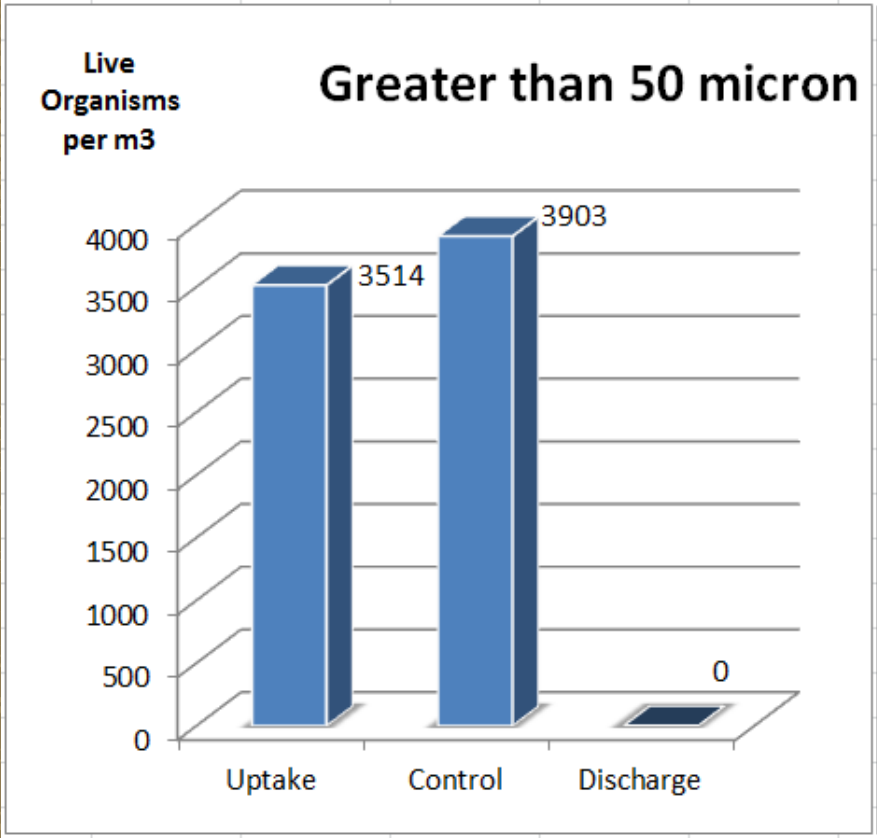
- In August 2014, Dr David Wright of Environmental Research Services and his team conducted shipboard status trials of the process using bleach as the biocide.
- Ranger III's tank mixing system was used due to the small size of the ballast tanks.

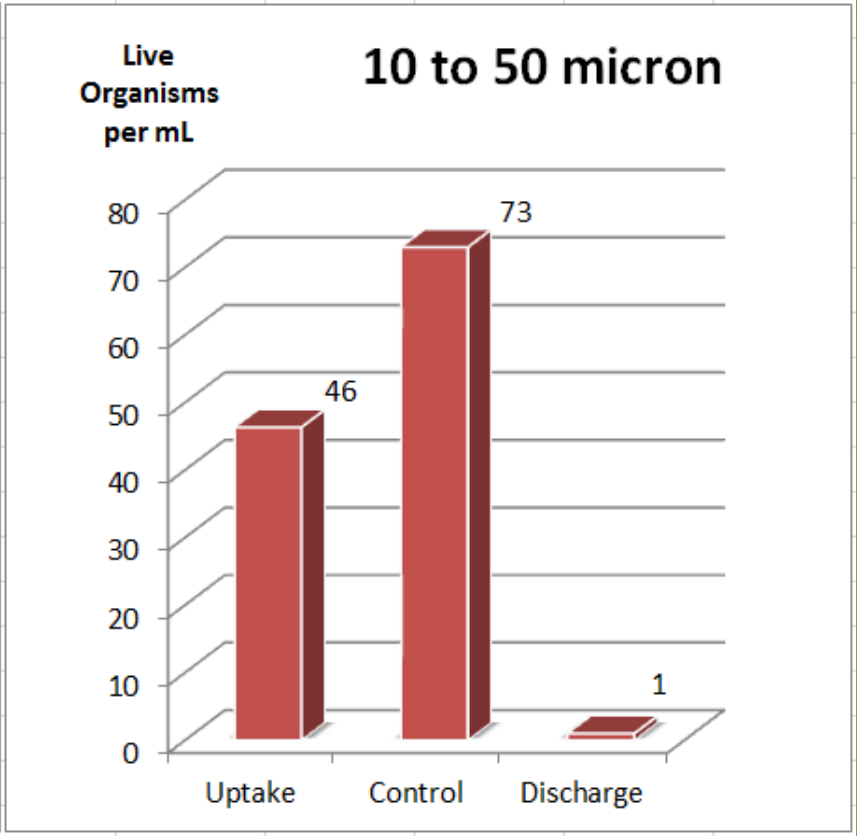
Golden Bear 2014

- Verification testing was conducted from 3 to 5 December 2014.
- Golden Bear Facility (GBF) conducted a series of bench-scale dose response tests followed by twelve full-scale development and verification tests on the United States Training Ship (USTS) *Golden Bear* using the Ballast Responder (BaR).
- Bench-scale trials to develop dose and time targets were performed by Dr. Nick Welschmeyer's biological oceanography group from Moss Landing Marine Laboratory (MLML). Biological efficacy testing was performed by the GBF with the MLML science team.

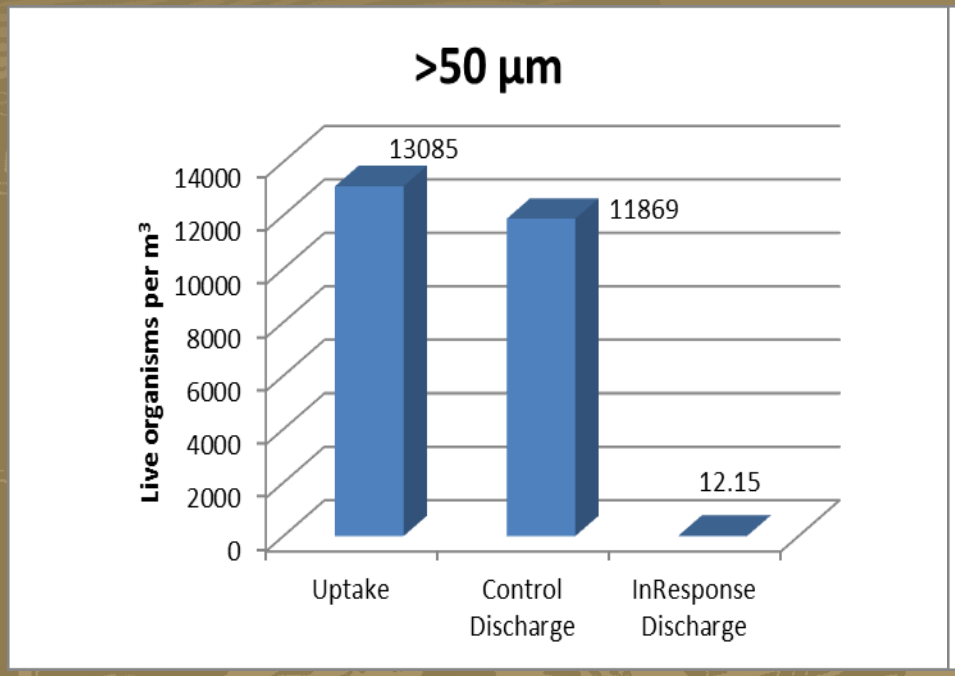
EXPERIENCE YOUR AMERICA

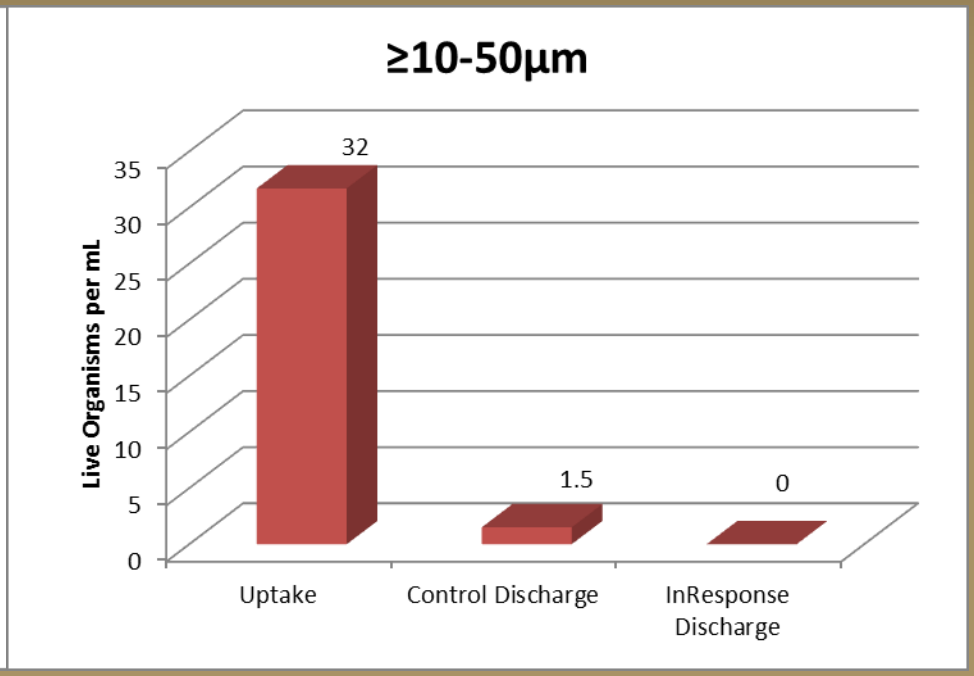
Dockside Ballast intake Results Fall 2015





Montreal to Sarnia Shipboard Trials 2016





Results: % reduction

Size Class	BWE	Ranger III	Golden Bear	ATB Dock 2015	ATB Ship Trial 2016
>50 µm	70 to 98	99.99	100	100	99.91
≥10-50 µm	Same as above	90.4	97.8	98.7	100
<10 µm					

ATB Testing Platform

- Funded by NPS, St Louis County (MN) Izaak Walton League and the MN DNR.
- This bulk carrier is a 6,916 gross ton tank barge that typically moves asphalt and heavy oils, operating on the Canadian eastern seaboard and in the Great Lakes St. Lawrence Seaway System.
- The vessel carries up to 4600 cubic meters of ballast water and can discharge at a rate of 680 cubic meters per hour. Survey findings are summarized below, with images provided at the end of this memorandum.

Permanent Treatment for "Lakers"

Still working at a small scale

Ranger III Permanent Treatment UV Chamber

IMO scheduled implementation September 2018

- Canadian Leaders in industry have implemented shipboard installments- FedNav
- Canadian ships will start installs to be in compliance with IMO.
- A handful of US ships are installing and finding solutions prior to USCG type approvals (Only one system is USCG type approved for fresh, salt and brackish-Optimarin)

Reducing uncertainty and risk for early adopters & preparing for long term needs

- IMO is evaluating how to work with early adopters to not have financial penalties if system fails.
- USCG is slow to type approve or may restrict systems to certain water conditions to ensure discharges can meet standard.
- New technology and the human factor: there will be failures.

Milestones

- 2008 MWRO and NOAA support for technical feasibility study plan
- 2009-10 American Steamship Company becomes a partner
- 2008 Clorox becomes a partner for Ranger III and expands support in 2010
- 2009 Great Lakes Ballast water collaborative formed.
- 2008/9 Great Lakes fisheries trust grant
- 200 9 published the Emergency treatment guide as a web based resources for spill and grounding responders.
- 2010 LCCMR grant
- 2010 Dow support with FIFRA compliance
- 2011 MARAD and GSI support – emergency prototype

Regulatory Void

- 7 to 10 years away from full implementation with specific standards, technology approvals, and compliance monitoring.
- Best management practices do not significantly slow down the spread of AIS.
- There is a need for
  - interim,
  - Contingency, and
  - emergency treatment.

Next steps- Emergency Treatment

- Two west coast states and two Midwest states have implemented emergency treatment language in their 401 certifications for the Vessel General Permit.
- Need to do live biocide testing for freshwater and saltwater for the emergency treatment . Funding and a ship test platform are barriers.
- MERC and GSI diverted emergency treatment 2012 testing in order to meet demand for permanent treatment. Need to work with them and Golden Bear to cover range of testing and port needs.
- Need to optimize current applications to reduce treatment mixing times and expand tank coverage.

Next steps- Freshwater Treatment

- Technical barriers related to stack gas cleaning and re-use for neutralization needs to be overcome.
- Full ship demonstration of technology.
- Documentation with certified lab.
- Submittal of results to regulators.

National Park Service
U.S. Department of the Interior

Emergency Response Guide for Handling Ballast Water to Control Non-Indigenous Species

Prepared for
National Park Service
Isle Royale National Park
Houghton, Michigan

File No. 09019.01
16 September 2009

DRAFT P1

EXPERIENCE YOUR AMERICA

Condition Factors Near 0.70

0.57

0.63

0.72

Predictions: Killer Shrimp

- Native to Ponto-Caspian
- Invasive in Europe
- Parameters
  - Introduction site: Duluth, Toledo, Ogdensburg, Green Bay, Goderich, and Detroit
  - Spread distance: 0-km
  - Probability of infestation: 0.75

Photo Credit: Simon Devin, Université de Metz, France

Breeding Birds

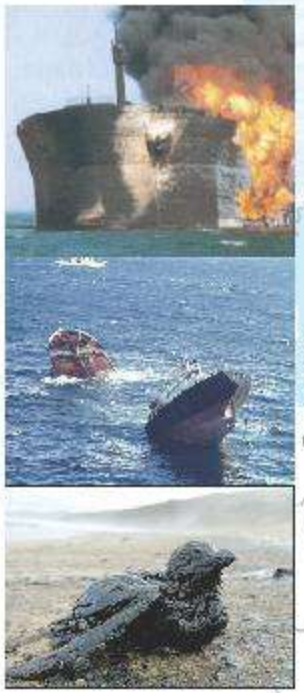
Approximately 60 species of breeding birds are identified at Isle Royale each year. The inland lakes and Lake Superior waters of the park include 108 nesting territories for loons. The archipelago's smaller islands host colonies of nesting herons, gulls, and cormorants.

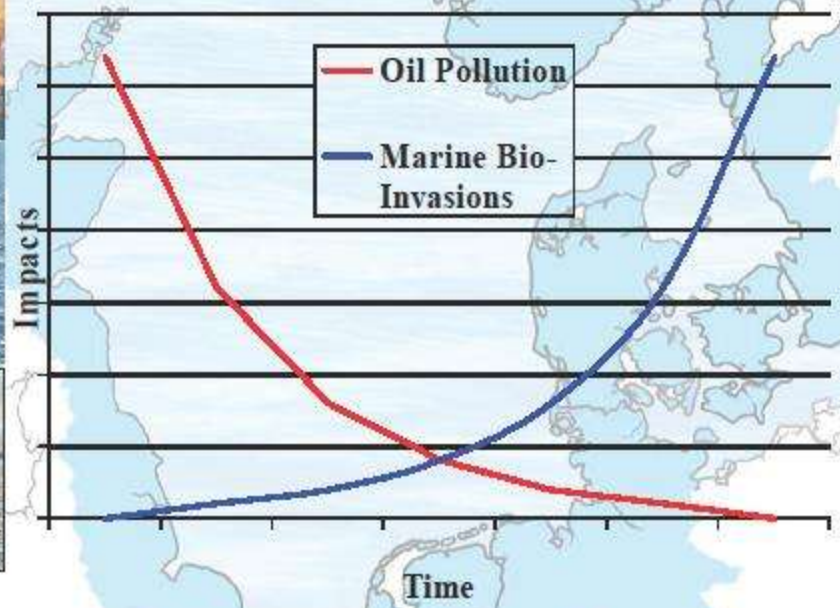
Partners- over $3M US invested

- Barnaby Watten USGS
- Noah Adams USGS
- Glosten Associates: Kevin Reynolds
- American Steamship Company
- GATX
- Canadian Shipowners
- Clorox
- Dow
- Department of Transportation Marine administration
- Great Lakes Fisheries Trust
- St Louis County
- Minnesota DNR
- National Park Service

NORTH SEA BALLAST WATER

Introduction





we must seek an outcome as outstanding as last year's lowest ever recorded level of oil spilled into the marine environment …
IMO Secretary General – opening speech, MEPC/INF.32

The Interreg IVB North Sea Region Programme

Isle Royale National Park
Houghton, MI

National Park Service
U.S. Department of the Interior

EXPERIENCE YOUR AMERICA

NPS Ballast Program Goals

- Goal 1) Prevent AIS transfers to and from Isle Royale National Park
- Goal 2) Prevent new AIS arrivals from salt water vessels
  - Emergency (or contingency or rapid response) treatment – the subject of today's discussion
- Goal 3) Prevent inter-basin transfers of AIS via the freshwater fleet
- Goal 4) Develop a path through the regulatory maze

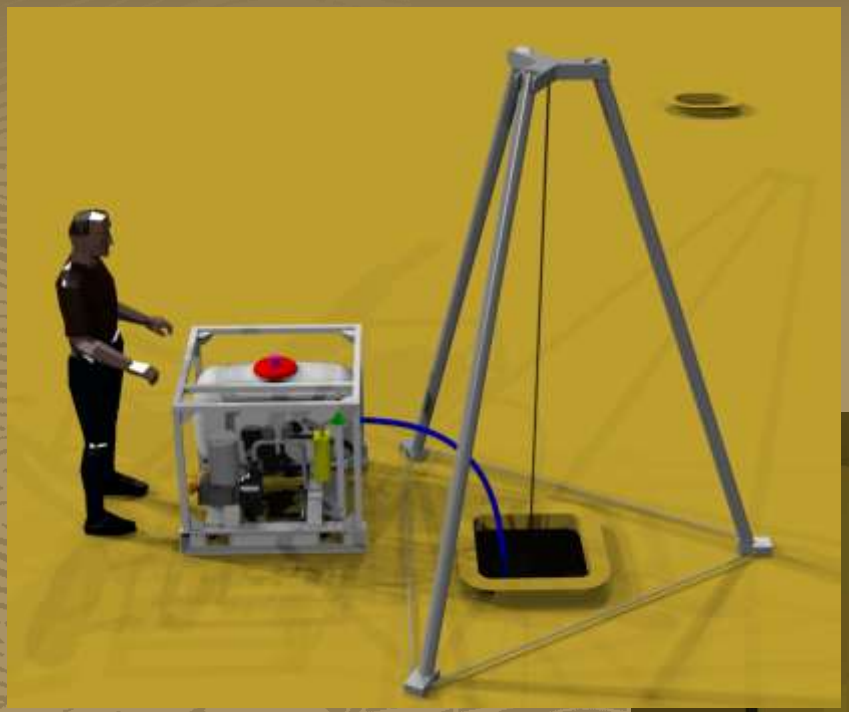
Results: % reduction

Size Class	BWE	Ranger III	Golden Bear	ATB Dock 2015	ATB Ship Trial 2016
>50 µm	70 to 98	99.99	100	100	99.91
≥10-50 µm	Same as above	90.4	97.8	98.7	100
<10 µm					

Regulatory Void

- 7 to 10 years away from full implementation with specific standards, technology approvals, and compliance monitoring.
- Best management practices do not significantly slow down the spread of AIS.
- There is a need for
  - interim,
  - Contingency, and
  - emergency treatment.

A Mobile BWT System



- Bleach biocide
- Sodium thiosulfate neutralizer

Why would a US shipowner install a ballast system when:

- Systems have been developed primarily for saltwater and this ship operates exclusively in freshwater.
- The size and scope of the ship is unique.
  - Produced a technical paper by Naval Architect firm that small ship owners can review. They do not have the resources of large ship-owners.
  - Generates US test data for suitability of a saltwater system for freshwater application.
  - Provides a test platform for other work in compliance and treatment development.
  - Early adopters can change the relationship with the vendor from strictly a business relationship to a partnership for meeting the needs of a unique situation.

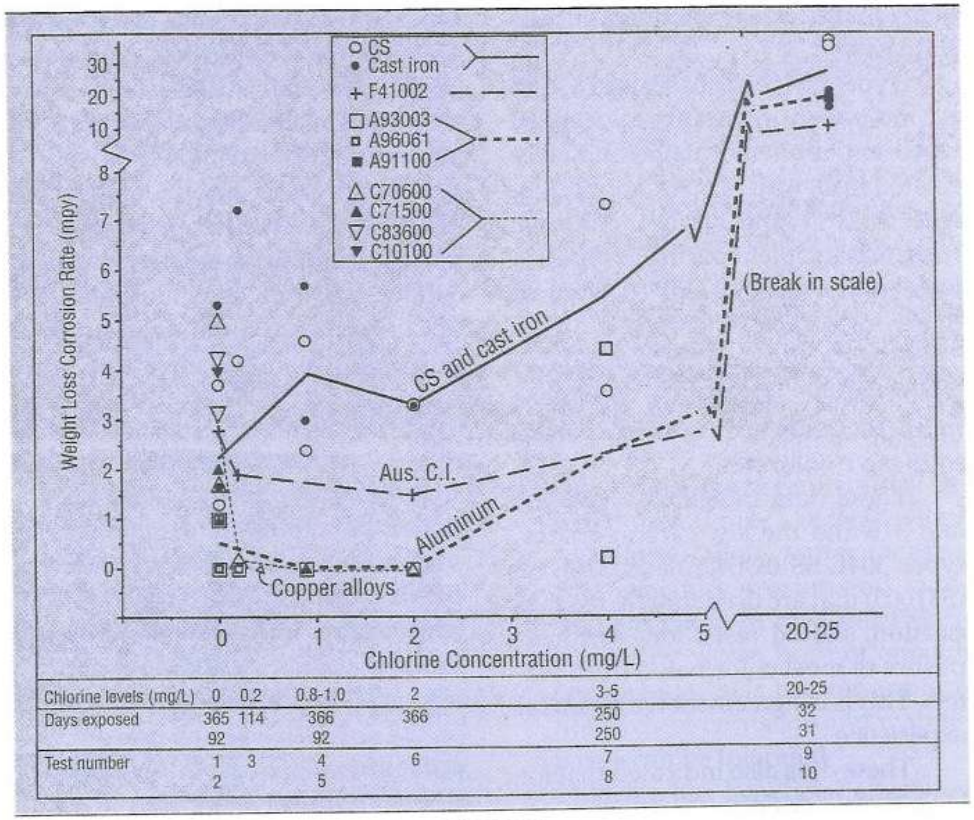

INDIANA HARBOR

30 Seconds

1 minute

8 minutes

Freshwater Chlorine Corrosion



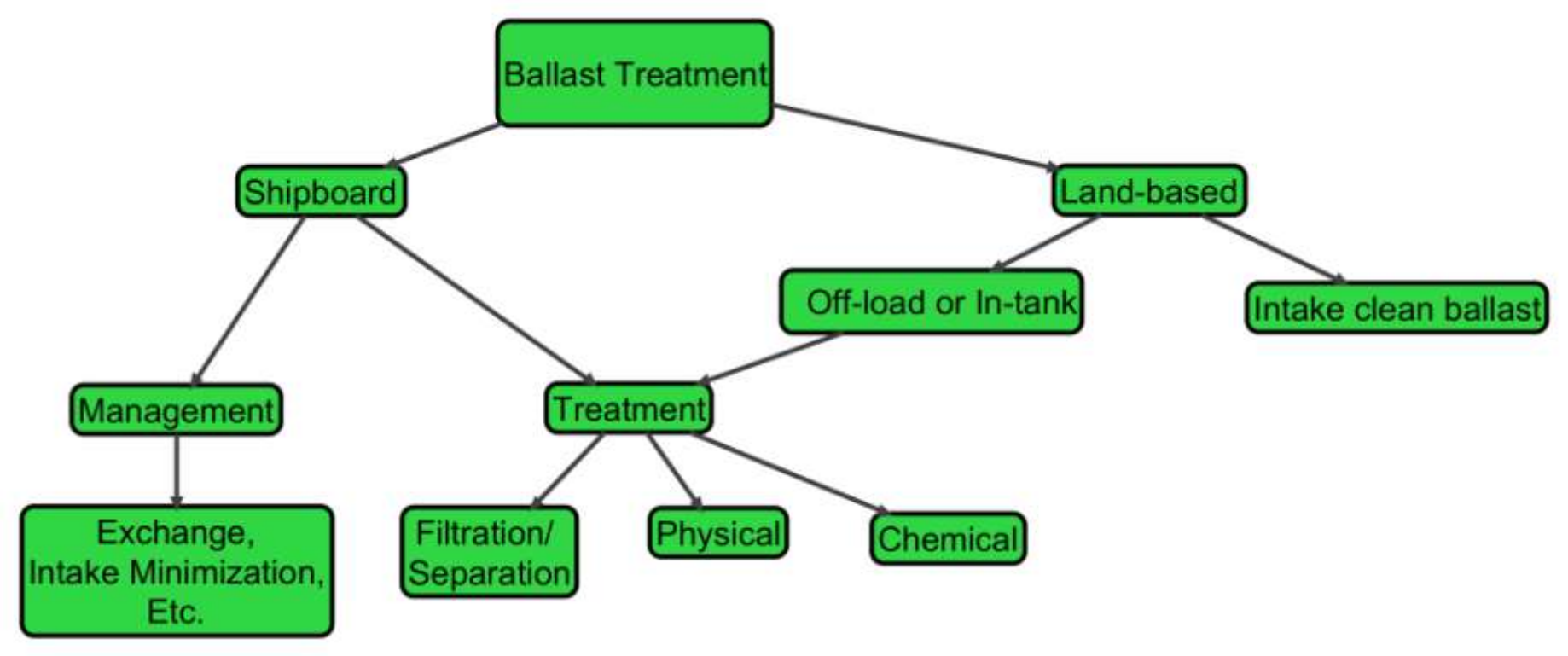
Chlorine levels (mg/L)	0	0.2	0.8-1.0	2	3-5	20-25
Days exposed	365 92	114	366 92	366	250 250	32 31
Test number	1 2	3	4 5	6	7 8	9 10

FIGURE 2

Corrosion Behavior of Various Alloys in Raw and Chlorine-Treated Fresh Water.
The four 0 ppm to 2 ppm residual chlorine tests were made at Rochester, New York, but the chlorine content was not reported in the original work. The plant is reporting 23 ppm chlorides currently. The fifth test was made at a Midwest treatment plant at which site the original data included 790 ppm chlorides.

Arthur H. Tuthill, R.A. Avery, S. Lamb and G Kobrin, “Effect of Chlorine on Common Materials in Fresh Water”, *Materials Performance*, November 1998, NACE, Houston, TX.

Numerous avenues to clean ballast



U.S. Chlorine Estimated Chlorine Consumption

	Consumption in the Sector (tons/yr)	G.L. Watershed (tons/yr)
Water Intake and Wastewater Treatment	409,000	54,400*
Drinking Water Treatment	146,000	19,400
Household Bleaching/Swimming Pool Use	290,000	38,600
Total Consumption (all uses)	13,684,000	1,820,000
Estimated Potential Use for Ballast		-- 34
Treatment		

- Notes
- 1. Amounts shown are expressed as tons/year of chlorine (Cl^2)
- 2. U.S. chlorine consumption is based on 1997 data provided by the Chlorine Chemical Council
- 3. Great Lakes consumption is extrapolated from the U.S. consumption, using the 1991 ration of total U.S. and Canada population in the Great Lakes Watershed to total U.S. population (ratio = 0.133
- 4. Ballast water treatment usage estimate is based on a 5 mg/l chlorine dosage rate, and assumes that all ballast water entering the Great Lakes is treated, including salt water ballast and water remaining in the tanks of NOBOB vessels.

- *At least 500 tons/year of chlorine is used for zebra mussel control at water intakes.
- Source: Bill McCraken, Michigan Department of Environmental Quality, May 2000.

IMO scheduled implementation September 2018

- Leaders in industry have implemented shipboard installments- FedNav
- Canadian ships will start installs to be in compliance with IMO.
- A handful of US ships are installing and finding solutions prior to USCG type approvals (Only one system is USCG type approved for fresh, salt and brackish-Optimarin)

A Mobile BWT System

- NPS has helped coordinate researchers at Michigan Technological University and U.S. Geological Survey among others in the design of a skid-mounted ballast treatment system that relies on the use of biocides to treat ballast in emergency situations.
- The US Maritime Administration funded the fabrication of a prototype by naval architects at Glosten.

National Park Service
U.S. Department of the Interior

EXPERIENCE YOUR AMERICA


MOTT
HOBART

Reducing uncertainty and risk for early adopters & preparing for long term needs

- IMO is evaluating how to work with early adopters to not have financial penalties if system fails.
- USCG is slow to type approve or may restrict systems to certain water conditions to ensure discharges can meet standard.
- New technology and the human factor: there will be failures.