Uncovering How Clean is Clean: Great Lakes Invasive Species

A collaborative project of the Northeast-Midwest Institute's Great Ships Initiative

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Project Rationale

- **There is a desire to reduce concentrations of live organisms in ballast water discharge to eliminate ship-mediated AIS invasions.**
- Premise: densities of live organisms (including AIS) arriving (**release**) influences probability of establishment (**risk**) (Ruiz & Carlton, 2003).
- National Research Council report (NRC, 2011) explored scientific basis for BW discharge standards:
  - Profound lack of data on the **risk-release** relationship across species, time, and environments, on which to base discharge standards.
  - Proposed path forward:
    - Use IMO standard as a starting point
    - Conduct research:
      - Short-term mesocosm experiments.
      - Longer-term (decadal) field surveys.
  - Little guidance on how to implement research productively.

Project History

- NEMWI, UWS already researching topic.
  - UWS-LSRI' s TenEyck conducted mesocosm studies for Ph. D dissertation with UMD's Branstrator
  - NEMWI's Cangelosi Served on NRC Risk Release Panel;2010: 2011-2013: NEMWI (Cangelosi) with UWS (TenEyck) submit GSI collaborative GLPF proposal)
- GSI team receives 2 year GLPF funding for "Phase 1", i.e., methods development
- Project team receives 2 year GLPF funding for "Phase II", i.e., methods validation

Project Objective

- Explore feasibility of determining the risk-release relationship in a Laurentian Great Lakes harbor using a combination of mesocosm experiments and field surveys;
  - If feasible, develop methods for doing so;
  - If possible, generate initial data on the relationship

Ultimately we aimed to make recommendations on the feasibility of our approach for broader applications in the Great Lakes region and elsewhere.

Characterizing Risk-Release Relationship Using Field Surveys

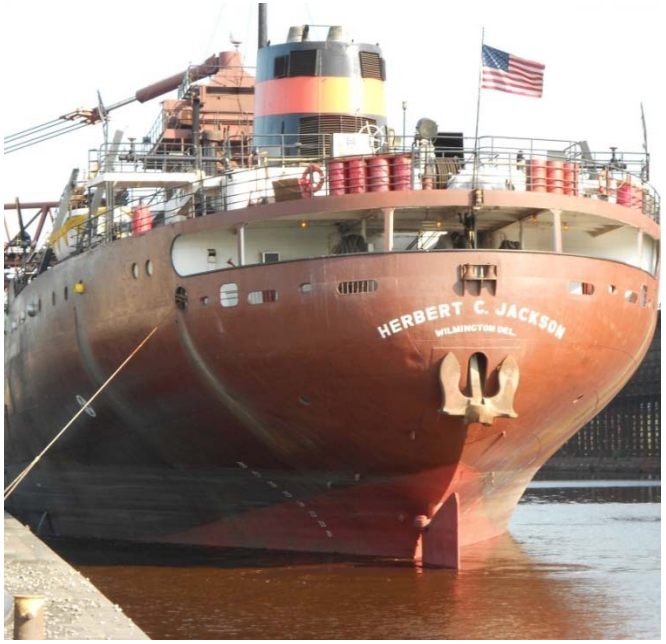



Photo Credit: Jeff Elliot NOAA


http://nas.er.usgs.gov

Validation of Tools used in Field Surveys

- Project Experiments:
  - Identify a target organism
  - Explore role of opportunity mapping for targeting ships/sampling sites
  - Validate genetic detection using eDNA as a screening method (preserved and raw samples)





Significance - Field Survey Results

Findings show:

- Harbor/BW quantitative screening for in-coming organisms likely feasible given:
  - *Target organisms*
  - *e*DNA as a screening tool (raw water samples)
  - Microscopic enumeration samples with eDNA hits
  - Time, replicates across harbors
    - should be decadal,
    - three or more locations in basin
- Identification of target receiving environments may or may not be feasible depending on
  - specialization of organism
  - Geophysical features of receiving systems
  - eDNA screening of receiving system water may be feasible alternative to conventional survey approach

Overview of Experimental Objectives for Mesocosm Methods Development

- Simultaneously fill multiple replicate mesocosms with natural Duluth-Superior Harbor water.

Duluth-Superior Harbor

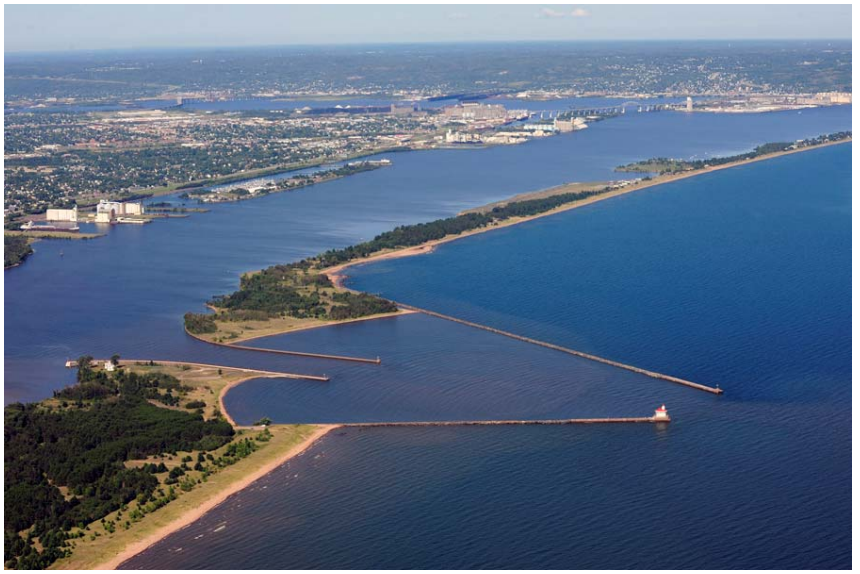


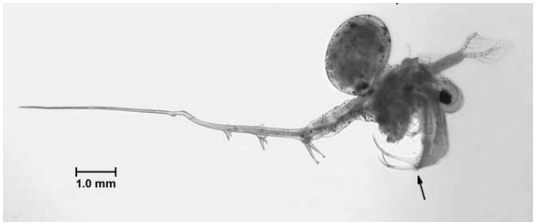
Photo credit: Army Corp of Engineers

- Determine trial duration and ability to recover 'invaders' based on:
  - life history/physiology
  - sample collection procedures

- Verify growth is possible under experimental conditions.

Surrogate Invaders

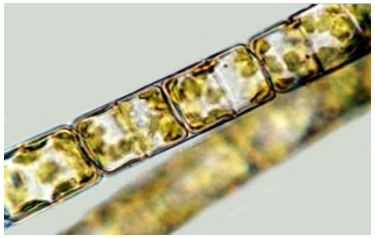
Bythotrephes longimanus
(Crustacea: Cladocera)



1000-L mesocosms,
2-week incubations

Carnivore

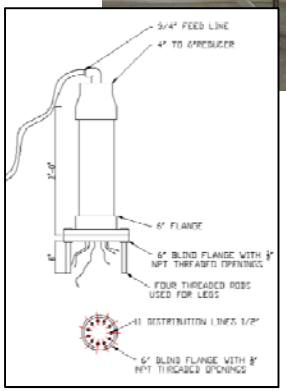
Melosira varians
(Protista: Bacillariophyta)



19-L mesocosms,
4-week incubations

Primary
producer

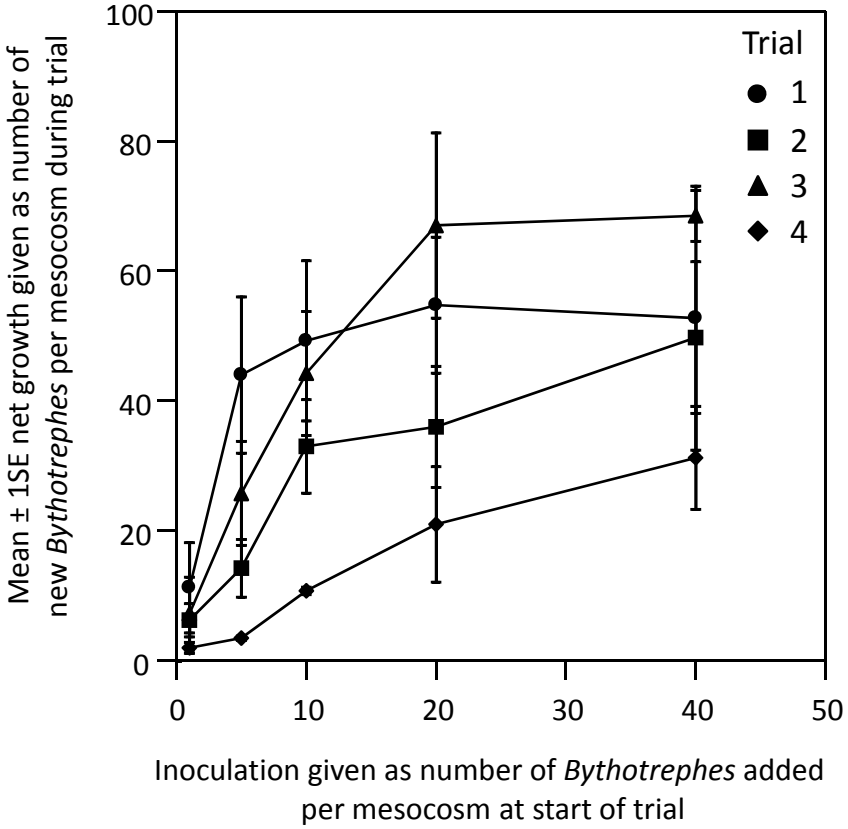
Mesocosm Tank Filling



Verification of growth

- *Melosira* – Multiple trials had positive growth.
- *B. longimanus* - reduced light levels (tanks covered and wrapped in black plastic) growth and reproduction occurred.
  - We see more 2nd and 3rd instar *Bythotrephes* after two weeks
  - Approximately 2x more *Bythotrephes* recovered
- Importance of keeping results in perspective
  - Highly preliminary; still sparse data
  - Not a natural system
  - Many variables can influence survival/reproduction

Bythotrephes results



Summary

Methods adequate to begin to examine risk-release relationship:

- Simultaneously fill multiple replicate mesocosms with natural Duluth-Superior Harbor water.
- Determine trial duration and ability to recover ‘invaders’.
- Verify growth is possible under experimental conditions.

We are beginning to characterize to the relationship between establishment probability and propagule-pressure of the aforementioned test species.

Significance of Results - Mesocosms

- Opportunities:
  - Replication
  - Control
  - Organism recovery
  - Containment
  - Assessment of environmental and demographic factors.
- Limitations:
  - Mesocosm volume
  - Experimental duration
  - Population sizes achieved
  - Life-cycle completion