Strategies and challenges in detecting non-indigenous species (NIS) in the Great Lakes

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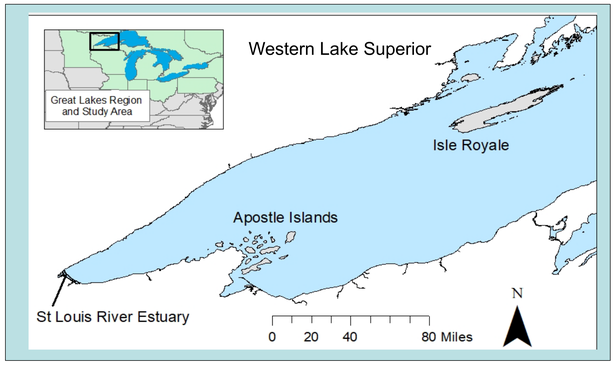
Background

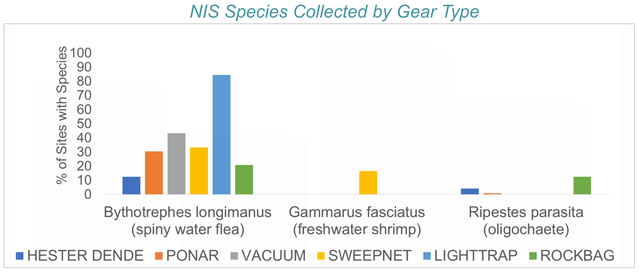


Great Lakes coastal systems are vulnerable to introduction of a wide variety of non-indigenous species (NIS). To increase detection of NIS in Western Lake Superior, the U. S. EPA and partners have implemented a variety of strategies including deploying a wide range of gear types, conducting high intensity sampling, and performing DNA analysis of tissue and water samples. This research has been conducted in remote areas of Lake Superior such as Isle Royale and Apostle Islands, as well as the St. Louis River Estuary, which has the most ship traffic in the Great Lakes.

Multiple Gears: Macroinvertebrates in Isle Royale

- *Remote, largest island in Lake Superior, with ~18,000 annual visitors to Isle Royale National Park*
- *252 sites in nearshore areas, Spring and Summer 2012*
- *Goal: To compare how gear type influences NIS detections*
- *Gear:light traps(52), sweepnet (18), hester dende (24), vacuum(30), rock bag (24), PONAR (105)*

NIS Species Collected by Gear Type



Results

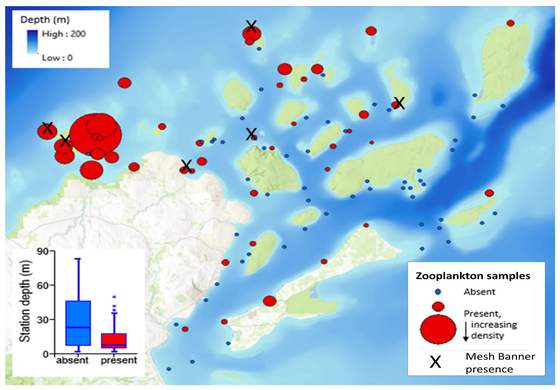
- 3 NIS species collected
- No single macroinvertebrate gear found all 3 NIS species
- Light traps captured spiny water flea at significantly more sites compared to other gear types

High Intensity Sampling: Dressenids in the Apostle Islands

- *Cluster of islands, frequented by motorized and non-motorized boats*
- *Before study, only a few cases of adult dreissenids had been found on shipwrecks by National Park Service*
- *50 random and 50 targeted sites, sampled in 2015*

Results

- Dreissenids (zebra or quagga mussels) found in 43 zooplankton samples using morphological ID
- Zebtra mussel DNA present in 6 mesh banners deployed for weeks and spanning numerous depths
- Follow up study indicated source of veligers (dreissenid larvae) may be St. Louis River Estuary due to movement by summer currents

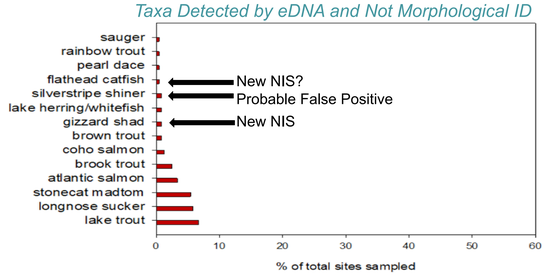


Map of Dreissena detections. Veligers found at very low densities (max 39/m^3, most <5/m^3). DNA detections were also at very low concentrations.

Environmental DNA: St Louis River Estuary

- **Most ship traffic of any port in Great Lakes**
- **240 sites, Spring and Summer 2016**
- **Water samples analyzed for DNA using Illumina Miseq (16s marker)**

Taxa Detected by eDNA and Not Morphological ID



Results

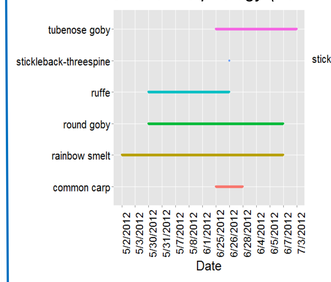
- 3 fish species found using DNA analysis of water samples had never previously been found in system
- **Gizzard shad** was later found in 2017.
- **Flathead catfish** may represent a new NIS taxa, as some flathead catfish may have been previously MisIDed as bullhead catfish
- **Silverstripe shiner** likely is not present and represents a false positive due to inability to differentiate between shiner species

DNA Metabarcoding

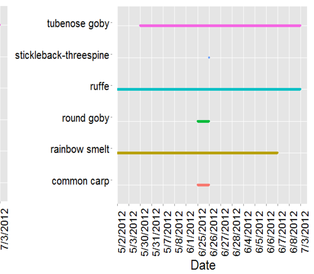
Larval fish: St Louis River Estuary

- **Multiple surveys (2012-2017)**
- **Tissue samples analyzing using Illumina Miseq (CO1); morph ID compared to DNA ID**

NIS Taxa-Morphology (2012)



NIS Taxa-DNA (2012)



Results

- DNA improved understanding of spatial and temporal patterns of NIS
- Larval fish notoriously hard to identify; DNA suggested ~42% of larvae were misIDed
- DNA found two new NIS species in larval tissue (2015), **white bass** and **gizzard shad**, before they were detected with traditional fish surveys.

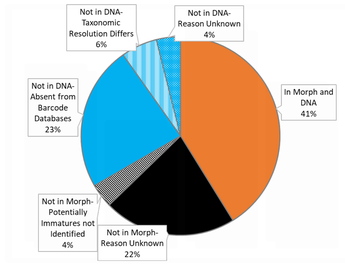
Zooplankton: Lake Superior

- **Nearshore and offshore, and deep water sites**
- **42 sites, Spring and Summer 2012**
- **Tissue samples analyzed using Ilumina Miseq (CO1,16s, and 18s); compared to morph ID**

Results

- 23% of zooplankton species were not detected using DNA because they were absent from online barcode databases
- For those species detected, probability of detection determined using occupancy analysis wa higher for DNA versus traditional ID: 55% versus 33%
- 4 potential new NIS species found; verification needed because potential for DNA false positives

Probable Reasons for Potential Mismatch between Species-Level Taxa Identified Using Traditional Morphology versus DNA



Summary

- A combination of strategies, including 1) multiple gear types, 2) high intensity sampling designs, and 3) DNA analysis of water samples and tissue have been used to identify NIS taxa in Lake Superior before they have become pervasive, and to understand the spatial and temporal patterns of invasion of new and established taxa.
- Lake Superior has fewer NIS species compared other Laurentian Great Lakes. This knowledge can be used to identify the source of past invasions, develop targeted efforts to limit NIS spread, and identify strategies to limit the source of future invaders. It can also be used to improve morphological ID in the future.
- Challenges include 1)expending large time and money towards study design; 2)identifying false positives with DNA data, 3)determining how filtering steps affect false positives and false negatives, and 4)choosing appropriate primers for DNA analysis

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