Dead giveaway:
Changes in mortality rates signal grass carp control strategy effectiveness

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• Grass Carp reproduction similar to other FMCC
• All enter rivers during high flow to spawn
Grass Carp ecology and history differs from other FMCC

- Eat plants, may damage wetlands
- Only FMCC known to reproduce in Great Lakes

https://www.youtube.com/watch?v=HRwoZdRzXFo&app=desktop
Timeline of grass carp in US

- **Imported to U.S. to control aquatic vegetation** (1963)
- **Triploid (sterile) grass carp developed** (1981)
- **Reports of grass carp captured by commercial fishers in Lake Erie** (1980’s)
- **Diploid grass carp that originated from the Sandusky River were captured** (2012)
- **Grass carp eggs found in the Sandusky River** (2015)
- **First strike teams deployed, grass carp larvae found in Maumee River** (2018)
Why are grass carp considered a threat?

- Grass carp captures have increased in recent years
- Most grass carp captured in the western basin are diploid
- Grass carp harm aquatic ecosystems when abundant
- Eat up to 100% of body weight per day
Project goals

• Remove GC from Lake Erie and tributaries
• Determine if removal is reducing population
  • How many fish are there?
  • Is removal affecting the population?
Variability in collection and data

- Commercial- incidental, voluntary, incentives
- Ongoing, removal
  - Sustained (sampling) and targeted (hunting)
  - Usually electrofishing and trammel net
- Evolving protocol
- Adapt to flow and weather
- Many participants!
Effort to manage grass carp is increasing

Total sampling days by agency
Initial Goal: Harvest 395 grass carp/year

Grass carp captured in Lake Erie, 2012-2021
## 2021 Lake Erie Grass Carp catch

<table>
<thead>
<tr>
<th>River</th>
<th>Fish removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandusky</td>
<td>104</td>
</tr>
<tr>
<td>Maumee</td>
<td>46</td>
</tr>
<tr>
<td>Lake Erie</td>
<td>1</td>
</tr>
<tr>
<td>Huron</td>
<td>2</td>
</tr>
<tr>
<td>Grand</td>
<td>5</td>
</tr>
<tr>
<td>Detroit</td>
<td>1</td>
</tr>
<tr>
<td>Cuyahoga</td>
<td>5</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>168</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Count (MI &amp; OH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial/Other</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Commercial/Other
Project goals

• Remove GC from Lake Erie and tributaries
• Determine if removal is reducing population
  • How many fish are there?
• Is removal affecting the population?
We have catch numbers

We want the number of fish present

Estimate number GC present in Sandusky River

https://epa.ohio.gov/dsw/tmdl/SanduskyRiver
Estimate number GC in Sandusky with Bayesian process

**Removal**
- data = 0/1

**Prior**
- detection probability via depletion study

**Estimation Model**
- probability of at least one GC in the sampling area
- scale to shoreline length
Little change in model GC abundance at a given time across three years. 2021 coming soon.
Project goals

• Remove GC from Lake Erie and tributaries
• Determine if removal is reducing population
  • How many fish are there?
  • Is removal affecting the population?
How has mortality rate changed?

Objectives:
- Age all grass carp captured in the Lake Erie Basin
- Examine changes in mortality over time using two methods: catch curve analysis and multilevel linear modeling
Catch-curve analysis estimates mortality

- Log number fish at successive ages
- < age-6, incompletely sampled
- Descending limb = decline in successive age classes
- Total annual mortality ($A$)

\[ A = 1 - e^{-Z} \]
Mortality estimates increasing, but high uncertainty

Grass Carp Mortality Rates, 2014-2021

Mortality Rate (95% CI)

Year


14 8 25 30 31 160 108 137
Before and after control suggests mortality is increasing.

**Grass Carp Mortality Rates**
Before (2012-2016) and After (2017-2021) Control Strategies

Mortality Rate (95% CI)

- Before: 39
- After: 443
Multilevel Modeling Analysis

- Estimate mortality with multilevel linear model
  - all age classes and years at once
- “Shrinks” each years mortality rate towards the overall mean
- Can correlate annual mortality with the total measures of fishing effort
Multilevel linear modeling groups data

Fish harvested  Effort (days)

Mortality (relative to overall mean)

Year

Age Class

Age class

Age Class

Age Class

Count

Count

Count
Preliminary: Mortality correlated with number of fish harvested per year

Mortality by grass carp harvested per year, 2014-2021
Cause for cautious optimism

- Removal effort is increasing
- Number of GC in Sandusky not changing
- Mortality higher after control (although variance also high)
  - Future work quantifying effort
  - Relatively short time span—keep going!
Thanks!

Funding Sources

Partners