Impacts of Multiple Stressors on Fish Production in Saginaw Bay

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Percids in Saginaw Bay

- **Walleye**
  - Historically important
  - Collapsed ~1950
  - Stocking initiated ~1980
- **Yellow perch**
  - Highly variable
  - Sport and commercial fisheries
- Recent collapse of L. Huron alewives has led to improved reproductive success, but poor growth and long-term survival.

*Fielder and Thomas 2006 MI-DNR; Fielder et al. 2007 JGLR*
Fisheries Management Objectives

- Management of dominant percid (walleye and yellow perch) populations and their associated fisheries
- Manage for diverse ecosystem, fish community and fisheries
- Restoration of native species and control of non-natives
- Manage for long-term sustainability
Manager Workshop (Winter 2008)
5 Research Priorities

1a-b) Walleye and yellow perch recruitment dynamics (early life factors affecting survival to later age...incl. habitat effects)

2a) Ecological connections between Saginaw Bay and Lake Huron

2b) Suitability of SB for lake herring

2c) Fish community dynamics
Saginaw Bay AIF

Ecosystem Stressors
- Land & Resource use
- Climate Change
- Invasive Species

Ecosystem Characterization
- Watershed model
- Hydrodynamic model
- Biophysical data and processes

Ecosystem Models
- Simple statistical (e.g., regression)
- Artificial Neural network
- Empirically based (Bayesian)
- Coupled biophysical 3D models

Ecosystem endpoints
- Fish community dynamics
- Water quality & Human health

Socio-economic integration to guide management
- Economic models
- Public preference
- Workshops

Recommendations for ecosystem characterization
- Experimental
- Monitoring
- Synthesis
Michigan DNR fall trawl surveys (1970-present)
Dynamic Factor Analysis (DFA)

- Smoothing technique
- Reduces n time series to m common trends
- Compares trends not values
- AIC to select how many common trends exist
Results- Long-term Trawl

Trend 1

Trend 2
CPUE Analysis

Graph showing trends over time (1980-2000) with Y-axis values from -0.4 to 0.4. The graph includes bars for yp-0, yp-1, yp-2, wae-0, wae-1, and wae-2.
Length Trend Analysis
Recruitment - Walleye

![Graph showing the relationship between Age-0 CPUE and Age-1 CPUE, Age-2 CPUE, and Age-1 CPUE. The graphs illustrate the trend with markers for different age categories: 80-89, 90-99, and 00-06. The plots show a linear correlation with increasing CPUE values.](image-url)
Recruitment - Yellow perch

* *
Density Dependence - Yellow perch

Age-0 CPUE vs Age-0 Length

Age-1 CPUE vs Age-1 Length

Age-2 CPUE vs Age-2 Length

* *
Density Dependence - Walleye

- Age-0 CPUE vs Age-0 Length
- Age-1 CPUE vs Age-1 Length
- Age-2 CPUE vs Age-2 Length

Legend:
- 80-89
- 90-99
- 00-06
Overwinter Survival

Yellow perch

Age-0 Length vs. Age-1 CPUE

Walleye

Age-0 Length vs. Age-1 CPUE
Implications of Analyses

– Walleye recruitment set by fall of age-0
– Yellow perch recruitment related to size at age-0

*Focus on early life survival and growth of percids through age-1*

*What are primary predators, prey, and competitors?*

– No cisco information

*Lake whitefish as surrogate*

Rutherford/Madenjian also exploring hatching success of cisco
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Ecosystem Stressors

Ecosystem Models

Ecosystem Characterization

Recommendations for ecosystem characterization

Socio-economic integration to guide management
Physical Characteristics of Bay

Temperature °C ± s.d.

Inner

Outer

Secchi Depth (m) ± s.d.

Inner

Outer
2002 age-0 Otolith Cores

Lake Michigan

Muskegon Channel

$\delta^{18}O$

$\delta^{13}C$

DuFour, Höök, Rutherford and Patterson CJFAS 2005
Zooplankton

- **Offshore:**
  - 180 vertical tows (64 μm, 103 at master sites)
  - 28 oblique tows for predators (333 μm, all at master sites)

- **Nearshore:**
  - 2 tows at each site (48 samples total)

- **Saginaw River:**
  - 5 vertical tows (64 μm)

- **Predatory samples completed**
Predatory Zooplankton

Preliminary: lots of large-bodied zooplankton...Brooks and Dodson in reverse???
Benthic Macroinvertebrates: Two sampling programs

1) Purdue/GLERL
   - 2 full ponars per master site
     - At least once/month (more in July)
   - 1 petite ponar per nearshore site visit
   - Sorted and identified to Order or Family
     - 64 offshore samples, 3 left to sort
     - 25 nearshore samples, all sorted
     - Nearshore samples slightly more diverse (mainly in insects)

2) GLERL/USGS
   - Focus on long-term trends
     - Ponar sampling
     - Diver surveys on hard substrate
Numbers of Benthic Macroinvertebrates

Average number in sample (n=2)

Site and month

- Unknown
- Trichoptera
- Tabanidae
- Sphaeriidae
- Pupae
- Oligochaeta
- Nematoda
- Isopoda
- Hirudinea
- Gastropoda
- Ephemeroptera
- Elmidae
- Dreissenidae
- Chironomidae
- Amphipoda
Invert Biomass

• Length of macroinvertebrates  
  – Up to 10 of each taxon/sample

• Mass of worms (Oligochaeta)  
  – Most of them are in pieces

• About 1/3 of lengths complete
Burrowing Mayflies

- One Hexagenia (small) at SB5 in October
- Several Ephemera (small and larger) at SB5 in October
- Adult Hexagenia in larval fish samples from N-1 and SB10 in late June/early July
### Dreissenid densities from Hard Bottom Diver Surveys (Tom Nalepa)

<table>
<thead>
<tr>
<th>Year</th>
<th>Inner Bay Density</th>
<th>Inner Bay Biomass</th>
<th>Outer Bay Density</th>
<th>Outer Bay Biomass</th>
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<tbody>
<tr>
<td>1991</td>
<td>9,305 ± 6,389</td>
<td>12.3 ± 7.6</td>
<td>3,408 ± 2,772</td>
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<tr>
<td>1992</td>
<td>31,334 ± 15,627</td>
<td>58.6 ± 28.1</td>
<td>4,695 ± 2,542</td>
<td>19.5</td>
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<tr>
<td>1993</td>
<td>3,803 ± 1,592</td>
<td>4.5 ± 2.1</td>
<td>5,813 ± 2,384</td>
<td>15.3</td>
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<tr>
<td>1994</td>
<td>5,633 ± 1,945</td>
<td>9.2 ± 2.4</td>
<td>9,925 ± 1,590</td>
<td>32.6</td>
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<tr>
<td>1995</td>
<td>2,562 ± 1,126</td>
<td>4.9 ± 1.6</td>
<td>3,824 ± 525</td>
<td>27.1</td>
</tr>
<tr>
<td>1996</td>
<td>5,261 ± 3,242</td>
<td>14.7 ± 6.4</td>
<td>6,981 ± 1,670</td>
<td>57.5</td>
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<tr>
<td>2008</td>
<td>538 ± 103</td>
<td>2.0 ± 0.4</td>
<td>596 ± 54</td>
<td>3.9</td>
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<tr>
<td>2009</td>
<td>421 ± 90</td>
<td>TBD</td>
<td>411 ± 55</td>
<td>TBD</td>
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</table>

Mean density (no. per m²) and biomass (tissue ash-free dry weight per m²) of Dreissena at sites in Saginaw Bay where divers collected samples in late summer/fall of each year. Variance term is standard error determined from station means in the inner bay, and from individual replicates (3) in the outer bay. Densities in 2009 are preliminary. TBD = to be determined.
Larval Fish Sampling

- **Offshore:**
  - 490 Bongo Net Samples (378 picked, 251 jars ID’d)
  - 21 Neuston Net Samples in many jars (53 picked)

- **Nearshore:**
  - 72 Push Net Tows in many jars (57 picked, 2 jars ID’d)

- **Saginaw River:**
  - 18 Bongo Net samples (6 picked, 2 jars ID’d)
Larval Fish Processing
Larval Fish Processing (on-going)

- Identify fish to lowest taxonomic level

- For yellow perch, lake whitefish and walleye:
  - Measure length
  - Examine diets and otoliths

[Image of larval fish with scale of 1mm]
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<tbody>
<tr>
<td>Burbot</td>
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<td>Carp</td>
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<td>Catostomidae</td>
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<tr>
<td>Clupeidae</td>
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<td>Deepwater sculpin</td>
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<tr>
<td>Lake whitefish</td>
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<tr>
<td>Moronidae</td>
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<td>Quillback</td>
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<td>Rainbow smelt</td>
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<td>Spottail shiner</td>
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<td>Trout-perch</td>
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<tr>
<td>Walleye</td>
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<tr>
<td>White sucker</td>
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<tr>
<td>Yellow perch</td>
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</tbody>
</table>

n = 6 141 94 142 1157 529
Larval fish per 1000 m$^{-3}$

- 4/13
- 4/20
- 4/27
- 5/4
- 5/11
- 5/18

**All Fish Species**

<table>
<thead>
<tr>
<th>TOTPER1000</th>
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<tbody>
<tr>
<td>0.000000</td>
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<tr>
<td>0.000001 - 1.000000</td>
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<tr>
<td>1.000001 - 10.000000</td>
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<tr>
<td>10.000001 - 100.000000</td>
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<tr>
<td>100.000001 - 500.000000</td>
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<tr>
<td>500.000001 - 1000.000000</td>
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</tbody>
</table>

North orientation and scale: 0 - 120 Kilometers
Lake whitefish larvae per 1000 m$^{-3}$

Rutherford/Madenjian also exploring hatching success of cisco
Walleye larvae per 1000 m$^{-3}$
Yellow perch larvae per 1000 m$^{-3}$

**Key:**
- Yellow perch

**Legend:**
- YEPPER1000
  - 0.000000
  - 0.000001 - 1.000000
  - 1.000001 - 10.000000
  - 10.000001 - 100.000000
  - 100.000001 - 500.000000
  - 500.000001 - 1000.000000

**Dates:**
- 4/13
- 4/20
- 4/27
- 5/4
- 5/11
- 5/18

**Note:**
- The maps show the distribution of yellow perch larvae at different times, with the density indicated by the size of the circles.
Larval Yellow Perch Lengths (mm)

Week of 4/27
- Count: 2

Week of 5/4
- Count: 33

Week of 5/11
- Count: 384

Week of 5/18
- Count: 101

Proportion of Count
Adult and juvenile fish

• 110 total bottom trawls at master sites (monthly)
• Seine collections at nearshore sites (biweekly, monthly)
  – Species identified, counted, and measured
  – Diets and energy densities
• Completed:
  – Age 1+ walleye
• Underway:
  – Age 0 walleye, rainbow smelt, lake whitefish, etc.
Age-1 + walleye diet - fish only (% by number)

Spring = May, June
Summer = July, August, September
Fall = October, November
Overview and Future Plans

• 2009
  – Zooplankton, benthic invertebrates, larval fish, adult fish, and water samples
  – These data feed into SAGEM and IBM

• 2010
  – Absolutely critical to sample in 2010 to collect fish (esp. perch and walleye) to assess overwinter mortality, and to collect fish from 2010 year class to assess overwinter mortality in 2011 spring