Experimental analysis of an early life history stage: Magnitude of loss and size-based survival of larval lake sturgeon

Patrick Forsythe, Jamie Crossman, Kim T. Scribner, and Ed Baker
Barriers to Lake Sturgeon Recruitment

Recovery and Rehabilitation?

- Many states have developed rehabilitation plans for lake sturgeon
- Research has been initiated
- Recruitment is still low
- Many lake sturgeon populations have not recovered from early decline

Lack of recruitment suggests:
1) Barriers to natural reproduction
2) During critical early life stages
Unique Study Site - Black Lake, MI

Black Lake

Upper Black River
Unique Attributes

- Fish spawn throughout a 1 mile stretch of river
- Sturgeon are easily visible from stream back
- Location is consistent on an annual basis
- Experimental manipulation
Critical Life History Stages
- Stages Potentially Limiting Natural Reproduction -

EGGS
LARVAE (Pre-Drift)
ADULTS

Abundance

Time

Spawner Abundance

<table>
<thead>
<tr>
<th>Year</th>
<th>Total # of Spawners</th>
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<tbody>
<tr>
<td>2001</td>
<td>115</td>
</tr>
<tr>
<td>2002</td>
<td>104</td>
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<tr>
<td>2003</td>
<td>121</td>
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<td>2004</td>
<td>100</td>
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<tr>
<td>2005</td>
<td>154</td>
</tr>
<tr>
<td>2006</td>
<td>234</td>
</tr>
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</table>

Sex Ratio

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex Ratio (Males:Females)</th>
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<tbody>
<tr>
<td>2001</td>
<td>1.50</td>
</tr>
<tr>
<td>2002</td>
<td>2.06</td>
</tr>
<tr>
<td>2003</td>
<td>1.95</td>
</tr>
<tr>
<td>2004</td>
<td>3.00</td>
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<tr>
<td>2005</td>
<td>2.30</td>
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<tr>
<td>2006</td>
<td>2.54</td>
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</tbody>
</table>
Critical Life History Stages
- Stages Potentially Limiting Natural Reproduction -

Abundance

EGGS

Egg Survival

Time 1
Time 2

Total Number of Eggs

-3 -2 -1 0 1 2 3

PCA1

Proportion of Eggs Surviving

0
0.2
0.4
0.6
0.8
1
1.2

Substrate Size

LARVAE (Pre-Drift)

LARVAE

ADULTS

Probability of Survival

0
0.2
0.4
0.6
0.8
1
1.2

Substrate Size

Time

1118
2115
1118
2115

Probability of Survival

0
0.2
0.4
0.6
0.8
1
1.2

Substrate Size

PCA1

Proportion of Eggs Surviving

0
0.2
0.4
0.6
0.8
1
1.2

Substrate Size

PCA1

Proportion of Eggs Surviving
Critical Life History Stages
- Stages Potentially Limiting Natural Reproduction -

Abundance

Time

EGGS

LARVAE (Pre-Drift)

LARVAE

ADULTS

Magnitude of Loss

Probability of Survival

Barrier?
Study Objectives

Objective 1: Determine drifting behavior of larvae
Objective 2: Estimate the magnitude of loss as larvae drift from spawning grounds
Objective 3: Test for size-based survival
Objective 4: Determine the role of predation in loss with laboratory experiments

Future Objectives:
Objective 5: Identify family specific dispersal behavior and survival
Drift net sampling was conducted during 2005 and 2006 at two sites on the UBR.

Five nets were deployed at each location.

We conducted at least 10 nights of simultaneous sampling each year.

Five hours of sampling at each site offset by one hour.

Larvae were counted after each hour and in each net at both sites.

Measurements of depth and flow were taken across the entire site and in front of each net.
Objective 1: Examine the dispersal behavior of larval sturgeon

Hypothesis 1: Subset of larvae leave spawning ground each evening

Hypothesis 2: Larvae disperse each evening but dispersal is extended
Objective 1: Examine the dispersal behavior of larval sturgeon

2005

2006

Number of Larval Sturgeon

SITE C
SITE D
SITE E

Number of Larval Sturgeon

0 500 1000 1500 2000 2500 3000 3500

21:00-22:00 22:00-23:00 23:00-24:00 24:00-01:00 01:00-02:00 02:00-03:00
Objective 2: Estimate the magnitude of loss (Based on Relative Abundance)

Observed Loss = 2047

Observed Loss = 1182
Objective 2: Estimate the magnitude of loss (Based on Larval Abundance Estimates)

Veshchev et al. (1994)

\[ P = \frac{(q \times N)}{O} \times K \]

- **P** = Number of larvae passing the sampling site
- **q** = is the flow volume (m^3 h^-1)
- **N** = Number of larvae collected in each net after 1h
- **O** = Volume of water sampled (m^3 h^-1)

**K** = Net efficiency

**Estimated Loss = 50377**
Objective 2: Estimate the magnitude of loss (Refining Methods for Estimating Abundance)

\[ P = \frac{(q \times N)}{O} \times K \]

Veshchev et al. (1994)

Questions:

What is K?

Does K depend on net placement, collection site or larval abundance?

Main Point: Obtaining accurate estimates of natural reproduction will be critical for guiding future population specific management activities
Objective 3: Test for size-based survival: Is bigger really better?

**Empirical Evidence:** Studies have demonstrated that the probability of survival is a function of larval size (Miller et al., 1988)

*Why?*
- Performance
- Predator detection
- Increased time to starvation

**Methods**

- 10 larvae from each site were collected every hour
- Larvae were brought back to the stream-side research facility
- Larvae were measured by hand (2005) or digitally imaged and measured against a standard at a later date
- Paired T-test conducted to test for differences in average size
Objective 3: Test for size-based survival - Is bigger really better?

Average Length

SITE C
SITE D

= Bigger is Better

Average Length

2005
Objective 3: Test for size-based survival - Is bigger really better?

= Bigger is Better

2006
Objective 3: Test for size-based survival - Is bigger really better?

2006

Average Length

<table>
<thead>
<tr>
<th></th>
<th>SITE D</th>
<th>LENGTH_E</th>
<th>REDBRIDGE</th>
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</thead>
<tbody>
<tr>
<td>Site D</td>
<td>21.5</td>
<td>20.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Site E</td>
<td>20.5</td>
<td>20.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Site B</td>
<td>21.0</td>
<td>20.5</td>
<td>19.5</td>
</tr>
<tr>
<td>Site C</td>
<td>21.5</td>
<td>20.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Site D</td>
<td>21.5</td>
<td>20.0</td>
<td>19.5</td>
</tr>
</tbody>
</table>
Objective 4: Determine the role of predation in loss with laboratory experiments

Methods

Larvae (N=10) placed in a blacked out 10 gallon aquaria

Rock bass were used as predators

Predators were acclimated to the tank for at least 24 hours before the trial

Conducted both day and night trials

Number of larvae remaining counted every 15 minutes for first hour
Conclusions

1) Larvae drift at a plug each night moving as far out of the UBR as possible

2) Magnitude of loss during drift is potentially high

3) Mortality may be size-based

4) Predation is likely a significant source of mortality during downstream drift

5) Pulse of larval sturgeon changes in both size and composition

6) Larval stage may be a barrier to reproductive success
Future Research

Genetic Implications of Loss

- Magnitude in loss may lead to decreases in genetic diversity or changes in the contribution of spawning adults
- Over the past several years we reared larvae collected at each site separately
- We have also observed family specific variance in hatching time and emergence
- On two nights, we collected and reared larvae separately by hour
- This will allow us to determine whether a pulse is comprised of related individuals
Acknowledgements

Collaborators
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Questions