Status of razorback sucker in Lakes Mohave and Mead: A conservation genetic perspective

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Funded by:
Background

• Endemic to Colorado River system
  – Formerly very abundant in main channels throughout the drainage

• Most abundant in Lake Mohave
  – Serves as a refuge

• Lake Mead
  – Evidence for recruitment
History of population declines

• Reservoirs fill
  – Populations expand

• Introduction of non-native species
  – Failure to recruit
  – Populations senesce and disappear
  – Demise hastened by large predators
• Genetic diversity decreases with population size
  – Can have negative effects on health of population (e.g., inbreeding depression)
  – Can be used to monitor population size
Objective

- Use molecular markers (microsatellites, mtDNA) to monitor levels of genetic diversity in Lakes Mohave and Mead
Lake Mohave Conservation plan

- Initiated in mid-1990’s
- Capture naturally produced larvae
  - across regions
  - throughout the spawning season
  - Monitor variation in these samples
Sampling

• 17 years worth of data!!!
• Larvae (1997-2013)
  – 300 collections, 7388 individuals
  – Temporally and geographically dispersed
• Adults
  – 303 wild fish
Genetic variation within larval samples over time

- **microsatellites**
  - \( r = 0.257, P = 0.319 \)
- **mtDNA**
  - \( r = 0.837, P < 0.001 \)
- Allelic richness is being maintained or increased over time
Genetic variation within repatriates over time

- **microsatellites**
  - $r = 0.224$, $P = 0.342$

- **mtDNA**
  - $r = 0.439$, $P = 0.053$

- Allelic richness is being maintained or increased over time
Distribution of mtDNA variation among larvae, adults, and repatriates

<table>
<thead>
<tr>
<th>SOURCE</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Among samples within groups</td>
<td>$F_{ST} = 0.003$</td>
<td></td>
</tr>
<tr>
<td>Among samples within life stages</td>
<td>$F_{SC} = 0.004$</td>
<td></td>
</tr>
<tr>
<td>Among life stages</td>
<td>$F_{CT} = -0.001$</td>
<td></td>
</tr>
</tbody>
</table>

No differences among larvae, repatriates, and adults!
Conclusions: Lake Mohave

- All measures of genetic variation consistent among samples of larvae and repatriates
- Variation is being transmitted from larvae to repatriates
- Increasing levels of mtDNA variation over time
We still have a problem!!!

• Despite all of our efforts, population size continues to be an issue

• Problem - ability to maintain genetic variation is constrained by population size

• This will lead to a loss of variation, resulting in decreased adaptability and potential issues with inbreeding
We still have a problem!!

• These estimates are from the basin
• Stocking has established a significant population in the riverine stretch above the basin
• Because of limited movement, riverine fish contribute little to reproduction
• As it stands, this may be a wasted resource

—How do we incorporate these fish into the reproductive population?
Lake Mead

- Essentially extirpated in the 1970s
- Re-appeared in late 1980s – early 1990s
  - Unlike other locations subadults have been found
- Goal
  - Assess patterns of genetic variation
## What’s happening in Lake Mead?

<table>
<thead>
<tr>
<th>Year</th>
<th>Adults (# samples)</th>
<th>Larvae (# samples)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lake Mead</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>1997</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>2002</td>
<td>29 (2)</td>
<td>57 (2)</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>61</td>
<td>50 (2)</td>
</tr>
<tr>
<td>2013</td>
<td>52</td>
<td>77 (4)</td>
</tr>
<tr>
<td><strong>Lake Mohave</strong></td>
<td>50</td>
<td>120</td>
</tr>
<tr>
<td><strong>Flannemouth</strong></td>
<td>25</td>
<td>0</td>
</tr>
</tbody>
</table>
Diversity

• Lower diversity than Lake Mohave
  — mtDNA reduction greater than microsatellites

• Within Lake Mead, lower diversity in more recent samples (2011-13)
Relatedness

- Reduced diversity can be due to increased relatedness
- Increased in Lake Mead in more recent samples (2011-13)

What about variation among populations?
Assignment testing: interpretation

- Color = group identifier
- Columns = individuals
- Height = probability of assignment to specific groups

$k = 4$ (50 replicates)

![Graph](image)
Flannelmouth-razorback sucker hybrids

- Only found in adults
- More frequent in recent samples (2011-13)
  - $X^2 = 71.6$, 6 df, $P < 0.05$
- Most common in the Colorado River inflow
  - $X^2 = 22.6$, 6 df, $P < 0.05$
Population structure

- Two groups of razorbacks
  - Lake Mohave (yellow)
  - Lake Mead (orange)

- Lake Mead group increased in frequency over time (especially in adults)
  - $\chi^2 = 64.1$, 4 df, $P < 0.05$
Conclusions

Lake Mead

- Diversity becoming more reduced in Lake Mead
  - Variation a subset of that found in Lake Mohave
  - Reduction has led to increased relatedness

- Lake Mead diverging from Lake Mohave
  - Impact of drift?
  - As exemplified by flannelmouth-razorback hybrids, increased influx from Grand Canyon?

- In addition to temporal samples, better geographic sampling is needed