Cedar Key Aquaculture Workshop
Report on Genetic Diversity in Florida Commercial Hard Clams, *Mercenaria mercenaria*

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What is genetic diversity?

- In most organisms, the genetic code (DNA) varies slightly between individuals.

|---------------------------|--------------------------------|

- Differences in a DNA fragment, measured across many individuals, are used to estimate genetic diversity within a population.

- Population size, age, history, and connections to other populations can all affect genetic diversity.
Should producers care about genetic diversity?

• Clam producers want high clam performance.

• Enhanced performance (mainly growth and survival) achieved through selective breeding.

• Selective breeding usually reduces genetic variability as a side effect.

• Performance and diversity are difficult to maintain simultaneously.
What is Inbreeding Depression?

• Inbreeding results in an increase of rare and sometimes harmful alleles (gene forms).

• *Inbreeding depression* is a common consequence of selective breeding.

• Inbred lineages may perform well for some traits, but poorly for others.

• Inbreeding depression is poorly understood. Effects on bivalves, including clams, remains unclear.

• Should producers be concerned? Maybe… but don’t stop selective breeding programs yet.
Should industry managers care about genetic diversity?

- Clams that are selectively bred to perform well in one environment may perform poorly if the environment changes.

- A single-strain crop may be wiped out by a disease, while a genetically diverse crop suffers only partial mortality.

- To individual producers, risks from low genetic diversity may be outweighed by benefits of selective breeding.

- From a manager’s or insurer’s perspective, low genetic diversity increases the risk of industry-wide crop losses.
Selective Breeding of Hard Clams,
*Mercenaria mercenaria*

- *Notata*
  
  0-6% of wild populations

  22-97% of hatchery stocks sampled
Questions

1. Is genetic diversity of commercial stocks of hard clams, *Mercenaria mercenaria*, lower than in wild stocks?

2. Does genetic diversity correlate with clam performance under commercial conditions?
Methods

1. Sample wild and hatchery clam stocks, compare molecular genetic sequences (mitochondrial DNA, COI gene fragment).

2. Rear multiple hatchery stocks under identical blind* conditions and compare performance (growth & survival) to genetic data.

*Researchers did not know identity of hatchery stocks.
## Genetic Diversity Results

<table>
<thead>
<tr>
<th>Stock</th>
<th>notata % wildtype</th>
<th>heterozygosity mean</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prince Edward Island</td>
<td>76</td>
<td>0.76</td>
<td>0.05</td>
</tr>
<tr>
<td>Long Island</td>
<td>79</td>
<td>0.79</td>
<td>0.07</td>
</tr>
<tr>
<td>Chesapeake Bay</td>
<td>83</td>
<td>0.83</td>
<td>0.06</td>
</tr>
<tr>
<td>North Carolina</td>
<td>91</td>
<td>0.91</td>
<td>0.04</td>
</tr>
<tr>
<td>Georgia</td>
<td>85</td>
<td>0.85</td>
<td>0.05</td>
</tr>
<tr>
<td>Matanzas River, Florida</td>
<td>81</td>
<td>0.81</td>
<td>0.04</td>
</tr>
<tr>
<td>Indian River, Florida</td>
<td>85</td>
<td>0.85</td>
<td>0.05</td>
</tr>
<tr>
<td>Cedar Key, Florida</td>
<td>90</td>
<td>0.9</td>
<td>0.04</td>
</tr>
<tr>
<td>Hatchery 3</td>
<td>3</td>
<td>0.74</td>
<td>0.04</td>
</tr>
<tr>
<td>Hatchery 5</td>
<td>5</td>
<td>0.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Hatchery 14</td>
<td>14</td>
<td>0.63</td>
<td>0.13</td>
</tr>
<tr>
<td>Hatchery 37</td>
<td>37</td>
<td>0.83</td>
<td>0.06</td>
</tr>
<tr>
<td>Hatchery 20</td>
<td>20</td>
<td>0.43</td>
<td>0.1</td>
</tr>
<tr>
<td>Hatchery 32</td>
<td>32</td>
<td>0.84</td>
<td>0.03</td>
</tr>
<tr>
<td>Hatchery 38</td>
<td>38</td>
<td>0.9</td>
<td>0.03</td>
</tr>
<tr>
<td>Hatchery 43</td>
<td>43</td>
<td>0.83</td>
<td>0.05</td>
</tr>
<tr>
<td>Hatchery 30</td>
<td>30</td>
<td>0.51</td>
<td>0.04</td>
</tr>
<tr>
<td>Hatchery 79</td>
<td>79</td>
<td>0.89</td>
<td>0.04</td>
</tr>
<tr>
<td>Hatchery</td>
<td>8</td>
<td>0.59</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Hatchery stocks tend to have lower genetic diversity* than wild stocks, as estimated by heterozygosity. However, heterozygosity of hatchery stocks is high in most cases.

*significant at $\alpha = 0.05$
Can wild-type vs *notata* be used as an index of reduced genetic diversity?

*Notata* appears to be correlated with reduced genetic variability, but it can account for only about half of the variation in the data.
## Hatchery Stock Performance

<table>
<thead>
<tr>
<th>Hatchery</th>
<th>Stock</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
<td>38.27</td>
<td>10.65</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>300</td>
<td>38.18</td>
<td>10.38</td>
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<tr>
<td>3</td>
<td>300</td>
<td>36.11</td>
<td>10.27</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>35.41</td>
<td>10.66</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>300</td>
<td>34.65</td>
<td>12.03</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>300</td>
<td>34.40</td>
<td>8.80</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>288</td>
<td>32.66</td>
<td>11.84</td>
<td></td>
</tr>
</tbody>
</table>

95% confidence intervals of mean clam weight (g)

- Hatchery stocks reared under identical conditions varied significantly in size. (Length & height data were similar.)
- Differences were small and possibly within the performance variation of any individual hatchery.

(red bars connect averages that do not differ significantly)
<table>
<thead>
<tr>
<th>Hatchery</th>
<th>Stock</th>
<th>N</th>
<th>Mean</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>6</td>
<td>85.37</td>
<td>11.11</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>6</td>
<td>85.08</td>
<td>15.56</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>6</td>
<td>78.30</td>
<td>16.36</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>6</td>
<td>72.00</td>
<td>12.03</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>6</td>
<td>66.40</td>
<td>31.59</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>6</td>
<td>56.32</td>
<td>35.55</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6</td>
<td>47.18</td>
<td>22.73</td>
</tr>
</tbody>
</table>

(95% confidence intervals of mean clam survival (%))

- Hatchery stocks reared under identical conditions varied significantly in survival rates.
- Within-stock variability nearly masked between-stock variability.
- Growth and survival were not correlated.
Genetic diversity was not correlated with performance

- Three indices of performance: clam weight, clam length, cohort survival
- Four molecular genetic indices: Tajima’s D, Fu’s Test, Mean Pairwise Differences, and heterozygosity
- None of the performance indices correlated with any of the genetic indices (Pearson’s Correlation)
Conclusions

• Commercial hard clam stocks in Florida show some evidence of reduced genetic variability.

• Overall, however, genetic variability of hatchery stocks remains high.

• There is no evidence that genetic variability is related to stock performance.
Thanks also to: Claudia Rocha, Georgia DuBeux, Paola Soto, Adam Trott, Luis Rocha, and the many people who donated specimens.