Shifting Baselines in Southwest Florida’s Oyster Populations: The Effects of Overharvesting by Native Americans and the Implications for Future Management & Restoration of Oyster Reefs

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Value of Conservation Paleobiology & Historical Ecology

- Conservation paleobiology & historical ecology?
- Oyster reefs as valued estuarine ecosystems in Southwest FL.
- The recent demise of oyster reefs:
  - Loss of habitat area.
  - Water management practices influencing the ideal salinity regime.
  - Efforts to restore oyster reefs through substrate building.
  - No commercial or sport oyster fishery has existed in SW FL since western development.

- Have human activities significantly influenced oyster productivity?
- Importance and awareness of shifting baselines.
- Conservation paleobiology & historical ecology provide a perspective: comparing paleoecological, archaeological, and historical records of oyster demographics.
Introduction

- Oysters (*Crassostrea virginica*) have been reef builders in SWFL estuaries for the last 3000-4000 years.
- Calusa Native Americans were present on the coast from ~4000 ybp until Spanish arrival in 16th Century and relied upon oysters as a significant food resource.
- Calusa were hunter-gatherers, living on coastal islands, beginning as early as 2000 BC.
- Their populations increased significantly beginning in the 2nd Century AD and remained high up to Spanish arrival.
- Two human population centers existed during this time: on Mound Key in Estero Bay, and on Pine Island in Pine Island Sound.
Research Questions

1. This research relies on archaeological materials in mounds that are presumed harvested for food (i.e., shell as cultch), rather than dead material mined as building material. Can this assumption be tested?

2. Did the Calusa over-exploit their oyster resource enough to influence oyster population structure and productivity?

3. Did over-harvesting impose a lasting effect on oyster populations?
Comparing middens & modern reefs

A. Mound Key – Caloosahatchee periods
B. Horseshoe Keys reefs – modern
C. Useppa south reefs – modern
D. Useppa Island – Late Archaic periods
E. Useppa north reefs – modern
F. Calusa Island & reefs – Late Archaic & modern
G. Pineland - Caloosahatchee periods
Mound Key, Estero Bay

Archaeological excavation, summer 2014.

LiDAR elevation map. Radial canals, extensive mounds, “water courts”.
Aerial view of Useppa Island; highly developed housing community

Shell midden interbedded with dune sands
Samples, Locations, Ages, Climatic Intervals

- Samples span 4000 years, 2 cultural periods, and numerous warm/cold climate intervals.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Region</th>
<th>Site</th>
<th>Age</th>
<th>Cultural Period</th>
<th>Climate</th>
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<tbody>
<tr>
<td>M-1-71</td>
<td>Pine Island Sound</td>
<td>Useppa Island</td>
<td>1180-1040 BC</td>
<td>LA-terminal</td>
<td>-cool</td>
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<td>-warm</td>
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<td>RWP-warm</td>
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<td>VM-cool</td>
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<td>AD 588-686</td>
<td>Cal IIA-early</td>
<td>VM-cool</td>
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<td>VM-cool</td>
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<td>Mound Key</td>
<td>AD 990-1050</td>
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<td>MWP-warm</td>
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<td>AD 1050-1169</td>
<td>Cal IV</td>
<td>LIA-cool</td>
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<td>AD 1270-1330</td>
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<td>Hs</td>
<td>Estero Bay</td>
<td>Horseshoe Keys</td>
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<td>-warm</td>
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<td>Us1</td>
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<td>Useppa Reef 1</td>
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<td>Pine Island Sound</td>
<td>Calusa Island Reef</td>
<td>Modern</td>
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<td>-warm</td>
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</tbody>
</table>

LA = Late Archaic  
Cal = Caloosahatchee  
RWP = Roman Warm Period  
VM = Vandal Minimum  
MWP = Medieval Warm Period  
LIA = Little Ice Age
Methods: Taphonomic Grading of Valve Interiors

- Grade oyster shell interior surfaces.
- Bioerosion & encrustation must occur after death in the estuarine environment.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Fragmentation</strong></td>
<td>Complete margin</td>
<td>&gt;75% margin</td>
<td>25%-75% margin</td>
<td>&lt; 25% margin</td>
</tr>
<tr>
<td><strong>2. Bioerosion / encrustation</strong></td>
<td>None</td>
<td>&lt;25% affected</td>
<td>25%-75% affected</td>
<td>&gt;75% affected</td>
</tr>
<tr>
<td>(shell interior)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. Loss of luster / color</strong></td>
<td>No loss of nacre or color</td>
<td>Nacre &amp; color slightly faded</td>
<td>Nacre &amp; color still present but faint</td>
<td>Complete loss of nacre and color</td>
</tr>
<tr>
<td>(shell interior)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Biologic Taphonomic Grades
Methods: Oyster Measurements

- Convex valve (left valve) length
- Growth lines in cross section of ligament hinge pit
- Periodicity of growth line production?
Results & Interpretations

Examples of Taphonomic Grade Distribution

Modern death assemblage

Archaeological midden sample
**Results & Interpretations**

Chi-square contingency analysis:
- Likelihood Ratio & Pearson tests both show: grade proportions different among 3 groups, $P<0.0001$.
- Greater likelihood for taphonomic grade = 1 for Archaic & Caloosahatchee.

Nonparametric Wilcoxon pairwise comparisons:
- Modern different from Late Archaic, $P<0.0001$.
- Modern different from Caloosahatchee, $P<0.0001$.
- Late Archaic slightly different from Caloosahatchee, $P=0.017$. 
Comparison of Convex Valve Lengths
Means + 1 Standard Error
Comparison of Convex Valve Lengths
Means + 1 Standard Error

Length (mm)

Log-transformed ANOVA groupings.
Results & Interpretations

Oyster Growth Rate

Convex Valve Length (mm) vs. Growth Lines

ANCOVA log-transformed data:
- Y-intercepts significantly different, $P<0.0001$.
- Slopes indistinguishable, $P=0.3302$. 
Conclusions

1. The materials composing Calusa middens have taphonomic characteristics consistent with those collected live for consumption.
2. During times of peak Calusa population density, oyster populations show shifts toward smaller sizes, suggesting oysters were over harvested.
3. Because modern death assemblages exhibit a population structure comparable to that found in the Late Archaic middens and because all samples have comparable growth rates, over harvesting did not drive a permanent, genetic change in the local population.
4. *Caveat: The problem associated with establishing periodicity of growth line production makes item 3 somewhat suspect.*
5. Consequently, modern oyster productivity in these two estuaries is comparable with that of pre- or early-human history. Though the extent of oyster reefs is much reduced, the genetic capacity for productivity is maintained.
6. Oyster reef restoration is predisposed for success!
Promoting Conservation Paleobiology & Historical Ecology

- Merely one example applying principles and methods from paleontology and geology to environmental management & restoration.
- Other great examples from this session.
- Important to promote these interdisciplinary approaches.
- Problems: Often geoscientists and environmental scientists work in different “shops”; training and education doesn’t transcend these fields.
- Solutions: Foster relationships and collaboration; host these types of sessions within each other’s disciplinary meetings.
Acknowledgments

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