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

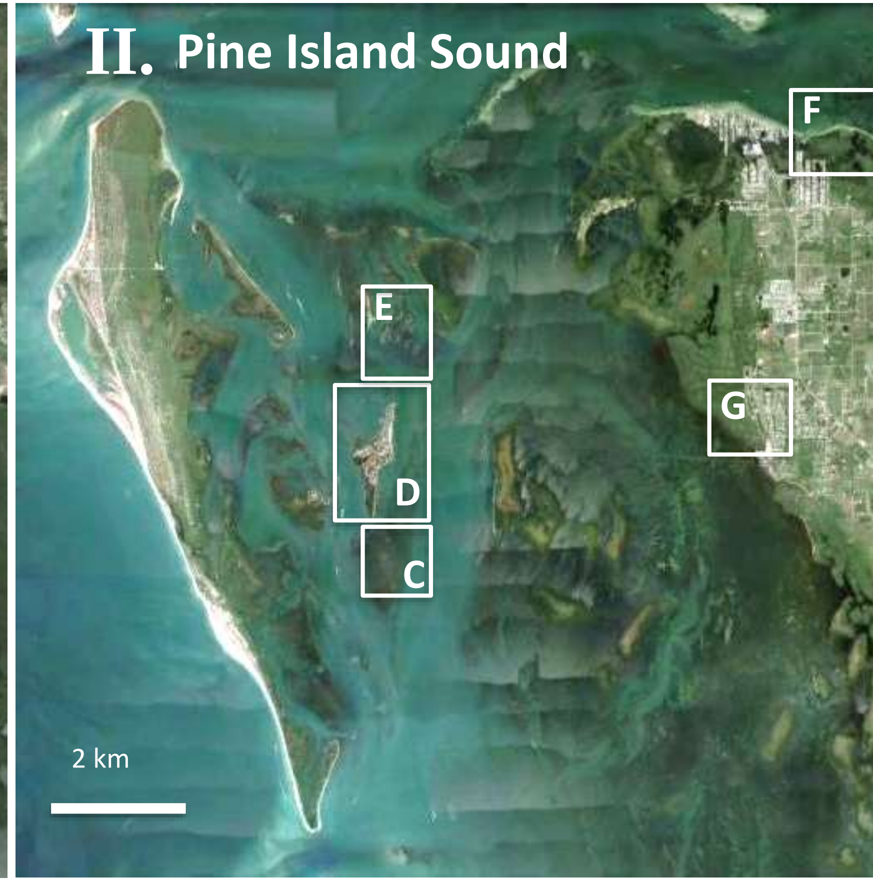
- Conservation paleobiology & historical ecology?
- Oyster reefs as valued estuarine ecosystems in Southwest FL.
- The recent demise of oyster reefs:
  - Loss of habitat area.
  - Water management practices influencing the ideal salinity regime.
  - Efforts to restore oyster reefs through substrate building.
  - 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?

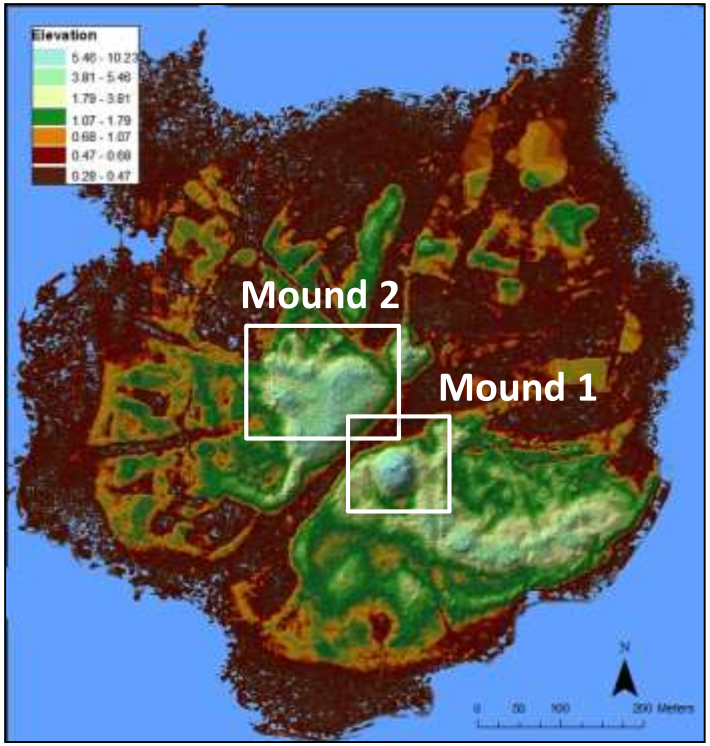


Study Area

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



LiDAR elevation map. Radial canals, extensive mounds, “water courts”.

Archaeological excavation, summer 2014.

Useppa Island

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.

Sample	Region	Site	Age	Cultural Period	Climate
B-13-15	Pine Island Sound	Useppa Island	2000-1860 BC	LA-preceramic	-cool
M-1-71	Pine Island Sound	Useppa Island	1180-1040 BC	LA-terminal	-cool
Cs1a	Pine Island Sound	Calusa Island	785-745 BC	LA-terminal	-warm
D-3-4	Pine Island Sound	Useppa Island	AD 1-180	Cal I-late	RWP-warm
A-8-101	Pine Island Sound	Pineland	AD 110-270	Cal I-late-f	RWP-warm
A-16-94	Pine Island Sound	Pineland	AD 270-420	Cal I-late-i	RWP -cool
A-16-92	Pine Island Sound	Pineland	AD 530-630	Cal IIA-early-a	VM-cool
C-1-94	Estero Bay	Mound Key	AD 588-686	Cal IIA-early	VM-cool
L-1-9	Estero Bay	Mound Key	AD 695-763	Cal IIA-late	VM-cool
M-1-35	Estero Bay	Mound Key	AD 990-1050	Cal IIB-late	MWP-warm
D-1-95	Estero Bay	Mound Key	AD 1050-1169	Cal IV	LIA-cool
I-2-66	Pine Island Sound	Pineland	AD 1270-1330	Cal IV	LIA-cool
Hs	Estero Bay	Horseshoe Keys	Modern		-warm
Us1	Pine Island Sound	Useppa Reef 1	Modern		-warm
Us2	Pine Island Sound	Useppa Reef 2	Modern		-warm
Cs Reef	Pine Island Sound	Calusa Island Reef	Modern		-warm

LA = Late Archaic
Cal = Caloosahatchee

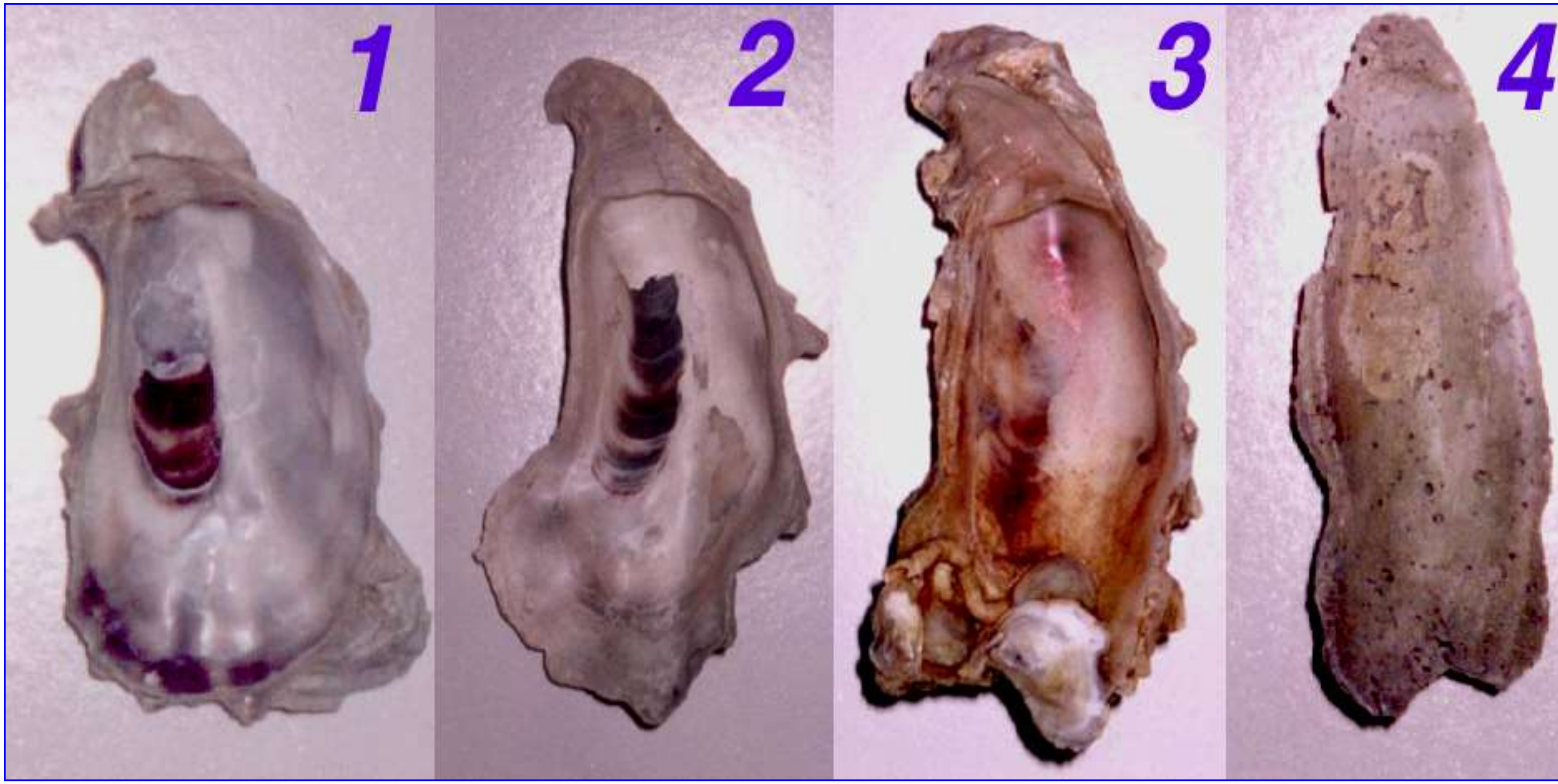
RWP = Roman Warm Period
VM = Vandal Minimum
MWP = Medieval Warm Period
LIA = Little Ice Age

Methods: Taphonomic Grading of Valve Interiors

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

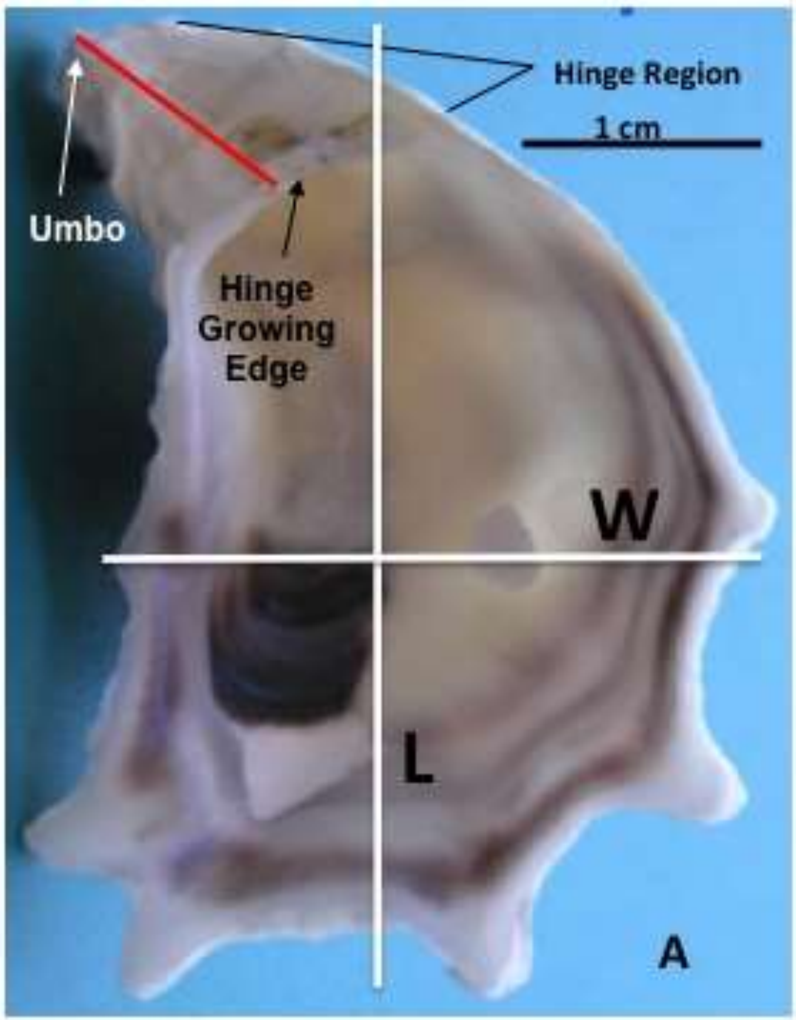
Characteristic	Grade 1	Grade 2	Grade 3	Grade 4
1. Fragmentation	Complete margin	>75% margin	25%-75% margin	< 25% margin
2. Bioerosion / encrustation (shell interior)	None	<25% affected	25%-75% affected	>75% affected
3. Loss of luster / color (shell interior)	No loss of nacre or color	Nacre & color slightly faded	Nacre & color still present but faint	Complete loss of nacre and color

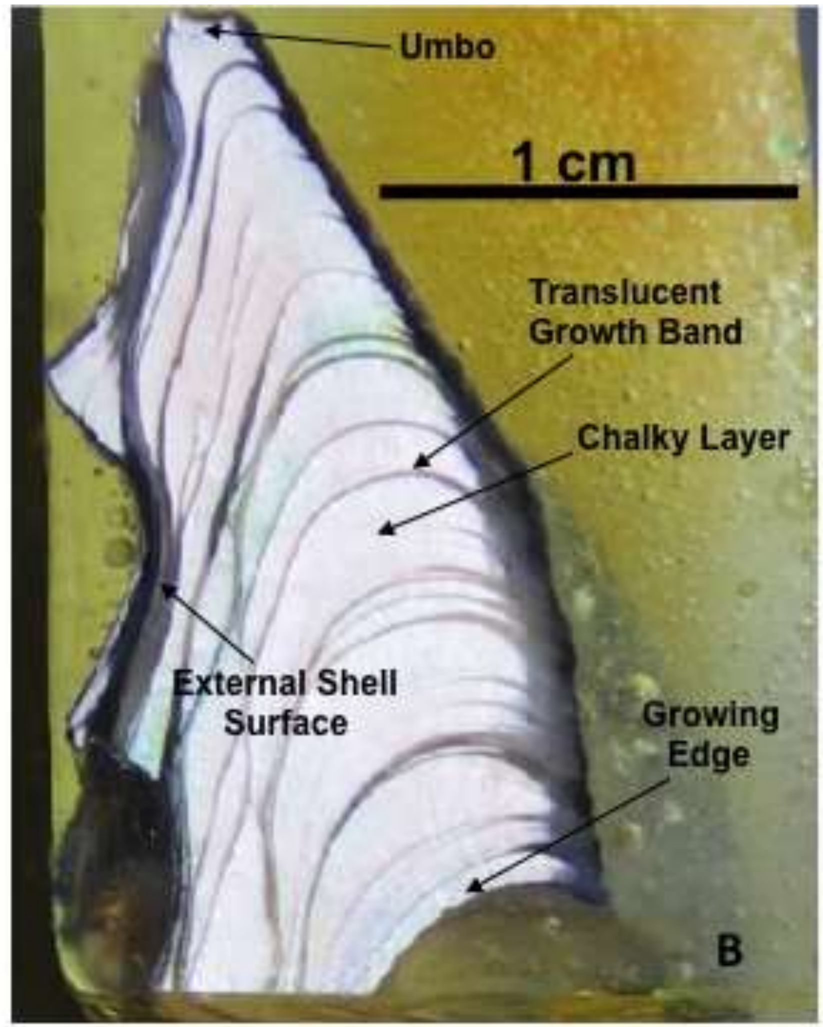
Biologic Taphonomic Grades



Methods: Oyster Measurements

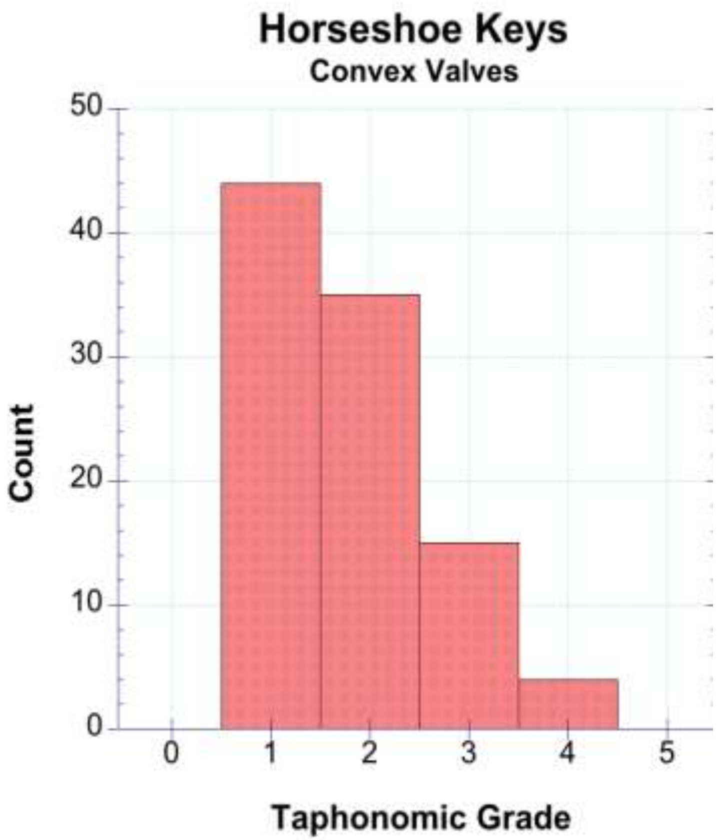
- Convex valve (left valve) length
- Growth lines in cross section of ligament hinge pit
- Periodicity of growth line production?



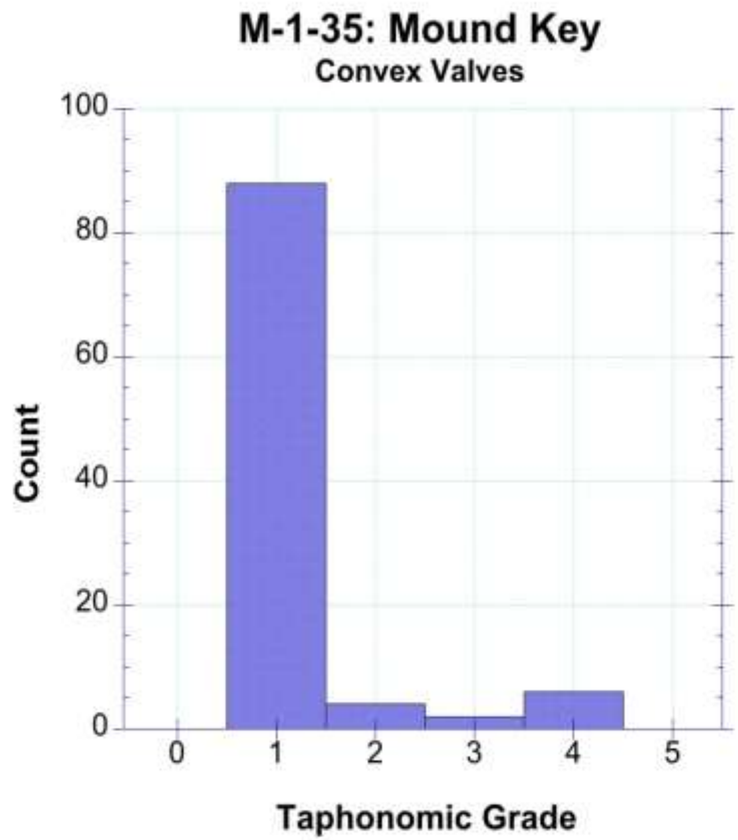


Results & Interpretations

Examples of Taphonomic Grade Distribution

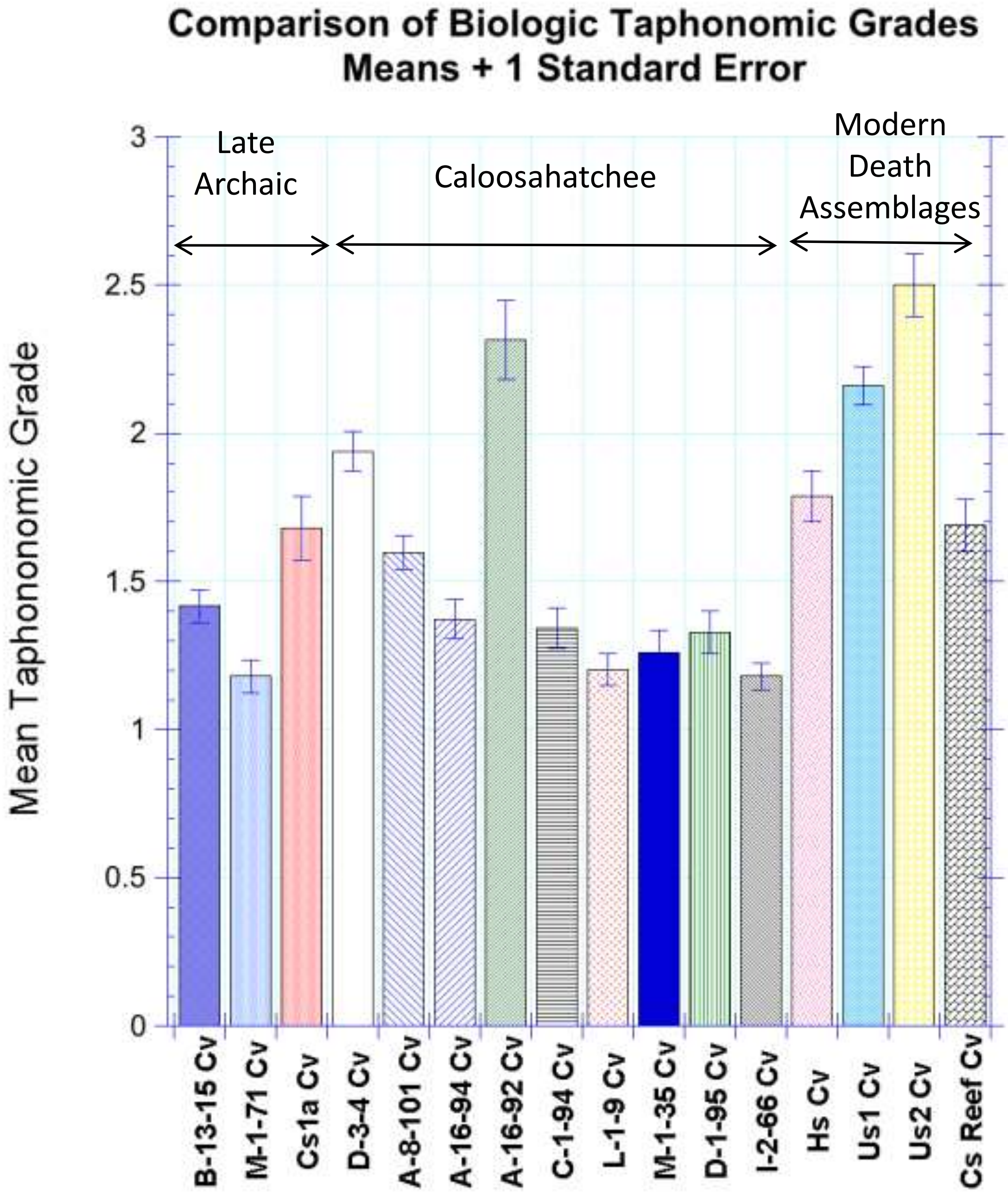


Modern death assemblage



Archaeological midden sample

Results & Interpretations

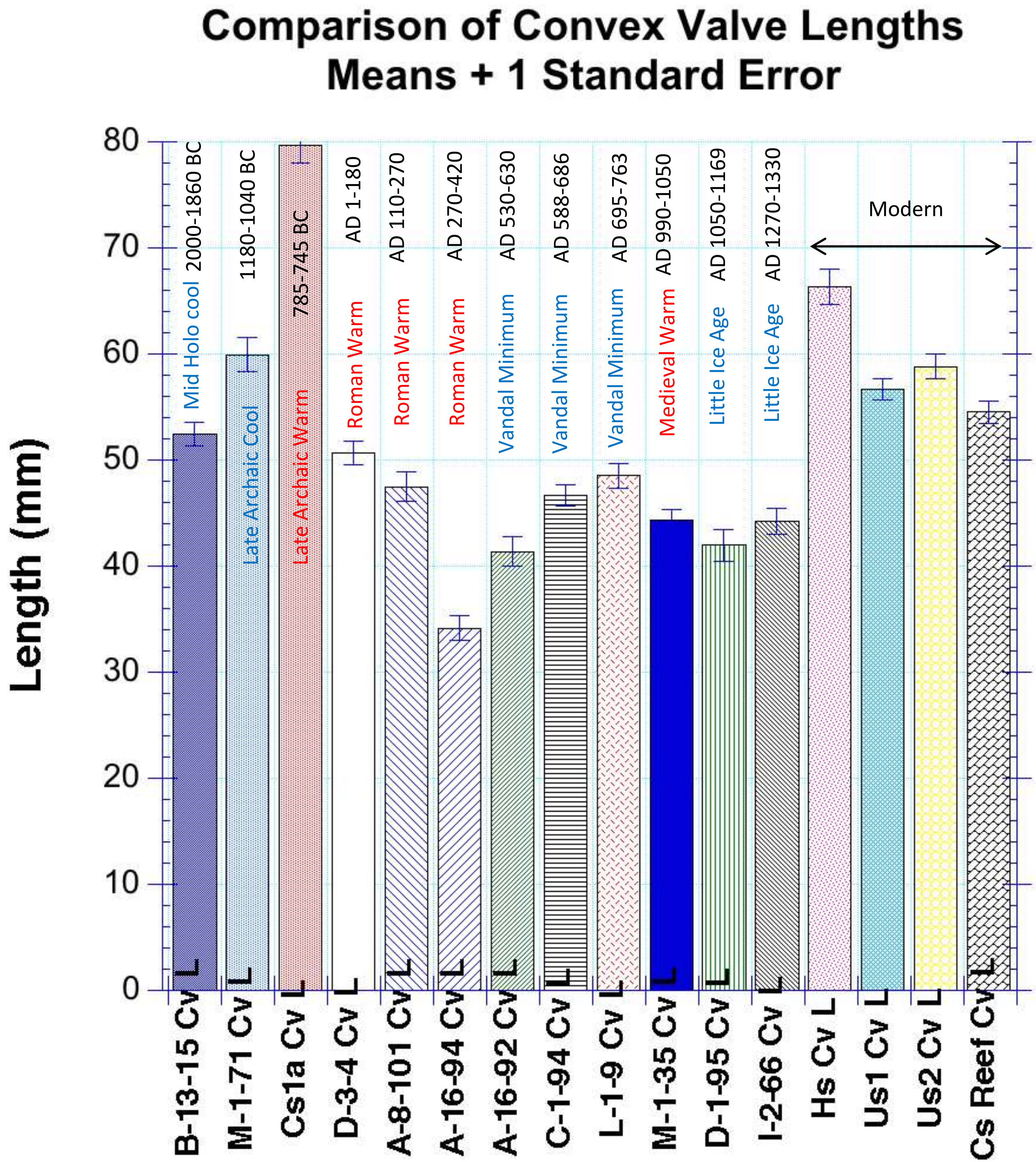


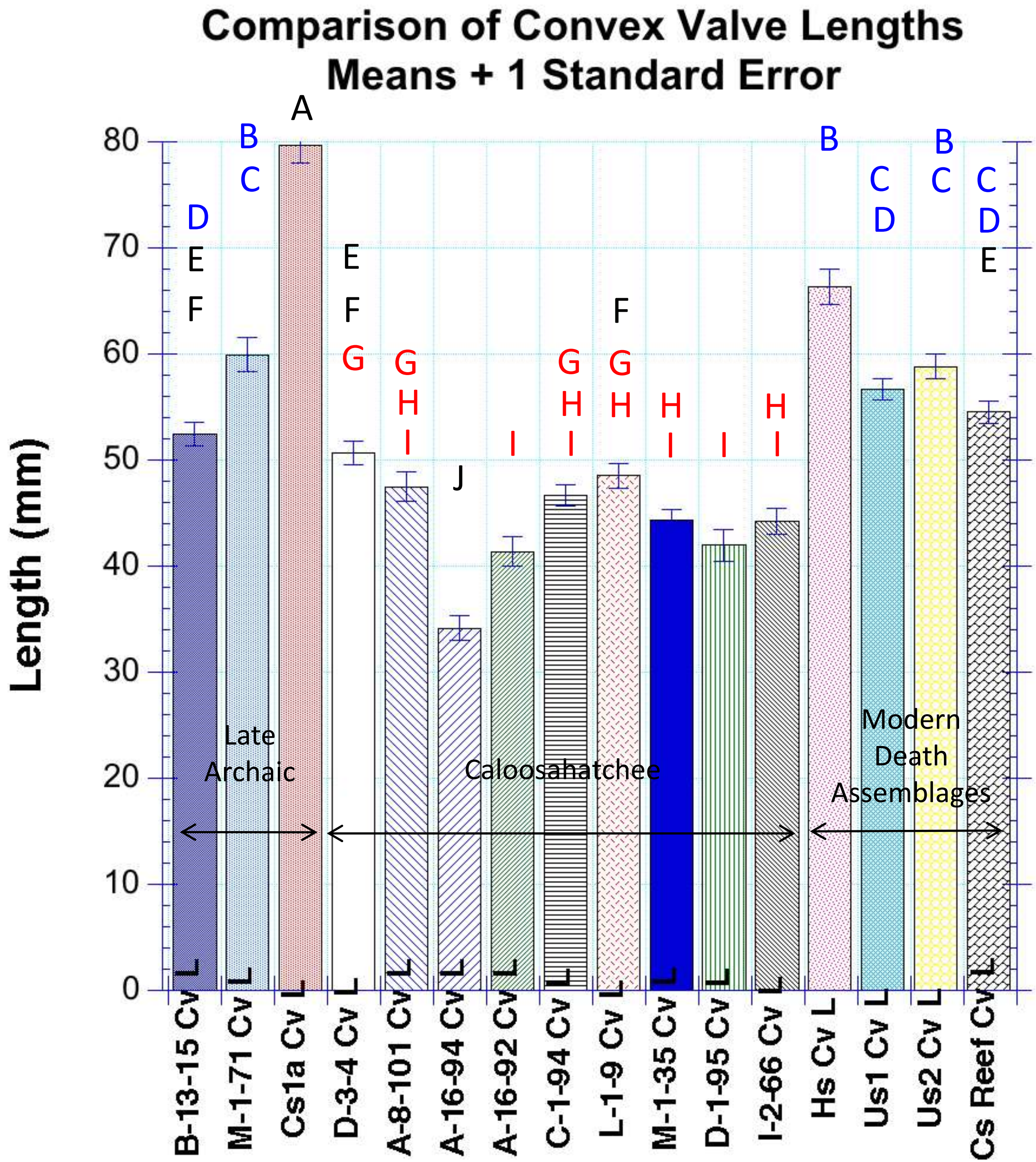
Chi-square contingency analysis:

- *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:

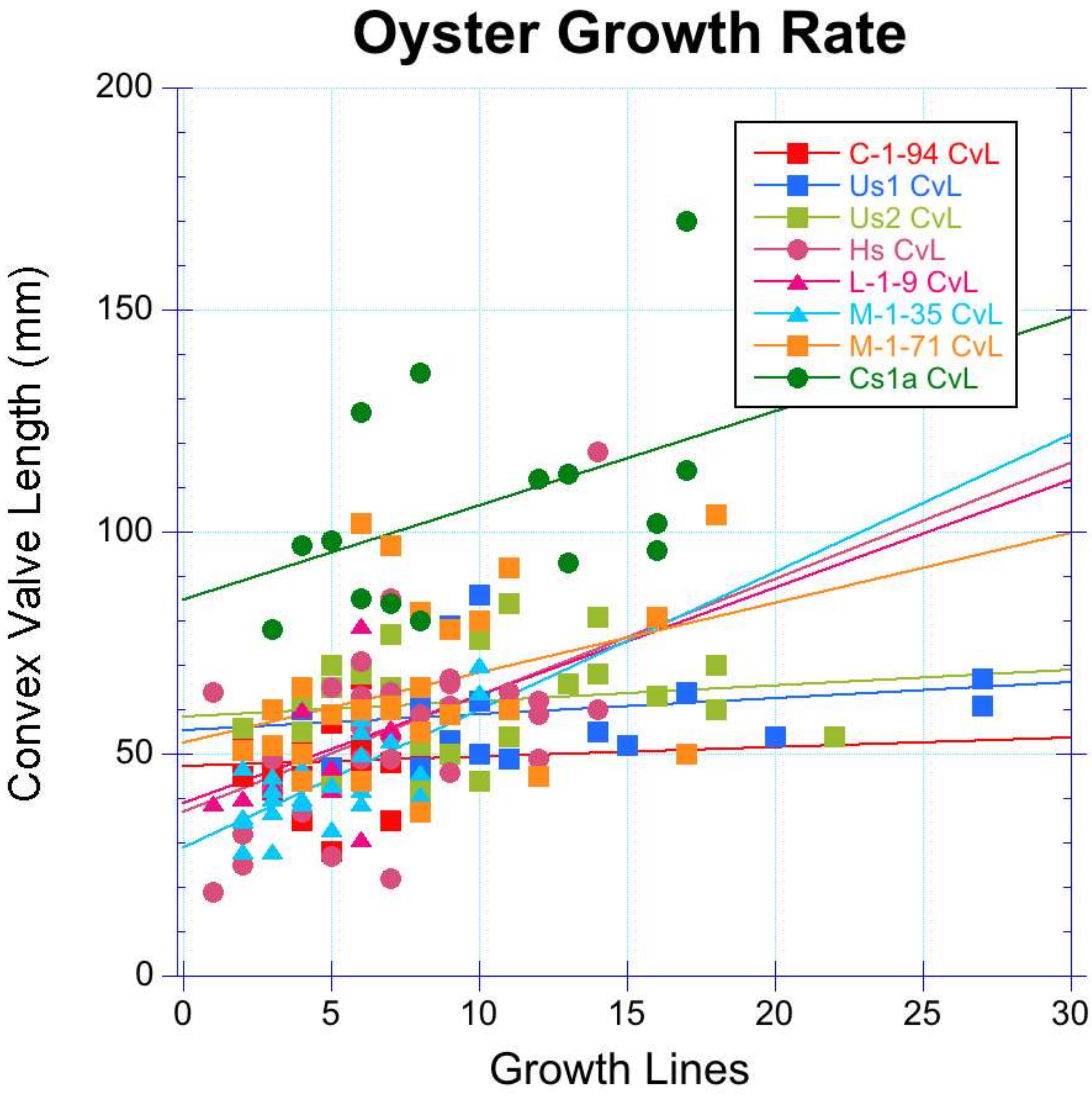
- *Modern different from Late Archaic, P<0.0001.*
- *Modern different from Caloosahatchee, P<0.0001.*
- *Late Archaic slightly different from Caloosahatchee, P=0.017.*


Comparison of Convex Valve Lengths
Means + 1 Standard Error
Length (mm)
0
10
20
30
40
50
60
70
80
Mid Holo cool 2000-1860 BC
Late Archaic Cool 1180-1040 BC
Late Archaic Warm 785-745 BC
Roman Warm AD 1-180
Roman Warm AD 110-270
Roman Warm AD 270-420
Vandal Minimum AD 530-630
Vandal Minimum AD 588-686
Vandal Minimum AD 695-763
Medieval Warm AD 990-1050
Little Ice Age AD 1050-1169
Little Ice Age AD 1270-1330
Modern
B-13-15 Cv L
M-1-71 Cv L
Cs1a Cv L
D-3-4 Cv L
A-8-101 Cv L
A-16-94 Cv L
A-16-92 Cv L
C-1-94 Cv L
L-1-9 Cv L
M-1-35 Cv L
D-1-95 Cv L
I-2-66 Cv L
Hs Cv L
Us1 Cv L
Us2 Cv L
Cs Reef Cv L



Log-transformed ANOVA groupings.

Results & Interpretations



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.

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