Ecological Succession within a Holocene Oyster Reef: An Indicator of Estuary Development in Southwest Florida

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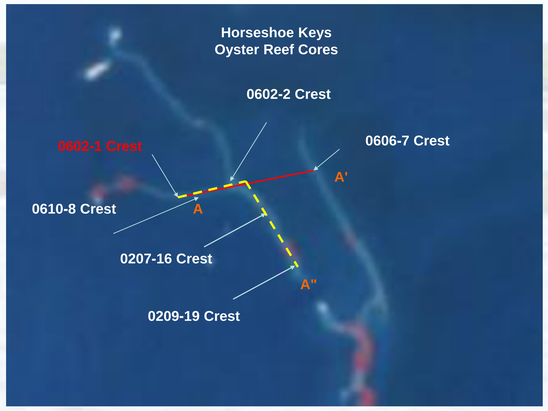
Abstract

Southwest Florida's coastal geomorphology and estuarine ecology depend upon the proliferation of oyster reefs, yet little is known about timing and environmental detail of coastal development. This study considers the paleontology and taphonomy through the late Holocene development of a vermetiform gastropod to eastern oyster (*Crassostrea virginica*) reefal succession within an archetypical region of Estero Bay. Six stratigraphic cores, spanning 2700 years of history, were studied stratigraphically and sedimentologically; one core's paleontologic and taphonomic characteristics were analyzed intensively. Reef construction is dominated through much of history (~2700-500 ybp) by sessile vermetiform gastropods; oysters co-occur with gastropods as builders beginning at ~2100 ybp; ultimately oysters build reefs exclusively from ~500 ybp until present. Patterns in faunal assemblages and in taphonomy support a shift from more marine, higher energy settings during the vermetiform-only phase to more brackish and protected conditions through the successional change to oyster-only frame building. Assemblages during the oyster-only phase contain euryhaline species, while the vermetiform-only and mixed phases contain stenohaline, marine taxa. The taphonomic grade of vermetiform gastropods improves upsection, supporting a more protected embayment through time. Patterns in oyster taphonomic grade are more equivocal, though here too preservational quality improves upsection. Analysis of biocorrosion and bioencrustation, characteristics indicative of marine conditions, does not support the transition to more estuarine conditions, while those indicative of time averaging (margin loss, coloration, luster) suggest increasingly lower energy conditions through time. Finally, the marine to estuarine transition is supported by the modern distribution of vermetids and *C. virginica*. A core taken more distally and behind the current barrier island indicates that Estero Bay existed as an open coast in the recent past. The reef succession in the barrier island's wake monitors the timing of estuarine development and perhaps the timing of island formation. This research demonstrates the value of studying proximal depositional settings to infer the history of estuaries.



Close-up image of reefs in northern Horseshoe Keys. Arrows denote the locations of six cores taken in this region. The core labeled in red was analyzed intensively for this study. Line A-A' denotes the East-West transect and line A-A" denotes the Northwest-Southeast transect.

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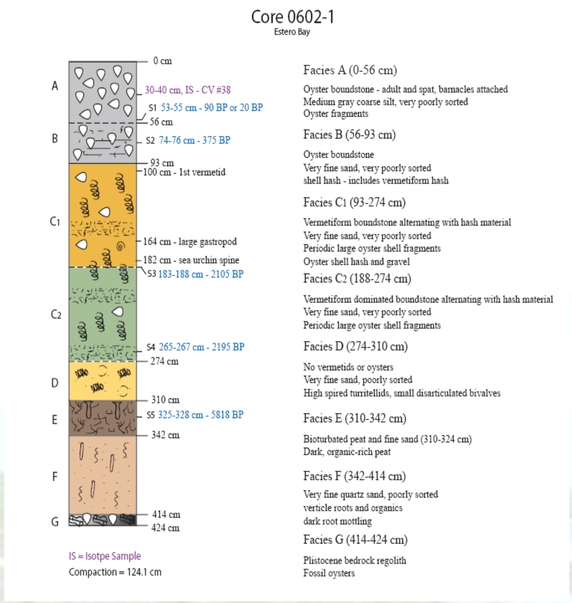
Stratigraphic Analysis

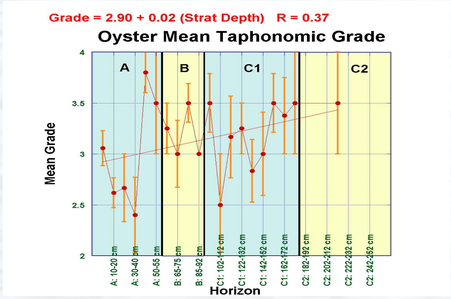
- Six cores were collected from the crest of an active oyster reef in Estero Bay.
- The cores were collected in three inch diameter aluminum pipes using both hand extraction methods and a vibracore.
- In the lab, each core was cut into one-meter sections and each section was cut in half lengthwise to expose the sediments.
- Each core was visually subdivided into discrete facies for which an upper and lower contact was identified and defined as sharp or gradational.
- A preliminary description of the sedimentology, sedimentary structures, paleontology, and taphonomy was made for each facies.
- A stratigraphic column was drafted for each core and lithostratigraphic correlations were made between cores at each study site providing a context in which to make environmental interpretations.



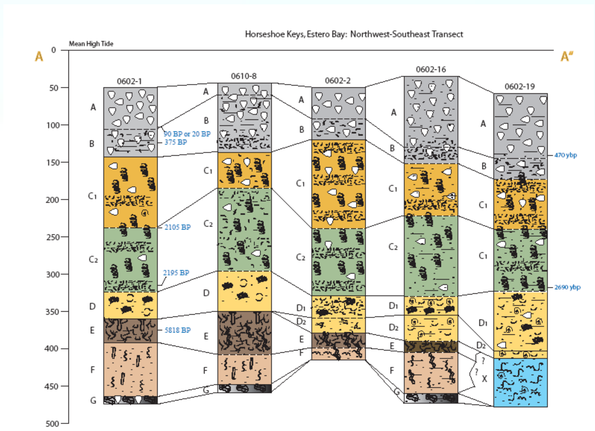
Stratigraphic column for core 0602-1 illustrating the representative facies sequence for this region. Radiocarbon dates (1 sigma calibrated results) derived from oyster shells, vermetiform shells, and peat help define the timing of reef development.

Taphonomic Analysis

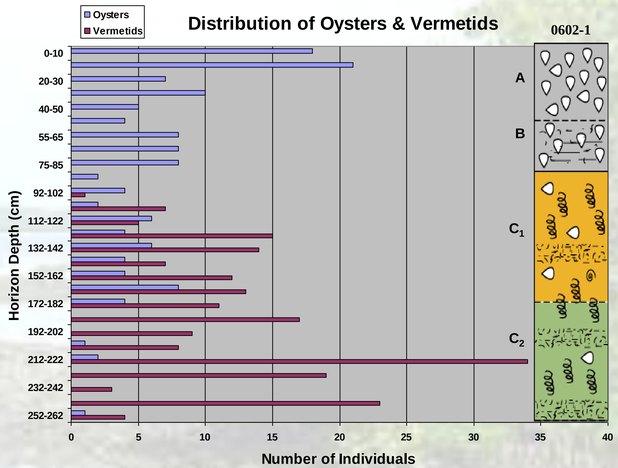
- Oysters ≥ 3 cm in length and vermetiform gastropods ≥ 2 cm in length were selected from the harvested material for taphonomic analysis.
- Specialized taphonomic grading scales were developed for oysters and vermetiform gastropods.
- Grades range from one for the best preserved shells to four for the worst preserved shells for both oysters and vermetiform gastropods.
- Each oyster shell was evaluated for individual characteristics as well as for overall condition.
- Vermetiform gastropods were categorized into large cluster, small cluster, individual, and hash and then overall grades were assigned to large and small clusters and individuals only.



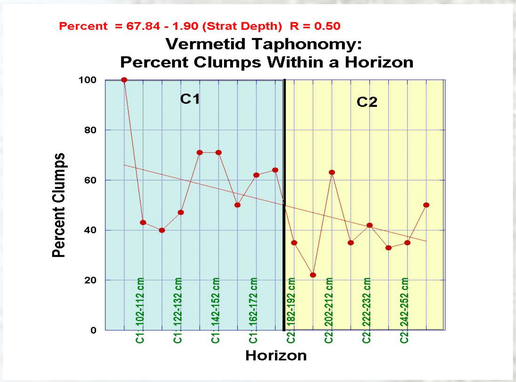
Plot of the mean overall taphonomic grade given to oysters with one standard deviation and a regression equation. Trends in taphonomic grades show an increase in preservation up core.



Fence diagram of the northwest-southeast Horseshoe Keys transect (A-A"). Each core exhibits the same transgressive stratigraphic sequence. The only exception is core 0602-19 which features an organic-rich, shell-poor, subtidal muddy sand facies underling facies D_2, as opposed to the typical basal transgressive peat. Dates given for cores 0602-1 and 0602-19 represent radiocarbon ages.



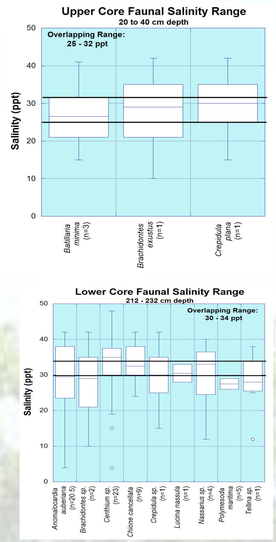
Bar graph showing the transition of reef-building organisms within core 0602-1 from vermetiform-dominated facies (C_2) to an a mix of vermetiform gastropods and oysters (facies C_1), to facies that contain exclusively oysters (facies A and B).

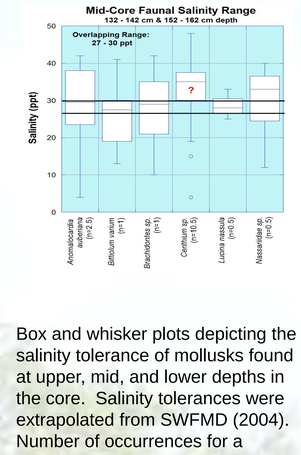


Plot illustrating the percentage of vermetiform clumps present in each horizon. Percentages were determined by dividing the number of clumps by the total number of occurrences. The number of vermetiform clumps increases up-core as indicated by the regression analysis.

Faunal Analysis

- Facies from half of each core representing reef environments were subdivided into ten centimeter horizons, with no horizon straddling a facies boundary.
- All material from an horizon was then harvested from the core and rinsed through a stacked 2 mm and 1 mm sieve set. Carbonate material from each fraction was allowed to air dry.
- Sub-fossils from two horizons in facies A (oyster dominated), C1 (mix of oyster and vermetiform gastropods), and C2 (vermetiform gastropod dominated) were sorted according to morphology.
- Organisms were identified to the lowest possible taxonomic level and absolute abundance was determined for each taxon.
- Salinity ranges for taxa were identified where data where available and box and whisker plots were used to analyze salinity range data.





Box and whisker plots depicting the salinity tolerance of mollusks found at upper, mid, and lower depths in the core. Salinity tolerances were extrapolated from SWFMD (2004). Number of occurrences for a species denoted by 'n'. Question mark denotes an erroneous salinity range.

Discussion

Stratigraphy

- The stratigraphy of Core 0602-1 illustrates a transgressive environmental progression through time from supratidal uplands, to intertidal swamp, to subtidal marine, to marine, to estuarine conditions.
- Vermetiform gastropods, which are the dominant species in facies C_2, constructed reefs under marine conditions, possibly creating a freshwater impoundment.
- Facies C1 illustrates a shift to brackish water conditions in which vermetiform gastropods and oysters were co-dominant.
- Oysters became the dominant reef-building organism, allowing for the formation of the coastal estuarine complex present today in Estero Bay, Florida.

Taphonomy

- Assuming higher energy in open-marine settings, an increase in vermetiform clumps up-core suggests calmer energy conditions indicative of a more protected estuarine setting.
- For oysters, the preservational condition of the valve margin, luster, and color are a function of energy and time averaging. The taphonomic grades for these characteristics improve up-core suggesting a decrease in energy or a decrease in time to burial.
- Borings and encrustations are largely a function of salinity. Although there is no change in grades associated with encrustation for our samples, the average number of borings per shell decreases up-core.
- Similarly, the overall taphonomic condition of oysters showed a trend towards less marine, lower-energy conditions.

Analysis of Associated Fauna

- Associated mollusk species in the lower, middle, and upper core exhibit overlapping salinity ranges that illustrate a trend from marine to estuarine conditions.

Conclusions

The combination of stratigraphic, faunal, and taphonomic characteristics evaluated for this study substantiates the argument that coastal conditions at this location have transitioned from open marine to a more brackish water environment in tandem with the reef-building organisms. Independently, each of these measures provides a subjective and interpretive view of reef history in this area. In concert, however, they provide a compelling argument in support of autogenic succession from marine to estuarine conditions in Estero Bay, Florida.