TIME ACCUMULATION ON AN OYSTER REEF: IMPLICATIONS FOR THE MONITORING OF ENVIRONMENTAL CHANGE

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INTRODUCTION

As brackish water ecotone indicators, oyster reefs are potentially useful for the reconstruction of sea level curves and for determining anthropogenic effects on water quality. Their acute sensitivity to change in water quality also makes them strong indicator species for the assessment of estuarine ecosystem health. For oyster reefs to fulfill this potential, the magnitude of time averaging must be relatively short. If oyster reefs accumulate shell material over long periods of time, their presence might misrepresent the position of sea level or the timing of environmental change. For example, if reefs persist at the sediment-water interface after the brackish water ecotone has transgressed beyond the reef's position, then their location may have little relevance for sea level tracking or current conditions of environmental health. I therefore examined the relationship between taphonomic grade (state of shell preservation), absolute age of dead oyster shells, and the magnitude of time averaging on modern oyster reefs, a previously taphonomically unstudied ecosystem along the Southwest Florida coast.

Time-averaging studies have been conducted previously in coastal settings (Flessa et al. 1993; Koweleski et al. 1998, Parsons-Hubbard et al. 1999). However, to date, no study specifically addressing time averaging on oyster reefs has been attempted, yet they are prolific throughout the Mesozoic and Cenozoic periods.

To better understand time averaging on oyster reefs, three questions were addressed by this study. How much time is represented within an oyster reef? The shorter the time represented, the more value the structure has to problems of coastal evolution and ecosystem health. Is there a more economical and methodologically simple proxy for assessing the magnitude of time averaging? If there is a correlation between the taphonomic grade and age of an oyster shell, this method may be acceptable as a gauge of time averaging. Does a correlation between the shells preservational status and its age improve or worsen under certain environmental conditions? An oyster reef located in an exposed environment may display worse preservational status than one located in a protected environment. Understanding taphonomic grade variations within and between reefs of varying energies will help determine a reef's usefulness in tracking sea level change. The hypotheses tested in this study are: the degree of time averaging is less for oyster reefs than for other coastal intertidal communities; oyster reefs from protected bays exhibit less time averaging than those from more exposed environments; and the taphonomic grade of oyster shells directly correlates with time averaging on oyster reefs.

MATERIALS AND METHODS

Time averaging was compared between two environments, a protected bay and an exposed bay reef. Both reefs were composed solely of the oyster species *Crassostrea virginica*. They were both located in the Blackwater River system on the Southwest coast of Florida (figure 1 in Savarese herein) to control as many unforeseen variables as possible. Using a tape measure, a transect was oriented on the exposed reef, traversing the most exposed sub-environment to the most protected sub-environment. The north to south width of this reef was 63 m; the east to west length was 180 m. The transect was replicated 5 months later for a second set of data. Because the protected reef was comparatively narrow, it required two 13-m transects in order to increase the sample size. Both were oriented in a parallel manner, one on the north end of the reef and one on the south end of the reef. These transects were also replicated 5 months later.

Approximately 1400 oyster shells were collected, one every 10 cm along the transects. No living shells and no clumps containing three or more cemented oysters were collected. The oysters were 3-7 cm in length, whole, fragmented, or articulated. A total of 880 shells were collected from the high-energy reef and 520 shells from the low-energy reef. Four taphonomic grades were established using a set of preservational criteria described by Flessa et al. (1993). Specimens were graded on a scale of 1 to 4 by three people (1 representing the best preservation and 4 the worst) (Fig.1). Grades were averaged for each oyster shell and 32 samples (16 from each reef, 4 from each grade) were chosen for amino acid racemization dating (Goodfriend 1989).

A topographic profile was measured along the transects of each reef to assess the relationship between the shells' taphonomic grade and the specific environmental energy where it was collected. The environmental energy of each topographic position was determined through facies analysis.

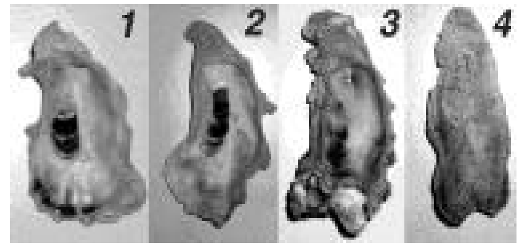

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Figure 1: Examples of taphonomic grades. Grade1 represents the best preservation and grade 4 represents the worst preservation.

RESULTS

The oldest shell sampled from both the exposed and protected reef came from the exposed reef. This shell's age was 520 years old indicating a time averaging minimum on the high-energy reef of 520 years. The oldest shell sampled from the low energy reef was 280 years old indicating a time averaging minimum of 280 years. These results differ from those of Flessa et al. (1993), Macintyre et al. (1978), and Meldahl et al. (1997) who found significantly higher time averaging magnitudes.

Histograms of taphonomic grade distribution were used to compare protected and exposed reefs. The average taphonomic grade of 866 specimens analyzed from the high-energy reef was 3.2 (the replicate sample was indistinguishable). The combined average grade of the 258 specimens from the low-energy reef was 2.6. The replicate sample yielded an average taphonomic grade of 2.4. The average taphonomic grade on the high-energy reef was significantly greater (less well preserved) than that of the low-energy reef (Wilcoxon Signed Ranks Test [$p<0.0001$]).

On the high-energy reef, the topographic height of a facies along the profile and each facies' sedimentary characteristics correlated with taphonomic grade. Facies located at high elevations along the profile had higher energy sedimentary characteristics and had oysters with worse taphonomic grades (Fig. 2).

Regression analyses of an oyster shell's amino acid racemization age versus its taphonomic grade showed a high positive correlation for both the high- and low-energy reefs (high: slope = 156.0, y-intercept = – 166.9 [R=0.91];

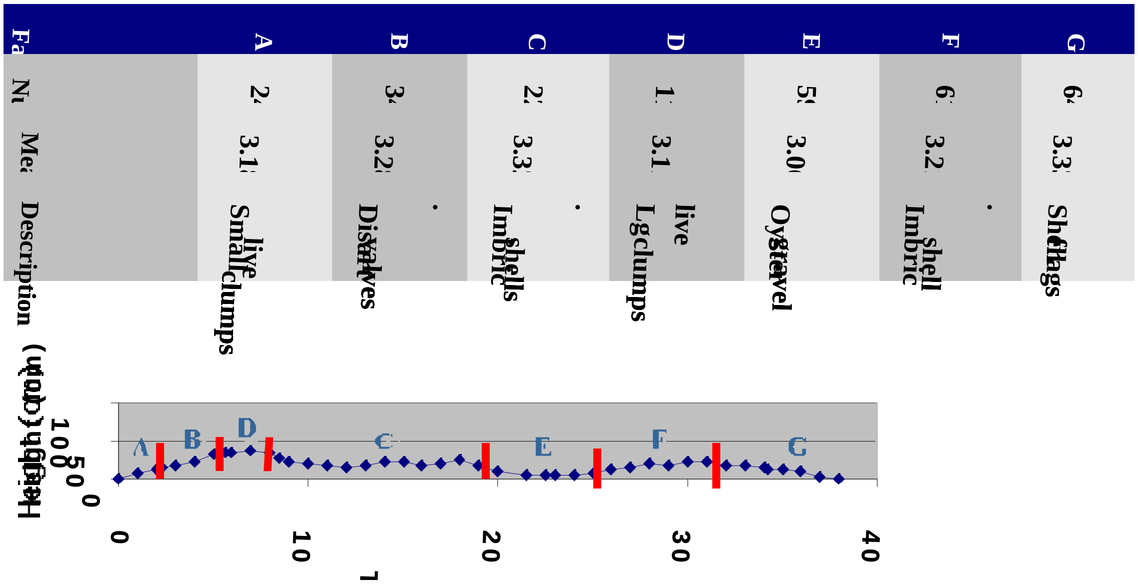

Figure 2: Topographic profile of the high energy reef. The taphonomic grades vary directly with the environmental energy.

and low: slope = 85.1, y-intercept = – 96.2 [R=0.88]). Shells with a higher taphonomic grade have an older age than those displaying better preservation. Conversely, those with a lower, better taphonomic grade have a younger age.

DISCUSSION

The degree of time averaging is less for oyster reefs than for other coastal intertidal communities. Both oyster reefs sampled exhibited better than millennial-scale resolution with a maximum age on the high-energy reef of 520 years and 280 years on the low-energy reef.

Flessa et al. (1993) found a much higher magnitude of time averaging (~3500 years) for intertidal bivalve cheniers from Bahia La Choya, Gulf of California. The bivalves composing these cheniers live unattached and infaunally while oysters are sessile and cemented together. These differences in life mode, coupled with the differences in environmental conditions may explain our incongruent results.

The protected bay oyster reef environments exhibited not only a better than millennial scale resolution, but also better taphonomic grades than the more exposed oyster reef environments. The differences in average overall grades among the reefs indicate that the shells on the high-energy reef are undergoing longer or more intense weathering processes than those of the low-energy reef.

The discordant results found between two reefs of different energies are also found at smaller spatial scales within a reef. The taphonomic grade of oyster shells within a reef varies directly with its topographic position and the facies sedimentary texture in which it lies (indicative of energy level). Shells that were sampled in a higher energy section of the reef displayed worse grades than those sampled in lower energy facies. Again, this indicates that the relative energy of the environment in which a shell sits has an impact on the shell's ability to maintain preservation before burial.

The regression analysis of amino acid racemization age versus taphonomic grade demonstrated a high positive correlation for both the high and low energy reefs (R=0.91 and R=0.88 respectively), suggesting taphonomic grade is a reasonable proxy for time averaging. This correlation differs from those obtained by MacIntyre et al. (1978), Flessa et al. (1993), and Meldahl et al. (1997).

These results indicate that the magnitude of time averaging on an oyster reef holds a better than millennial scale resolution and a shell's taphonomic grade correlates with its absolute age. With precaution, therefore, oyster reefs could be used to track the historic position of sea level as well as assess the anthropogenic forcing of climate change and ecosystem health.

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