RECOGNIZING TILEFISH MOUNDS IN THE ROCK RECORD: EVIDENCE FROM CLAST SIZES AND TYPES IN MOUNDS FROM COZUMEL, MEXICO

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INTRODUCTION

Many marine organisms make trace fossils that are preserved in the rock record. The sand tilefish (*Malacanthus plumieri)* constructs a burrow in which to hide from predators. After digging a burrow, the tilefish constructs a roof and mound from surrounding carbonate clasts for added protection and support. We studied twenty-one mounds along the western coast of Cozumel, Mexico, an island 18 km east of the Yucatan Peninsula. The tilefish in this region use coral, shell fragments, and rhodoliths to build mounds. *M. plumieri* selectively uses irregular fragments (Clifton and Hunter, 1972). The goal of this study is to determine if the distribution of clast sizes and types in tilefish mounds is distinct from that of the surrounding area. If so, this characteristic feature may aid in the recognition of mounds in the rock record.

METHODS

The data collection process was conducted using SCUBA, and consisted of two tasks performed by two groups. One group measured clasts on the tilefish mound; the other measured clasts in the surrounding areas. The mound data were collected using half-meter square frames made of "PVC" piping with string cross-tied at 10 cm intersects. The frames were placed over the area of study and clasts were picked from each string intersection and measured using calipers. The long, short and intermediate axes of these clasts were measured and recorded on data boards; clast type was also noted. The frames were placed systematically so that all sections of the mound were studied.

The surrounding area was sampled using a transect line, oriented approximately parallel to a contour and the reef system. Two tape measures were connected in the center of the mound and run equal distances from the mound. Each transect was sampled at 2.5, 5.0, and 12.0 meters. The frames were divided (with string) into quadrants. The students counted all the clasts in one quadrant at a time. If twenty-five or more clasts were counted in the first quadrant the students moved to the next distance; and if fewer than twenty-five were counted the students measured clasts in the next quadrant. If fewer than twenty-five were counted in the whole frame then it was moved to the opposite side of the tape measure and the process was repeated. A maximum of four frames were counted at any given distance.

Our data analysis consists of two data sets. First, the long-axes measurements of the grid-selected clasts in the mounds are compared with the long-axes measurements of all transect clasts from each site. These are plotted on cumulative frequency graphs. Using these we can determine the "size" selectivity of the tilefish. The second data set compares the percent of each type of clast in each mound to corresponding transects. Histograms of clast lengths for mounds indicate that all mounds are composed primarily of clasts less than 40 mm in length. We filtered out all transect clasts smaller than 40 mm in length. This essentially evens the size data at the site, which makes a "type" or diversity analysis between mounds and transects possible. These data are plotted on scatter point graphs, with a standard of 1.0. Thus, the closer to 1.0 the less selectivity is seen in the mound.

Sedimentary Environment

Ocean currents from the southerly direction have a great influence on organisms and sediment in Cozumel. Considerable influence on the growth and distribution of organisms is due to the intensity and direction of the current and waves (Muckelbauer, 1990). One clast type that tilefish use is the rhodolith, which is very dependent on these underwater currents. A rhodolith is formed when calcareous red algae encrust a clast (Harris et al; 1996). Their structure is formed by algal growth and repeated clast rotation, resulting in concentric laminations about a nucleus. The two factors that are fundamental to the growth of rhodoliths are a suitable environment for coralline growth and episodic entrainment (Prager and Ginsburg, 1989). *M. plumieri* uses these rhodoliths, usually in the pebble to cobble range in addition to shells, branching corals, and other corals.

RESULTS

Comparison of Clast Sizes on Mounds and Transects

The cumulative frequency graphs of the clasts measured on the mounds show an "S-shaped" curve, which means the clasts in the mounds have normal size distribution (fig. 1). The transects have a skewed clast size distribution. At *Playa Corona* (Fig. 1a), the distribution of clast sizes on the mound is near normal and relatively coarse grained despite being in an environment with a fine-grained clast distribution. The mounds have a moderately constant range of clast sizes (40-80 mm). Data from *Villa Blanca* (Fig. 1b)

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Fig. 1a- **Site *Playa Corona*: Note the distribution of clast sizes on the mound remains normal and coarse grained in an environment with a fine-grained clast distribution**

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Fig. 1b- **Plot of cumulative frequency curves of clast sizes from a mound and transect at *Villa Blanca.* Note the near normal size distribution of the mound and the more skewed distribution of the transect.**

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Fig 1c**- Site *Villa Blanca South*: Note the near normal distribution of clast sizes in both the mound and the transect. This case of normal clast size distribution for the transect occurred in only one out of 21 sites.**

indicate that mound clasts have a normal distribution, with the highest proportion of clasts having lengths between 40 and 90 millimeters. There were some sites that show skewed mound distributions. At one site, *Villablanca South* (Fig. 1c) we found that both the mound and transect have a skewed distribution curve. These data are dissimilar to the distributions found in most other mounds.

Comparison of Clast Type on Mounds and Transects

Plots of clast types from the mounds indicate that the types of clasts in mounds are generally in proportions similar to those found in the transect. In these plots, the bold line at "1.0" marks an equal distribution of a specified clast type between the mounds and transects. If the point lies above the line, that clast type constitutes a greater proportion in the mound. If the point is below the line, the greater proportion of the clasts is in the transect. Rhodoliths are generally the most abundant clast available for mound construction along transects. The proportion of total rhodoliths available in the transect to the proportion of rhodoliths larger than 40 mm, shows differences in abundance ranging from 20 % to 90 % (Fig 2a).

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Fig 2a- Plot of (1) percent rhodolith clasts in mound compared with those in filtered transect (2) percent rhodoliths clasts in filtered transect (3) clast density (clast/m^2) along the transect.

This graph shows that the when the rhodoliths in the transect are filtered to >40 mm in length, there are some cases when the mound has a greater abundance of rhodoliths than the transect. At site *Las Palmas,* the proportion of rhodoliths in the filtered transect are the lowest, yet the proportion of rhodoliths in the mound is the highest. This means that the fish is choosing to build its mound out of rhodoliths even though the surrounding area has relatively fewer clasts >40 mm. The use of rhodoliths in some cases and the non-use in others make their use for recognition of a fossilized mound in the rock record difficult.

It appears that tilefish often selectively use bivalve shells (Fig. 2b) because they typically occur in greater proportions in the mound than in the

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Fig. 2b**-Plot of bivalve shells in mound and transect shows that tilefish often will select bivalve shells if they are available in the transect.**

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Fig 2c. - **Scatter plot comparing percent branching coral and the percent rhodolith clasts in the mound and transect. This shows that in many cases that branching coral was a greater percentage in the mound compared to rhodolith clasts. This means that when branching coral was available, it was commonly chosen over rhodolith clasts.**

transect. It is possible that the clasts measured here were part of a roof of the mound with "shingles", which are usually derived from shells (Clifton and Hunter 1972). The proportion of rhodolith clasts and branching coral in mounds is compared with those found in the transects in figure 2c. At several sites when rhodolith clasts were not used branching coral were. The rhodoliths are used in some cases instead of branching coral, but this trend is seen a lot less. This shows possible selectivity toward branching coral when it is in the same vicinity as rhodoliths.

In our analysis of the short axes of some clasts measured, we plotted the axis lengths on histograms (transect and mound). We found a similar pattern to that of the long axis measurements. For the eight mounds plotted, seven transects had a skewed clast distribution compared to the normal, "S-shaped", distribution curve on the mound. Therefore, the normal distribution of clasts within the mound generally holds true whether long axis or short axis of clasts is considered. However, there was one histogram that revealed a different distribution. For one mound and transect the distribution was skewed for both distributions.

DISCUSSION

We concluded, using the clast size comparison data, that the mounds have clasts that are more normally distributed compared to those in the associated transects. We suggest this is a result of the selectiveness of the tilefish. There are several factors that control the size of the clasts within the mound. First, the clast sizes could be due to the stage of development of the fish. A larger fish could make a mound with larger clasts. Additionally, the mound could have been in an early or late stage of development. As seen from various mounds and mound deconstruction, in a newly constructed mound the pieces are most likely smaller clasts and in a later stage of development the mound would have larger clasts.

The clast-type-analysis data are inconclusive. There appears to be some selectivity of certain clast types (bivalve shells). Additionally, it appears that branching coral is often chosen over rhodoliths. Additional studies need to be done to further examine the relationship between clasts in mound and in surrounding areas.

CONCLUSIONS

Tilefish mounds are characterized by normal clast size distributions, with a strong mode (40-100 mm), compared with associated transects. In Cozumel, a majority of the clasts are rhodoliths, therefore a large size range of rhodoliths occur in the mounds. The mounds also exhibit some clast-type sorting. In this study, rhodoliths are often the most available clast in the transects and they have slightly lower abundances in the mounds. However, in a few cases rhodoliths are less available in the filtered transects, but are more abundant in the mounds. Analysis of clast types reveals that branching coral and bivalve shells are often favored more than other clast types in mounds. This research demonstrates that tilefish mounds have unique sedimentary features that may contribute to their recognition in the rock record

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