RECOGNIZING TILEFISH MOUNDS IN THE ROCK RECORD: IDENTIFICATION AND ENVIRONMENTAL CORRELATIONS

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INTRODUCTION

The sand tilefish, *Malacanthus plumieri*, contributes to sedimentation processes on the ocean floor by collecting and organizing clasts into mound structures (Clifton, 1973). Previous work suggests that the types of clasts used for the mound building depend on the composition of material in the surrounding area (Büttner, 1996). Because the materials available to tilefish are likely related to environmental variables, correlations between mound clasts and characteristics of the surrounding environment are important for future paleoenvironmental reconstruction studies. Also, a thorough understanding of mound shape, structure and composition is necessary for identification of mounds in the fossil record. Our study location, the leeward coast of Isla Cozumel, Mexico, is characterized by an extensive reef system and is an ideal location for studying tilefish mounds.

METHODS

Researchers located mounds using SCUBA, and collected data from the first identifiable active mound at each dive sight. It is likely that there was a bias towards larger mounds during site selection. GPS readings were recorded from a boat immediately prior to entering or after exiting the water, depending on which location better reflected mound position. We identified and measured clasts in each mound at sixteen evenly spaced points within a 0.25 m^2 grid. The grid was moved over the mound until data from the entire surface of the mound were collected. On mounds with surface areas of less than 1 m^2, additional data were collected along grid borders at 10 cm intervals.
To gain an understanding of the surrounding substrate for each mound, divers placed a 0.25 m^2 frame at 2.5, 5, and 12 m distances along transects that were oriented approximately parallel to bathymetric contours. In each of the six frames, clasts were measured and classified, and photographs were recorded. The percentage of vegetation cover of the substrate at each site was estimated from the photographs. Underwater photography was also used to document the surrounding environment, and distance to the nearest reef was estimated.

Project members deconstructed one inactive mound at Villa Blanca at a depth of 7.3 m (N 20º 29' 17.6", W 86º 58' 7.3"). All clasts in the mound were measured and classified. Data for clasts in the top layer of the mound and data for those underneath were recorded separately.

RESULTS AND DISCUSSION

Mound Characteristics

Along the coast of Cozumel tilefish mounds are composed of various types of clasts, including rhodoliths, corals, and shells. The mean lengths of the long axis of clasts for each mound range from 44 to 86 mm. The measured mounds range in length from 0.6 to 2.4 m, in width from 0.35 to 1.7 m, and in height from 0.08 to 0.3 m. Twenty-one mounds were studied at depths between 7.3 and 17.7 m.

All measured mounds smaller than 1 m^2 are circular to slightly elliptical. Most larger mounds tended to have a distinctive "C" shape with an *Ircinia strobilina* (black-ball sponge) growing nearby (Figure 1). Because sponges typically colonize on hard substrate, tilefish might use them to identify suitable substrate for mound construction (Büttner, 1996).

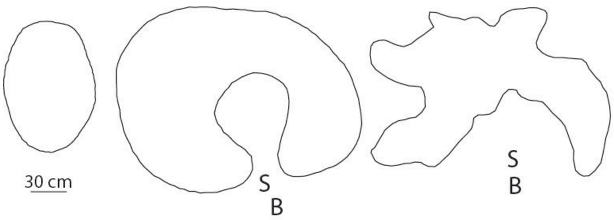

Figure 1. Tracings of mounds from photographs. Typical sponge, S, and burrow, B, positions relative to mound are noted where applicable.

Tilefish burrows are typically 8 to 12 cm in diameter and commonly have a small assortment of clasts assembled around the entrance. These clasts were not measured or identified if they were separated from the mound or there was a risk of collapsing the burrow. The burrows have been described as nearly horizontal (Büttner, 1996) and dipping 10-20° into a chamber below the mound (DeLoach, 1999). Our observations support these descriptions. To the extent that we could see into the burrows, nearly all appeared to dip at shallow angles. Tilefish, which are approximately 30-60 cm long (DeLoach, 1999), enter narrow burrows headfirst and were frequently in their burrows in a "head-out" position. Therefore, we infer there is a chamber, whether hollow or filled with soft sediment, beneath the mound so tilefish have room to turn around. Because burrows are located below mounds that are likely resistant to many typical erosional forces on the seafloor, preservation potential for the majority of the burrows is high. Figure 2 shows schematic cross sections of an active mound and a collapsed burrow as it might appear in the fossil record.

Not all mounds studied display the characteristics of a typical mound, which is probably a reflection of fish behavior. For example, tilefish sometimes inhabit or take clasts from abandoned mounds (Clifton, 1972). Some mounds seemed to show evidence of such recycling. One mound at Yucab, located at a depth of 15.8 m (N20º 25' 11.3", W87º 01' 3.4"), appeared to have the remains of an older mound adjacent to it. Also, a number of mounds contain some extremely large clasts, such as one over 300 mm in length found in a mound at Chankanaab (N20 26' 24.4", W87 00' 6.1"). It seems doubtful that tilefish are able to move such clasts. However, and if such clasts arrived at the mound by other processes, it is possible that some of the smaller clasts may also have become incorporated into mounds in other ways.

Two mounds were particularly unusual because the tilefish did not assemble many clasts and instead primarily used the existing hardground. In one Paradise (N20º 28' 6.3", W86º 59' 4") mound at a depth of 15.5 m, the tilefish burrow was located below a substantial amount of hard substrate with few clasts accumulated above it. The mound at a depth of 7.6 m at Playa Corona (N20 26' 18.6", W87 00' 2.2") was also organized around a mass of hard substratum from which sponge and coral grew. Therefore, variations will exist in mounds preserved in the rock record.

Variation also occurs within a single mound. For the excavated mound the mode length of long clast axes in the upper layer is 54 mm, whereas it is 40 mm in the lower layer. The upper layer is composed primarily of rhodoliths (70%), with a small proportion of branching coral (9%). The lower layer has a lower proportion of rhodoliths (41%) and more branching coral (31%). The lower layer is composed of more irregularly shaped clasts than the upper layer, except for the lowermost clasts, which are smaller and more regularly shaped. Branching coral and other irregularly shaped clasts in the mid to upper mound often interlock. Sand rich in *Halimeda* segments filled much of the pore space among the lowermost clasts. Based on these data, the mound is stratified. Similar stratification was previously observed in a study on a West Indian mound (Clifton, 1972).

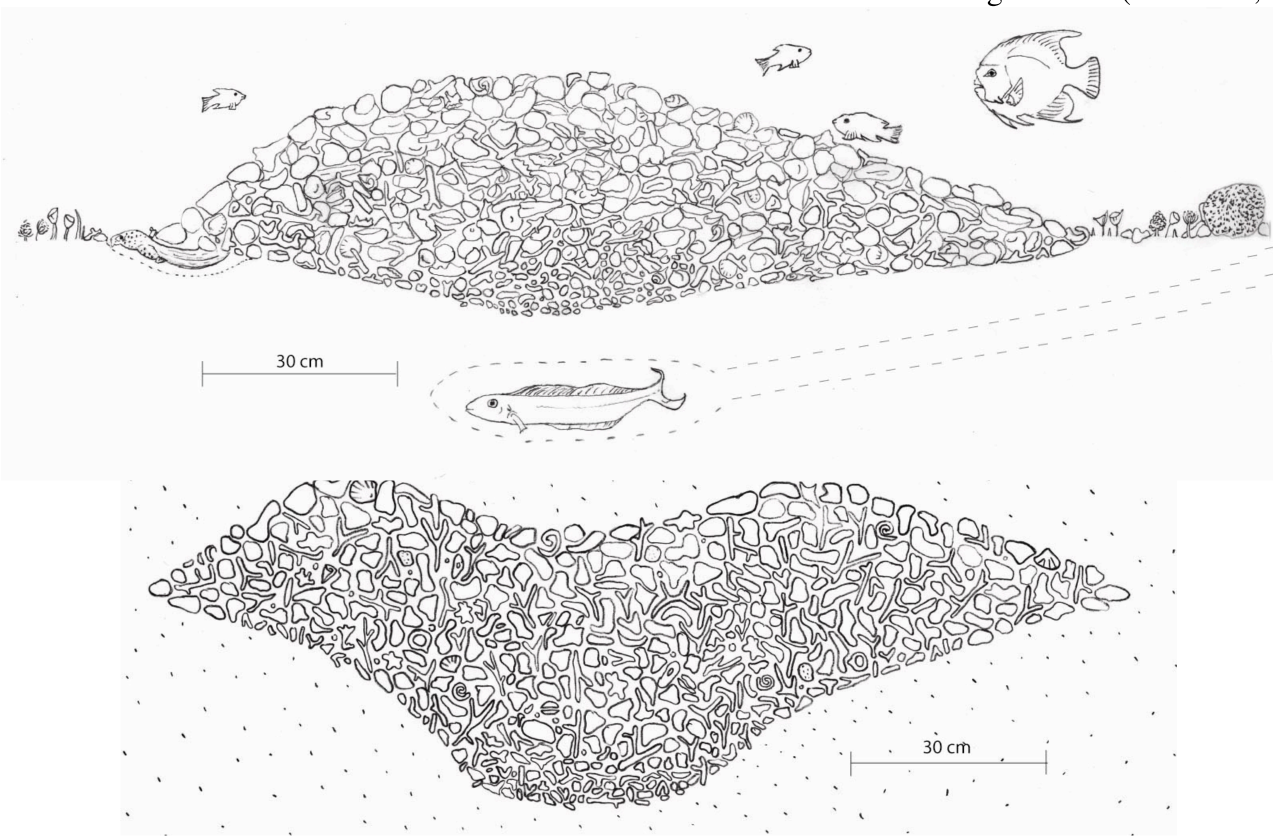

Figure 2. Schematic diagrams of mound cross sections. Vertical exaggeration is 2x. a. **Active mound, tilefish is in burrow. Also shown: angelfish, damselfish, sharp-tail eel, *Halimeda*, *Rhipocephalus*, *Penicillus* and *Ircinia strobilina*.** b. **Mound collapsed into the burrow, view is at 90º to figure 2a. Structure could be caused by sedimentation over the mound. Possible shape to look for in the rock record.**

Environmental Correlations

Environment is likely to be a primary factor in the composition of these mounds. Proximity of a mound to a reef structure correlates to certain types of clasts in the mound. Mounds within 10 m of a reef are likely to have more branching coral (53% versus 10-29%) and fewer rhodoliths (33% or more versus 15%) than mounds that are more distant (figure 3).

The same trend exists for clasts in the substrate surrounding mounds (see Bevis, Douglas and Mathers, this volume). Also, the percentage of rose coral (*Manicina*) found in the upper layers of mounds increases with distance away from a reef (figure 3). This increase makes sense given that rose corals commonly grow unattached to major reef structures and inhabit areas of coral rubble or sand and vegetation (Humann, 2002). In general, tilefish in Cozumel do not strongly select certain types of clasts (see Diggins and Feucht, this volume). This is supported by Büttner's work. Therefore, materials in a mound are likely to correspond to material available in the surrounding substrate.

Cozumel reef morphologies have been previously classified, but non-reef environments were not considered (Fenner, 1988). Mound sites are classified here as patch reef (located on a sandy substrate in between or near reef structures), inactive sand flat, or flat with active sand movement. Although the two types of flat environments

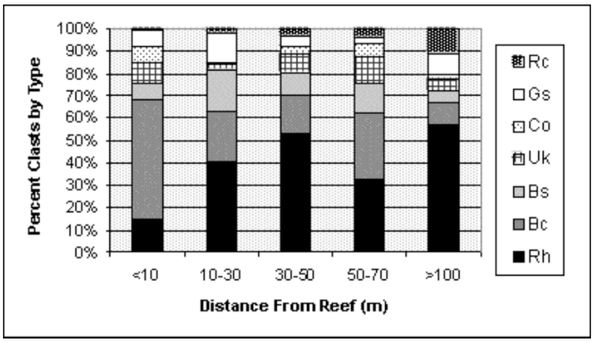

Figure 3. Plot shows distance of mound from reef versus the mean percentages of clast types in mound. Abbreviations as follows: *Rc*= Rose coral; *Gs*=Gastropod shell; *Co*=Column coral; *Uk*=Unknown; *Bs*=Bivalve shell; *Bc*=Branching coral; *Rh*=Rhodolith

occur in active sand flats compared to inactive flats (figure 4).

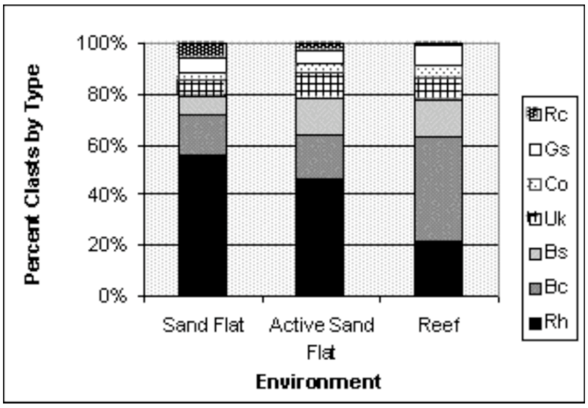

Figure 4. Plot shows environment versus the mean percentages of clast types in mound. Abbreviations as in figure 3.

There is far greater variation in mound composition and size than can be explained by correlations with reef and flat environment, and patterns are not necessarily evident from our limited data. For example, figure 5 shows mound distance from the reef versus mean length of the long axis of clasts. Although it appears that clasts might be longer in mounds greater than 50 m from a reef, these differences are not statistically significant. However, because our observations indicate that a trend might exist, we suggest that this correlation be pursued in future studies.

The percentage of vegetation cover on the substrate shows no correlation to size or types of clasts in the mound. Although our data also do not support a correlation between depth and mound size, our observations suggest that mound size decreases with increasing depth and we recommend future study over a broader depth range.

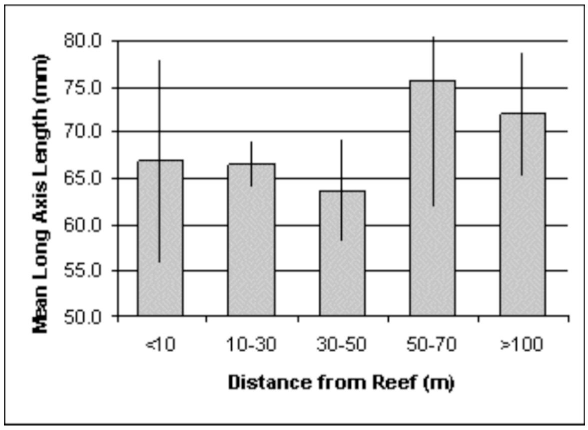

Figure 5. Plot shows distance of mound from reef versus mean clast sizes in mound with error bars showing one standard deviation.

In this study, factors such as size of the individual tilefish, age of the mound, and any possible site selectivity that may have occurred when researchers chose mounds to study were not taken into account. Full consideration of these variables and a larger sample size could lead to more correlations with environment. It may be useful to study mounds in a wider variety of environments, for example, to compare tilefish mounds off the Cozumel shore to those in other areas of the world.

CONCLUSIONS

Based on our research, *M. plumieri* mounds are lensoid, stratified accumulations of clasts that largely correspond to the types of clasts in the surrounding substrate. Viewed from above, mounds vary, but they often exhibit distinctive ellipsoid or "C" shapes. Mounds range in mean length from 0.6 to 2.4 m, and clasts range in mean length from 44 to 86 mm. Mounds closer to reefs are likely to have greater proportions of branching coral than those farther away. Because preservation potential for mounds is high, diagnostic characteristics such as these are valuable for interpretation of marine carbonate rocks.

ACKNOWLEDGEMENTS

Thanks to Carol Mankiewicz, Karl Wirth and Steve Ballou for organizing such an amazing project, keeping us constantly excited about what we were learning and helping us improve our research and analysis techniques. Also, thanks to the Keck Consortium for giving us the opportunity to conduct our own research and get a tan. Thanks to our sponsors, Peter Crowley and Eric Grosfils, for helping us get here, and to Pomona and Amherst Colleges for making our participation possible. Finally, thanks to the other students on the project for being wonderful to spend time with, both in and out of the water.

REFERENCES CITED

Büttner, H., 1996, Rubble mounds of sand tilefish *Malacanthus plumieri* (Bloch, 1787) and associated fishes in Colombia: Bulletin of Marine Science, v. 52, p. 395-417.

Clifton, H.E., and Hunter, R.E., 1972, The sand tilefish *Malacanthus plumieri*, and the distribution of coarse debris near West Indian coral reefs, *in* Colette, B.B., and Earle, S.A., eds., Results of the Tektite program: Ecology of coral reef fishes: Natural History Museum, Los Angeles County Science Bulletin, v. 14, p. 87-92.

Clifton, H.E., 1973, Role of reef fauna in sediment transport and distribution: Helgolander wissenschaftliche Meeresuntersuchungen, v. 24, p. 91-101.

DeLoach, N., 1999, Reef fish behavior: Jacksonville, FL, New World Publications, Inc., 359 p.

Fenner, D.P., 1988, Some leeward reefs and corals of Cozumel, Mexico: Bulletin of Marine Science, v. 42, p. 133-144.

Humann, P., and DeLoach, N., 2002, Reef Coral Identification: Jacksonville, FL, New World Publications, Inc., 278 p.