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Spur and Groove Coral Reef Morphology

Introduction

Numerous patch reefs occur along the Florida Keys Coral Reef Tract. They are composed of a variety of soft and hard coral-producing organisms, with many exhibiting a similar geomorphic structure identified as spur and groove morphology. This hard coral framework has also been reported at reefs around the world. Even some "prehistoric" reefs appear to exhibit this morphology. Spur and groove morphology at the Florida Keys Coral Reef Tract demonstrates intelligence in its design and a preferred end state for the growth and development of a healthy Elkhorn coral-dominated (i.e., *Acropora palmata*) patch reef.

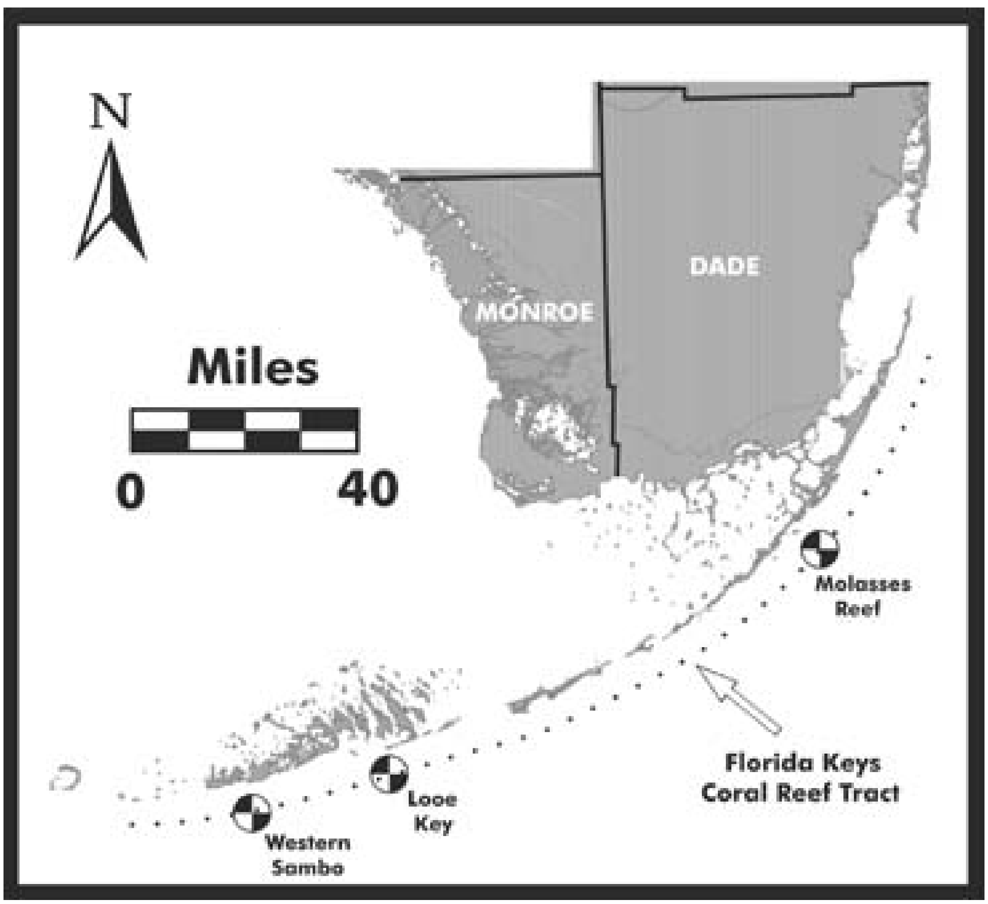


Figure 1. Base map showing location of Western Sambo Reef, Looe Key Reef, and Molasses Reef. The modern coral reef tract (represented by the dotted line) is located several miles offshore and is composed of numerous patch reefs, many of which exhibit spur and groove morphology.

Spur and Groove Morphology

The term "spur and groove" was first used by Shinn (1963) in reference to coral reef morphology identified at various patch reefs along the Florida Keys Coral Reef Tract (Figure 1). Previously, this reefal structure was referred to as the buttress zone at a reef in the Pacific Ocean (Odum and Odum, 1955). In describing spur and groove morphology, Shinn (1963) stated:

> The "spur and groove" system is a geomorphic feature that is present on the seaward side of most reefs ... Externally, spurs are coralline fingers as high as 30 feet that are separated by grooves ... On Florida reefs, the spurs vary in width from

> 25 to 200 feet and extend into the prevailing seas and swells several hundred feet and down to depths of 100 feet (p. 291).

It should be noted that while spurs and grooves were found at some depth, there are actually two terraces of coral reef exhibiting spur and groove morphology in places along the Florida Keys reef tract; only the shallow portion of the reef (water depths less than 25 ft) demonstrates active Elkhorn coral (i.e., *Acropora palmata*) growth (Figures 2 and 3). The lower terrace is covered with bladed growths of *Milleopora complanata* that have overgrown dead spurs of *Acropora* (Shinn, 1963).

According to Enos and Perkins (1977), scleractinian corals:

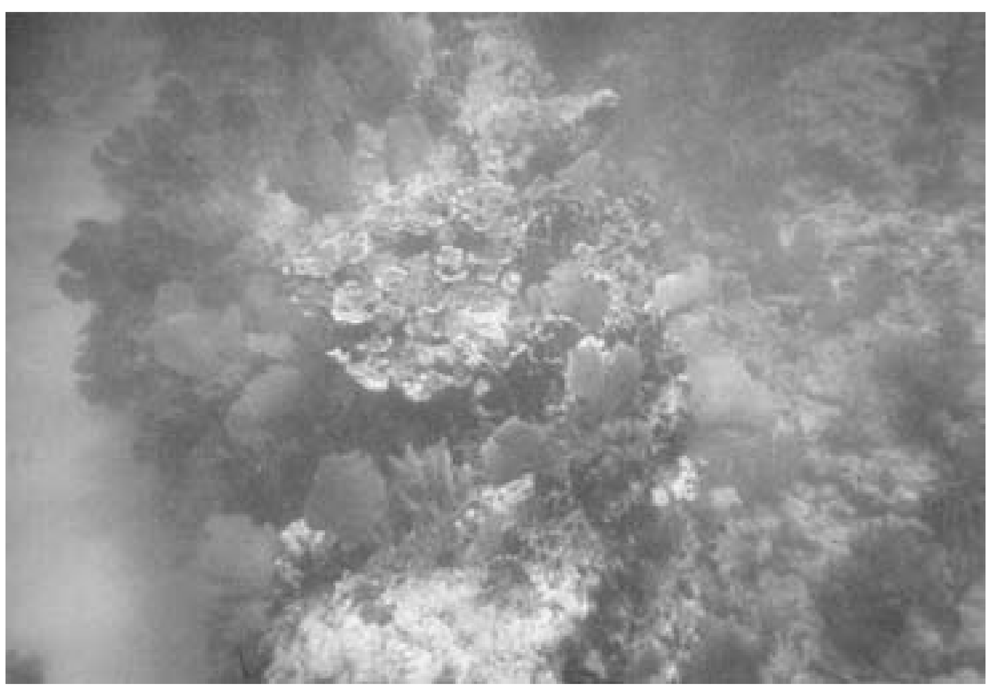
> ...are the most spectacular organisms of the south Florida shelf. Their distribution is among the most clearly zoned ... *Acropora palmata* ... is the chief framework-former of the outer reefs. It is the prime indicator of maximum wave action and open circulation. It grows from the surf zone to depths of at least 8 m (26 feet), and is abundant in reefs several kilometers landward from the slope break where no outer barrier exists (p. 35, parenthesis mine).

Acropora coral branches tend to grow together into thickets. According to Shinn (1977):

> Continued unidirectional growth causes individual colonies to coalesce into fingerlike spurs that project as much as 200 feet into oncoming seas. These "living spurs" die from crowding when they reach the surface... (p. 209).

The coral branches forming the spurs are more circular and massive in cross section com-

above: **Figure 2. The Western Sambo patch reef with a dive boat approximately 30-feet long on the right side of image. The dark spurs are composed of *Acropora* coral that approach the water surface. They are separated by the light-colored deep grooves. The shallow area behind the spur and groove structure is the reef flat.**



right: **Figure 3. A small crop of *Acropora palmata* coral is growing on top of a spur at Molasses Reef. Sea fans (predominately *Gorgonia ventalina*) dominate much of the spur surface.**

Figure 4. Small spur and groove structure at Looe Key Reef. Note person at top of image for scale.

approximately 200 feet more than the total thickness of the carbonate layer presently recognized as composing the Florida Keys Coral Reef Tract (see Froede, in press). Uniformitarian scientists assert that the Florida Keys (i.e., Pleistocene age coralline islands) and adjacent Holocene coral reef tract have been developing for the past 100,000 years (Hoffmeister, 1974). This disparity of the apparently missing coral has not been addressed by naturalists in defining the differences between the amount of coral found today across the Keys and the amount that should be present if tens-to-hundreds of thousands of years have been available for coral reef development (Froede, 1999).

pared to those growing in protected or calmer waters (Shinn, 1963). However, even in the more massive form, storm waves can still break apart the Elkhorn coral (i.e., *Acropora*) contributing to reef debris. If not flushed of the accumulating carbonate material, the grooves (Figure 4) can fill and extend the reef flat toward the open water, thereby limiting the space available for further spur development.

Spur and groove morphology is not limited to the Florida Coral Reef Tract. This reefal structure has been identified at many coral reefs around the world (Table 1).

Acropora palmata Growth Rates

Under modern reef conditions, *Acropora palmata* can grow relatively quickly, as much as four inches per year (Shinn, Halley, and Hine, 2000). At this rate and with accommodation space provided by sea level changes, *Acropora* could grow 333.3 feet in as little as 1,000 years! This is

Paleozoic-Mesozoic Spur and Groove Morphology

Spur and groove morphology has also been proposed for a number of reefal mounds found in both the Paleozoic and Mesozoic Periods (e.g., Barthel, 1977; Wood and Oppenheimer, 2000). It is important to note that scleractinian corals (i.e., the hard, radiate kinds of corals that compose the modern coral reef) did not exist during this period of time in naturalist history. Whether the morphology operated in the same (or similar manner) in which this form operates today is completely interpretative. In fact, some argument could be made that these pre-scleractinian structures were not "reefs" at all but structures with features that suggest a similar morphology (Braithwaite, 1973).

Discussion and Conclusions

Spur and groove morphology is best developed on the seaward side of an *Acropora* dominated patch reef as a function of wind and wave energy. Its widespread occurrence, not

Table 1. Although not a comprehensive list of references dealing with the subject of spur and groove morphology, the cited articles provide information related to the development of this unique coral reef from around the globe.

Atlantic Ocean	Pacific Ocean	Indian Ocean	Red Sea	Caribbean
1) Macintyre, 1988 2) Chiappone and Sullivan, 1996	1) Wolanski and Delesalle, 1995 2) Pandolfi, 1995	1) Gabrié and Montaggioni, 1982 2) Sheppard, 1981	Sneh and Friedman, 1980	1) Roberts, Wilson, and Lugo-Fernández, 1992 2) Steiner, 1999

only across the Florida Keys but also worldwide, suggests that it does not develop by accident. Changing sea level position has served to create at least two tiers of spur and groove structure along portions of the Florida Keys. What appears to be missing is the physical evidence that supports 100,000 years of coral reef development.

The suggestion that spur and groove morphology is functionally equivalent for "prehistoric" reefs is completely subjective. Too many unknowns exist to accurately determine if the inferred structure operated in a similar manner with creatures that are now extinct.

The coordinated growth of separate stands of *Acropora palmata* form the spur and groove morphology exhibited along the Florida Keys Coral Reef Tract. How individual coral polyps could have evolved to communicate in a manner that directs their growth into this successful form has not been addressed by naturalists. The consistent development of this reef structure worldwide demonstrates intelligence in design and the preferred end state for maximizing the growth and development of healthy *Acropora*-dominated patch reefs.

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