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Spatial and temporal patterns in reef sediment accumulation and composition, southwestern insular shelf of Puerto Rico

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Abstract.—Effects of terrigenous sedimentation are considered a serious threat to Puerto Rico's coral reefs. This study assesses: 1) the composition of sediments accumulating at reef sites on the southwestern shelf of Puerto Rico; 2) the spatial extent to which terrigenous materials are reaching these reefs; and 3) the spatial and temporal variability of sediment composition, grain size and trap collection rates. Sediment traps were deployed at 9 sites from inner shelf to shelf edge. Analyses of total sediment weight (April 2006 - April 2007) show a similar temporal pattern at all sites with June and August having the highest accumulation rates. In general, there is a decrease in trap accumulation rate with depth. Carbon composition analyses indicate that samples consist primarily of calcium carbonate with lesser amounts of terrigenous and organic material, and a slightly higher percentage of terrigenous material in the <63 μm fraction. At a given site, the percentage of terrigenous material is fairly constant regardless of trap collection rate, suggesting that observed changes in accumulation rates are due to resuspension of existing material rather than an influx of new terrigenous material. These results, illustrate that in some reef systems, resuspension of existing bottom sediments is as important as the influx of new terrigenous material.

Keywords.—Coral reef, sediment accumulation, terrigenous sediments, sediment traps, resuspension, Puerto Rico

Introduction

Terrestrial runoff into the coastal environment has become a serious concern due to its negative effects on marine ecosystems, particularly coral reefs. In reef environments, terrigenous sediment entering coastal waters during runoff events is considered a contaminant, whether the sediment settles or remains in suspension (ISRS 2004; Te 1997). Sedimentation is linked to various types of reef degradation, including lower growth rates due to a reduction in coral calcification rates, fewer recruits due to a reduction in fecundity, bleaching due to turbidity and necrosis due to smothering (Acevedo et al. 1989; ISRS 2004; Rachello-Dolmen et al. 2007; Torres et al. 2002). The impacts of sediment stress depend on a wide array of physical and biological factors in the system and are well documented (Acevedo et al. 1989; Babcock and Devies 1991; Hewitt et al. 2003; Nemeth and Nowlis 2001; Rachello-Dolmen et al. 2007; Riegl 1995; Rogers 1990; Weber et al. 2006; Woolfe and Larcombe 1999). Coral reef survival is greatly affected by the duration of high sediment accumulation rates, depth, distance from shore, and the amount, grain size and composition of sediments being introduced and/or resuspended.

Sediment samples from shallower depths may contain lower concentrations of silt and clay as wave energy tends to winnow out the finer grains (Acevedo et al. 1989; Bothner et al. 2006; McLaren 1981). Although nearshore reef sediment accumulation rates are typically much higher than accumulation rates at reefs farther from shore (Smith et al. 2008), silt- and clay-sized sediments which remain in the water column for prolonged periods of time have great transport potential and can impact reefs farther from their source (Fabricius 2005; McLaren 1981). Though both coarse and fine-grained sediments have the potential to inflict sub-lethal and lethal effects on corals after short-term exposure, sand-sized grains are more readily removed from the coral surface (Weber et al. 2006). In addition, samples containing a large fraction of clay and silt-sized

sediments typically have greater concentrations of organic chemical contaminants (Pait et al. 2008). Fine-grained terrigenous sediments reduce efficiency of photosynthesis in coral reefs more than fine-grained carbonate sediments (Te 1997), highlighting the importance of compositional analysis of sediments in reef sedimentation studies. Resuspension of sediments is also of critical importance in reef systems and can exert a fundamental control on the survival of some coral reefs. Sediments that are resuspended during the higher energy daytime settle during the calmer evenings only to be resuspended again the next day. Thus, the very same sediment grains can impact a coral reef repeatedly and may not be removed from a given reef system until finding a protected area or large drop-off in depth (Ogston et al. 2004).

The shelf area off La Parguera is a natural reserve located off of southwestern Puerto Rico (Fig. 1). La Parguera has been considered to be a relatively unpolluted area in terms of terrigenous sediments, turbidity and coral abundance. This is due to the fact that compared to other coastal areas of Puerto Rico, there is less land development of the coastal watershed, low precipitation, low wave energy compared to the northern coast and no major river inputs nearby (Acevedo et al. 1989; Warne et al. 2005; Garcia et al. 2003, Warne et al. 2005). In addition, mangrove habitats along the La Parguera shoreline trap locally derived terrigenous sediment in the coastal zone before it can travel seaward and affect offshore reefs (Morelock et al. 2001; Torres et al. 2002). Previous studies show that reefs off La Parguera typically have a higher

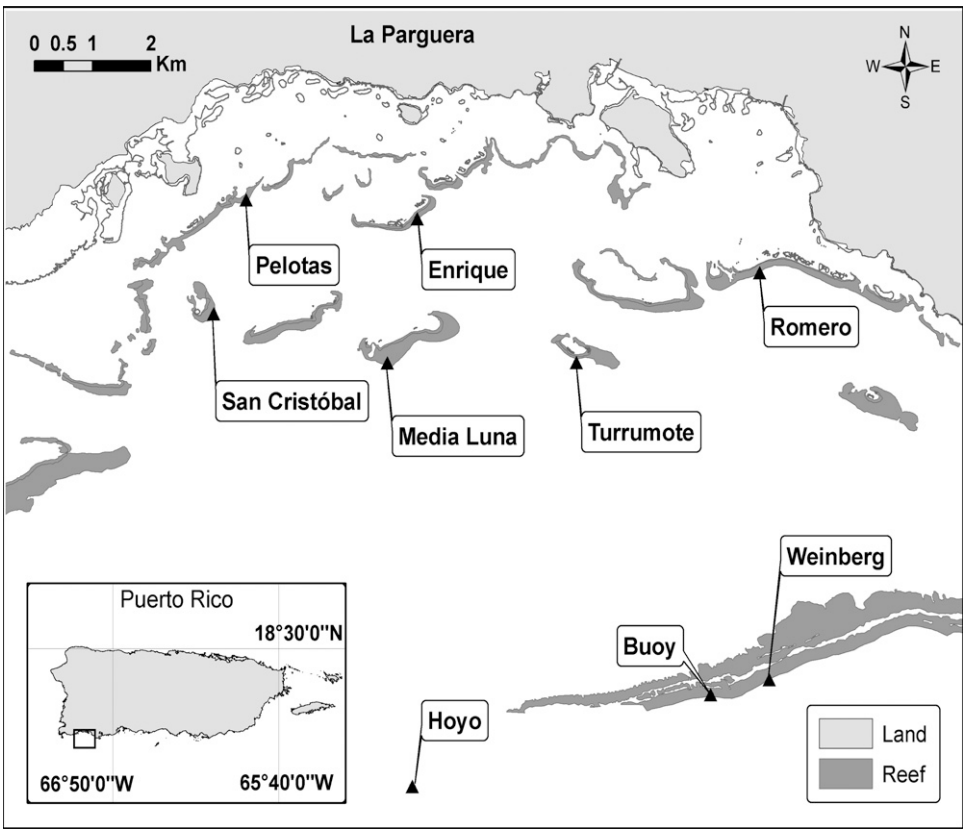

FIG. 1. Map of study site. Inner-shelf reefs – Pelotas, Enrique and Romero; Middle-shelf reefs – San Cristobal, Media Luna and Turrmote; Shelf-edge reefs –Hoyo, Buoy and Weinberg.

percent coral cover than surrounding areas and contain sediments composed primarily of coarse calcium carbonate grains with little terrigenous material (Acevedo et al. 1989; Ballantine et al., 2008; Morelock 1987; Ryan et al. 2008).

This study is part of a larger study coral reef ecosystem study (CRES) in which dynamics of processes affecting coral reefs at a series of cross-shelf sites off La Parguera, P.R. have been examined. One of the principle tenants of the CRES program is that the integrity of coral reef ecosystems depends upon low influx of watershed-based materials to the marine environment, i.e., that there exist mechanisms (based on geomorphology, wind stress, tidal flow, floral elements, etc.) that constrain runoff to the nearshore environment. However, this has not been confirmed by the direct analysis of sediments accumulating at reef sites. To date, present sediment accumulation rates on the insular shelf off La Parguera that take into account both spatial and temporal variability across the shelf have not been clearly established, nor has the composition of these sediments been determined. This study assesses: 1) the composition of sediments accumulating at reef sites on the insular shelf off La Parguera, PR; 2) the spatial extent to which terrigenous materials are reaching these reefs; and 3) the spatial and temporal variability of sediment composition, grain size and accumulation rate at reefs off La Parguera.

Materials and Methods

The study area (Fig. 1) is located off La Parguera on the southwestern coast of Puerto Rico (17° 56′ N, 67° 03′W). La Parguera is a small coastal community characterized as semi-arid with no river inputs and local runoff generally trapped by mangroves close to shore (Acevedo et al. 1989). The broad insular shelf off La Parguera extends approximately 8-10 km offshore and contains three primary, shore-parallel reef tracts with open sandy areas in between. The three reef tracts are inner-shelf reefs (~1-2 km offshore), middle-shelf reefs (~2-4 km offshore) and shelf-edge reefs (~8 km offshore). Inner- and middle-shelf reefs are emergent reefs that rise to sea level from depths of ~15-20 m. The shelf-edge reefs are submerged reefs that occur at the shelf break at water depths of ~18-24 m. They are typically low relief with variable spur and groove formations (Hubbard et al. 1997; Ballantine et al. 2008). The shelf edge drops off at about 20m with an abrupt, steep slope (García et al. 2003).

Three reef sites along each of the three primary reef tracts were chosen for this study: Pelotas, Enrique and Romero (inner-shelf reefs), San Cristobal, Media Luna and Turrumote (middle-shelf reefs) and Hoyo, Buoy and Weinberg (shelf-edge reefs). The sediment traps used were wide-mouth, Nalgene 1-liter plastic bottles attached to an iron bar and covered with a coarse mesh with ~1 cm^2 mesh size. These traps are similar to those used by Torres and Morelock (2002) in previous studies in La Parguera. At each site, replicate sediment traps were deployed at a given depth. At inner- and middle-shelf sites, traps were placed at four depths extending down the reef front from ~1m to ~15 m water depth. At shelf-edge sites, replicate traps were set at four locations between ~18 m and ~24 m. The traps were collected, and processed monthly over a period of 13 months (April 2006 through April 2007), with the exception of December 2006 and January 2007, which were collected together at the end of January. Although analyses for this study ended with the April 2007 samples, the sediment traps continued to be deployed and collected by other researchers for separate studies. The months of August 2007 and October 2007 were of special interest to this study due to the passage of tropical cyclones Dean and Noel, respectively. Because trap material was available for these months, a subset of samples was analyzed to determine the potential impacts of these events on sedimentation patterns as well as compare data from these months with the long-term average for April 2006 through April 2007.

In the laboratory, a subset of samples was split into sand (>63 μm) and mud (<63 μm) fractions by wet sieving, and then oven dried at 60° F. Dry weight was determined for all samples. A subset of these samples

was ground in an agate mortar for compositional analyses. Bulk carbon composition (TC, TIC and TOC) was determined by carbon coulometry techniques (Engleman et al. 1985) conducted at the Limnological Research Center/National Lacustrine Core Facility, University of Minnesota – Twin Cities. The mineralogy of the samples was determined by X-ray diffraction (Hardy and Tucker 1988). To isolate the non-carbonate (i.e., terrigenous) fraction, a subset of samples was treated with a 10% HCl solution. The remaining insoluble residue was examined under a stereomicroscope and its mineralogy determined by X-ray diffraction. Statistical tests including one-way RM ANOVA and Pearsons correlation were used to establish significant differences and correlations among the data. Wave data were generated from the NOAA WAVEWATCH III model (Tolman 1997, 1999) using the virtual buoy south of Puerto Rico at 17.5° N, 66.5° W.

Results

Analyses of total sediment accumulation from April 2006 to April 2007 showed a similar temporal pattern at all sites, with June 2006 and August 2006 having significantly higher sediment accumulation rates than other months (Fig. 2). San Cristóbal, a middle-shelf reef, consistently received the greatest total sediment accumulation of all sites throughout the April 2006 – April 2007 study period, with an annual average accumulation rate of 14.8 mg cm^{-2} d^{-1}. The annual average sediment accumulation rates for the inner- and middle-shelf reef tracts were 6.9 mg cm^{-2} d^{-1} ± 1 and 8.2 mg cm^{-2} d^{-1} ± 1, respectively, while the shelf-edge reef tract had a significantly lower annual average

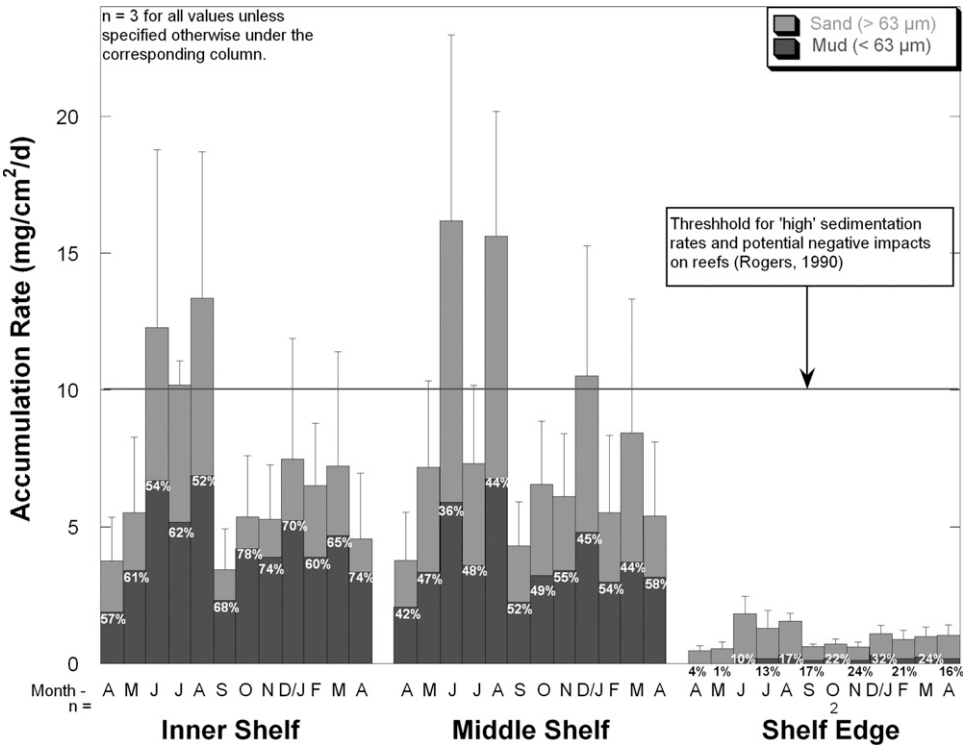

Fig. 2. Average daily sediment accumulation by month from April 2006 through April 2007. Rogers' (1990) threshold for high sedimentation of 10 mg/cm^2/d was well surpassed at inner and middle shelf sites during June and August. Percentages within the column represent the average percent of <63 µm material.

rate of 1.0 mg cm^{-2} d^{-1} ± 0.1 (mg cm^{-2} d^{-1} ± Standard Error.). At inner- and middle-shelf sites, shallow traps at ~1-5 m in depth received greater amounts of sediment with a higher percentage of coarse material than deeper traps at ~7-15 m depth (Fig. 3).

Carbon composition analyses reveal that terrigenous material is reaching all sites. However, the trap sediment consists predominantly of calcium carbonate, with lesser amounts of terrigenous and organic material (Fig. 4). Terrigenous material is found in both the >63 µm and <63 µm size fractions. However, there is consistently a slighter higher percent terrigenous material in the <63 µm fraction. At a given site, the percentage of terrigenous material remained relatively constant over time (Fig. 5). An increase in the total amount of sediment accumulation did not necessarily equate to an increase in the relative amount of terrigenous material. The percentage of terrigenous material decreased with distance offshore, with the inner-shelf, middle-shelf and shelf-edge reefs averaging 21.9%, 19.4% and 12% terrigenous material, respectively. There was a significant difference in terrigenous accumulation rates between the shelf-edge sites and both the inner- and middle-shelf sites. Average annual terrigenous sediment accumulation rates were 1.6 mg cm^{-2} d^{-1} ± 0.2 at the inner shelf, 1.5 mg cm^{-2} d^{-1} ± 0.2 at the middle shelf and 0.1 mg cm^{-2} d^{-1} ± 0.02 at the shelf edge.

The carbonate fraction of trap sediments consists of sand- and gravel-sized skeletal grains and lime mud. X-ray diffraction (XRD) analyses of the carbonate fraction

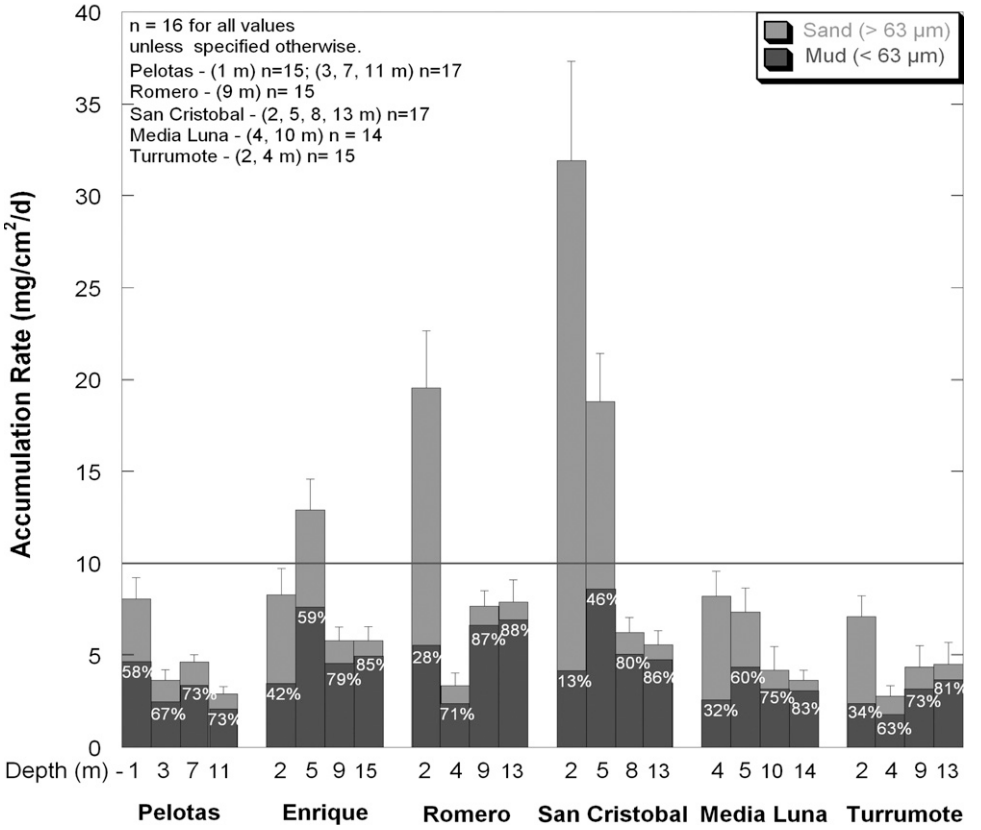

FIG. 3. Average sediment accumulation rate with depth from April 2006 through April 2007, showing percent sand and mud material. Depth in meters for each trap is indicated below the corresponding column.

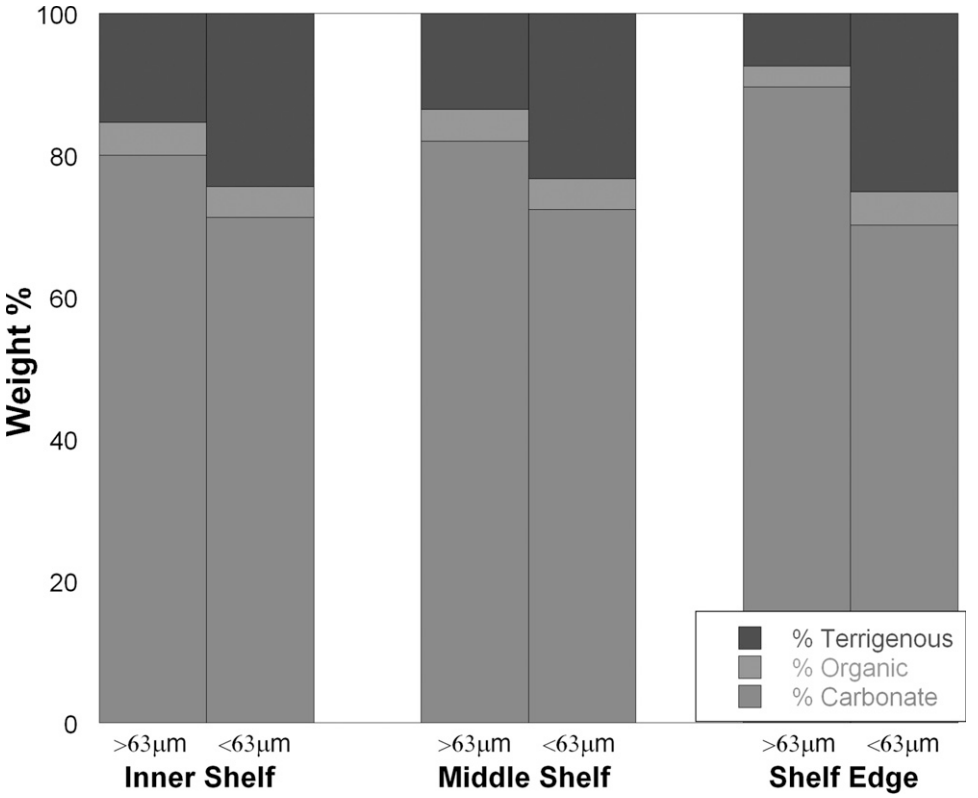

FIG. 4. Average bulk composition of trap sediments from April 2006 through April 2007 given in weight percent for the >63 µm and <63 µm fractions.

indicates that it consists primarily of aragonite and magnesian calcite (~14 mole % $MgCO_3$) with lesser amounts of calcite (~3 mole % $MgCO_3$). The insoluble residue remaining after HCl dissolution consists primarily of a fine, brown amorphous material with rare (<3%) sponge spicules. No large non-carbonate grains, such as quartz or rock fragments, were evident in samples. XRD analyses of the insoluble residue indicate that this material consists of clay minerals, quartz and plagioclase feldspars. These results confirm that the "other" fraction determined by carbon coulometry is terrigenous material and not silica of marine origin, such as spicules or tests.

During August 2007 (Hurricane Dean) total sediment accumulation was significantly greater than all other months during the April 2006 - April 2007 study period (Fig. 6). Sediment accumulation rates during both August 2007 and October 2007 were generally quite variable within each reef site. This along with the smaller sample size for these months is reflected in the standard error values. The average sediment accumulation rates for August 2007 were 49.3 mg cm^{-2} d^{-1} ± 13.1 at the inner shelf, 132.5 mg cm^{-2} d^{-1} ± 74.6 at the middle shelf and 85.1 mg cm^{-2} d^{-1} ± 31.1 at the shelf edge. Total trap collection rates for October 2007 were much lower than August 2007 rates, 14.1 mg cm^{-2} d^{-1} ± 2.2 at inner-shelf sites, 44.9 mg cm^{-2} d^{-1} ± 27.2 at middle-shelf sites, and 2.7 mg cm^{-2} d^{-1} ± 1.3 at shelf-edge sites. During both August and October 2007, San Cristóbal remained the site with the highest total sediment accumulation rates, (343.4 mg cm^{-2} d^{-1} in August 2007 and 121.9 mg cm^{-2} d^{-1} in October 2007). Perhaps most notably, there were dramatic increases in accumulation rates at shelf-edge sites during August 2007, in particular at the

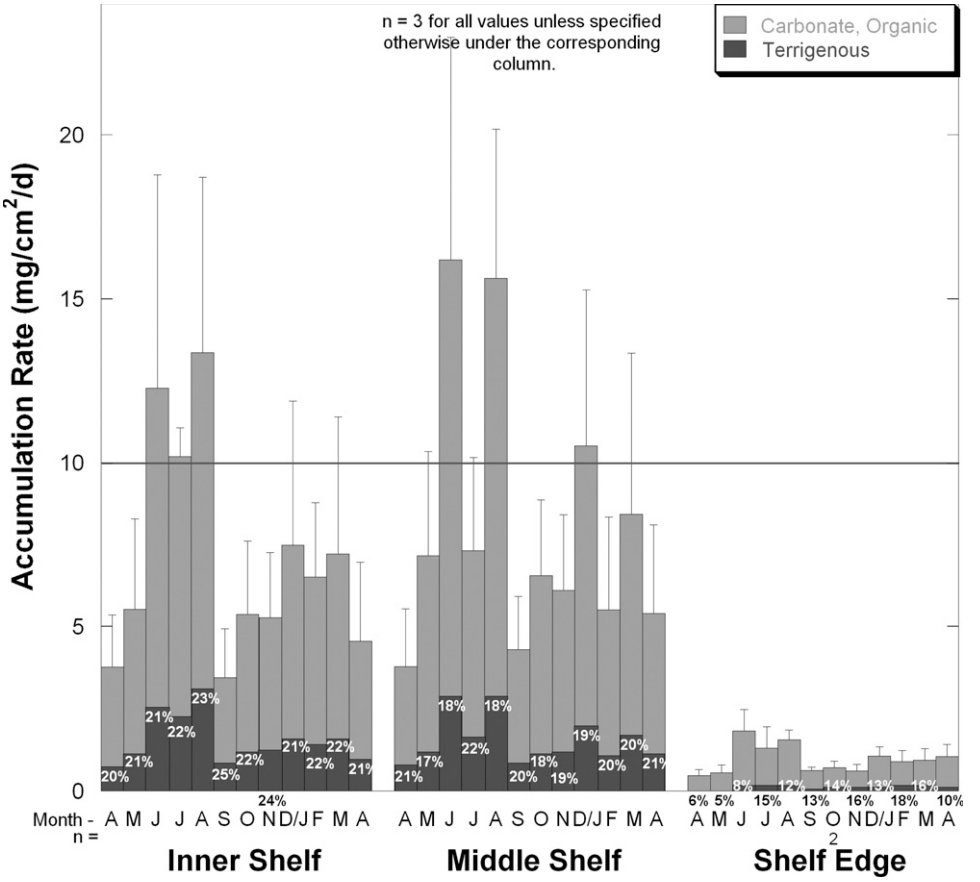

Fig. 5. Average daily sediment accumulation by month from April 2006 through April 2007, showing percent terrigenous material. Although Rogers' threshold for high sedimentation of 10 mg/cm^2/d was reached at inner and middle shelf sites during June and August, the terrigenous accumulation rate was well below the threshold. Percentages within the column represent the average percent of terrigenous material.

Weinberg and El Hoyo sites. Traps at the Weinberg site collected the second highest accumulation rates across the shelf (161.8 mg cm^{-2} d^{-1}). These rates are over 195 times greater than the annual average at this site. Traps at El Hoyo collected 84.3 mg cm^{-2} d^{-1}, which are over 40 times greater than the annual average accumulation rates at this site. Although average total sediment accumulation rates were significantly higher during August 2007 (Hurricane Dean) versus all other months, the average percent terrigenous material was significantly lower in August 2007 versus all other months including October 2007. The average percent terrigenous material for August 2007 was ~9%, while the average percent terrigenous material for all other months ranged from ~14 to 19% (Fig. 7).

Discussion

Similar changes in sediment accumulation rates from one month to the next occurred at all sites, establishing temporal sediment accumulation patterns and a general trend of decreasing total sediment accumulation with distance from shore. This consistency indicates that the method of collection was recording actual trends in sediment accumulation rates and not just an isolated occurrence at an individual trap or site. Total sediment accumulation rates were similar for inner- and middle-shelf

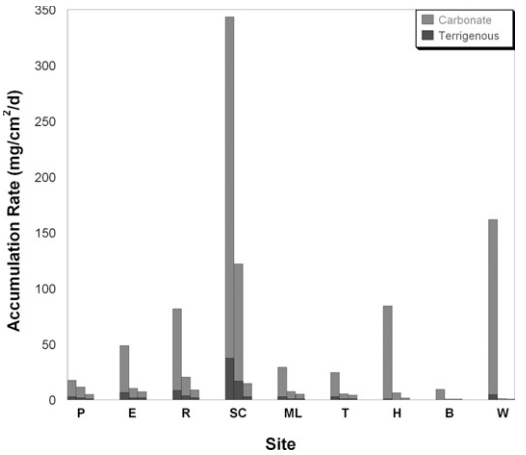

FIG. 6. Average total and terrigenous sediment accumulation rates during August 2007 (Hurricane Dean), October 2007 (Tropical Storm Noel) and the long-term average from April 2006 through April 2007. Letters below columns indicate reef sites: Pelotas (P), Enrique (E) and Romero (R) - inner-shelf reefs, San Cristobal (SC), Media Luna (ML) and Turrumote (T) - middle-shelf reefs, and Hoyo (H), Buoy (B) and Weinberg (W) -shelf-edge reefs. Moving from left to right within each set of three columns are accumulation rates for August 2007, October 2007 and the annual average value for April 2006 – April 2007, respectively.

sites and significantly lower for the shelf-edge sites. This is most likely due to the greater depth and lower wave energy of the shelf-edge traps as opposed to the middle and inner shelf sites. The general trend of a decreasing percentage of terrigenous material with distance from shore is consistent with a land-based source of this mateal.

In a review of the effects of sediments on coral reefs by Rogers (1990), chronic average sediment accumulation rates of 10 mg cm^{-2} d^{-1} were considered high and suggested as a threshold for stress responses of coral reefs. This 10 mg cm^{-2} d^{-1} threshold suggested by Rogers (1990) was subsequently supported by Nemeth and Nowlis (2001). They found that reef sites in Caret Bay, St. Thomas USVI, that were exposed to average sediment accumulation rates of between 10 and 14 mg cm^{-2} d^{-1} had a greater percentage of coral colonies experiencing pigment loss than reefs receiving average sediment accumulation rates of 4 to 8 mg cm^{-2} d^{-1}. As shown in Figure 5, total sediment accumulation rates at the inner and middle shelf reefs off La Parguera greatly exceeded the 10 mg cm^{-2} d^{-1} threshold only during

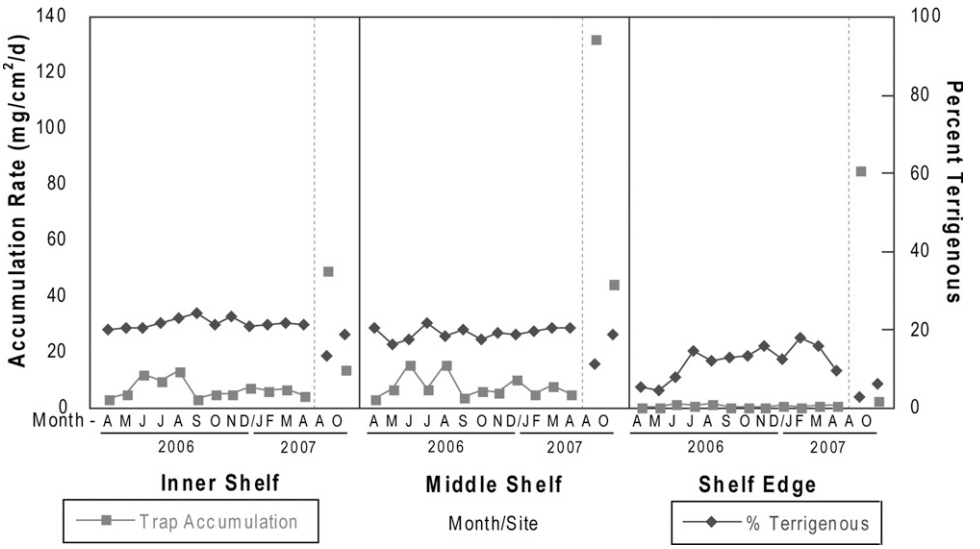

FIG. 7. Percent terrigenous and total trap accumulation rate with time: April 2006 through April 2007 as well as August 2007 (Hurricane Dean) and October 2007 (Tropical Storm Noel). Inner-shelf, middle-shelf and shelf-edge values for August 2007 and October 2007 are shown as isolated points indicating gaps in monthly sampling from April to August and August to October 2007.

June and August. In general, average sediment accumulation rates at these reefs were ≤8 mg cm^{-2} d^{-1}. In addition, the terrigenous accumulation rate consistently remained well below the 10 mg cm^{-2} d^{-1} threshold throughout the year at all sites. Thus, the present study suggests that La Parguera's reef systems would not be considered stressed in terms of terrigenous sediment accumulation.

The primary source of the sediment in both the sand and mud fractions is the *in situ* production of calcium carbonate. Some reef sedimentation studies have assumed that the sand fraction contains mostly carbonate material and the mud fraction mostly runoff or terrigenous material (e.g., Nemeth and Nowlis 2001). However, the results presented in this study show that this assumption is not always valid as both the sand and mud fractions were composed predominantly of carbonate material. The bulk of the <63 μm fraction for this study consists of a lime mud, which is a common reef sediment typically formed by bioerosion and mechanical disaggregation of larger carbonate grains such as calcareous green algae (Tucker and Wright 1990).

Terrigenous sediment was found at all sites studied at La Parguera in both the sand and mud fractions. Although present in both size fractions, terrigenous material isolated by HCl dissolution consisted predominantly of mud-sized material, which can be repeatedly resuspended and transported across the shelf. The presence of terrigenous material in the sand fraction may be due to the cohesive nature of fine clay and silts as they may aggregate and stick to larger particles (Perry and Taylor 2007). No sand-sized, terrigenous grains were noted in visual inspection of samples. Average terrigenous percentage values reported here for the three reef tracts are higher than values reported by Ryan et al. (2008) for a back reef setting at La Parguera (~12%) and values reported for Turrumote (<5%) by Torres et al. (2002). It is unclear whether these differences represent actual changes over time or are due to differences in respective analytical techniques used. Though higher than previous studies in the area, the values are still well below values reported by Torres et al. (2002) for other reefs in southern and western Puerto Rico. At a given site, the average percentage of terrigenous material in the present study is fairly constant regardless of sedimentation rate, suggesting that observed changes in sedimentation rates are due to resuspension of existing material rather than an influx of new terrigenous material.

The comparison of total sediment accumulation rates with the percentage of <63 μm material also supports resuspension as the main source of sedimentation on coral reefs at La Parguera, because results display a correspondence of spikes in total sedimentation to dips in the percentage of <63 μm sediment accumulation (Fig. 8). Resuspension is more evident upon examination of sediment accumulation with depth (Fig. 3). In general, total sediment accumulation and percent sand material is greatest at shallower depths. At greater depths, there is typically a decrease in total sediment accumulation and percent sand with a corresponding increase in the percent mud. This demonstrates the direct influence of depth and wave energy on sediment resuspension at depths less than ~5 m. Figure 9 illustrates the relationship between total trap accumulation rates and significant wave height. In general, peaks in significant wave height correspond to those months with peaks in sediment accumulation rates, i.e. June 2006, August 2006, August 2007 and October 2007.

On August 18th, 2007, Hurricane Dean passed south of Puerto Rico with wind speeds of 268 km/hr sending large swells toward the south coast of Puerto Rico. On October 26th, 2007, a tropical low, which would later become Hurricane Noel, passed south of Puerto Rico resulting in La Parguera receiving a week of rain along with winds of 46 km/hr. For La Parguera, the passage of Hurricane Dean was a large wave event, while Tropical Low Noel was a rain event. Sediment accumulation rates for August 2007 were the highest rates recorded in this study and orders of magnitude higher than the April 2006-April 2007 average. Of the three reef tracts, trap accumulation at the middle shelf seemed to be most affected by the August 2007 and October 2007 weather

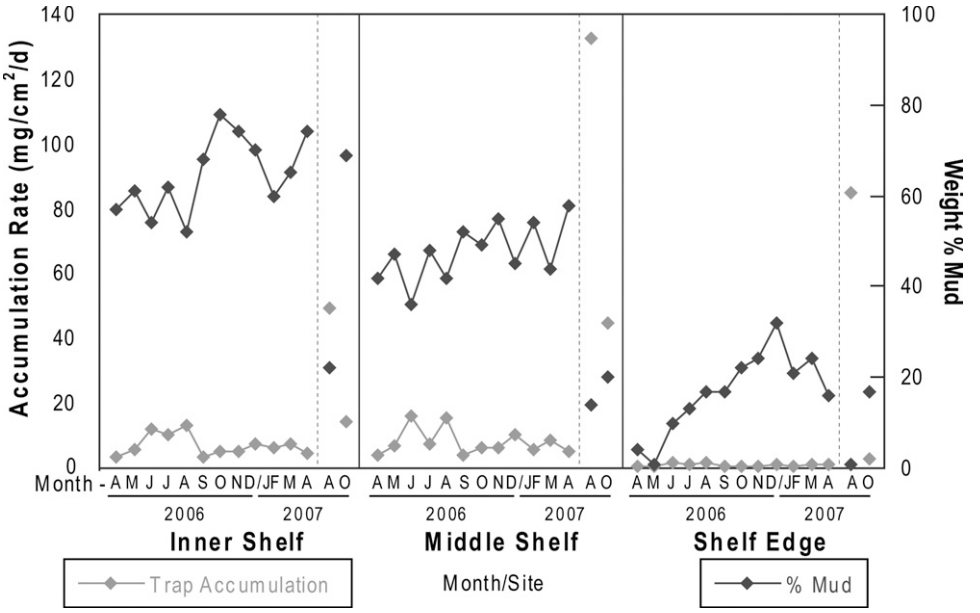

FIG. 8. Percent <63 μm fraction and total trap accumulation rate with time: April 2006 through April 2007 as well as August 2007 (Hurricane Dean) and October 2007 (Tropical Storm Noel). Spikes in total sediment accumulation typically correspond with dips in the percent of <63 μm sediment accumulation (e.g. June 2006 and August 2006 at the inner- and middle-shelf sites). Inner-shelf, middle-shelf and shelf-edge values for August 2007 and October 2007 are shown as isolated points indicating gaps in monthly sampling from April to August and August to October 2007.

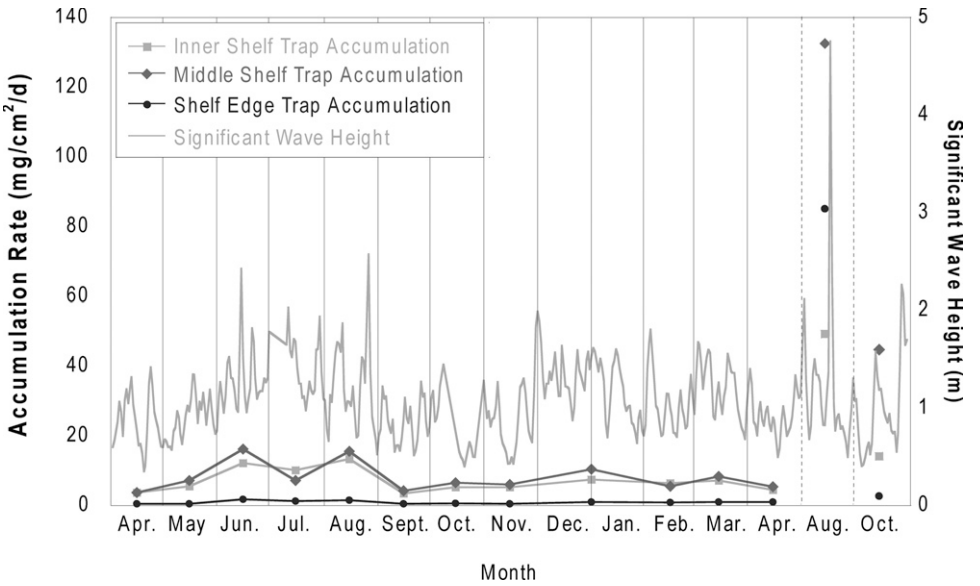

FIG. 9. Significant wave height and total trap accumulation rate over time. Peaks in wave height generally correspond to peaks in total trap accumulation, e.g. June 2006, August 2006, August 2007 and October 2007. Inner-shelf, middle-shelf and shelf-edge values for August 2007 and October 2007 are shown as isolated points indicating gaps in monthly sampling from April to August and August to October 2007.

events (Fig. 9). However, during both of these months, the percent terrigenous material either remained close to or dropped below the long-term average. The drop in percent terrigenous material associated with the passage of Hurricane Dean in August 2007 was likely a result of the high-energy conditions resuspending large amounts of material and maintaining the finer grains in suspension. The high accumulation rates for October 2007 at the middle shelf, associated with the passage of Tropical Storm Noel, also seem to be related to resuspension of existing material as the relative percent terrigenous remained near the long-term average. The percent terrigenous material did not rise during either of these weather events as might be expected if there were a large influx of new terrigenous material.

Of special importance within the data collected for August 2007 are the exceptionally high accumulation rates recorded at shelf-edge sites, which reach >195 times the average accumulation rates at these sites. In some cases hurricane and storm events have the potential to play a positive role in maintaining the balance between sediment influx and export by periodically flushing excess sediments from the system via cross-shelf transportation to the shelf edge (Hubbard 1992, Warne et al. 2005). The results in the present study indicate significant sediment movement and redistribution at the shelf edge during these high-energy events. Similar large-scale sediment movements at shelf-edge sites have been noted by Hubbard (1992) in St. Croix and by Walsh and Nittrouer (1999). These results highlight the potential impact that these infrequent high-energy events can have even in deeper shelf-edge settings of La Parguera.

To determine the degree to which a reef is potentially influenced by terrigenous sedimentation, it is important to look at both the total sediment accumulation rate as well as the composition of sediments (Fig. 10). Among the sites studied during the April 2006 – April 2007 period, San Cristóbal and Romero experienced the highest terrigenous influence, but for different reasons. San Cristóbal showed the highest terrigenous sediment accumulation due to an overall high sediment accumulation rate. However, its percent terrigenous material was comparable to that of other inner and middle shelf sites. Although Romero had a lower total sediment accumulation rate than San Cristóbal, it had a similar terrigenous sediment accumulation rate to San Cristóbal and showed the highest percent terrigenous material amongst all sites. Thus, the high terrigenous influence of Romero is a result of a greater influx of terrigenous material and the high terrigenous influence of San Cristóbal results from the resuspension of existing material.

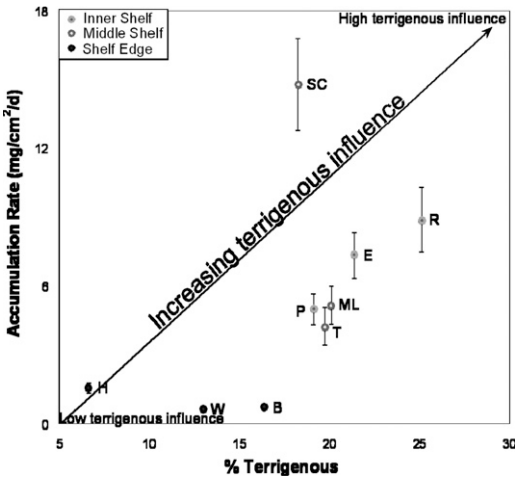

FIG. 10. Average total sediment accumulation versus percent terrigenous material from April 2006 – April 2007 at the three reef tracts: inner shelf, middle shelf and shelf edge. The arrow indicates increasing terrigenous influence. Sites that plot in the upper right of the graph are more exposed to terrigenous material. Letters indicate reef sites: Pelotas (P), Enrique (E) and Romero (R) - inner-shelf reefs, San Cristobal (SC), Media Luna (ML) and Turrumote (T) - middle-shelf reefs, and Hoyo (H), Buoy (B) and Weinberg (W) -shelf-edge reefs. San Cristobal (SC) and Romero (R) experience the greatest terrigenous influence.

In summary, the establishment of temporal and spatial patterns in sediment accumulation and composition at nine sites across the La Parguera shelf provide an important baseline for future comparisons and correlations in studies conducted at La Parguera and elsewhere. This study shows the extent of terrigenous sediment influence within the La Parguera reef system and demonstrates that resuspension of existing

material is the main force driving sediment accumulation rates. It also highlights the importance of understanding both total accumulation rates and sediment composition in determining terrigenous influence on a reef system.

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