# STATUS REPORT FOR THE SUBMERGED REEF BALL™ ARTIFICIAL REEF BEACH STABILIZATION PROJECT FOR THE GRAND CAYMAN MARRIOTT HOTEL

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July 2002

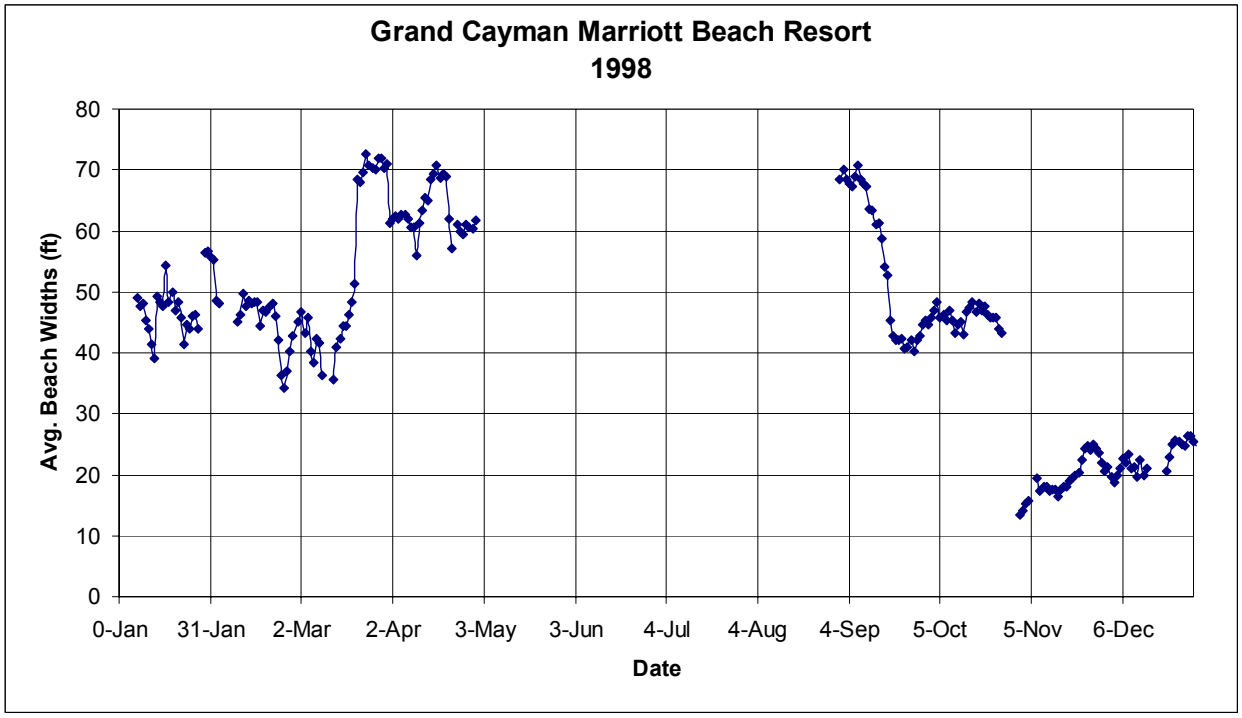
This report presents an update on the submerged Reef Ball™ artificial reef breakwater that was installed to assist with beach and shoreline stabilization during the summer and fall of 2002. Initial field inspections were first performed in February 2002 to investigate the beach erosion problem at the Marriott Hotel on Seven Mile Beach on Grand Cayman Island, and to determine alternatives that can be considered to restore and stabilize the beach at this site. An array of alternatives were considered, and a submerged breakwater constructed of 200 Reef Ball™ artificial reef units was chosen. Design and permitting of the project was performed during the winter and spring of 2002, with fabrication of the units and deployment offshore completed

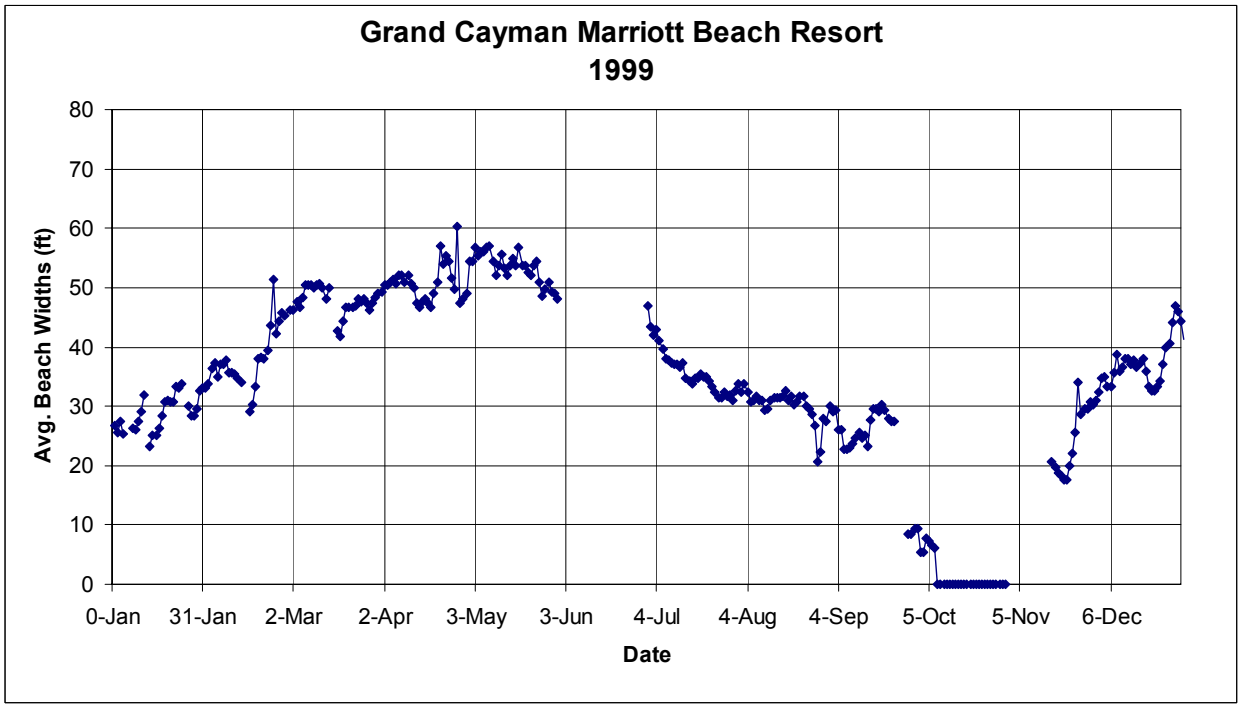
## *Beach Erosion Problem*

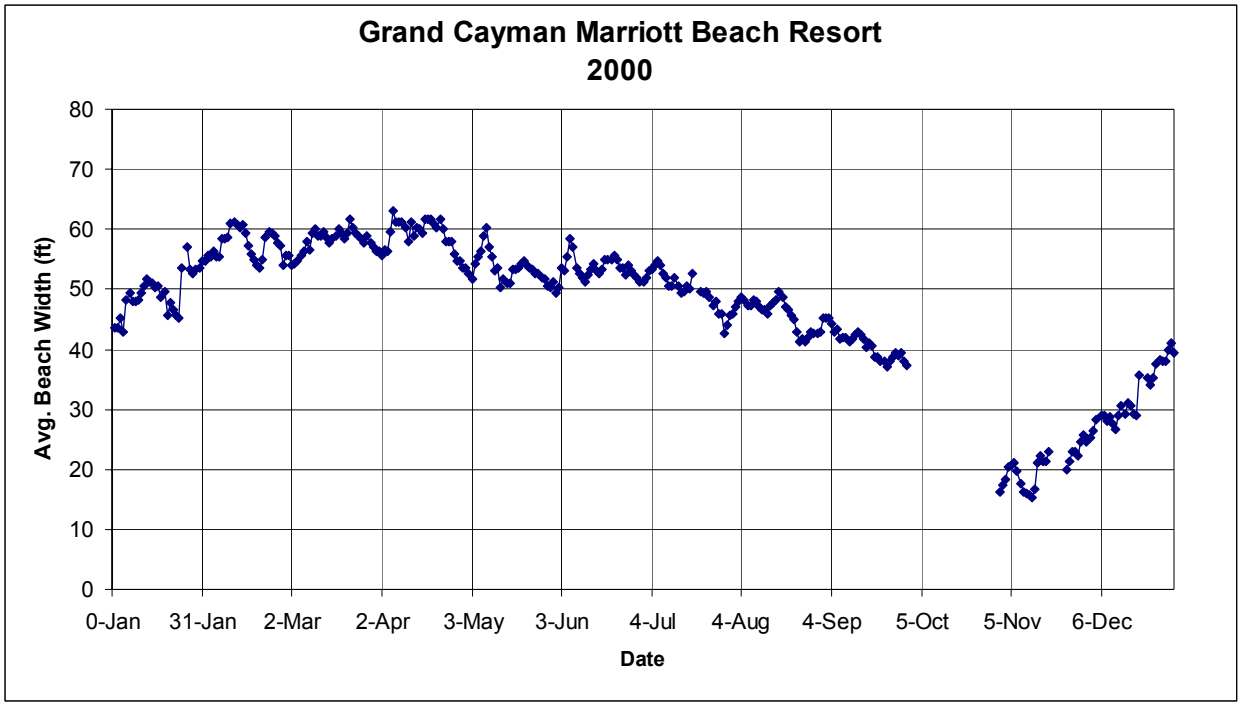
The Marriott Hotel lies at the southern end of Seven Mile Beach. The beaches in this area have been very narrow in recent years, having last been stripped of sand during Hurricane Michelle in November 2001 and again during storm events in 2002. The beaches to the north generally become wider as you go north from the Marriott Hotel to the central Seven Mile Beach area, while to the south there is only a short stretch of sand beach that is followed by a rocky shoreline as you approach the Treasure Island Resort. There are some rock groins that were constructed in this area, and the shoreline here curves around to the east. This rocky shoreline to the south and reorientation of the shoreline effectively blocks any potential transport of sand from the south to the Marriott's beaches.

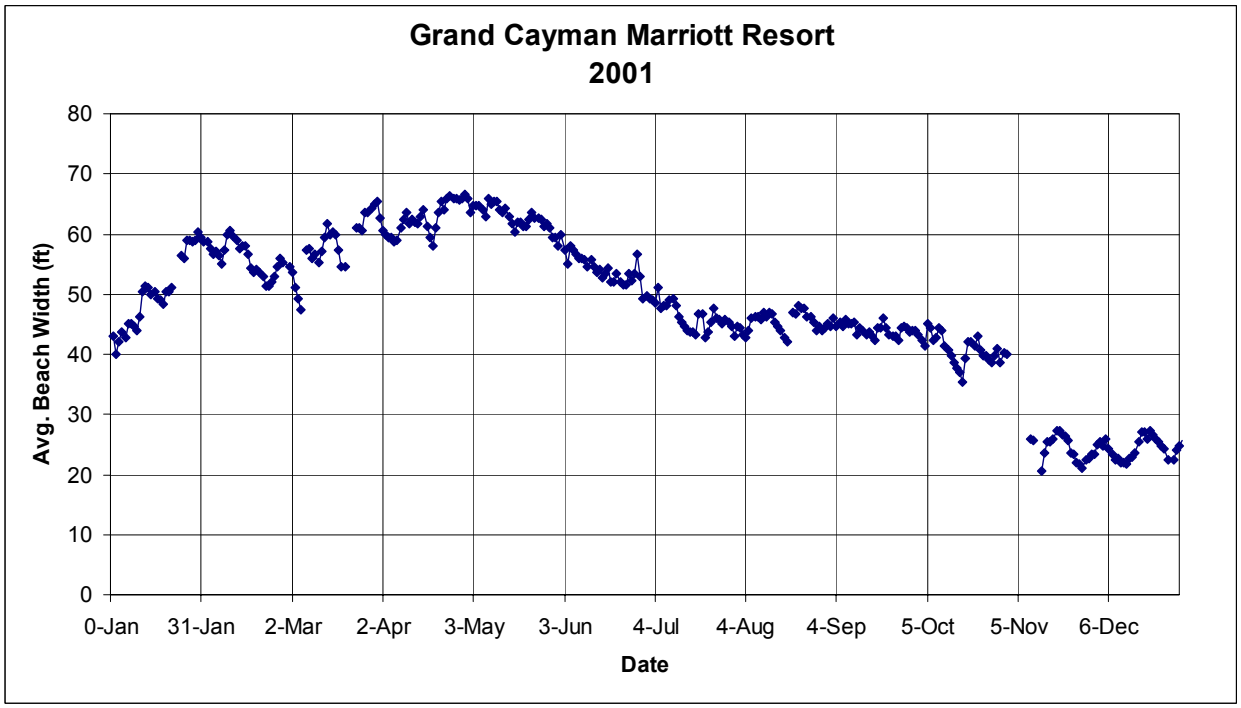
Therefore the Marriott's beach area is particularly susceptible to erosion from waves coming from the southwest, due to the lack of sand along the coast to the south. Waves from the southwest, especially during storm events, transport sand to the north. Waves from the northwest tend to transport sand to the south along the Seven Mile Beach area which nourishes the beaches at the south end (including the Marriott), but this occurs at a much slower rate, and an increase in southwest waves over the past few years has prevented the beach from accreting out to the beach width that the Marriott had prior to 1996. Due to the erosion of the beaches along the southern reach of the Seven Mile Beach area, natural sand accretion and return of the beach width to that in the mid 1990's could take several years, if at all, and any future southwest wave events will further erode the beaches in this area, and slow this natural recovery.

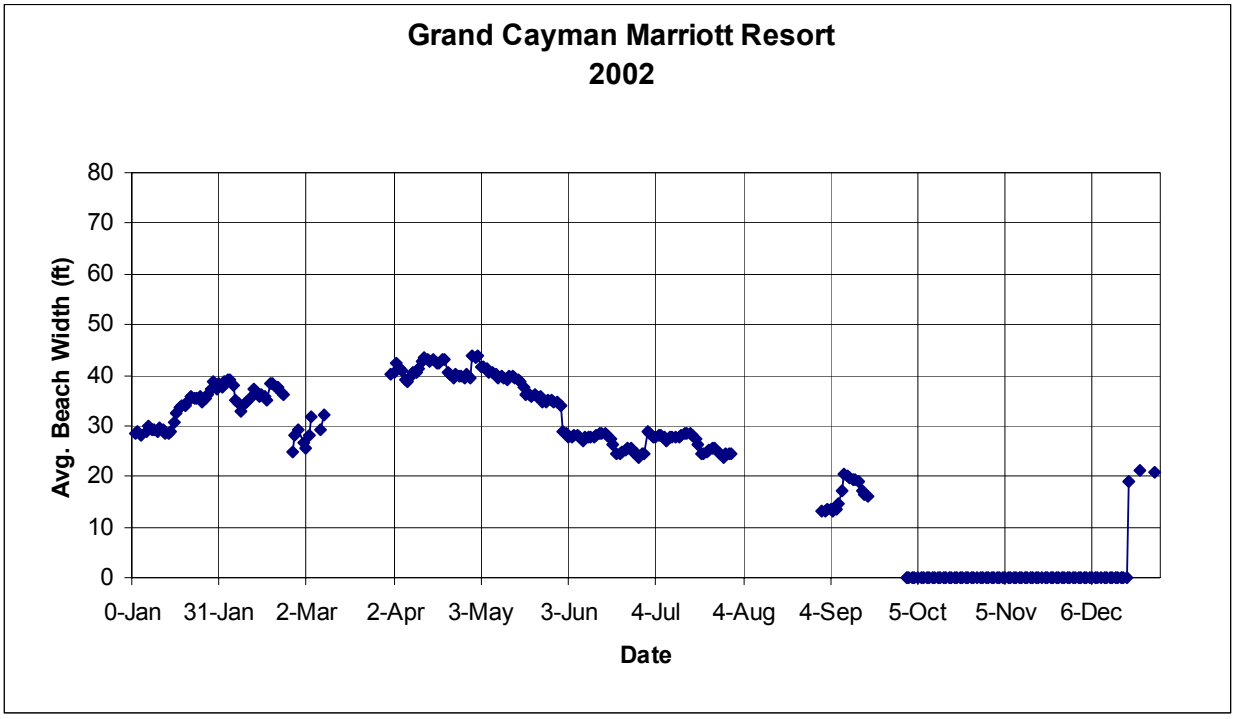
The Grand Cayman Marriott Resort has experienced beach erosion. The existing beach width varies seasonally and with storm events, and although it does begin to recover by sand transport into the area from the north, the beach continues to be eroded away by waves coming from the southwest each fall. The staff at the Marriott measures the beach width from the seawall at the north, center and south end of the property every day, with this information providing a good record of beach changes, and should be continued to be collected. These data are shown in the graphs below for the variation in the average beach width in front of the Marriott over time:

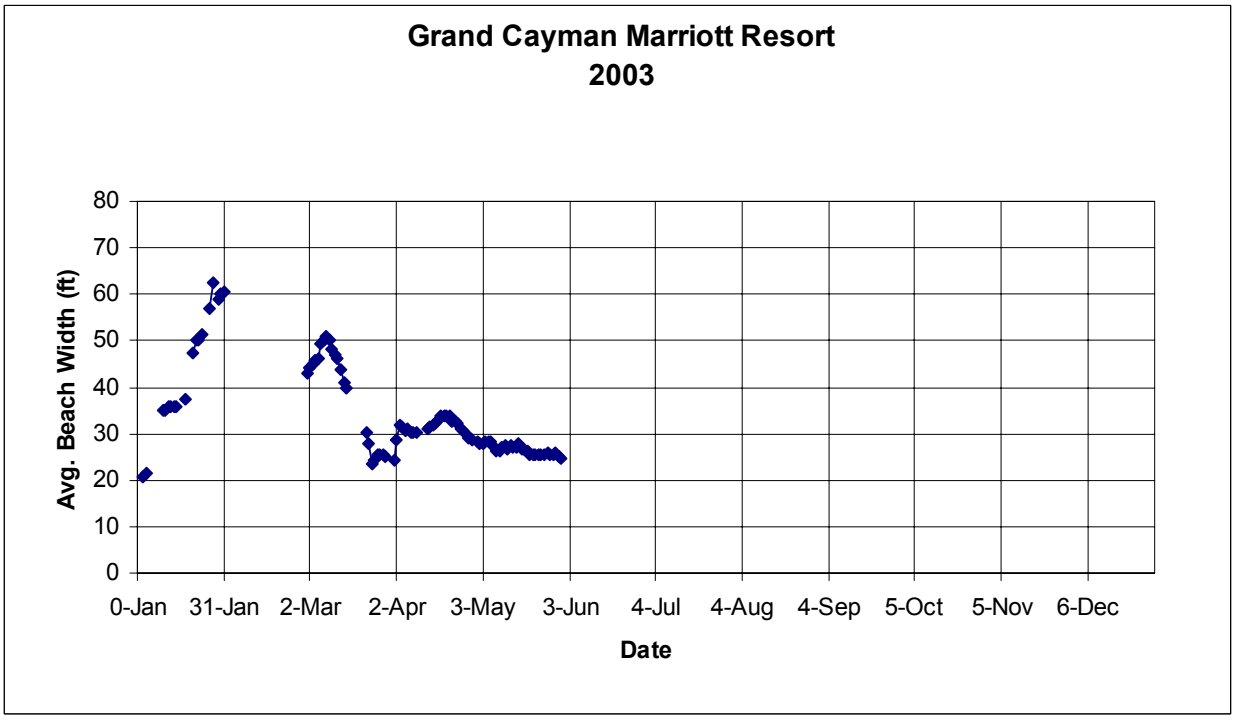



Grand Cayman Marriott Beach Resort
2000
Avg. Beach Width (ft)
80
70
60
50
40
30
20
10
0
0-Jan
31-Jan
2-Mar
2-Apr
3-May
3-Jun
4-Jul
4-Aug
4-Sep
5-Oct
5-Nov
6-Dec
Date


Grand Cayman Marriott Resort
2001
Avg. Beach Width (ft)
80
70
60
50
40
30
20
10
0
0-Jan
31-Jan
2-Mar
2-Apr
3-May
3-Jun
4-Jul
4-Aug
4-Sep
5-Oct
5-Nov
6-Dec
Date




Note that these graphs show that there are seasonal changes in the beach width, but prior to the installation of the Reef Ball breakwater at the end of 2002, the beach width was decreasing each year. In 2002 the maximum beach width was only 45 feet and the minimum width was zero, and the zero beach width occurred over a much greater time period than in prior years. Following the installation of the Reef Ball breakwater (completed at the end of 2002) the data to date for 2003 show that the beach width reached a width in excess of 60 feet, with the minimum width of 25

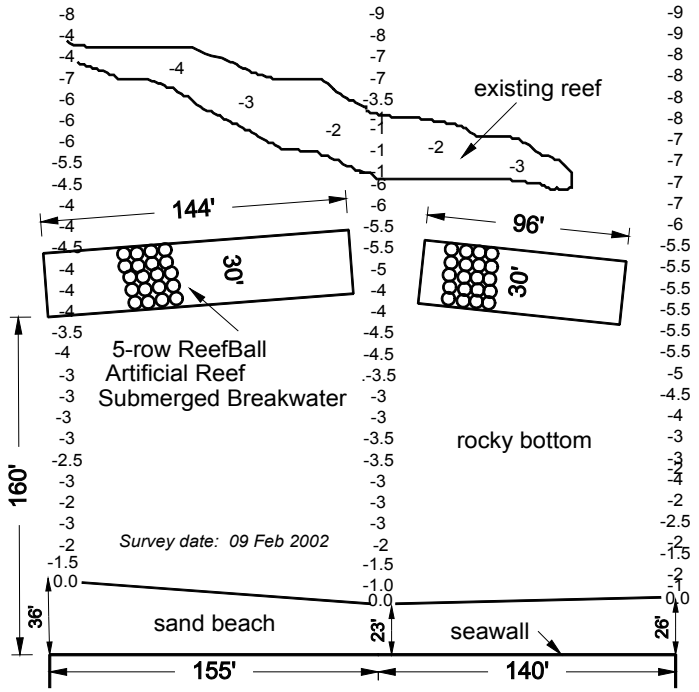
feet. The fall tropical storm and hurricane season has the narrowest beach widths, which may reduce the existing beach width further.

## *Artificial Reef Submerged Breakwater Project Design*

To stabilize and enhance the beach at the Grand Cayman Marriott Resort, an artificial reef submerged breakwater was recommended and installed to reduce the wave action reaching the beach. A submerged breakwater reduces the wave action that reaches the beach, thereby assisting to stabilize the shoreline. Unlike traditional breakwaters that project above the water surface and stop all wave action, submerged breakwaters allow the smaller waves to pass over the structure so that sand transport along the coast is maintained during normal conditions. During large wave events, the larger waves are forced to break on the submerged breakwater, thereby reducing the wave energy reaching the beach from large waves, and reducing the associated beach erosion. The disadvantage of submerged breakwaters is that they become less effective as their depth of submergence increases, so that they are less effective at reducing wave action during elevated water levels due to storm surge. The use of artificial reef units for a submerged breakwater also provides underwater habitat, enhancing the environment.

The submerged Reef Ball artificial reef breakwater has assisted in stabilizing the shoreline by reducing the wave action that impacts and erodes the beach, especially when the waves strike and reflect from the vertical seawall. The existing reef offshore of the hotel is only sufficiently wide and high enough to assist with wave attenuation in one spot, which is where the gap between the two breakwaters was designed.

The recommended and installed design shown in Figure 6 uses 5 rows of Reef Ball™ artificial reef units to provide a 30-foot wide submerged breakwater. The 3.7 to 4.5 feet high artificial breakwater units were installed in low tide water depths of 4 to 5.5 feet, so that the top of the units are slightly below the lowest normal water level (0.3 to 1.8 feet).



As presented in Table 1, various sizes and weights of Reef Ball™ artificial reef units are available. To obtain the highest heights and individual unit weights possible, the largest Reef Ball™ units (Ultra Balls and Reef Balls) fabricated with the maximum volume of concrete for the molds were used, resulting in each individual Reef Ball™ unit weighing approximately 4,000 pounds (2 tons). Microsilica and other additives were used in the concrete to increase the strength and workability plus decrease the pH of the concrete to that of marine environment.

**Table 1. Reef Ball™ Sizes, Weights, Volume & Number of Holes**

| Style | Width | Height | Weight | Concrete Volume | No. of Holes |
|---|---|---|---|---|---|
| **Ultra Ball** | 6 feet (1.83m) | 4.5 feet (1.37m) | 4000-6000 lbs (1814-2722 kg) | 1 yard 0.76$m^3$ | 29-34 |
| **Reef Ball** | 6 feet (1.83m) | 4 feet (1.22m) | 3000-6000 lbs (1360-2722 kg) | 0.75 yard 0.57$m^3$ | 29-34 |
| **Pallet Ball** | 4 feet (1.22m) | 3 feet (0.91m) | 1500-2200 lbs (680-998 kg) | 0.33 yard 0.25$m^3$ | 17-24 |
| **Bay Ball** | 3 feet (0.91m) | 2 feet (0.61m) | 375-750 lbs (170-340 kg) | 0.10 yard 0.08$m^3$ | 10-16 |

The sea bottom where the submerged breakwater is installed consists primarily of barren rock with some patches of sand, so that scour and settlement of the artificial reef units are not a problem. For increased stability of the structure, sleeves for fiberglass rebar were pre-cast into the Reef Ball™ units, with No. 5 fiberglass rebar driven or drilled into the bottom to provide additional resistance to sliding of the units. If desired, the central cavities of the Reef Ball™ units can be filled approximately one-third full with small rocks to provide additional weight and habitat.

## *Field Investigations*

Inspections of the Reef Ball submerged breakwater constructed offshore the Marriott Resort on Grand Cayman, Cayman Islands were performed on February 6-8, 2003 and on May 26-28, 2003. This included inspections, surveys, and photographs of the beach areas at the property, and the beach areas to the south and north along Grand Cayman's western Seven Mile Beach shoreline.

The photographs below show the condition of the beach in February 2003, which increased in width from zero to over sixty feet wide following the installation of the Reef Ball breakwater. Over 200 Reef Ball units were installed in the design template, with top elevations near but below the normal low tide elevation as was designed and permitted.

**View North:**

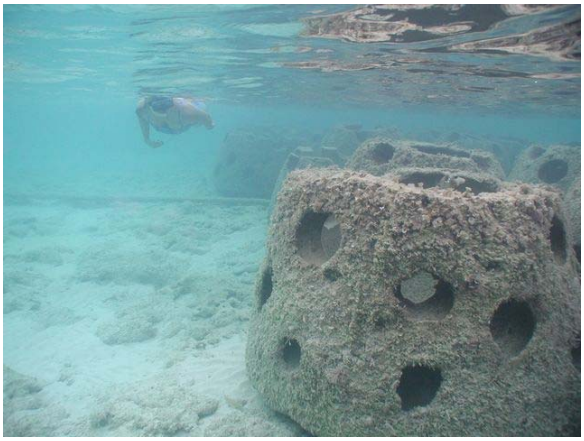
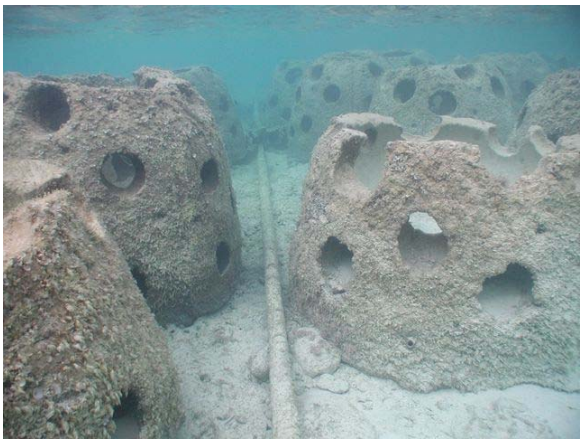
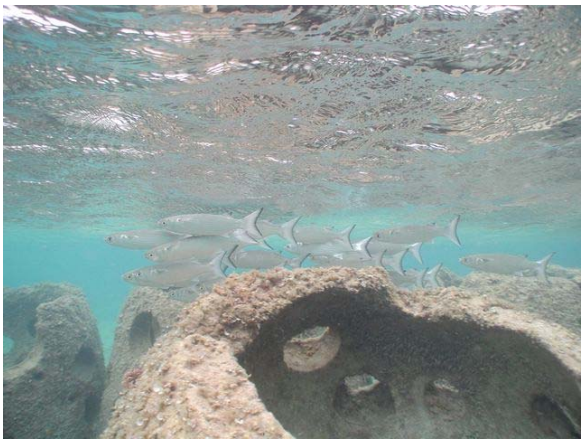
**View South:**

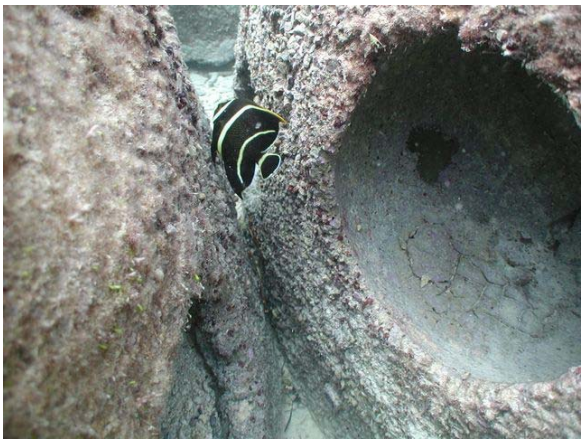
The photographs below taken in February 2003 show the offshore Reef Ball breakwater:

**Northern breakwater:**

**Southern breakwater at extreme low tide.**

The underwater photographs below show the condition of the Reef Ball units. After only 3 months, there is considerable marine growth on the Reef Ball units and several species of fish in and around the artificial reef units. Note that some of the Reef Ball units had to be fabricated shorter than the standard size, due to the shallower water depths at the south end of the breakwater.

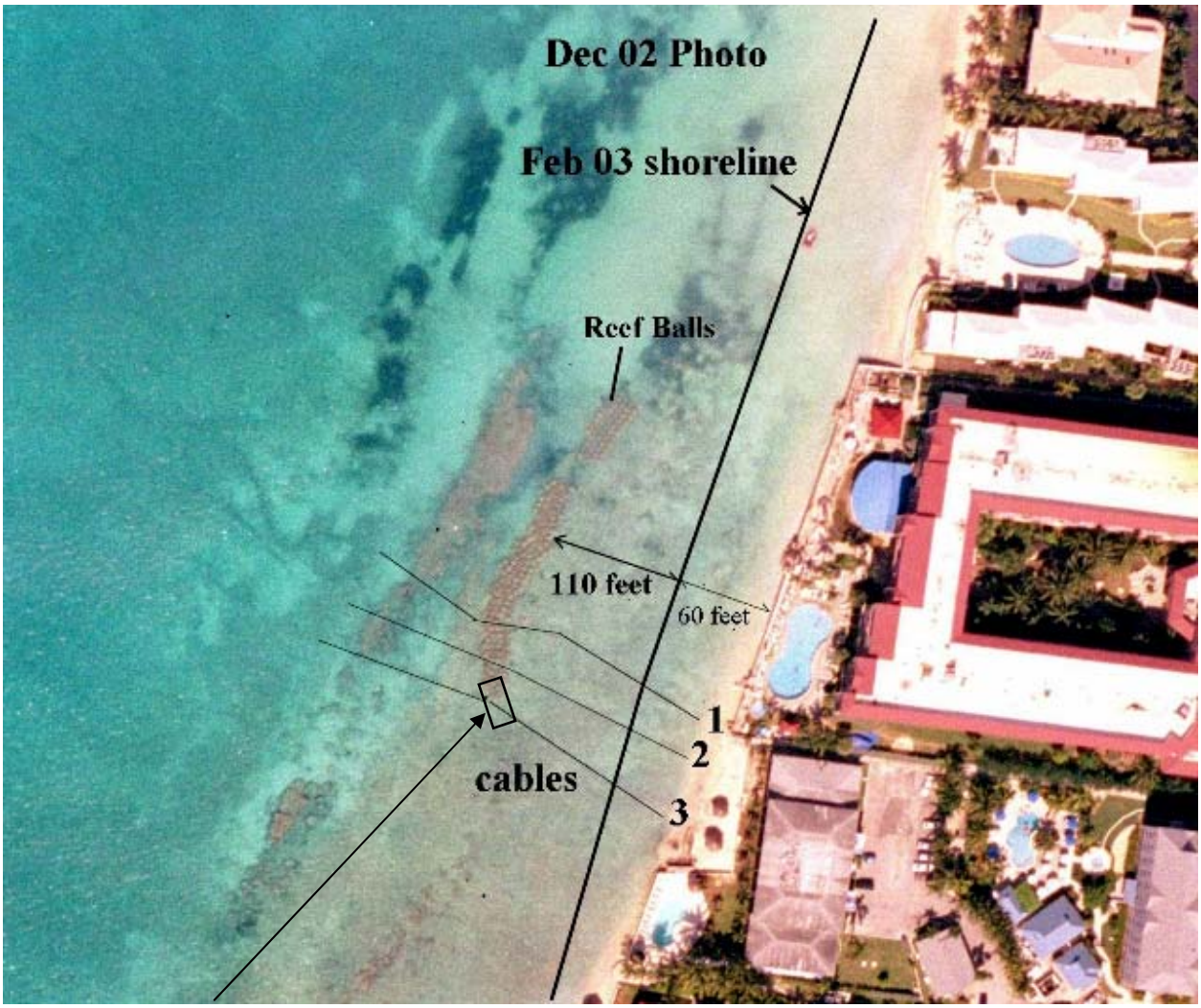







## *Additional Reef Balls*

A survey of the water depths in the vicinity of the south end of the breakwater was performed to investigate the proposed addition of 32 more Reef Ball units at the south end to increase wave protection from the SW. Special permission was required from the property owners to the south, as this extension will be located offshore of the north end of their property. The proposed extension is shown in the aerial photograph below, which would increase protection for the Marriott from waves from the southwest.

**December 2002 Aerial Photograph showing Reef Ball breakwater:**




**Proposed additional Reef Ball units:**

## *Other Alternatives*

As discussed in previous reports, there are several alternatives that can be used to stabilize and restore the beach. The most direct approach is to add sand to the beach, and this method has been employed in the past, but the sand is easily eroded away by southwest waves. Structures such as groins or a nearshore sill can be employed to assist in holding the sand in place, but these structural elements can affect the adjacent beaches, and impede the natural transport of sand along the beach.

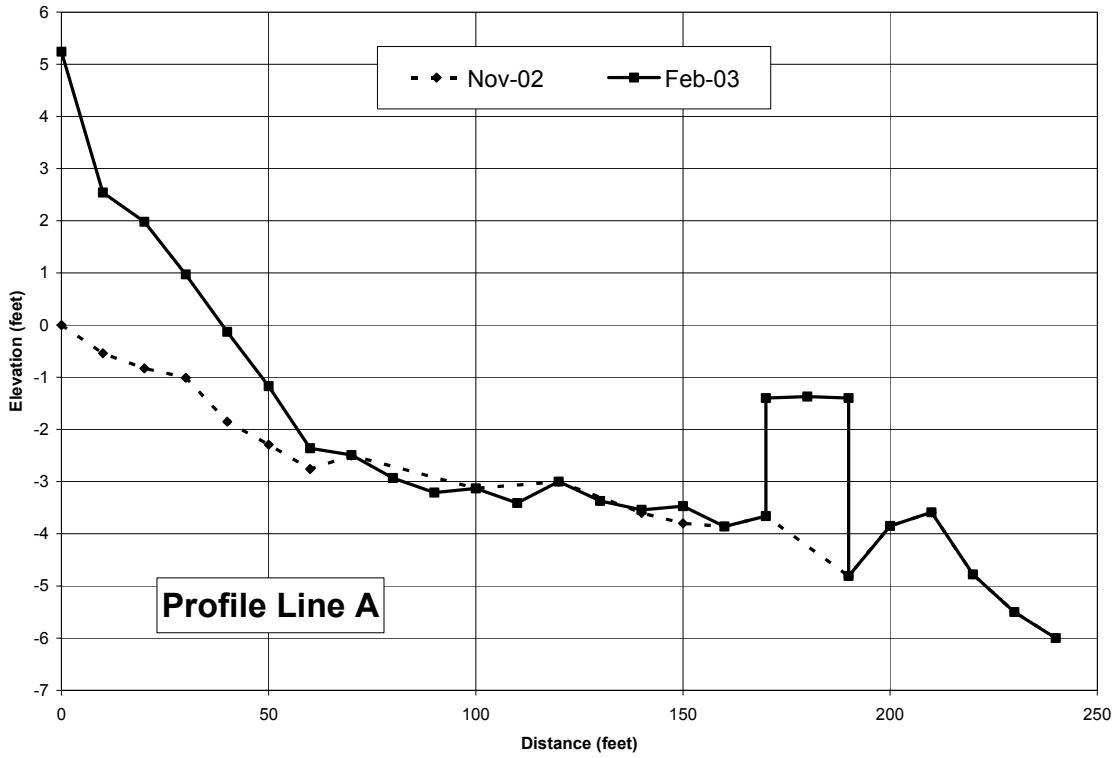
The recommended and most environmentally friendly option is an offshore submerged breakwater to reduce the wave action reaching the beach. The use of artificial reef units to form a submerged breakwater provides marine habitat, as well as allowing some of the wave action to pass through and over the breakwater so that the natural flow of sand along the beach can

continue. This is the present system at the Marriott, which has been assisting with wave attenuation and shoreline stabilization since its completion at the end of 2002.

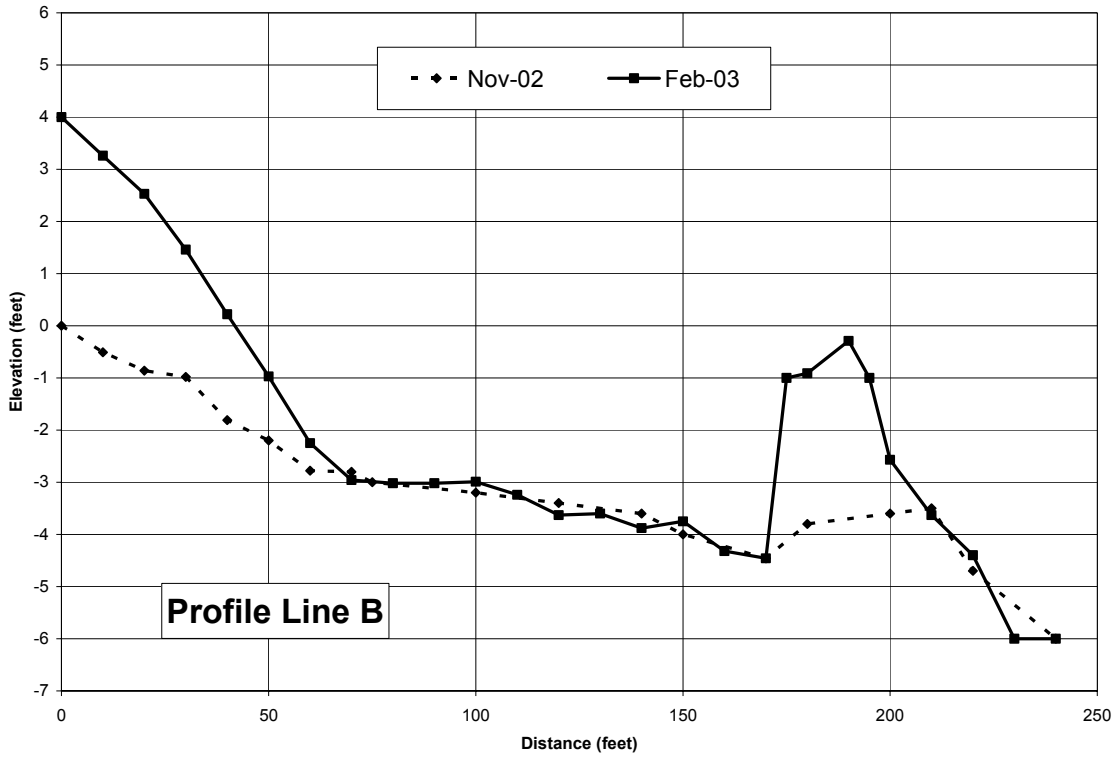
## *Recent Beach Profile Data*

Surveys were performed in February 2003 which document the beach condition after 3 months, and are compared with the beach condition immediately following the completion of the Reef Ball breakwater in November 2002, as shown in the Figures below for the 3 profile lines at the south end of the Marriott.

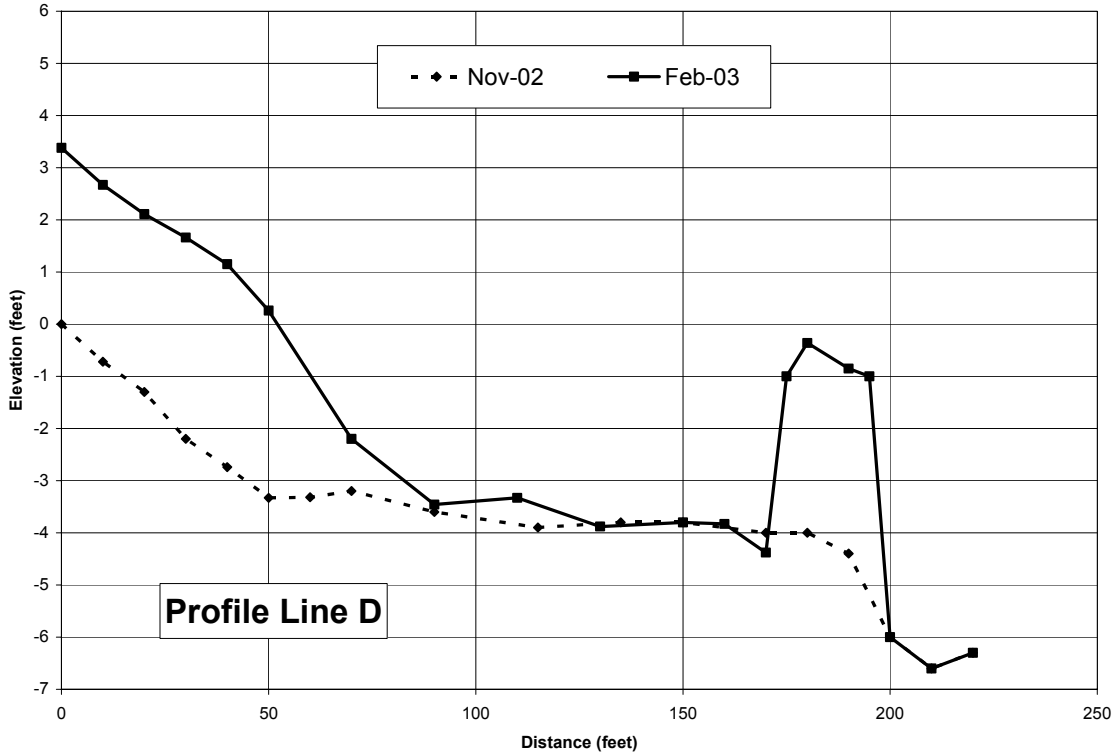
These graphs below show the additional sand that accreted seaward of the Marriott seawall following the installation of the Reef Ball breakwater. The beach width increased from zero to 40 to 55 feet in width from November 2002 to February 2003, whereas the widest beach width in all of 2002 was 45 feet. Recent wave action has reduced the beach widths to 25 feet at the Marriott (but even less at adjacent beaches in the area), and the current tropical storm and hurricane season may further erode the beach. However, the completed Reef Ball breakwater (and extension if added) is designed to minimize the beach erosion and assist with the stabilization of the beach at the Marriott.




Profile Line A – Across South End of Reef Ball Breakwater




Profile Line B – 30 feet North of Southern End of Reef Ball Breakwater




**Profile Line D – 130 feet North of Southern End of Reef Ball Breakwater**