

# **CALLAWAY MARINE TECHNOLOGIES INC.**

*Specializing in environmentally sensitive construction and mitigation*

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April 20, 2009

Industrial Economics Inc.  
Att: Mark Curry  
2067 Massachusetts Avenue  
Cambridge, MA 02140

Re: *T/V Margara* Grounding Restoration Recommendation

Mr. Curry,

The purpose of this letter is to outline my opinion regarding the most suitable restoration methods to be implemented at the *T/V Margara* (Margara) grounding site. Opinions are based on observations made during a site visit and personal knowledge and experience with large scale coral reef restoration projects.

The grounding site is approximately 8,400 square meters (m<sup>2</sup>) and encompasses numerous individual injury areas ranging in size from 5 m<sup>2</sup> to 400 m<sup>2</sup>. NOAA personnel have identified areas totaling 2,605 m<sup>2</sup> for primary restoration.

Upon arrival at the site, initial dives were performed within un-impacted areas to determine the representative natural conditions. Subsequent dives were conducted to determine the restoration alternatives appropriate for the individual injury areas based on the uninjured surrounding areas. The injury areas were characterized by rubble fields consisting primarily of relic coral fragments of varying sizes, typically ranging from 2-5 inches. These areas were mostly devoid of new growth or coral recruitment. Observations of previous restoration efforts revealed varying results. A more detailed description of the inspection findings is given in the Field Observation Report for the Margara Grounding Site Reconnaissance submitted by Craig Kruempel (TtEC) dated January 12, 2009.

Initial restoration efforts at this site focused on stabilization and reattachment of displaced corals and substrate. The damage observed is so extensive that re-attachment of all of the available onsite material would cover only a small percentage of the impacted area. The majority of the original reef surface (or crust) has been crushed, exposing large amounts of unconsolidated rubble. Proper restoration of the site will require reconstruction of the lost topography and three dimensional complexity of reef. In addition, the restoration objective must include stabilization of the rubble to prevent further damage to the surrounding corals and expansion of the impacted areas from rubble movement. Observation and extensive documentation of other vessel grounding incidents has revealed that unstabilized, loose rubble can cause significant damage to surrounding coral, thus increasing the extent of the impacted area.

## **Restoration Alternative**

At the Margara Grounding Site, the relatively large size of the impacted areas may make it cost prohibitive to “cap” all of the areas with rock and concrete as with previous restoration efforts at other grounding sites (Figures 1-4). The recommended restoration alternative at the Margara site would be the construction of individual patch reef within the injury sites, covering and stabilizing as much area as possible while leaving grooves between the areas to maximize the restored footprint. An illustration of how the constructed patch reef alternative would be implemented within an injury area is presented in Figure 5.

The individual areas selected for application of the constructed patch reef alternative will be spaced and oriented to provide maximum protection of the area from storm events. Securing the existing reef to prevent undermining is important to the restoration effort. By placing the constructed reefs adjacent to and incorporated into existing reef, the supplemental concrete and limestone will aid in the prevention of further scouring of the intact reef. The general method proposed is a variation of the same techniques used successfully for the restoration of the Columbus Iselin grounding at Looe Key and the Allie B/Igloo Moon grounding sites in Biscayne National Park.

Incorporation of prefabricated reef “modules” into the repaired areas would be beneficial because they can be constructed onshore and then deployed to the injury sites. Performing a portion of the construction onshore increases quality control and allows for more focus on habitat enhancements with the rock placement since production is not limited by weather windows or diver bottom time. Due to the site conditions and unpredictable weather patterns, the modules would be designed to be stable without having to be physically anchored or tied to the existing reef structure. The modules would be constructed of limestone boulders held together by concrete and dressed with smaller material. The “dressing” of the modules would be conducted while on site and would involve the attachment of biota such as stony corals and gorgonians.

Each constructed patch reef will be independently stable for the maximum expected wave height, which is calculated to be approximately 30 feet. Design wave determination and stability analysis were performed by Coastal Planning and Engineering Inc. The thickness of the rubble layer in many areas precludes anchoring of the repair units to solid substrate. As a result, stabilization of the repair areas will be achieved by a size and relative weight great enough to provide independent stability. A typical reef patch would consist of a 2 meter x 1.5 meter (m) module placed in the center of a 6 m x 6 m rock and concrete area. (Figure 5).

The Margara site is situated within an area that commonly experiences high sea states; therefore, large scale, long-term operations are considered to be prohibitive. Should a rapid demobilization occur due to weather, the self-stabilized modules would be secure, thus minimizing collateral damage to the surrounding unimpacted areas. Using a stable module as the starting point for the restoration will accelerate production and restore the area more quickly.

Wave and weather conditions at the Margara site are more extreme than those where comparable restoration alternatives have been employed (i.e., Looe Key site). Therefore, modifications to the construction methods will be required. Specifically, the predominant wave conditions and the

suddenness that wave heights can change at the work area may pose a safety hazard to traditional crane and barge operations. As such, it would be advisable to utilize more mobile vessels such as a supply boat(s) (100-150 feet length). These vessels can be more easily moved on and off of the site while still providing the deck space required for the equipment and materials needed. These vessels may not be suitable for the placement of larger rock, however, which is typically handled by clam shell bucket or grapple. These material handling attachments are not common for the smaller hydraulic cranes found on supply vessels. To mitigate against this problem, larger rocks would be incorporated into the prefabricated modules that will serve as the center piece of each constructed patch reef area. The modules can be lifted by slings or have lift eyes incorporated into them. Modules such as those proposed for the Margara grounding site have been successfully placed from smaller vessels. After the module is placed, rock and concrete are placed around it securing it into the patch reef area. Available loose rock and coral near the site, as well as rubble from the surrounding injury areas, can be used to dress the surface of new concrete before it hardens.

An important part of the restoration is the incorporation of available loose material from on and around the site into the wet concrete. This greatly enhances the biological recovery process.

The use of smaller vessels will ensure that the site will not be impacted by the restoration equipment. The proposed vessels are maneuverable and can be quickly demobilized from the site should weather preclude safe working conditions. Potential staging areas were identified that could provide suitable dockage material storage, and equipment to assist with material handling.

For the purposes of defining repair area and material volume requirements, NOAA personnel have identified 2,605 m<sup>2</sup>, of which 70% or 1,823 m<sup>2</sup>, is to have its topography restored and be fully stabilized. These identified areas are to be the focus of primary restoration efforts.

It is somewhat difficult to accurately project volume calculations based on the limited information available. The final design could greatly vary the material quantities and specific site restoration characteristics identified by NOAA. For estimating purposes, rock volume were determined using rock placement void ratios provided by the US Army Corp of Engineers Shore Protection Manual (SPM) and correlating those values with extensive experience placing rock underwater. It is estimated that approximately 1,400-1,600 tons of rock would be needed to cover the primary restoration areas. More calculations are needed to determine the minimum thickness of the concrete required for stability and strength of the constructed patch reef areas, however, for estimating purposes it was assumed that an 8 inch (in) layer of concrete will be placed in the interstitial spaces between the rock. Based on these assumptions, it is estimated that 200-250 cubic yards (yd<sup>3</sup>) of concrete would be required to secure the limestone in place.

### **Estimated Cost**

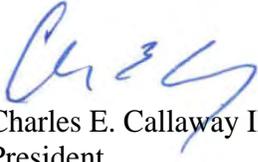
The estimated cost range to perform the work as described above is \$3.5 to \$4 million. This is for construction activities only and does not include costs for monitoring or oversight. This is a rough estimate that can be refined after concept approval with further investigation into rock prices and equipment availability and location.

## **Conclusion**

The restoration alternative described above will serve to restore topography and complexity, as well as stabilize the area impacted by the ship grounding. It will prevent further damage to surrounding areas due to movement of the rubble during high energy wave events. This method has been used successfully in the past to create a suitable, stable substrate that encourages coral recruitment and helps jumpstart the recovery process.

Please feel free to call me at 561 471-1771 should you have any questions.

Sincerely,

A handwritten signature in blue ink, appearing to read 'C. Callaway III', written in a cursive style.

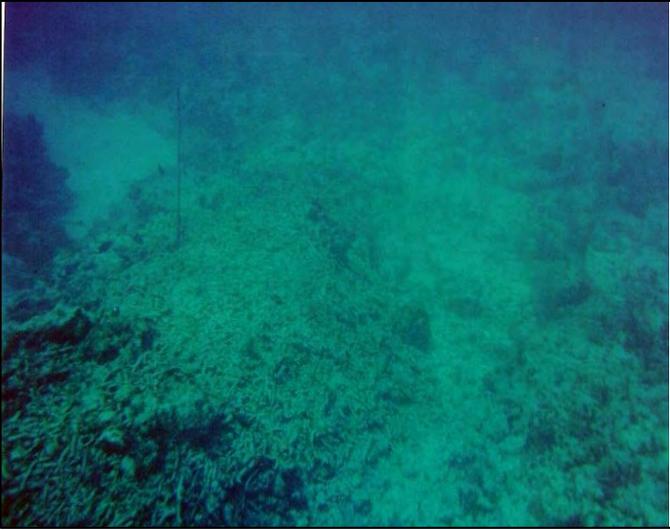
Charles E. Callaway III, P.E.  
President



**Figure 1. Natural Reef Area at the Margara Site**



**Figure 2. Impacted Area at the Margara Site**



**Figure 3. Columbus Iselin Grounding Site Prior to Restoration (Looe Key)**



**Figure 4. Columbus Iselin Grounding Site Post Restoration (Looe Key)**

