

M/V CONNECTED Grounding Site Restoration and Recovery in the Florida Keys National Marine Sanctuary

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Coral reefs, recognized as significantly productive habitat, are experiencing severe degradation and the worst may be occurring in the Caribbean where coral cover has declined 80% in some areas. Causes of the degrading injuries are both natural and anthropogenic in origin and are attributable to small localized factors such as ship groundings and relatively large-scale factors such as disease and climatic change. Restoration represents an important step in reducing the cumulative impact of coral reef injuries to preserve this unique habitat and if appropriately conducted, will significantly reduce impact recovery time. The presented case study is an example of a cooperative effort between the responsible party, their representative, and the trustee (U.S. Department of Commerce National Oceanic and Atmospheric Administration; NOAA) to successfully conduct long-term habitat restoration that can provide guidance for future restoration efforts.

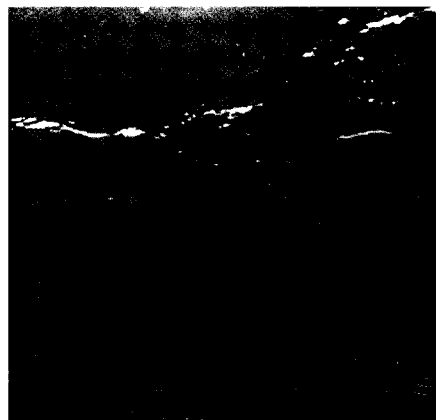
On 27 March 2001, the M/V CONNECTED, an 18-m (60-ft) Viking® sport vessel, grounded in a water depth of 1 to 1.5 m on the shallow *Acropora palmata*-dominated reef crest of Western Sambo Reef in Western Sambo Ecological Reserve in the Florida Keys National Marine Sanctuary (FKNMS). The M/V CONNECTED was removed from the site on the same day as the grounding event. FKNMS personnel conducted an impact assessment survey at the grounding site and estimated over 450 coral fragments, mostly elkhorn coral (*A. palmata*) were displaced during the grounding and were available for reattachment. As trustee of the natural resources, NOAA was responsible for overseeing the restoration and the ultimate recovery of the impacted resources. In cooperation with NOAA-FKNMS, the responsible party and their representatives contracted Marine Resources Inc. (MRI), marine habitat restoration specialists, to evaluate possible restoration options, based on assessed conditions and ecological setting of the grounding site and to subsequently implement restoration.

The amount of time for natural recovery of hard coral habitats is highly variable depending on the environment and degree of disturbance, but is generally thought recovery is slow and may require several decades to return to a condition similar to its original state. To facilitate enhanced natural recovery, activities to restore structural and functional components of the habitat were conducted at the M/V CONNECTED site. The objectives of the M/V CONNECTED habitat

restoration project were 1) to provide lost habitat structure, 2) to salvage and reattach displaced coral fragments, and 3) to stabilize reef substrate along the impact track.

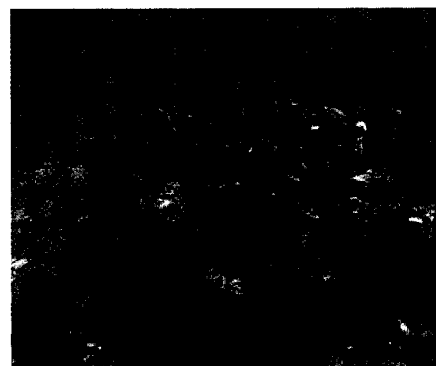
Previous reattachment techniques for elkhorn coral fragments which included the use of stainless steel wire, stainless steel masonry nails, threaded rods and expansion anchors, and clustering of fragments onto commercial tiles have been utilized with some success, based on site-specific conditions. MRI developed and field-tested in-situ fabricated reef replacement modules to provide a stable and slightly elevated platform for clustering of reattached hard corals, utilizing cement in shallow water habitats. The reef replacement modules are created using a containment form which ensures the reattached corals remain fixed within the cement matrix during set-up and minimizes the potential for cement matrix wash-out. The NOAA restoration plan for the M/V CONNECTED site proposed utilizing specially designed (Reef Tech Inc. with applied for patent) pre-fabricated reef replacement modules thought to be best suited to accomplish restoration objectives. The pre-fabricated reef replacement modules were cement-based cylinders with embedded limestone rock boulders and a vertical relief of approximately 0.4 m (1.3 ft). Twenty reef replacement modules were positioned and deployed along the impact track using lift bags and/or a specialized flotation platform. Reef replacement modules used for habitat restoration included two sizes. A large cylinder with an outside diameter of 1.2 m (3.9 ft) and an inside opening provided an approximate area of 0.6 m² (6.5 ft²) for coral reattachment; and a smaller cylinder with an outside diameter of 0.76 m (2.5 ft) and an inside opening that provided an approximate area of 0.17 m² (1.8 ft²) for coral reattachment. A total of 370 hard corals were reattached within and to the outside aesthetic dressing of 20 reef replacement modules used to stabilize and augment reef structure along the M/V CONNECTED impact track.

Preparation of positioned reef replacement modules prior to hard coral reattachment included, placement of fiberglass and/or metal rebar into the substrate within the cylinder opening, to provide sheer strength and matrix reinforcement, removal of loose debris within the opening, and filling voids between the hard substrate and the artificial structure with reef substrate fragments. Following reef replacement module structure placement and preparation, a concrete mix-



ture of approximately 1 part Portland type II cement to 1 part sand was made for filling the inside opening of the cylinder and subsequently reattaching hard coral fragments displaced during the grounding event and loose corals found outside the impact track. The cylinder was filled to a level even with the perimeter sidewalls. The concrete fill was smoothed and graded to slightly slope away from the center of the full cylinder to prevent trapping sediment and inundating reattached hard coral tissue. Concrete was also placed along the outside edge of the cylinder at locations of visible voids between the module and substrate to prevent scouring and subsequent undercutting. Aesthetic enhancement of the restoration included attachment of reef substrate and coral fragments to the outside edge of the cylinder. Reattachment of hard coral fragments within the reef replacement modules closely resembled the natural coral distribution of the existing habitat.

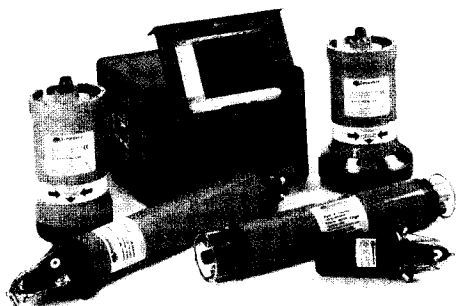
Once hard coral reattachment was complete and the concrete was set, a uniquely labeled numeric tag was attached to each module to facilitate distinction for mapping and potential monitoring. The distance and bearing (i.e., compass heading) of each module relative to a geo-reference benchmark was utilized to calculate their navigational coordinates. Video data were collected of



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each completed module to document condition of the cylinder and reattached corals and provide baseline data for potential monitoring.

Site visits were conducted by FKNMS personnel during the two and one half year interim following the commencement of habitat restoration at the M/V CONNECTED site. Site visit objectives were to:

- evaluate the stability, attachment status and relative health of reattached corals within the reef replacement modules;
- assess epibiotic colonization on the modules to determine spatial and temporal biological succession; and
- evaluate the structural integrity of the modules and underlying reef framework.

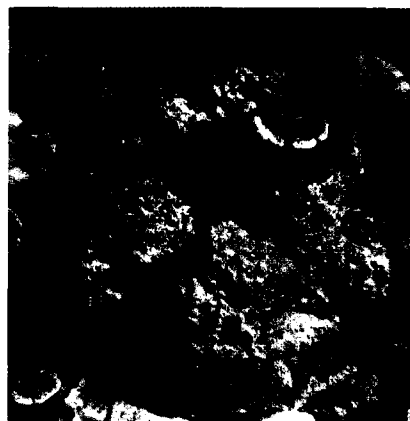
The site visits observed that reattached hard coral fragments were stable and most of the larger fragments exhibiting varying amounts of tissue growth. "Rosette" growth formations, typical of confluent branching of elkhorn coral, were evident on reattached fragments within most of the modules. Lateral growth of coral tissue onto the limestone and cement substrate of the modules was commonly observed at the restoration site. Some smaller reattached fragments were dead and apparently had succumbed to elevated water temperatures during the summer, following reattachment. The conditions of the reattached hard coral fragments concerning bleaching, mollusk predation, and algal overgrowth were not considered to be different than the natural hard coral assemblage.

Observations made during the site visit confirmed that the reef replacement modules and adjacent natural substrate were stable with no indication of structural fissures, matrix degradation, scouring, or bioerosion. Restoration conditions at the time of the FKNMS site visit were uncompromised, concerning the stability and long-term placement of the modules.

The tasks of the grounding impact emergency restoration were to save detached and fragmented live coral and

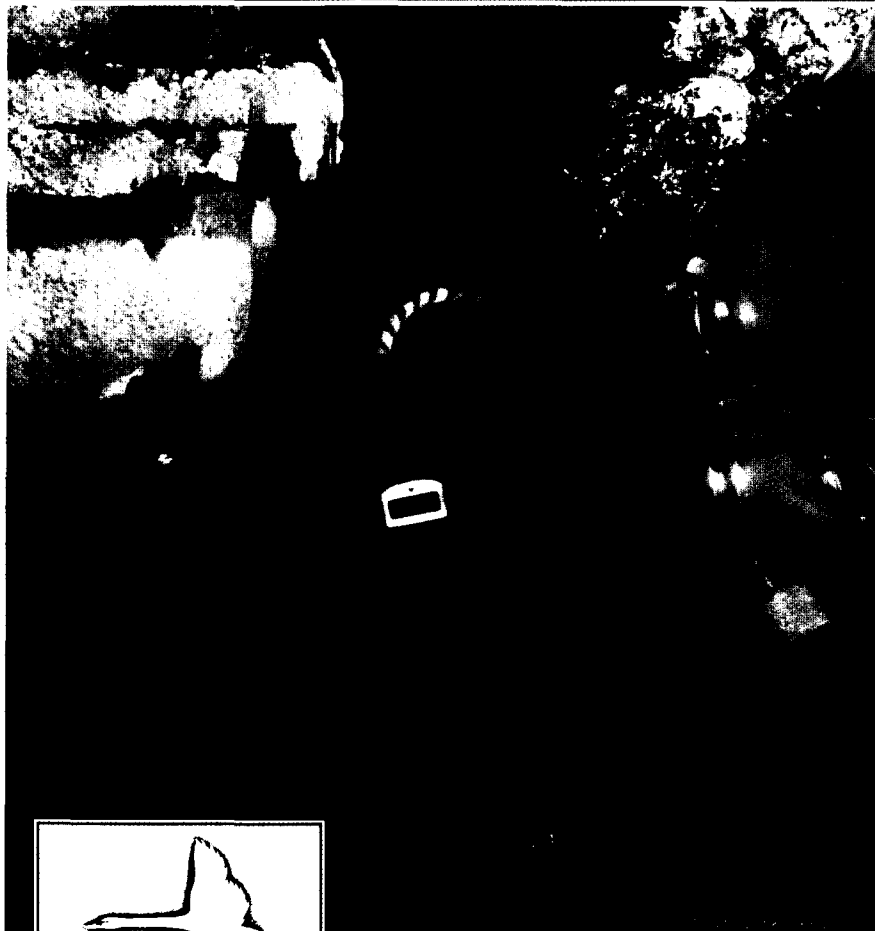
repair sections of reef framework fractured and destabilized during the grounding event. Coral rescue was considered a priority since elkhorn coral is the primary biological and structural component of this shallow-water habitat. Hard corals are the slowest growing of the impacted biotic community and successfully reattached corals will provide a localized parental stock to facilitate natural recruitment. By performing these tasks in an expeditious manner, significant amounts of live coral tissue were saved, time for impact recovery was substantial-

ly reduced, collateral damage due to future natural events (i.e., storms and hurricanes) was minimized, and much of the three-dimensional structure was restored. Restoration was conducted in a manner that created substrates and topography that closely resembles the existing habitat and minimizes visual degradation. Natural resource recovery will ultimately depend on successful recruitment, survival, and coral development to withstand natural perturbations and to provide structural and biological three-dimensional relief. ■



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NOAA's Climate Monitoring Network

A new, high-tech climate monitoring network designed by NOAA scientists keep tabs on the nation's temperature and precipitation trends is set to debut nationwide in January 2004. The U.S. Climate Reference Network (CRN) is expected to improve the ability of decision-makers to form policies about programs impacted by climate variability and change. A spokesman for the U.S. National Oceanic & Atmospheric Administration said the CRN currently plans to include 100 automated observing stations throughout the United States that will monitor temperature, precipitation, solar radiation, and wind speed. NOAA's geostationary operational environmental satellites (GOES) will transmit the data received from these ground-based stations in near real time to NOAA's National Climatic Data Center (NCDC) in Asheville, North Carolina. NCDC will make the observations available online in near real time to users around the world. NOAA engineers are currently fine-tuning the network, software, and data calibration checks, according to Gregory W. Withee, assistant administrator for NOAA's National Environmental Satellite, Data & Information Service (NESDIS). The basis of the network can be credited to Thomas Karl, NCDC director, who proposed 10 climate principles that were adopted by the U.S. National Research Council. These principles include extensive information on instrument status and health, local conditions around the station, assessing changes in the network on monitoring climate variability and change, and freedom of access to the data and supporting information. NESDIS, the parent agency to NCDC, operates three data centers that house global databases in climatology, paleoclimatology, oceanography, solid earth geophysics, marine geology and geophysics, and solar-terrestrial physics.

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www.ncdc.noaa.gov/oa/climate/uscrn/
www.nesdis.noaa.gov/

WHOI Scientists Discover New Type of Ocean Ridge

Scientists from the Woods Hole Oceanographic Institution (WHOI) report they have identified a new type of ocean ridge that is spreading so slowly that earth's mantle is exposed over large regions of the sea floor. Their findings of a new ultraslow class of ridge, reported in the November 27 issue of the journal "Nature," offer a major change in thinking about the formation of the great crustal plates that make up the surface of the earth. Lead author Henry Dick and WHOI colleagues Jian Lin and Hans Schouten of WHOI's Geology & Geophysics Department studied two of the most remote locations on the planet — the Southwest Indian Ridge in the Atlantic and Indian Oceans, and the Gakkel Ridge beneath the Arctic ice cap. Ocean ridges form a chain of mountains and valleys that encircle the globe like seams on a baseball. Dick writes that he first noticed the ultraslow spreading ridges — a name for the ridges given by WHOI scientists — because the crust there was much thinner than at ridges found elsewhere in the ocean. Initially, he thought they were just a very slow variety of slow-spreading ridge, creaking apart at only 0.15 to 0.8 inches per year. Slow and fast ridges — the other types of ocean ridges — spread at a rate of 1 to 7 inches annually. Dick says that the ultraslow ridges account for 12,000 miles of the total 30,000-mile mid-ocean ridge system. Among other reasons, this is important as hot springs at these ridges are now known to be far more abundant than anyone had suspected. These springs produce deposits rich in copper, zinc, and other metals at ocean ridges and the ultraslow ridges may contain the largest future ore deposits to be found in the oceans.

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First Look at Giant Crab Habitat

Australian scientists got their first look at the habitats and ecosystem that support Australia's largest commercial crab — the "giant crab". A series of five surveys are planned in waters of 150-350 meters depth to assess the seabed habitats of the giant crab (*Pseudocarcinus gigas*) at the edge of the continental shelf around Tasmania. According to a spokesman for the Commonwealth Scientific & Industrial Research Organization's (CSIRO) Marine Research group, the pilot survey was completed on Tasmania's east coast earlier this month in a collaborative project between CSIRO Marine Research and the Tasmanian Aquaculture & Fisheries Institute (TAFI), University of Tasmania. "We used a specially designed camera platform towed behind a research vessel to provide a tremendously exciting first look at the type of habitat that supports the giant crab fishery," says project scientist, Dr. Alan Williams, from CSIRO Marine Research in Hobart. "We were as pleasantly surprised by the extremely good detail provided by the new cameras system as we were by the range of habitats we were able to film," he said. Seafloor features observed ranged from large plains of muddy sands supporting communities of small invertebrate animals, to ridges, and rock outcrops more than 20 meters in height. The project includes a study of the distribution of the giant crab in relation to habitat features, evaluating ecosystem links with the seabed habitats and assessing the abundance, sex, condition and size of the giant crabs. "Sustainability of all Australian fisheries is reliant on healthy habitats and ecosystems and this project seeks to identify the characteristics of the system and what, if any, impacts are occurring as a result of fishing activity," TAFI's Dr. Caleb Gardner, project leader, said. The long-lived, slow-growing giant crab is highly prized, especially in the Asian market. Although mostly sold at around 4 kilograms and with a shell of 20 centimeters or less, the crab reaches a massive 13.5 kilograms.

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www.utas.edu.au/tafi
www.marine.csiro.au/