Coral Reef Restoration: Returning the caretakers to the reef

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Photo by Martin A. Moe

The Caloosa Rocks reef off Lower Matacumbe Key in September 2001. Algae and sediment coat the giant dying coral heads.

sediments and grass beds because algae on the reefs could not growth rapidly enough to fully support the urchin population.

The urchins are gone now. Seagrass grows up to the edges and into the patch reefs and fleshy algae growth dominate the eroding limestone skeletons of ancient coral formations that were alive and vibrant only two decades ago. The complex ecological structure that built and sustained these reefs is rapidly disappearing and the ecological web of diverse organisms that inhabits living coral reefs diminishes with every passing year.

The long-spined *Diadema* sea urchins of the tropical western Atlantic coral reefs died in 1983. Harilaos Lessios, a Senior Scientist at the Smithsonian Tropical Research Center, located on Barro Colorado Island at the mouth of the Caribbean entrance of the Panama Canal, noticed in mid January of 1983 that the ubiquitous long-spined sea urchins found in immense numbers on all Caribbean and Western Atlantic reefs were in trouble. Just how serious this trouble was would soon be very evident. The urchins became lethargic, did not retreat to shelter during the day, lost color and began to drop spines, and became easy prey for fish predators. Death followed quickly after the symptoms were first observed and within a few days all the *Diadema* on the reef were dead. The disease spread rapidly. Soon the entire Caribbean was affected and within a year urchin populations from the Florida Keys and the Bahamas northward to Bermuda were devastated. It is estimated that 92 to 99.9 percent of all the billions of *Diadema* sea urchins in this vast 1.35 million square miles of oceanic habitat died within 12 to 13 months. This was the most extensive mass mortality of any marine animal ever reported and the species was suddenly very near extinction. The rapidity and totality of the plague made it all but impossible to identify the causative organism. Two species of bacteria, however, *Clostridium perfringens* and *C. sordelli* were implicated since they caused the same symptoms followed by death when they were isolated from moribund urchins and injected into laboratory held *Diadema*.

The ecological impact of the loss of the *Diadema* urchins was soon apparent. In Jamaica, algae cover on the shallow reefs increased from 1% to as high as 95% within two years of the loss of the *Diadema* urchins, and at St. Croix, algal biomass increased by 27% within five days of the *Diadema* mortality and then algae biomass increased by 300 to 400% above the pre *Diadema* mortality levels. Similar increases in algal biomass following the mortality were observed throughout the Caribbean and tropical western Atlantic reefs.

After 20 years, even the limited return of the *Diadema* populations that has occurred in the Caribbean has not been seen along the Florida reefs. The return of *Diadema* to Florida waters may not occur for decades, if ever, and by that time there will be little left of the glorious coral reefs of the Florida Keys. It may be possible, however, to aid the return of these urchins to the reefs and it is imperative that we at least research this possibility. Perhaps the first step would be to find out what would happen to a reef in the Florida Keys if a pre plague population of *Diadema* could be returned to the reef. And this first step has already been accomplished.

Ken Nedimyer, a marine life fisherman, and Martin Moe, a retired marine biologist, both members of the Florida Keys National Marine Sanctuary Advisory Council, were convinced that the loss of *Diadema* on the Florida reefs precipitated the drastic decline of these reefs and were determined to demonstrate what would happen if *Diadema* were returned to the reefs. They obtained a small grant from a NOAA reef restoration fund and began work on a *Diadema* restoration project with the support and counsel of the Sanctuary staff.

The project began in the fall of 2001 offshore of the Upper Keys. We wanted to explore the feasibility and ecological results of translocating juvenile long-spined sea urchins from areas with relatively high settlement and extensive winter urchin mortality, the unstable reef crest rubble zones, to nearby deeper water (about 25 feet, 7.5 m) patch reefs at densities approaching those on Florida reefs before the *Diadema* mortality. This project, involving just the straightforward transfer of at risk juveniles from rubble zones to deeper reefs, was designed to determine whether these juveniles could survive such translocation and if they did survive in adequate numbers, could they change the ecology of the reefs.

Photo by Martin A. Moe

A coral head battling algae growth on experimental reef #1 in September 2001. Also note the algae growth on the brain coral head behind and to the left of the central star coral head.

Photo by Martin A. Moe

The same star coral head in September of 2002, one year after placement of Diadema urchins on the reef. The algae on both coral heads have been greatly reduced and the coral tissue appears healthier.

Four patch reefs: two experimental and two controls, varying in size from about 44 to 96 m^2 were selected for the study. During the period from September 2001 to December 2001, 434 juvenile long-spined urchins were placed on experimental reef #1 (96 m^2), a total potential density of 4.5/m^2, and 262 were placed on experimental reef #2 (88 m^2), a potential density of 3.0/m^2. An additional 16 urchins were placed on reef #2 on 10/23/02 bringing the total urchins placed on reef #2 to 278, a potential density of 3.2/m^2. No *Diadema* urchins were placed on the control reefs. The translocated populations were evaluated for number and placement of surviving urchins 10 times on reef #1, and 11 times on reef #2 over various intervals during the period from September 8, 2001 to February 5, 2003. NURC (NOAA's National Undersea Research Center) was contracted to perform a rapid habitat assessment of the four project reefs on 08/31/01 and 09/01/01, before translocation of the urchins and again on 09/18/02, about one year after translocation of the urchins to document the ecological changes that might occur on these reefs.

Initial survival after translocation of the juvenile *Diadema* urchins was very good. Survival rates for the juvenile urchins were 81 and 93 percent on experimental reefs #1 and #2 over the first month of the project. Survival declined to about 45 percent on both reefs after about three months and the slowly declined to about 20 to 25% after 17 months. On experimental reef #1, survival after 17 months was 27%. The average density over this 17 month period was 1.6 urchins/m^2, and the final density on 02/05/03 was 1.2/m^2. On experimental reef #2, survival was 20% after 17 months, the average density was 1.0/m^2, and the final density on 02/05/03 was 0.6/m^2. The slow decline of the translocated *Diadema* population was due to steady predation on the urchins and lack of recruitment of enough juveniles to maintain the population.

No urchins were placed on control reefs #3 and #4. (A small population of *Diadema* urchins, about 6 to 10, was present on reef #4 before and during the study.

Results of the ecological assessments

NURC carefully assessed the ecology of all four reefs before and one year after translocation of the *Diadema* urchins. The ecological effects of

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