Coral Reef Restoration

Restoration of a coral reef is actually repairing, in one way or another, the basic ecology of a tropical aquatic ecosystem. All the species that have evolved over a great expanse of time to survive in this ecosystem are important to the ecological functioning of this web of life. However, as with all ecosystems on this planet, some species are more important than others. In a coral reef ecosystem, the basic energy flows are between corals that grow and provide the physical structure of the ecosystem, algae that photosynthesize and transform the energy of the sun into a physical substance that provides nutritional energy to herbivores, and carnivores that feed on the herbivores. Thus a balance of life—a food web based on transformation and distribution of the energy of sunlight—is created that results in a stable ecology that builds and maintains a vibrant coral reef. Of course, the biology and ecology of a coral reef is much more complex than this simple explanation, life flows into and out of coral reefs on oceanic currents and coral reef life is interconnected with all other nearby marine ecosystems in nearshore and offshore environments, but essentially a coral reef cannot exist without a stable ecological balance between the life forms that create the coral reef ecosystem.

The ecological balance that maintains a coral reef is broken on Florida's reefs and also on many of the reefs of the Caribbean and the Bahamas. There are many reasons for the decline and loss of many of the species that have provided ecological balance to these reefs. Disease, pollution, overfishing, physical destruction, and climate change (which includes warming waters and ocean acidification) are the major factors. When we look at the big picture, how most of these destructive factors stem from world-wide or extensive regional impacts, it seems like there is little that can be done to improve the condition of our reefs. But actually there is a lot that can be done locally to improve our reefs and begin the process of ecological restoration.

Ken Nedimyer (Coral Restoration Foundation) has begun the process of coral restoration through selection and propagation of staghorn and elkhorn corals (now considered threatened/endangered species). Thousands of established fragments that can grow into new colonies have been started and planted on the reefs of the Upper Keys and some have developed into colonies reminiscent of the staghorn corals of 40 years ago. Other organizations like The Nature Conservancy and Mote Marine Laboratory are also propagating and planting staghorn and elkhorn corals on Keys reefs and the stage is set for reestablishment of resilient colonies of these and other corals on our reefs.

Although it is wonderful to once again see the presence of reef building corals on the reefs, ecological restoration must also include the return of the keystone herbivore, the long-spined sea urchin, *Diadema antillarum*, to these reefs. The vast populations of this urchin were decimated throughout the Western Atlantic by a plague in 1983. They have not returned to abundance since that time due to changes in the exposed substrates on the reefs and populations too small for effective reproduction. This herbivore not only clears the reefs of macro algae that out competes coral for light and space, but also scrapes and cleans the surface of the limestone rock and creates the substrate that allows coral larvae and the larvae of other invertebrates to settle and survive. Efforts are now underway by Mote Marine Laboratory to propagate these sea urchins and initial success indicates that it soon may be possible to create and maintain populations on selected reefs that will be ecologically and reproductively functional.

There is another large group of species that are an essential component of coral reef ecology and that has been greatly impacted by the loss of corals and the structures that they create. These are reef fish, the small species, both herbivores and carnivores that occupy the complex structures of coral reefs and form the base of the coral reef fish populations. It may not have been a disease, pollution, or overfishing that produced a decline of these species on Florida coral reefs, it may have been just the simple loss of live coral, both the physical structure that supplies their habitat and also their specific food organisms, the micro fauna that live coral structures support that prevented survival of the larvae that settled on dead and dying reefs.

So is there nothing we can do about that? Must we wait for new, more resilient corals to propagate and grow; must we wait until herbivory returns to the reefs before the populations of small reef fish species can rebound? Well, yes. If the habitat is not there, the small fish will not return in numbers until the habitat returns. However, it may be possible to create, in certain carefully selected reef areas, temporary habitat for some small reef species. And if this can be done, then these reef fish populations will be able to expand, reproduce, and occupy natural habitat much more quickly. And these artificial structures can be removed as the staghorn and elkhorn coral attain the structure to support the pioneer populations of small reef fish that can survive in the artificial structures.

The physical structure of natural coral reefs is very complex but basically consists of a tangled thicket of vertical and horizontal rods, like staghorn coral, vertical plates on the reef tops, like fire coral, flat horizontal plates some distance above the bottom, like elkhorn coral, and holes, crevices, and caves, such as the under structure of bolder and mounding corals. I may be possible to create an adequate substitute for these natural structures with artificial structures, a small artificial reef for small reef fish, with a structure of PVC pipe and integrated flat cement plates mounted vertically and horizontally in the PVC pipe structure. The horizontal plates may be more numerous near the bottom to provide stability and support for the structure and also near bottom habitat mimicking bolder coral habitat. Horizontal plates above would provide the type of habitat the elkhorn coral presents, and vertical plates could provide habitat similar to the vertical plates of fire coral, where, for example, the yellow tailed reef fish (jewelfish) place their eggs. Such habitats could be developed in modular fashion and then assembled on the site to suit the ecological requirements of the location and to make handling, construction of various shapes, and eventual removal reasonably easy.

Placement of temporary small reef fish habitats may or may not be possible, ecologically, functionally, politically, or economically. But on the other hand, placement of such structures may greatly enhance restoration efforts. There may be a synergy between the presence of the various species of small reef fish and the growth and survival of small reef fish that augments the survival of both elements. Of course, if there is interest in assessing the possibilities that such structure may present, then funding, research, experimentation, and analysis must be done to access the value of such a program.

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