

Coral Reef Restoration in the Next Millennium

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Statement of Issue

CORAL reefs around the world have changed dramatically over the past two decades. Many types of disturbance—separately and in combination—are changing the face of reefs. These include: hurricanes, coral bleaching, diseases of corals and sea urchins, over-fishing, destructive fishing, nutrient loading, sedimentation, hyper- and hypothermic stress, various forms of pollution, harvesting of reef invertebrates, coral mining, trampling by tourists and divers, and the destruction and devastation caused by ship anchors and groundings. It is obvious that this resource needs protection, and that many of the cited anthropogenic causes can be reduced or avoided by implementation of scientifically-based management programs.

At the present rate of destruction, reef ecosystems will likely suffer continued significant degradation, possibly to the point of irreversible decline. Accordingly, one appropriate course of action is to replace or restore damaged and disturbed reefs with functional ecosystems at a rate resulting in no-net loss of ecosystem value (that is, rate of reef destruction offset by rate of reef repair). While a potentially worthy goal, the discipline of coral reef restoration is in its infancy. Not only do managers and policymakers need to understand the effects of human-induced disturbances and to be able to properly assess these damages, they also need the knowledge, understanding, and tools to successfully develop restoration efforts on degraded reefs under their stewardship. In addition, it may be futile to attempt restoration unless some chronic causes of degradation, such as pollution or sedimentation, are first reduced or eliminated. These issues were addressed at the 9th ICRS and relevant findings are presented.

State of Knowledge

To date, most coral reef restoration programs have been focused on the physical damage caused by humans. Of these, ship groundings are among the most destructive chronic anthropogenic factors causing significant localized



The freighter Miss Beholden being pulled off the Sambo Key reef, Florida Keys National Marine Sanctuary

Photo: Florida Keys National Marine Sanctuary

damage on coral reefs and have been the focus of many early attempts at reef restoration. In fact, much of what we know about the rehabilitation of coral reef systems stems from our work in trying to repair reefs injured by vessels that have run aground.

The main themes in reef restoration include:

- The most widely accepted definition of restoration is “the return of a habitat to a close approximation of its condition prior to disturbance.” This includes placing all restoration efforts in a landscape context where the restored patch is integrated into an ecosystem.
- As we move into the new millennium, it will be imperative that we restore anthropogenically disturbed reefs to a level that closely resembles (both functionally and aesthetically) a pre-injury baseline.
- Available technology allows us to grossly recreate almost any lost physical structure.
- Research is ongoing to determine best substrates and expected interactions of substrates composition, texture, orientation, and design with the damaged environment and biota desired to be restored.

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- Developing countries could be aided by the development of low cost and low-tech restoration programs.
- Coral nursery programs, the use of cultured coral larvae, and larvae attractants could be a bellwether for returning coral cover to damaged reefs.
- The quantity of reef restoration projects has been slowly increasing over the past decade. Compared to terrestrial and wetland restoration, which range in the 1,000's of implemented projects, coral reef restoration is in its infancy (10's of projects).
- Finding appropriate solutions to a particular damage scenario is often hampered by a general lack of quantitative descriptions of the ecological effects of anthropogenic disturbance on coral reefs and an even greater lack of data describing the direction and rate of natural reef recovery. Therefore, there is little basis for understanding what works, what does not, and why.

Implications for Management and Policy

- Hypothesis-driven, ecological research coupled with quantitative assessment and long-term monitoring programs are the keys to answering these critical questions in reef restoration.
- Restoration results may vary significantly with methods and at different locations. If restoration designs are not meeting the desired objectives, modifications should be considered. The use of adaptive management techniques to guide future restoration efforts can also be an important approach.
- Developing successful restoration efforts in the future will depend upon acquiring and applying a scientific base to this emerging discipline. In addition, because of the infancy of this enterprise, the continued sharing of information will be vital to improving restoration strategies over time. The status of reef restoration has advanced a great deal in a short time; as reef scientists and managers, we should be excited about the opportunities that lie ahead.

Specific Recommendations for Action

- Develop and implement hypothesis-driven, ecological research coupled with quantitative assessment and long-term monitoring programs to address critical questions.
- Formulate and test hypotheses about the response of both corals and reefs to disturbances and about the process of reef recovery, to establish:

- (1) the degree to which corals and coral reefs have the capacity to naturally recover,
- (2) how intervention in recovery can retard or enhance the process (or have no effect),
- (3) the scientific protocols necessary to design and implement restoration strategies, and
- (4) a scientific baseline for developing quantifiable success criteria, and the efficacy of the restoration effort.

Useful References and Resources

This paper was prepared from presentations at the 9th International Coral Reef Symposium, Mini-Symposium D4 *Coral Reef Restoration in the Next Millennium*. Authors and titles of presentations can be found at:
<http://www.nova.edu/ocean/9icrs/>

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Florida Keys National Marine Sanctuary. Web site:
<http://www.fknms.nos.noaa.gov>

Damage Assessment and Restoration Program of NOAA.
 Web site: <http://www.darp.noaa.gov/>