



The Workshop to Advance the Science and Practice of Caribbean Coral Restoration occurred Nov 15-17 in Fort Lauderdale, Florida. The goals achieved at the workshop were to foster collaboration and technology transfer among coral restoration scientists, practitioners, and managers, and to initiate a community of practice that will continue to address the multiple, rapidly expanding and evolving paths to active coral restoration in the evolutionary history of coral reef ecosystems. The theme of scaling up restoration to meet the needs of ecosystem recovery was woven throughout sessions on translating genetics into the practice of coral restoration, increasing efficiencies of in-water nurseries, improving outplanting techniques, the role of larval propagation, monitoring to quantify restoration success at multiple scales, and more.

NOAA led the planning and funded most of the international travel while Nova Southeastern University's Oceanographic Center provided an ideal setting for the 100 in-person participants from 20 Caribbean nations, and robust remote participation for another 100 virtual participants. The Pew Charitable Trusts, through a grant from the Herbert W. Hoover Foundation, paid for travel for the Pew Marine Fellows - established academic scientists who lent this event a critical big picture viewpoint. TNC Caribbean supported travel for nursery operators from Cuba and helped recommend participants from their network of restoration practitioners throughout the Caribbean. Mote Marine Lab and Nova Southeastern University sponsored successful networking events, and Mote Marine Lab and the Coral Restoration Foundation partnered to award an inaugural set of exciting Coral Restoration Training Fellowships.

Participants displayed overwhelming interest in continuing the exchange of information begun at the workshop, and were strongly supportive of establishing a coral restoration consortium. A powerful form of scaling up restoration is a rapid download of practical knowledge from veterans to the numerous startup coral nurseries throughout the Caribbean. Considering the rapid decline of coral ecosystems, maintaining communication and rapidly advancing the field of restoration is urgent, and the consortium is intended to facilitate this communication. The structure of this consortium is under development and will include formal and informal ways to continue and improve collaboration among researchers, managers, and practitioners. Planning is already underway for future workshops on more specific topics, an on-line forum has already been set up, and quarterly topical webinars are on the calendar. A number of the larger NGO partners expressed strong interest in helping to lead the consortium and to undertake ambitious collaborative projects that foster cross-fertilization and innovation and restoration at an appropriate ecological scale. The consortium will develop a strategy for tackling some or all of the following recommendations from the workshop.

Primary Recommendations from the Workshop:

1. **We need to restore reefs in targeted geographic areas to demonstrate the effectiveness of restored reefs in decreasing wave propagation and thus risk of coastal degradation.** Other ecosystem services such as increases in fisheries yields and tourism should also be measured in these demonstration projects. These "proof-of-concept" projects will facilitate messaging and communication about the importance of reefs and restoration, and may unlock new funding sources.

2. **The efficiency and scale of coral restoration must be dramatically increased to achieve the overall goal of establishing self-sustaining, sexually reproductive populations.** Sexual reproduction is central to the coral crisis as it involves the evolutionary mechanisms (e.g., recombination) that will enable adaptation to the future –mostly unknown – conditions that corals will face.
 - a. **Optimizing current techniques and outplanting asexually derived coral fragments with radically greater efficiency is a priority.**

Restoration practitioners compared outplanting methods and coalesced on the need to utilize and develop more rapid outplanting techniques. There was agreement that in order to develop new techniques the community needs to reach beyond traditional partners in the biological sciences, and could benefit from collaboration with researchers in other areas, such as engineers (process, material, and mechanical). There is a need for guidance on how to achieve the goal of self-sustaining populations, for example recommendations on the size and density of outplants for particular species over a given area.

 - b. **Larval propagation is showing promise and could assume a larger role in coral restoration.** Tremendous progress has been made in the research and application of using sexually derived larval recruits in coral restoration (e.g. collecting and culturing gametes/larvae, settlement) and the successful integration of sexual offspring in restoration efforts is an important avenue to improving genetic variability, enabling long-term ecological adaptation, and ultimately increasing population resilience. These techniques are particularly important for non-acroporid species that do not fragment as frequently or grow as quickly. Remaining restoration hurdles largely concern post-settlement survivorship of larval recruits, and this needs to be a focus of research/development activity. Working on this

in conjunction with restoration practitioners holds great promise for larval propagation to play a larger role in overall restoration and long-term resilience of reefs.

- 3. Workshop participants agreed on the need to (a) develop monitoring guidelines that cover both basic and detailed levels of information (genetics and demographics of out-planted corals, areal extent of hard coral cover, ecosystem functioning, and metadata on restoration behavior), and (b) share data to facilitate regional understanding of ecosystem status.** Recognizing the tradeoff between conducting restoration activities and monitoring the effects of those activities, participants were encouraged to consider monitoring for change at multiple scales: from the individual coral colony to the reef ecosystem. Emerging technologies such as image mosaics were promoted as a useful way to detect change over time, create permanent records, and effectively demonstrate and communicate the value of restoration. The guidelines will be developed in coordination with existing monitoring protocols in an effort to avoid redundancy and enhance efficiency.
- 4. The workshop revealed a critical need for dialogue among geneticists, practitioners, and permitters, and for the development of recommendations on several issues related to coral genetics.** We need a clearinghouse of genotypic information for outplants along with recommended guidelines on how to characterize those genotypes. We also need to provide quantitative recommendations on how to maintain and enhance genetic diversity over a given geographic region, when the natural population is declining in health and abundance, and outplants may comprise a significant portion of the population. Analysis and subsequent guidance is needed on the costs, benefits, and risks of pursuing various intervention strategies (e.g. selecting for climate resilience while examining potential trade-offs in reproductive capability) to insure the long-term persistence of corals and shallow-reef Caribbean ecosystems in a rapidly changing climate.
- 5. Communicate.** Participants expressed strong support to develop a Caribbean Coral Restoration Consortium to improve communication, promote collaboration, amplify messaging about the utility and need for restoration, and transfer knowledge to other ocean basins.