

Connectivity & Large-scale Ecological Processes

Effective management of coral reefs must take into account the variety of interconnections between local populations and the spatial and temporal scales across which these occur. However, developing management strategies and tools depends on a better understanding of connectivity processes, supported by sound empirical data.

Importance to Management

Theoretical studies suggest that population connectivity plays a fundamental role in local and meta-population dynamics, community dynamics and structure, genetic diversity, and the resiliency of populations to human exploitation. However, modeling efforts have been hindered by the paucity of empirical estimates of, and knowledge of the processes controlling population connectivity in ocean ecosystems. While progress has been made with older life stages, the larval-dispersal component of connectivity remains unresolved for most marine populations. This lack of knowledge represents a fundamental obstacle to obtaining a comprehensive understanding of the population dynamics of marine organisms. Furthermore, a lack of spatial context that such information would provide has limited the ability of ecologists to evaluate the design and potential benefits of novel conservation and resource-management strategies.

Connectivity Working Group aims

The CRTR Connectivity Working Group aims to advance the science of connectivity and large-scale ecological processes and demonstrate its effectiveness for selected species in the Meso-American region.



Researcher Dr. Bob Steneck (l) and PhD student Susie Arnold working on a settlement plate at Glovers Reef, Belize

Major areas of research activity and capacity building are:

- Development of techniques for tracking dispersal of planula larvae.
- Genetic studies of coral populations to discern likely connectivity patterns.
- Studies of a typical fish species that does not aggregate over large distances to spawn.
- Factors responsible for critical bottlenecks in coral recruitment.
- Lobster recruitment and larval biology for use in building models of larval dispersal.
- Assist local management agencies to understand connectivity, recruitment, protected area management, and population resilience.

Highlights of the Group's research to date are summarised below.

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The Coral Reef Targeted Research & Capacity Building for Management Program (CRTR) is a leading international coral reef research initiative that provides a coordinated approach to credible, factual and scientifically-proven knowledge for improved coral reef management.

The CRTR Program is a proactive research and capacity building partnership that aims to lay the foundation in filling crucial knowledge gaps in the core research areas of Coral Bleaching, Connectivity, Coral Diseases, Coral Restoration and Remediation, Remote Sensing and Modeling and Decision Support.

Each of these research areas are facilitated by Working Groups underpinned by the skills of many of the world's leading coral reef researchers. The CRTR also supports four Centers of Excellence in priority regions, serving as important regional centers for building confidence and skills in research, training and capacity building.

The CRTR Program is a partnership between the Global Environment Facility, the World Bank, The University of Queensland (Australia), the United States National Oceanic and Atmospheric Administration (NOAA) and approximately 50 research institutes and other third parties around the world.

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Tracing coral connectivity – using DNA and magnets

Collecting coral tissue from juveniles, small adults and large adults across large sections of reefs in Belize and Mexico, the Group has characterised the genetic composition of these coral populations. Genetic analysis has



PHD student Susie Arnold working with American students on recruitment monitoring at Callabash Caye, Belize. Photo: Bob Steneck

been based upon DNA extracted from the samples and is then used to assess if juveniles of a species have been produced by the local adult population.

Tools to trace dispersal of planulae of *Montastrea faveolata* are being developed based on larval biology and behavior, immunogenetic probes to identify planulae, and magnetically attractive beads to trace patterns of water flow. The resulting data will then assist with development of reliable dispersal models of this species. Tracking at Glovers Reef has already confirmed the exchange of particles between the inside and outside of the reef, while at Belize Barrier Reef sites, particles have been collected up to 20 kilometres from the release site.

Investigating post-settlement bottlenecks

Coral is most vulnerable in the first year of settlement, with mortality exceeding 90% on the Meso-American Barrier Reef. However juvenile corals that make it through to a size refuge of about 40 mm have much more promising prospects with an estimated 75% chance of long term survival.

Critical bottlenecks in the months between settlement and reaching a viable size may be the primary determinant of patterns of coral connectivity. To assess these bottlenecks in coral recruitment,

the Group is monitoring the settlement of corals at five sites in Belize, Guatemala and Honduras, with permanent transects established at each. This forms the basis of large scale annual monitoring which is important as local marine populations are interconnected in a variety

of ways, and the scale(s) of these interconnections must be considered if management programs are to be fully effective.

The project is evaluating the demography of naturally occurring coral recruits and the factors affecting settlement. Measurements of algal biomass and juvenile coral

abundance show an inverse relationship, indicating that macroalgae might adversely impact on the survival of newly settled corals.

More generally, the survival of newly settled corals is likely to be strongly influenced by the local biological environment, with a dynamic equilibrium between the positive effects of settlement facilitators and the negative effects of algal abundance and other barriers to settlement. The project has already accumulated evidence that localised recruitment potential of reefs is a critical component of connectivity.

Connectivity in bicolor damselfish

Research on bicolor damselfish is assessing several approaches to measuring connectivity in those reef species which do not aggregate over large distances to spawn. Sampling from Mexico to Honduras, the Group has made excellent progress combining genetic assignment tests, otolith microchemistry, ecology of settlement patterns, and hydrodynamic and habitat data to develop patterns of connectivity for populations of this common species. The work has provided the first empirical estimates for likely dispersal distance for larvae of this species, and has provided evidence

of the interannual variation in connectivity for this species. The studies have also revealed a number of complicating features that make the determination of connectivity patterns using genetic or otolith techniques far from routine, yet still feasible, and it is anticipated that this will prove true for most reef fish species.

Modelling lobster larval dispersal

The Group has obtained data from a rearing study on the longevity of the multiple larval stages of Caribbean Spiny Lobster (*Panulirus argus*) which will be critically important to the development of dispersal models for this species. Studies of larval behavior, and a catalog of adult population size (spawning potential) at sites throughout the Mesoamerican Reef provide further data for developing dispersal models. The first stages of modeling larval dispersal are now under way. Recruitment continues to be monitored to provide data for validating outputs of the model.



Parrotfish Exclusion Device (PED) and PED control at Glovers Reef, Belize. Photo: Susie Arnold

Capacity building and outreach

Much of the information on connectivity and recruitment data gathered in this research, and synthesised from other work, has supported training workshops for managers of reefs and protected areas. Members of local reef management communities have also been trained in monitoring procedures, in principle enabling data collection over a large area, but also providing these managers with feasible management strategies that they can implement at the local scale.

Further Information

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