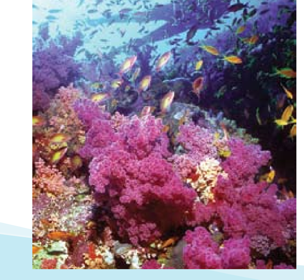
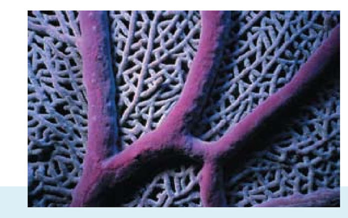
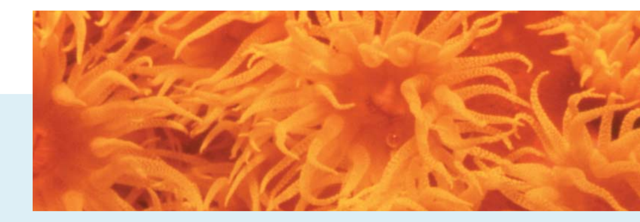






Over one-half
of the world's population lives
within 100 kilometres
of the sea.

Coral Reef Targeted Research & Capacity Building for Management

Connectivity and Large-Scale Ecological Processes Working Group

Connectivity: What is it? How is it measured? Why is it important for management?

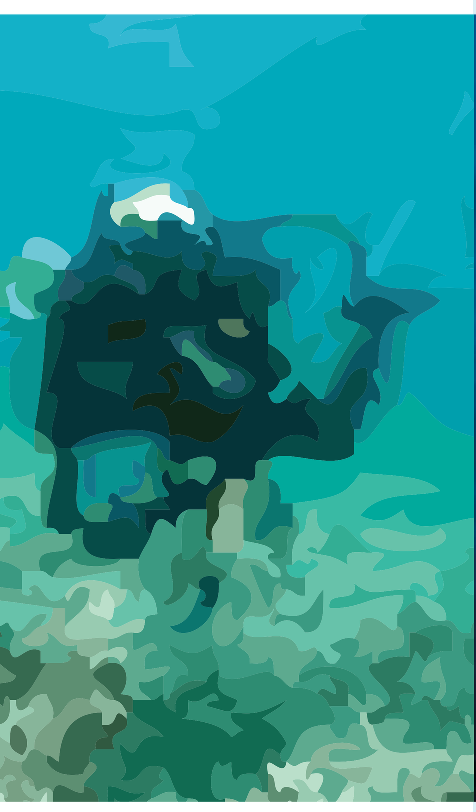


image: Gary Bell (Ocean Wide Images)

image: Steve Turek

Members of the Connectivity working group at Calabash Caye, Belize in 2005

Implications for Coral Reef Management

Until now, management of coral reefs, where it exists, has been reactive rather than proactive. With coral reefs entering a time of even greater stress, it is mandatory that managers develop more proactive approaches, strongly embedded in science.

The use of connectivity information to accurately assess linkages among locations, and local demographic capabilities is going to be essential if we are to have management programs that are capable of sustaining coral reefs. The CRTR Connectivity program is providing and testing new methods for building the connectivity database that effective management will use.

Marine Protected Areas (MPAs) are a management tool holding great promise. Realizing that promise requires Connectivity science as an essential tool for guiding the design and implementation of MPAs.

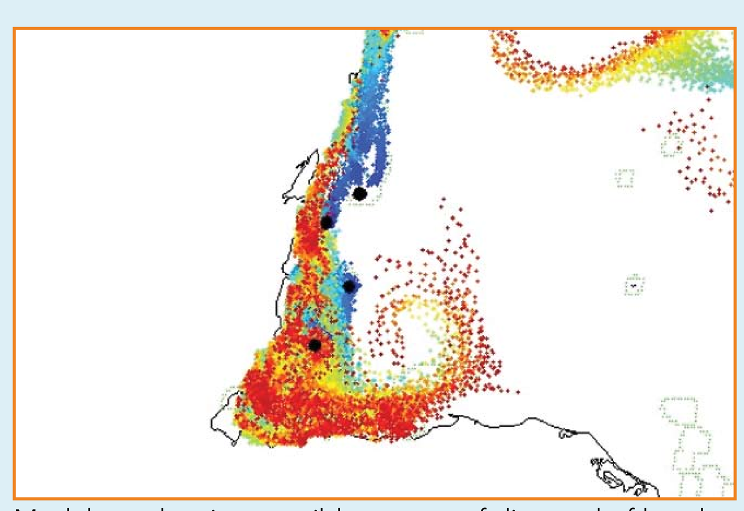
Monitoring fish recruitment using a line transect and 1m wide T-bar to delineate a belt transect. Used in the recruitment monitoring program of Project 6.

Goals:

The Connectivity Working Group is undertaking *demonstration projects* in the Mesoamerican region that will *develop tools* and apply them to determine *connectivity patterns for selected species in that region.* Work is being done in *collaboration with local management agency* personnel, *students* from the region are receiving advanced education, and efforts are being made to use the projects and results to *inform local communities* and show how connectivity data can be obtained, and *used effectively in management planning.*

What?

Most reef species have pelagic larval stages. The dispersal during larval life means that neighboring populations are connected by the exchange of lavae. Movements of adults may also connect populations, but this is usually far less important than larval exchange. This linking of populations is termed connectivity.



Model run showing possible pattern of dispersal of larval snapper from known spawning sites in Belize during May 2004. Red represents greatest number of larvae while blue represents fewest Belizean larvae arriving at that location after 30 days of larval life. An example of the modeling done in Project 7.

How?

Measuring connectivity is *technically difficult* for several reasons, including:

- **Long *larval lives***
- **Larvae *too small* to be tagged**
- **Dispersal a complex product of *passive* transport and *active movement.***

Many species are larval for many days or weeks and potentially able to travel large distances during this time. The movement of water around complex coral reef topography is itself far from simple, and dispersal of larvae is strongly influenced by patterns of water movement. But larvae can also sense their surroundings, respond to them, and swim, sometimes surprisingly well. Larval behavior also changes as the larvae develop and grow.

Searching a collector for lobster larvae. Technique used in monitoring lobster recruitment in Project 6.

Measuring connectivity requires field observations that are:

1) ***Over large regions* to encompass the potential extent of larval movement;**
2) ***Timed* to coincide with critical biological events such as spawning pulses, and;**
3) **By people with *a broad range of skills* – physical oceanographers, ecologists, behavioral scientists and others.**

It also benefits from use of sophisticated laboratory-based sciences including *molecular genetics, trace-element chemistry*, and advanced *computer modeling.* This is not routine monitoring.

Why?

Management of coral reefs, for conservation and/or for sustainable fisheries requires that we manage human impacts to levels that ensure the sustainability of the populations of reef organisms. This depends on the ability of the local (impacted) population to grow, and population growth depends upon connectivity as well as on local reproductive potential. Design and management of Marine Protected Areas, in particular, depends on knowledge of the connectivity relationships of the local populations of targeted species.

Graduate student Ainhoa Zubillaga testing immunogenetic assay for coral planulae of Montastrea faviolata.
This assay is being developed to screen water samples for presence of larvae of specific coral species in Project 4.

At present there is very little information on levels of connectivity in coral reef regions, and MPA management depends too much on good luck and 'guesstimates'.

If we are to be successful in maintaining coral reefs into the future, we must incorporate much more real information on connectivity into our management plans and procedures. The first step is to develop the tools to collect that information.

Progress to date

The Connectivity program has commenced several distinct, but interrelated projects in the Mesoamerican region. They are intended to advance the science, and demonstrate its effectiveness in measuring connectivity for particular kinds of species. We work closely with local management agencies to build a database of recruitment of particular species at sites through the region, because recruitment data can inform us of the demographic rates of local populations, and can provide basic data needed for determining connectivity patterns.

Belizean student, Nataniel Alvarado, attaching settlement plates to monitor recruitment of coral larvae for Project 3.

Studies of fish concern one typical species that does not aggregate over large distances to spawn, and one species that aggregates for spawning once a year. Quite different methods are required for these different kinds of species.

Studies of corals center on technique development for tracking dispersing planula larvae and for identifying them to species. Genetic studies of coral populations are being used to discern likely connectivity patterns both now and in the past. Studies of coral settlement and early survival are being done because this early benthic phase may be a critical bottleneck to coral success.

The spiny lobster has one of the longest larval lives of any reef species, so determining is connectivity patterns may be very difficult. We are collecting data on lobster recruitment, and on lobster larval biology for use in building models of larval dispersal. Validated models can provide information on connectivity among locations.

A tiny postlarval stage of the Caribbean spiny lobster sitting on a finger. This is the larval stage that enters reef habitat, and the stage that recruits to collectors used in Project 6..

More information

The University of Queensland is the Project Executing Agency (PEA). More information about the CRTR Program can be obtained from the PEA:

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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 40 research institutes and other third parties around the world.
The four sites or Centers of Excellence are **Southeast Asia**: Marine Science Institute of Bolinao, University of the Philippines; **East Africa**: Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania; **Mesoamerica/Western Caribbean**: Unidad Academica Puerto Morelos, Universidad Nacional Autonoma de Mexico, Mexico; and **Australasia/South Pacific**: Heron Island Research Laboratory, Centre for Marine Studies, The University of Queensland, Australia.

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