Coral Reef Targeted Research & Capacity Building for Management

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





Coral Bleaching and Local Ecological Responses Working Group

Understanding coral bleaching


The Coral Reef Targeted Research and 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), UNESCO-Intergovernmental Oceanographic Commission (IOC/UNESCO) and approximately 50 research institutes & other third parties around the world.

October 2006

Implications for Coral Reef Management

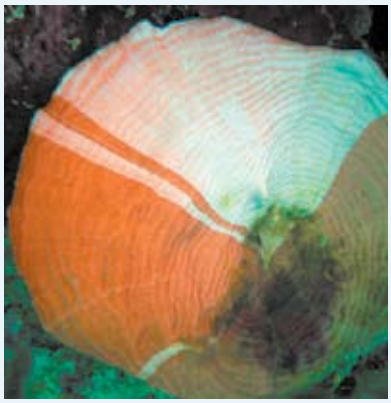
The CRTR Bleaching Working Group is focused on filling critical information gaps with respect to coral bleaching and mortality with the aim of supporting management responses for the coming century of climate change.

Major research Themes

The Bleaching Working Group has identified four major research themes into which it will put its efforts. These themes are interconnected and are aimed at improving the scientific basis upon which management responses will be developed as the climate warms and carbonate ion concentrations in our oceans decline.

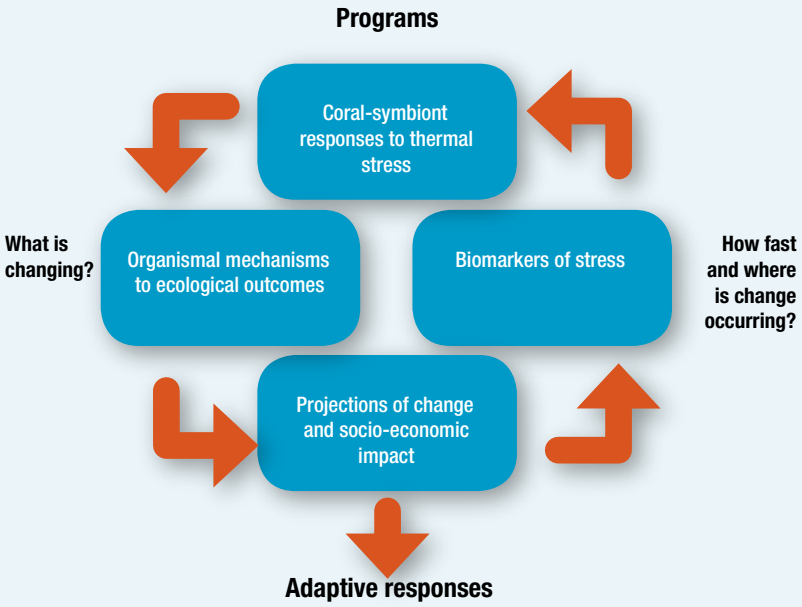
Large scale bleaching affected the world's largest continuous coral reef in early 2002. More than 60% of the Great Barrier Reef bleached and up to 5% have been severely damaged.

Bleaching refers to the loss of symbiotic dinoflagellate algae, *Symbiodinium*, within the coral host leading to a bleached, white appearance. Bleaching is a stress response of the coal host and associated with elevated sea water termperature. Over extended time periods a bleached state can lead to death of the coral, and can occur over lage areas of coral reef.



WORKING GROUP GOAL

Advance our understand of the susceptibility and tolerance of corals to rising sea temperatures, improving our understanding of (and the linkages between) physiological stress and the ecological outcomes of thermal stress and deliver the scientific basis from which stress on coral reefs can be identified and managed on coral reefs.

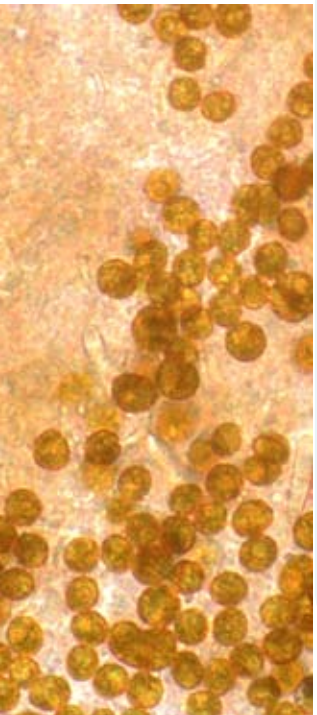


Coral-Symbiont Responses to Thermal Stress

Reef-building coral and their symbionts are critical to coral reefs as the frame-builders, providing the habitat for tens of thousands of other. They are also among the organisms most affected by climate change at this point. While bleaching events have profound effects on coral reefs, we know little about how the mechanisms behind bleaching, the differences in susceptibility of different corals and symbionts, and how physiological stress translates into ecological changes at the reef level. Work is progressing steadily by the group to progress these issues. Experiments done by the Working Group in 2005 on the plating coral *Montipora monasteriata* under short term heat stress have recently been written up as publication (Dove, Ortiz, Enríquez, Fine, Fisher, Iglesias-Prieto, Thornhill, Hoegh-Guldberg 2006; Limnol. Oceanogr. 51: 1149-1158).

The Bleaching working group is pursuing projects aimed at resolving the molecular mechanism of stress, and determining what characteristics of corals and their symbionts drives their different tolerances to stress. Some work has indicated that the symbiont type may be important to how one coral-symbiont combination may fair better than another. With this in mind, the Bleaching Working Group is compiling a library of symbiont genotypes for each of the four CRTR regions and is exploring how different these symbionts are in terms of their physiology inside and outside the coral host. The Working Group membership has produced a review recently that summarizes our understanding of '*The evolutionary history of Symbiodinium and Scleractinian hosts—Symbiosis, diversity, and the effect of climate change*', Stat et al (2006; Plant Ecology, Evolution and Systematics 8: 23–43).

Corals live in close association with a wide variety of organisms, including a wide variety of bacteria and endolithic (skeleton-dwelling) algae. Until recently, these associates have been largely ignored but are now thought to play a prominent role in coral health, through symbiotic and other close relationships. The Bleaching Working Group is focused on these coral associates and is exploring their role in bleaching and disease in collaboration with other groups within the CRTR. So far, it appears that bacteria do indeed play a prominent role in coral health but do not play a role in causing coral bleaching. Endolithic algae, on the other hand, appear to interact closely with corals and may important in coral recovery following bleaching. These discoveries are providing important information on the reasons for bleaching and the factors that may determine recovery following bleaching events.



Organismal Mechanisms to Ecological Outcomes

Changes to the physiological and cellular function of reef-building corals and their dinoflagellate symbionts invariably result in changes to the life-history parameters. These in turn result in changes to the population dynamics of reef-building corals. Understanding how changes to reproduction, mortality and other aspects of coral populations is important for a number of reasons including the ability to detect and understand the changes that are occurring on coral reefs around the world and for establishing better projections of the future. The project will also examine whether colony size distributions can be used as a tool for detecting and understanding change on coral reefs.

The Bleaching working group has established permanent study sites within three of the CRTR study regions: Zanzibar (East Africa); Puerto Morelos (Mexico) and Heron Island (Western Pacific). These study sites are focused on exploring the population dynamics of coral populations under natural and perturbed conditions, and is examining the spatial patterns in population size frequency distributions and examine temporal changes of the populations in and out of bleaching events. The project involves students and staff from different regions and is seeking to identify the generalities associated within the impacts of coral bleaching and mortality on coral population dynamics. Ultimately, the project would like to lay the basis for a generalized understanding of how coral populations are affected by changes in recovery and mortality.

The impacts of warming oceans go far beyond that of the coral themselves. Many organisms on coral reefs are dependent on corals for shelter and food, with the implication that they will disappear if coral decline in abundance on coral reefs. Work within this research theme is also aimed at resolving the potential impacts of changes in coral health on the many other coral reef species. One project within these themes will

summarize the existing data on the corals and fish and their interaction, using the many examples of where coral was lost in the 1998 and subsequent bleaching events to investigate the effect of these disturbances on coral dependent species. A meeting is planned for November in Zanzibar in which investigators from one of the heaviest hit regions, the Western Indian Ocean, will meet to compare data, undertake meta-analysis and provide a critical review of how fish populations are likely to be affected by downturns in the health and abundance of corals on reefs worldwide. The work will be done through the efforts of the post-doctoral person who will coordinate and organize a meeting, the data, analysis and synthesis for publications on the changes in space and time.

Biomarkers of Stress

One of the problems that often face reef managers and policy makers is that they are confronted with reefs in which damage has occurred but the reasons are less clear. In this respect, determining changes due to climate change per se versus declining water quality can have important implications on which direction a reef manager may take. Underlying the response of reef building corals to stress, are a series of molecular responses that differ depending on whether corals are being exposed metal ions, elevated inorganic nitrogen or elevated water temperatures. Having tools by which to distinguish these different stresses could be very useful for reef management.

The Bleaching Working Group is working on distinguishing different stress responses with corals and their symbionts. Research within this theme will use microarray technology to generate a series of potential markers at molecular and physiological levels. This will generate molecular chips with the principal expression products that respond to thermal, light, metal toxin, nutrient and disease stressors. In addition, studies will investigate molecular markers of the microbial community associated with coral in relation to stress and investigate the physiological and biophysical properties of mucus secretion.

The group is also investigating and developing other technologies for detecting stress. One of these has been a partnership to develop the use of colour cards for quantifying the detection of changes in coral colour. Current methods assaying the extent of bleaching rely on human observers that may differ substantially in perceptions of bleaching. This project will develop a new approach using inexpensive colour (Siebeck et al., Coral Reefs, in press) and a careful protocol to

assess the extent of coral bleaching within the major CoE regions. This tool will allow users to assess coral bleaching within at least 10 levels, which is far greater than the existing three levels (bleached, partially bleached and normal) used by previous studies. The methodology will be available to anyone with secondary education or above - and can involve dive companies and other reef users (e.g. tourists). This project will be integrated into regional CoE interactions with managerial communities and will be used to promote community involvement on a broad scale within the larger project.

Projections of Change and Socio-Economic Impact

Ultimately, managers need to know how coral reefs will change as the world's oceans warm and acidify. Without this information, effective management and policy responses will remain ill-defined. The accumulated insights of the Bleaching Working Group into how reef-corals and the reefs they build respond to stress will lay important groundwork for understanding the rate, detail and direction of change on coral reefs as the climate changes. Toward the end of the first phase of the CRTR Program, the Bleaching Working Group will broker a series of meetings in which information about details of potential climate impacts in the coming decades will be assembled. This information will be communicated to reef managers and policy makers through a variety of different forums. This information will form crucial input into strategies designed to assist adaptive responses by coral reef management into the coming century of stress.

Progress to date

The CRTR Bleaching Working Group continues to bring together and lead the formerly fragmented research efforts in the area of coral bleaching and ecological change research. Key outcomes include:

- Generated over 50 publications in peer-reviewed journals such as Science, Nature, and Global Climate Biology on the physiology and ecology of coral bleaching and disease.
- Held major research workshops and training sessions in several regions including Mexico, Australasia and Indonesia.
- Investigated and reported on mass bleaching events that occurred recently in Mexico (Sep-Oct 2005) and Australia (Jan-Feb 2006)
- Improved current working model of the mechanisms underpinning coral bleaching, disease and mortality.
- Created a world wide catalogue of the genetics of coral symbionts (Symbiodinium) and have identified potential tolerant combinations of corals and Symbiodinium.
- Produced a database of over 1300 potential stress proteins from Symbiodinium and have printed a "stress chip" for developing better ways of detecting stress in corals.
- Improved the current understanding of how light exacerbates the effects of temperature on coral reefs.
- Established long-term monitoring sites in Mexico, Tanzania and Australia for investigating community dynamics underpinning coral bleaching and mortality.

There are currently 35 postgraduate students involved in research from Australia, Venezuela, Bahrain, India, Israel, Italy, Kenya, Mexico, The Netherlands, Sweden, Tanzania, Thailand, United Kingdom and the United States.

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- RESEARCH UPDATE

Further Information

Coral Bleaching and Local Ecological Responses Working Group

Chair: Professor Ove Hoegh-Guldberg
University of Queensland, Australia
Email: oveh@uq.edu.au

Co-Chair: Professor Yossi Loya
Tel Aviv University, Israel
Email: yosiloya@post.tau.ac.il

Project Executing Agency:
Coral Reef Targeted Research & Capacity Building for Management Program
C/O Centre for Marine Studies
The University of Queensland
St Lucia QLD 4072
Australia

Telephone: +61 7 3365 4333
Facsimile: +61 7 3365 4755
Email: info@gefcoral.org