

Annual Report

Coral Reef Targeted Research &
Capacity Building for Management Program



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Acknowledgements

This report was developed and collated by Melanie King (Executive Officer, Project Executing Agency) with significant contributions from the following Program members:

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Contributions have also been received from Working Group members through their individual reports.

Further Information

Information used in this report has been collated from the individual Working Group and Centres of Excellence 2008 Annual Reports and from communication activities during the reporting period. Additional information has been produced with the input of the Management Team.

For further information regarding this report and/or to request copies of individual Working Group and Centre of Excellence reports, contact the Executive Officer, Melanie King at m.king4@uq.edu.au.

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Executive Summary

The Coral Reef Targeted Research & Capacity Building for Management (CRTR) Program is seeking:

- To fill the critical gaps in our global understanding of what determines coral reef ecosystem vulnerability and resilience to a range of key stressors – from localized human stress to climate change; and
- To inform policies and management interventions on behalf of the coral reefs and the communities which depend upon them.

Nearing the completion of Year Four in the first five-year phase of the CRTR Program, much of the research is now culminating in the synthesis and release of results. This Annual Report covers the period 1 April 2008 to 30 September 2008.

As the Program moves into the final year of the Phase during 2009, many of the scientific Working Groups and the Centres of Excellence will begin consolidating their findings and information and producing information 'products' for audiences, including scientists, coastal and coral reef managers and agencies, and policy-makers.

The past year has seen the emergence of research findings, including:

- A model detailing biology, behaviour and geographic patterns of spawning potential for the Caribbean Spiny Lobster, *Panulirus argus*. It is expected that patterns of lobster connectivity for the Mesoamerican region will be able to be produced.
- Preliminary data into the effects of aquaculture effluent on coral health and disease is showing that poor water quality may compromise aspects of immunity.
- Research into investigations as to whether coral disease patterns are influenced by the establishment of MPAs is supporting the hypothesis that when a fish community is protected from over-harvesting, it will create healthier conditions in the reef community and lower coral disease prevalence. Information from this research will have important impacts on MPA planning and design in the future.
- Regional scale models for the Mesoamerican and Philippine regions which test scenarios of human and biophysical drivers in the system, continue to be 'fine-tuned'. When completed, these models will be useful for management and policy work, particularly when they are coupled with the appropriate socio-economic models under development.
- The creation of decision-support and analysis software for monitoring the health of coral reefs using remote sensing is well on its way towards completion. These models will be useful for students and scientists from developing countries who cannot afford the commercially-available solutions.

The Program's four regional Centres of Excellence continue to cement their place as a 'hub' for research and training opportunities in their regions, with research results from local projects now being used to influence government decisions on coastal development, as demonstrated this year with the Mesoamerican Centre of Excellence.

"Research results from local projects (are) now being used to influence decisions on coastal development."

Complementing the work under the Working Groups and Centres of Excellence has been their support of studentships. Following the enormous success of last year's Future Leaders Forum which brought together all of the CRTR-supported students, the student network now extends to approximately 60 students from 17 countries. While these young scientists are contributing to the work of the Working Groups and Centres of Excellence, they are also building and expanding on their linkages with each other. Following a meeting at the ICRS in July, the student group has formed its own communication committee and is working on joint journal articles and products.



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



Local community representative is validating satellite image of coral reef, Vitu Levu, Fiji. Photo: Chris Roelfsema

In addition to the research element, the Program has continued to make strong in-roads into building the capacity of scientists and managers in developing countries through student scholarships, training workshops and courses, and the release of new information. During 2008 the Program undertook or participated in 69 events – training courses, workshops, media opportunities, meetings and conferences. In addition to this, Program members produced 174 publications, comprising journal articles, book chapters, conference papers, media articles or electronic products. These publications are classified as either fully or partially supported by the Program, or not supported but having an influence on, or being influenced by, the research being undertaken by the Program Working Groups and Centres of Excellence.

Information products continue to be developed and disseminated through various channels. In July, the ICERS saw the release of the *Coral Disease Handbook: Guidelines for Assessment, Monitoring and Management*, and *Underwater Cards for Assessing Coral Health for Indo-Pacific and Western Atlantic Reefs*. These products are aimed at assisting managers and researchers to recognise the signs of coral disease and how to measure the impact and monitor the outbreaks. These products are available through the CRTR Program's website at www.gefcoral.org.

In addition to the Handbook and Underwater Cards, the Restoration Guidelines have now been produced in three languages – English, French and Bahasa Indonesia and available through the website. A Spanish translation is underway and will be available during 2009. Further publications include updated Research Updates and Advisory Papers.

The fifth and final year of Phase One will see a culmination of synthesised research information, information outputs and capacity building activities being undertaken, together with a major planning effort as the Program develops its plans for Phase Two.



Members of the Synthesis Panel give a press conference. L to R - Prof Roberto Iglesias-Prieto (Universidad Nacional Autonoma de Mexico), Dr Peter Sale (United Nations University), Dr Marea E. Hatzioles (World Bank), Prof Ove Hoegh-Guldberg (Centre for Marine Studies, The University of Queensland).

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The number of countries where students sponsored by the CRTR Program are from

Addressing Knowledge
and Technology Gaps

1

Component

Addressing Knowledge and Technology Gaps

During the past 10 years, more people have become aware of the importance of coral reefs, especially in light of their rapid decline in many regions and their significance to developing countries. However, what remains fundamentally unknown about these ecosystems is alarming, especially when management interventions are becoming increasingly important.

Significant gaps in understanding coral reefs remain. The CRTR Program's six scientific Working Groups, consisting of interdisciplinary teams of scientists from developing and developed countries, are addressing these issues through targeted research across the following themes:

- Coral bleaching and local ecological processes
- Coral reef connectivity and large scale ecological processes
- Coral disease
- Modelling and decision support
- Coral restoration and remediation
- Remote sensing

The CRTR Program is undertaking research across these themes in various locations around the world. Each Working Group is operating within the locations of the regional Centres of Excellence (Australia, Tanzania, Mexico and the Philippines), as well as other locations including Palau, Belize, the Red Sea, and various other locations to extrapolate research results and link them into information for coral reef and coastal managers, policy-makers and decision-makers. The progress in the past year for each of these themes is outlined in this report.



Participants of a Capacity Building Workshop learn to use remote sensing as a decision support tool. Photo: Robert Canto

Coral Bleaching and Local Ecological Effects

Working Group Members:

Prof Ove Hoegh-Guldberg, Chair – Centre for Marine Studies, The University of Queensland, Australia

Prof Yossi Loya, Co-Chair – Department of Zoology, Tel Aviv University, Israel

Prof Robert van Woesik – Department of Biological Sciences, Florida Institute of Technology, USA

Dr Tim McClanahan – The Wildlife Conservation Society, Kenya

Dr Roberto Iglesias-Prieto – Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México

Dr Ruth Gates – Hawaii Institute of Marine Biology, University of Hawaii, USA

Dr Michael Lesser – Department of Zoology, University of New Hampshire, USA

Dr John Bythell – Department of Marine Sciences & Coastal Management, University of Newcastle, UK

Dr David Obura – CORDIO East Africa, Kenya

Dr Ron Johnstone – Centre for Marine Studies, The University of Queensland, Australia

The fundamental science that has been produced by the Group continues to improve the understanding of the impacts of global warming on coral reefs. A major highlight of the work from the Bleaching Working Group (BWG) members during the past year has been the demonstration of the effect of thermal history on the susceptibility of reef-building corals to heat stress; a more precise understanding of the photoprotection pathways in symbiotic dinoflagellates and; the demonstration that the susceptibility and mortality of corals is determined by fine scale differences in symbiotic types.

Work has continued on the geographical diversity of *Symbiodinium* project, with samples that were taken in 2008 filling many of the gaps in our knowledge about the geographical distribution of the all-important symbionts of reef building corals, *Symbiodinium*. In addition, Group members have produced several papers which have contributed to the understanding of host-symbiont mutualism, as well as the close associates and the accompanying responses of corals to environmental change. The work by Dr Ruth Gates is showing there may be a link between the type of *Symbiodinium* and the susceptibility of corals to disease. Papers in this area have emphasised the observation that corals associate with many more organisms than simply dinoflagellates, and that these microbial partners may be critical to our understanding of both the stability and the instability of corals to environmental change.

“The Working Group has produced a series of high-profile papers on the impact of global warming and ocean acidification on coral reefs.”

Research continues on trying to understand the relationship of other coral reef organisms to coral communities, with a series of 11 papers published that describe the ‘whole of community’ changes that have been occurring in the Western Indian Ocean. This effort is complementary to the long-term ecological studies that are now occurring at all four Centres of Excellence, where three years of data has been gathered.

Under the ‘*Understanding the mechanisms of coral bleaching*’ project undertaken by Dr Iglesias-Prieto, the research is continuing to provide an in-depth understanding of how light interacts with thermal stress to cause coral bleaching. Complementing this work, is the work undertaken by Dr Lesser exploring the molecular genetics of oxidative stress and nitrogen fixation in corals, anemones and symbiotic dinoflagellates. The work will deliver new insights into the mechanisms that lead to bleaching.

Using the insights gained through research efforts, the Working Group has produced a series of high-profile papers on the impact of global warming and ocean acidification on coral reefs. The Group, like all CRTR Working Groups and Centres of Excellence, was well-represented at the 11th International Coral Reef Symposium held at Fort Lauderdale during July. The Group contributed over 40 abstracts to the Symposium with members also playing a major role in the Symposium’s organisation.

Coral Reef Connectivity and Large-Scale Ecological Processes

Working Group Members:

Prof Peter Sale, Chair – Biological Sciences, University of Windsor, Canada
 Dr Carmen Ablan – Molecular Genetics Laboratory, The WorldFish Center, Malaysia
 Dr J Ernesto Arias – Lab. Ecologica de Ecosistemas de Arrecifes Coralinos, CINVESTAV-U, Mexico
 Prof Mark Butler IV – Department of Biological Sciences, Old Dominion University, USA
 Prof Robert Cowen – Rosenstiel School of Marine and Atmospheric Science, University of Miami, USA
 Dr Bret S. Danilowicz – Paulson College of Science & Technology, Georgia Southern University, USA
 Dr Geoff Jones – School of Marine Biology & Aquaculture, James Cook University, Australia
 Dr Serge Planes – Centre National pour la Recherche Scientifique, Universite de Perpignan, France
 Prof Barry Ruddick – Department of Oceanography, Dalhousie University, Canada
 Dr Yvonne Sadovy – Society for the Conservation of Reef Fish Aggregations, The University of Hong Kong
 Prof Robert Steneck – School of Marine Sciences/Darling Marine Center, University of Maine, USA
 Prof Alina M. Szmant – Coral Reef Research Group, Center for Marine Science, University of North Carolina at Wilmington, USA
 Dr Simon Thorrold – Biology Department, Woods Hole Oceanographic Institution, USA
 Dr Mary Alice Coffreth – Department of Biological Sciences, State University of New York, USA
 Dr Ken Lindeman – Environmental Defense, Miami, USA
 Dr Enric Sala – Center for Marine Biodiversity and Conservation, Scripps Institute of Oceanography, USA

Year Four (2008) was the final period of direct research funding for the Connectivity Working Group, with the final year in Phase One (2009) to be a period of focusing on analysis and publication of results. The Group aims to concentrate efforts on the transfer of information to the management community and synthesising results. The research activities under the Working Group have continued to progress with some of the most innovative work in reef fish connectivity being undertaken in Papua New Guinea under Drs Geoff Jones, Simon Thorrold and Serge Planes through complementary funding external to the CRTR Program.

Research activities funded by the Program are making good progress with the project '*Connectivity in Bicolor damselfish*' evaluating the use of several approaches to measuring connectivity in fish species that do not aggregate over large distances to spawn. Using the bicolor damselfish as the model species and undertaking fieldwork in Mexico, Honduras and Belize, the research is combining genetic assignment tests, otolith microchemistry, ecology of settlement patterns and data on hydrodynamics and habitat (collected during the ECONAR project), to develop data on patterns of connectivity of populations of this common species in the Mesoamerican Caribbean. The project will finalise the analysis in 2009, applying both otolith chemistry and genetic parental assignment approaches to the same individual recruits to determine the congruence in answers concerning their natal sources.

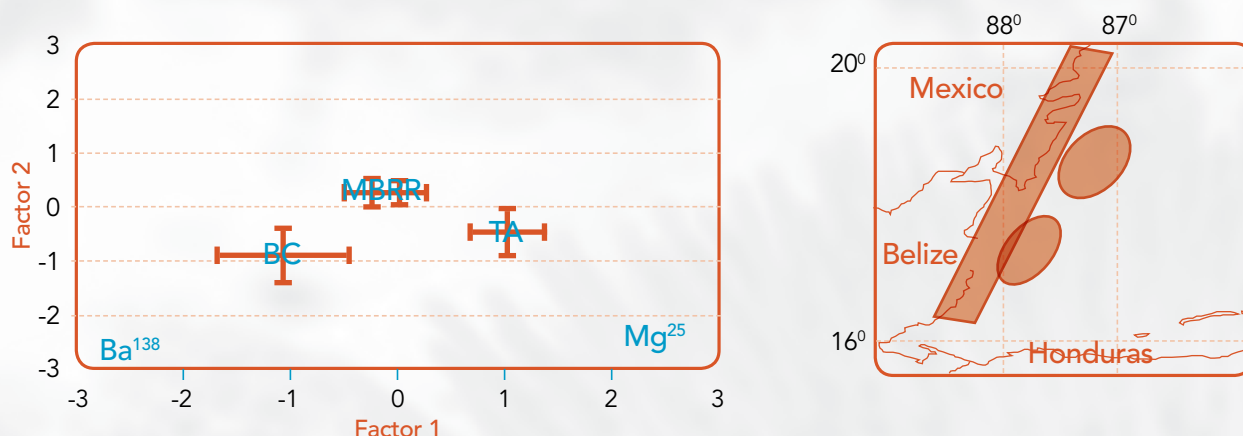


Figure 1 A plot showing the chemical differences among the three sub-regions (Barrier Reef, Turneffe Atoll and Banco Chinchorro) within the MBRS and a map putting these differences into a geographical context. Figures reproduced from JD Hogan Dissertation (2007).

Regular censusing of coral recruitment and early survivorship under the 'Settlement Bottlenecks' project has now been completed with patterns of coral settlement and recruitment showing they are clearly dissociated by factors such as a lack of grazing of algae at many sites. The research has found a surprising widespread inverse relationship between algal biomass and the density of newly settled corals, their survivorship, juvenile coral population density and their survivorship. This pattern shows no similar relationship with the population density and/or species density of scleractinian corals. The strength of these local effects is so great, that they could mask demographically relevant connectivity occurring from a distant source.

The 'Coral Connectivity' project is taking a variety of approaches and applying them to studies of coral larval biology and behaviour, genetic variation among coral populations, immunogenetic tools for recognition of coral planulae, and magnetic bead techniques for fine-scale demonstrations of dispersal of particles that 'behave' like planulae. The project has been successful in refining the various tools and approaches but due to limited funding, progress against a large-scale field experiment to demonstrate dispersal from a spawning event has been limited.

The 'Lobster dispersal and connectivity' project has been more successful as it studies the biology, behaviour and geographic patterns of spawning potential of the Caribbean Spiny Lobster, *Panulirus argus*. The research team is using existing or new finer-resolution hydrodynamic models with recruitment data providing a way to validate model output. The project is now primarily in a model-building phase, although the effort to monitor recruitment will continue until early 2009. It is expected that the project will be able to generate an expected pattern of lobster connectivity for the Mesoamerican region.



Front page of 'Coastal Development and Habitat Connectivity' brochure.

In addition to building the research effort, the Working Group has continued to support students and undertake training workshops. The Group completed a successful joint workshop with The Nature Conservancy (TNC) and the network of Mesoamerican managers in Fort Lauderdale in July, following the ICRS. In addition to this, the results of the October 2007 Townsville workshop with the Australian Research Council's Centre of Excellence for Coral Reef Studies has been packaged as six review papers on aspects of connectivity and management which will be submitted to Coral Reefs for review and publication in late 2009.

The annual workshops with management agency and NGO personnel in the Mesoamerican region continue to be successful with more senior managers now attending as the focus shifts towards how to use connectivity and recruitment data in guiding management of protected areas. The preparation of reports in accessible formats is a high priority and the Group will continue to work with TNC in facilitating communication. Already a flyer has been produced in English and Spanish - 'Coastal Development and Habitat Connectivity' - which looks at the connectivity implications of coastal development is available for download from the UNU-INWEH website at www.inweh.unu.edu.

Coral Disease

Working Group Members:

Prof C. Drew Harvell, Chair – Section of Ecology and Evolutionary Biology, Cornell University, USA

Prof Bette Willis, Co-Chair – School of Marine Biology and Aquaculture, James Cook University, Australia

Dr Garriet Smith, Co-Chair – Department of Biology and Geology, University of South Carolina-Aiken, USA

Dr Eric Jordan Dahlgren – Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México

Prof Farooq Azam – Scripps Institution of Oceanography, University of Southern California, USA

Dr Laurie Raymundo – Marine Laboratory, University of Guam, USA

Prof Eugene Rosenberg – Department of Molecular Microbiology and Biotechnology, Faculty of Life Sciences, Tel Aviv, Israel

Prof Ernesto Weil – Department of Marine Sciences, Universidad de Puerto Rico Mayaguez, Puerto Rico

The annual coral disease surveys remain an important aspect of the Disease Working Group's (DWG) research initiative as it provides valuable information on temporal and spatial changes in coral community structure and disease syndromes/signs prevalence, and the long-term data gathered will facilitate informed management decision-making for the maintenance of ecosystem health. During the past four years the Group has conducted surveys at all CRTR Centres of Excellence as well as establishing comprehensive monitoring programs in locations including the Caribbean, Western Atlantic and Guam.

Members of the DWG have also been instrumental in working on the issue of identifying links between water quality and coral disease. Early results from this research indicate that poor water quality causes syndromes such as Aspergilliosis, Black Band, and Yellow Band to progress more quickly. Work in the Yucatan under Dr Eric Jordan is also assessing the potential relationships between the relative digress of local development and several community processes and structural characteristics, as well as on basic population parameters of selected species.

With the growing demand for aquaculture the DWG is also focusing on the effects of aquaculture effluent on coral health and disease. Work being undertaken by Prof Farooq Azam and his team in Bolinao, Philippines has confirmed the presence of strong nutrient and microbial gradients from the fish cages surrounding the reef. Initial results are suggesting that algal blooms near the fish cages are persistent through at least two seasons, whilst corals transplanted along a water quality gradient displayed the greatest response within the first few days after transplantation particularly in poor water quality. Preliminary data is suggesting that poor water quality may compromise some aspects of immunity.

Work is also continuing under the guidance of Dr Laurie Raymundo into investigations as to whether coral disease patterns are influenced by the establishment of MPAs. Data from the 2006 and 2007 surveys is supporting the hypothesis that when a fish community is protected from over-harvesting, it will create healthier conditions in the reef community and lower coral disease prevalence. Further data analysis is being conducted to elucidate the mechanisms of this relationship, but the presence of certain families of fish appears to be most closely related with disease prevalence.

A high priority of the Working Group has been to identify which disease syndromes are caused by infectious agents. In 2008, Prof Bette Willis and her group made significant progress with four papers on causative agents of diseases in the Indo-Pacific (skeletal eroding band, brown band, white syndrome, and atramentous necrosis). In the Caribbean, eight years of data on disease prevalence and average lesion growth rates (cm/month) of CYBD showed significant correlations with average surface water temperatures in Puerto Rico. This year Working Group members (Jordan, Weil and Smith) performed additional infectivity experiments with Caribbean Yellow Band Disease (CYBD) in Puerto Morelos and in Puerto Rico, with particular focus on whether higher water temperature facilitates transmissibility of disease. Data shows some effect of temperature when pathogens are directly inoculated, but no transmissibility was observed in either of the experiments.

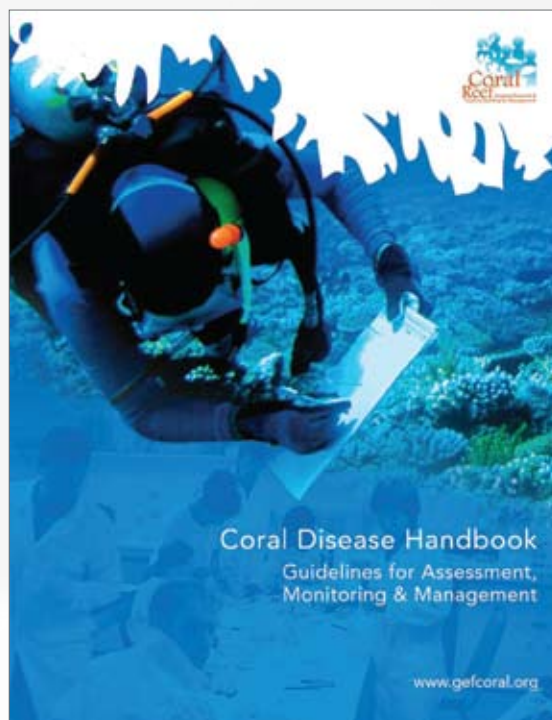
A number of training workshops have also been initiated with Australian-based workshops under Prof Bette Willis, providing basic training in disease identification to marine biologists and dive operators working in the tourism industry and to the AIMS Long Term Monitoring Team in order to improve their capacity to survey reef health annually. In the Caribbean, Dr Ernesto Weil has conducted annual workshops to train students, NGOs, government personnel and the general public how to identify coral diseases and continue the monitoring program after the final surveys in 2009. These workshops have raised awareness about coral disease and have resulted in an expanding network of "eyes on the reef", which will enable our working group to better document the occurrence of coral disease on reefs.

Building on the collaborative project initiated in 2007 with the RSWG, members of the Disease Working Group have refined the Disease Algorithm model exploring the links between thermal stress and disease abundance. The new model highlights the complexity of the relationship between temperature and disease abundance. The existing models will now be improved by increasing the resolution of the satellite data, including additional metrics, and incorporating new coral health parameters. The model uses predicted sea temperature data and will therefore be able to consider future scenarios and identify the potential efficacy of various management outcomes.

Coral Disease Handbook: Guidelines for Assessment, Monitoring and Management

One of the primary initiatives of the Working Group in 2008 was the production of the Handbook and Underwater Cards, which are forming the basis of programs to educate managers and professionals working in the reef tourism industry, enabling them to gather information on coral disease and contribute to a database on the abundance of disease and occurrence of outbreaks on the Great Barrier Reef. The Cards are also assisting to train managers to recognise signs of coral disease throughout the Indo-Pacific and Western Atlantic, thereby contributing to decision-making about appropriate management actions.

The Handbook outlines procedures for describing signs, measuring disease impacts, monitoring disease outbreaks, assessing causes, and managing reefs to minimise losses due to disease. The Handbook aims to integrate critical, current scientific information about coral disease to support and strengthen coral reef management.



Underwater Cards for Assessing Coral Health for Indo-Pacific and Caribbean Reefs

The cards start with a decision tree for assessing the health status of corals. The decision tree is colour coded to assist with navigation through the cards. This step-by-step approach enables users to assess the health status of a coral. Observations can be recorded on a datasheet provided at the end of the card set. By using the underwater identification cards, managers, researchers and other interested parties can:

- Learn to identify coral diseases and survey techniques for measuring coral disease prevalence;
- Gather information on the distribution and abundance of coral diseases on local reefs;
- Monitor the health of local coral reefs and identify potential drivers of disease abundance;
- Contribute to a world-wide database on coral disease; and
- Help to conserve the world's coral reefs.

Samples of these products can be viewed and/or orders placed from the CRTR Program's website at www.gefcoral.org/publications. Products are available for ordering at US\$20 or AUD\$24.20 each from the website.



Modelling and Decision Support

Working Group Members:

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Dr Pascal Perez, Co-Chair – Research School of Pacific and Asian Studies, Australian National University, Australia

Dr Porfirio Alino – Marine Science Institute, University of the Philippines, Philippines

Dr Ernesto Arias – Lab. Ecología de Ecosistemas de Arrecifes Coralinos, CINVESTAV-U, Mexico

Dr Peter Campbell – Advanced Computer Applications Center, Argonne National Laboratory, USA

Dr Bohdan Durnota – Tjurunga Pty Ltd, Australia

Prof Rob Seymour – University College London, UK

The Modelling and Decision Support Working Group (MDSWG) has maintained the momentum of the previous year - in particular in the area of parameterisation of the various models through consistent cooperation within the group, and collaborations with other Working Groups and Centres of Excellence. The MDSWG is developing a set of novel, state-of-the-art models at the local, regional and global scales of the interaction between coral reef ecosystems and the human societies that depend on them. These models will help users understand the complex interactions between the biophysical processes in reefs and the socio-economic processes in their associated human communities. They will also allow users to explore new and better ways to both sustain these ecosystems and extract greater economic value from them. Thus the models are directed to the twin goals of the sustainability of coral reef ecosystems and the alleviation of poverty in neighbouring communities.

For the fundamental ecological models, the Group now has a fully-validated fundamental mathematical framework to underpin local and regional models that interact with each other. Group members have completed the first attempt at deriving parameter ranges for Banco Chinchorro (Mexico) and Bolinao (Philippines), and have continued to run parameter sweeps to determine the likelihood of different types of phase shifts (e.g. continuous or discontinuous) with a decrease in grazing pressure, as well as properties associated with a phase shift (such as the change in coral and algal covers at equilibrium), and to analyse the implications. Members have successfully implemented the local models using Vensim, a simple systems dynamics tool, to provide a user-friendly interface. This will make the models available for direct use by MDSWG colleagues in Mexico and the Philippines to test new scenarios specific to their locations.

In addition to the ecological aspects, the Group is developing socio-ecological models which will enable the Group to build the next generation of socio-economic models in an open, extensible and realistic way. The MDSWG has continued to work on resolving a deep technical problem to do with the modelling ontology. This work resulted from an all-hands review at the Bolinao workshop and is needed to ensure that the coupling of the models between natural and social science domains and across scales proceeds smoothly. While some difficulties remain, a satisfactory ontology is now emerging to allow coupling of the models in Year Five. The joint ontology is being formalised and should be available for review on the Group's CRTR ontology website before the end of the year.

Regional-scale coupled models

The assembly and analysis of temporal biophysical datasets allows us to empirically anchor our local and regional models with realistic parameterisations. The coupled local/regional models of the MBRS can form a platform for the creation of development scenarios for the MBRS region because they capture the main biophysical drivers in the system. They will be useful in the near future for management and policy work, but will become more valuable when they are coupled with the appropriate socio-economic models that are currently being developed. The parameterisation and scenario testing for the Mesoamerican Barrier Reef System (MBRS) system using the regional-scale bio-physical model is currently being finalised. Larval connectivity data (fish, corals and urchins) for the MBRS has been successfully integrated into the regional-scale model. Preparatory discussions on a parameterisation of the regional model for the Philippines region of the South China Sea have been held and a workplan for developing a Philippines/South China Sea implementation of the regional model has been developed.

Models of Mesoamerican Barrier Reef System

The assembly and analysis of temporal biophysical datasets allows the Group to empirically anchor the local and regional models with realistic parameterisations. Work has continued in collecting, analysing and synthesising fundamental ecological data for a wide range of coral reefs of the MBRS. This data is of unparalleled quality and unique in the region. The work involves sophisticated multivariate analyses to extract required parameters or their proxies and advanced geospatial analyses to relate observed ecological patterns to the physical environment. The ecological parameterisation of Alacranes Reef, Chinchorro Bank, Pto Morelos, Boca Paila and Mahahual coral reefs to a level which will allow the analysis of coral and fisheries dynamics has been developed, and the ecological parameterisation of the fringing reefs of 11 Mexican Caribbean reefs has been completed.

Models of Philippine reefs

Dr Perry Aliño and Rollan Geronimo continue to work on the parameterisation of Bolinao coral reefs for local and regional models in collaboration with Tak Fung. The raw fisheries data from the Sagip Lingayen Gulf Project has been collected and the data is currently being processed to obtain fish catch information per trophic group. Local parameters are also being compiled for selected reefs along the South China Sea in preparation for the regional modelling work next year in collaboration with Jess Melbourne-Thomas.

Rollan Geronimo has also completed the trophic model parameterisation of the Bolinao-Anda reef complex (1990s vs. 2000s). Formal analyses of spatio-temporal changes in reef fisheries of the Bolinao-Anda reef complex from the 1980s to present are on-going and will help calibrate the trophic-dynamic simulations of fishing and algal productivity impacts on the reef's food web structure.

Global models

Global models form the third leg of our work and are being developed now as we gain confidence in our local and regional models. To enable an understanding of the network structure of the global model, especially the trade network, Dr Bohdan Durnota has performed a weighted network analysis of the recent historical trade network. This has led to an understanding of important underlying trends in some of the important factors affecting the global reef network from the social side. In order to generate a credible "business-as-usual" scenario for the global model, evaluations on a number of time series forecasting methods of various weighted network metrics has occurred. The results thus far are mixed, and will need some refinement. Lastly, an approach is being developed to forward generate hypothetical network structures that are consistent with the recent past network evolution. The results thus far look promising. Hypothetical trade network futures from the present to 2050 are being generated.

An important next stage in the development of the global model will be the parameterisation of the mutually interconnected networks (such as reef and trade) and other variables (such as population). The afore-mentioned work on network analysis will feed into this effort. Various visualisations of the global model, such as Google Earth and Map displays, have been developed to enable easy confirmation of the baseline data, whilst the desktop version of the global model has been enabled to deliver the information over the web for access by the wider community.

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The number of publications – journal articles, book chapters, conference papers, media articles or electronic products – produced by CRTR Program members in 2008.

Remote Sensing

Working Group Members:

Prof Peter Mumby, Chair – Marine Spatial Ecology Lab, School of Biological Sciences, Hatherly Laboratory, University of Exeter, UK

Dr Laura David, Co-Chair – Marine Science Institute, University of the Philippines, Philippines

Prof Stuart Phinn – School of Geography, Planning and Architecture, The University of Queensland, Australia

Prof Ellsworth LeDrew – Faculty of Environmental Studies, University of Waterloo, Canada

Dr Mark Eakin – Marine Applications Science Team, Coral Reef Watch Project, NOAA, USA

Dr William Skirving – Coral Reef Watch Project, NOAA, Australia

Dr Alan Strong – Marine Applications Science Team, Coral Reef Watch Project, NOAA, USA

New results emerging from the Remote Sensing Working Group (RSWG) are indicating that (i) processing of video streams can yield quantitative monitoring data on coral cover, (ii) acoustic remote sensing can be used to discriminate the quality of reef fish habitat for many juvenile fish species, (iii) fusing acoustic and optical methods of remote sensing can lead to a 30% increase in the accuracy with which Caribbean reef habitats can be discriminated, (iv) coral bleaching should be detectable using hyperspectral data providing that coral cover exceeds 25% and the bleaching events are fairly intense, and (v) coral reef areas demonstrate striking patterns their exposure to chronic and acute (bleaching) thermal stress that can be used to assist the stratification of reef management activities.

The creation of decision-support and analysis software for monitoring the health of coral reefs using remote sensing is well underway with the plane-parallel radiative transfer modelling software now in Alpha-test version (the final version prior to release of the first Beta-version). It was recently demonstrated at a shallow water remote sensing workshop with the software being well received. This project is aimed at releasing an industry-standard method for modelling light interactions in natural waters available to students and developing country scientists who cannot afford current commercial solutions. Work is also continuing on the construction of an automated computer script-based system for running different scenarios through the plane-parallel model. This framework builds the complicated required data structures on demand and greatly simplifies the modelling process. This work is already finding uses and is contributing to a European Space Agency (ESA) funded project designed to estimate the efficiency of the MERIS satellite sensor for detecting coral bleaching.



Hurricane Dean makes landfall along the Yucatan Peninsula on August 21, 2007. Source: NASA.

CRTTR researchers continue to be in-demand in providing advice and information to policy and decision-makers. Professors Mumby and Steneck (CWG) are currently undertaking work in Bonaire and provided presentations to the marine park management committee and general public on factors influencing the health of reefs in Bonaire. After further consultation with Stinapa (the management agency), advice has been provided on a new initiative to ban fish traps. Professor Mumby will also be providing a series of public and policy-level talks in December following discussions with the Fisheries Administrator in Belize in an effort to strengthen public and political commitment to reducing the harvest of parrotfishes.

In addition to this, Dr Laura David and her team have been involved in working with Local Government Units (LGUs) in the Philippines to provide technical assistance with respect to their coastal resources to serve as the basis for coastal use zoning, MPA planning and management of extent and limitation of capture/mariculture fisheries. In 1991 the Philippine Government decentralized power and responsibilities from the National to the Local Government Units (LGUs). Each LGU now has responsibility for its own resources. In 1998 the creation of the

Fishery Code further strengthened the power of the LGUs over its "municipal waters", designated to be waters up to 15km from its coast. Included in the mandate is for each LGU to designate as fish sanctuaries at least 15% where applicable of the total coastal areas in each municipality based on best available scientific data. Aside from typical coastal habitat mapping there are three areas which the RSWG is hoping to address: (i) rapid assessment of the state of reefs specifically after catastrophic events eg bleaching, oil spills etc; (ii) historical

and prospective assessment of vulnerability of reefs to climate change in order to feed into MPA planning; and (iii) assessment of the capacity of reefs to recover from catastrophic events.

“The creation of decision-support and analysis software for monitoring the health of coral reefs using remote sensing is well underway.”

Available Tools:

Habitat maps: The Working Group has also progressed in its aim to demonstrate the use of acoustic remote sensing to map fish density in Belize from a managers perspective. The project is currently producing a series of habitat maps of Glovers Reef to identify areas of higher substrate complexity that are important as fish habitats. Maps have been created with (i) only optical data; (ii) only acoustic data; (iii) a 3-band image comprising a depth invariant bank and 2 acoustic layers and; (iv) a 4-band image comprising these acoustic layers combined with 2 optic bands.

Creation of an Ocean Atlas and tools to manage coral bleaching: Regional Virtual Station webpages for sites around each Centre of Excellence (Australia, Southeast Asia and the Indian Ocean). There are now 109 Virtual Stations available on the NOAA Coral Reef Watch website at http://coralreefwatch.noaa.gov/satellite/current/experimental_products.html. The development of an experimental data product combining satellite measurements of light and temperature to predict coral bleaching is nearly completion with NOAA's new GOES-satellite light product undergoing final approval prior to release as an operational product. Once the product is operational it will be freely available on the NOAA website.

Coral reef mapping from field and satellite image data – Fiji and Cook Islands: In collaboration with SOPAC, Working Group members have been involved in the development of building coral reef habitat mapping capacity for their scientific staff, as well as local government resource management staff from the Cook Islands. The project was successful in delivering a benthic habitat map of Aitutaki reef in the Cook Islands, a process description to create the map, and a spectral library of main benthic features.

Coral Restoration and Remediation

Working Group Members:

Dr Alasdair Edwards, Chair – School of Biology, University of Newcastle, UK
Emeritus Prof Ed Gomez, Co-Chair – Marine Science Institute, University of the Philippines, Philippines
Dr Richard Dodge – National Coral Reef Institute, Nova Southeastern University, USA
Dr Aileen Morse – Marine Biotechnology Center, Marine Science Institute, University of California-Santa Barbara, USA
Dr Buki Rinkevich – National Institute of Oceanography, Haifa, Israel
Dr Makoto Omori – Akajima – Marine Science Laboratory, Japan
Dr Tadashi Kimura – Japan Wildlife Research Center, Japan
Dr Andrew Heyward – Australian Institute of Marine Science, Australia
Dr James Guest – Bolinao Research Station, Philippines

The world-wide degradation of coral reefs, particularly in the past two decades, has prompted greater attention to restoration and remediation activities. During the past four years the Restoration and Remediation Working Group (RRWG) has been focusing upon:

1. Integrated long-term monitoring of natural recovery processes and selected interventions on standardised substrata (Standardised Modules – SMs) to evaluate efficacy and cost-effectiveness and elucidate key processes driving/hindering recovery Interventions may include transplantation, enhancing algal grazing, augmenting coral larval supply, and enhancing other invertebrate (and hence coral) settlement.
2. Enhancing coral larval recruitment - mass culture in open sea from egg to colony, using attractants, or by augmenting larval supply to the reef.
3. Enhancing recovery by culture and transplantation of corals – using transplants direct from reef or nursery reared branches, nubbins, and spat.

Results for the Working Group are beginning to be obtained and in the important project exploring long-term (5-10 years) monitoring to evaluate the efficacy and cost-effectiveness of restoration techniques, the Working Group has been steadily collecting data from sites in Bolinao (Philippines), Palau and Mexico. Analysis at the Bolinao site of the settlement tiles collected six-weeks after the mass-spawning and enhancement showed a 5.5-fold enhancement of larval settlement on tiles on treated Standardised Modules (SMs) compared to those on untreated SMs. Whereas transplants on the Mexico SMs have had a 98% survival overall, following the bleaching event and predation by COTs and corallivorous snails, less than 20% of transplants have survived at Bolinao. An adaptive management intervention to replace the dead corals in 50% of transplant treatments with hardy nursery reared species is being carried out in between typhoons.

The aim for ‘*Enhancement of coral larval recruitment*’ projects, has been to understand constraints on site-specific coral recruitment rates and the influence of larval supply on subsequent reproductive success, and to investigate whether *controlled* settlement and metamorphosis of coral larvae onto “larval flypapers” can be used as a successful tool for reef restoration; and to develop simple cost-effective artificial substrates for deployment both in a land-based hatchery and for attachment to reef substrate and/or SMs. The results on competency and stock recruitment will directly support development of better connectivity models and decision support models associated with larval supply issues. Since March 2008 progress has been made with the experiments using sexually reared corals for restoration. Following the March 2008 spawning, attempts were made to carry out large scale larval rearing in Bolinao using *Acropora* corals. Colonies of two of the three collected species spawned and around 200,000 larvae were successful reared to competency. These were settled onto around 2000-conditioned coral plug-ins. Settlement was observed but average spat numbers per plug-in were relatively low after one month suggesting that settlement was relatively low or that post-settlement mortality was high.

Under the complementary project ‘*Enhancement of coral recruitment and restoration using “larval flypapers”*’, the aim is to investigate whether *controlled* settlement and metamorphosis of coral larvae onto “larval flypapers” can be used as a successful tool for reef restoration; and to develop simple cost-effective artificial substrates for deployment both in a land-based hatchery and for attachment to reef substrate and/or SMs. During fieldwork in September 2007, it was decided to test the feasibility of raising coral fragments both in the previously constructed hatchery tank and attached directly to reef substrate (this was in the absence of sexual recruits). By January 2008 all fragments and the hatchery tank were overgrown by algae so the results of the experiment could not be interpreted.

However, *Acropora digitifera* fragments collected and out-planted back to the three sites from which they came survived very well; also visual inspection of individuals strongly suggest that fragments were not only surviving but also growing. The objective of this experiment was to test the differential rates of survivorship and growth in length and biomass over time in fragments (in same modules as above) placed at the three different reef sites in Palau and to test the difference in branch extension of these transplanted fragments versus local colony branch extensions. Results from the monitoring (April 2008) of this field experiment indicate that after six months 100% of the 25 fragments deployed on Luke's Reef had survived; that 83% of the 30 fragments deployed on Lighthouse Reef had survived; and that 50% of the 28 fragments deployed on Uchul Reef had survived. From these early results it seems that there may be site-specific factors such as prevailing physical (relative wave action and/or depth) properties of individual locations that influence differential survival.



Coral reef gardening - measuring progress. Photo: Gidi Levi

The Working Group is also continuing its research into the cost-effectiveness of mass culture of juvenile corals on substrates with juveniles of grazing snail, *Trochus niloticus* in mid-water nurseries, and efficacy of transplantation to the reef after one year. The project aims to develop mass culture techniques for *Acropora* corals from egg to colony in open water in Palau where there was mass bleaching damage in 1998. Growth and survival rates of juvenile corals in co-culture with grazing snails in mid-water nurseries are being studied, and the research team is also evaluating the effect of transplanting the juveniles on the reef after one year of rearing. The surveys in March/April 2008 indicated disappointing results of the mass culture experiments in Palau for the last two years. Because of heavy sedimentation and occurrence of encrusting sessile organisms such as *Ascidacea* on the tiles in 2006-07 and of outbreak of coral disease in 2007-08, survival rates of one year old coral colonies in mid-water cages in both years were much lower than expectations. In addition, nearly all one year old colonies on 191 tiles (850 colonies in total), that were transplanted on March 2007 to Pallet Balls at Lukes reef, were decimated probably by fish grazing within three months after transplantation. Results are indicating that there are still a number of hurdles that need to be sorted out before the technology can be applied widely.

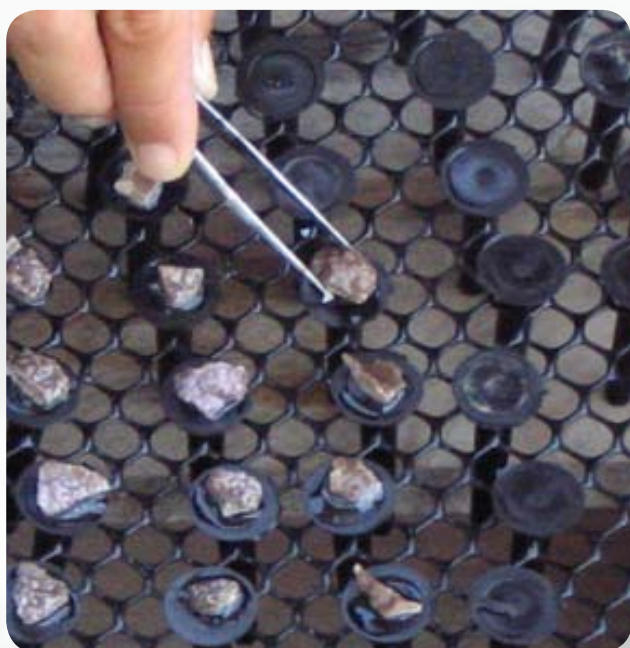


Coral reef gardening – floating nursery. Photo: Gidi Levi

The project 'Enhancing recovery of transplantation of corals' has been focusing on *Montipora digitata* transplants. The experiments were essentially completed in the middle of 2007 except for the final fish visual census, which was conducted last February 2008. Monitoring of biological and environmental parameters of the other single species experiments, which include *Porites cylindrica* and *Pavona danai* transplants, was completed on October 2007 and March 2008, respectively. The set up for the mixed species experiment of *Porites cylindrica* and *Hydnophora rigida* was completed last February 2008 at Malilnep. The objective of the experiment is to compare the survival and growth of the two species in single species transplant plots with those of the mixed species transplant plots. During the May 2008 monitoring, 65% of the *Hydnophora rigida* transplants (70% in the single and 60% in the mixed species plots) were found dead which resulted from predation by *Drupella* spp. and *Acanthaster planci*. *H. rigida* transplants in two single species plots and in one mixed species plots were wiped out completely. This led to the decision to replace the *H. rigida* transplants with *P. frondifera* on the same month. As a result, the mixed species experiment of *P. cylindrica* and *P. frondifera* experiment is now at the Binlab and at the Malilnep sites.

Single species plots of *P. frondifera* were also set-up at the source site in Victory as a control treatment. The experiment is comparing the survival and growth of *P. frondifera* natural colonies and fragments transplanted at the source site in Victory and at the transplantation sites in Binlab and Malilnep. After six months, the survival of *P. cylindrica* fragments at Bolinao remained above 99% for both single and mixed species plots while the survival of *P. frondifera* fragments transplanted on single and mixed species plots was 95% and 90%, respectively. On the other hand, the survival of *P. frondifera* fragments at Malilnep was as low as 17% after three months in the single species plots, wherein one of the three plots experienced 100% mortality. The *P. frondifera* fragments on the mixed species plots, on the other hand, had a survival rate of 66% in contrast to the survival of *P. cylindrica* fragments that remained above 99% for both single and mixed species plots. This may be an indication of an advantage of having mixed species of transplants, when considering the *P. frondifera*, which may be more susceptible to predation than *P. cylindrica*. In the Control treatments, the survival of the *P. frondifera* transplants and natural colonies at Victory remained 100% after five months.

The final project under the Working Group, 'Enhancing recovery by in situ culturing of corals in nurseries' is also making progress. During the period March 2008-September 2008 the work has been continued on the major aim, reef restoration through the application of the 'gardening concept'; the *in situ* culturing of corals in nurseries and their transplantation. Work was performed in two of the CoE areas (Bolinao, the Philippines and Zanzibar/Mafia Island, Tanzania). This research applies cutting-edge approaches for the *in situ* farming and culturing of coral material (large and healthy coral colonies amenable for transplantation into degraded reef areas) for reef restoration. The research team continued to maintain the nurseries in Silaqui Island (the Philippines) that suffered from several natural catastrophes last year, and the two rope nurseries. All nurseries that were established in last reporting period have been filled with coral fragments and were maintained and monitored on a monthly basis.



Coral reef gardening – preparation for rearing. Photo: Gidi Levi

The rope nursery in Malilnep is very successful until a recent storm hit the nursery, causing mass mortality. Two other floating nurseries that were established in Tanzania (see half-year report) were filled with several thousands of coral fragments that have grown well. Those colonies that have already reached sufficient size for transplantation have now been transferred to denuded reefs. In Bolinao, the 1290 colonies transplanted in the third year of the research onto degraded bommies in shallow water (using a new methodology of transplantation onto metal mesh) have been monitored monthly. All transplants suffered from last year's mass-bleaching event and subsequent coverage by fouling organisms. Monitoring activities were concentrated on survival, rate of bleaching, attachment of corals to the substrate, etc., and the evaluation of transplantation protocols. During this reporting period, as in former periods, limited manpower was available for proper nurseries maintenance, and as a result many of the farmed fragments suffered and died.

Students

Following the Future Leaders Forum in December 2007, which was designed to get the CRTR student network going, the student network has established itself as one of the leading 'lights' of the Program. The students have maintained their linkages through a web-based forum and through other exchange opportunities. This year the students arranged a meeting at the International Coral Reef Symposium in Fort Lauderdale for those who would be attending, to discuss ways in which the network can continue to link together and the possibility of some joint papers and/or products. From the meeting, a Communication Committee was established with the responsibilities of ensuring information is up-to-date and maintained for the network on the website. Ideas were also put forward for potential joint publications and reports detailing success stories from around the world. The student network is continuing to grow with students external to the Program now becoming involved and part of the network.

"The network of students sponsored by the CRTR now extends to more than 60 students from 17 countries."

Young scientists call for action to save coral reefs

Fourteen young Filipino marine scientists joined 40 other young researchers from 17 countries in the GEF/World Bank Coral Reef Targeted Research (CRTR) Program's Future Leaders Forum in Brisbane, Australia from December 10 to 14, 2007. The forum was aimed at developing "the network of the future leaders in marine and coral reef ecosystem research and management; assist in building capacity to understand global issues impacting on these ecosystems; and develop new knowledge and skills to assist young scientists in their current and future roles." Leading coral reef scientists mentored the forum and provided lectures and workshops on inspiration, vision, discovery, and leadership.

The Philippine contingent made up 25% of the total number of young researchers. Of the 14 from the country, 13 are from the UP Marine Science Institute (UPMSI), headed by the internationally distinguished UP Professor Emeritus Edgardo Gomez, coordinator of the Philippines/SEA Center of Excellence of the GEF-CRTR Program and one of the lecturers in the forum. Two of the young scientists from the UPMSI, Kareen Vicentian and Dexter de la Cruz, won awards for Best Presentation and runner-up for Best Abstract. Another award went to the sole student from Silliman University, Kathryn Rosell, for Best Photo.

One of the highlights of the event was a press briefing on a recent paper on the threats faced by coral reefs worldwide



Participants to the GEF Future Leaders Forum: Dexter de la Cruz (extreme left), runner-up for Best Abstract; Kathryn Rosell (second from right), winner, Best Photo on Coastal Management; and Kareen Vicentian (second from right, second row), Best Presentation. The others are (front, left to right): Rachel Gutierrez, Mahela Puelles, Andy Hosten, Ms. Vanessa Barua, Candice Lumbo, Ellen Peltzner; (back, left to right): Patrick Cabalan, Mark Vergara, Victor Tizon, Dr. Peter Sale, and Rollan Geronimo.

under rapid climate change. The paper was published in the prestigious *Science* magazine and authored by participants in the forum, including Professor Emeritus Edgardo Gomez. The paper paints a dire future for coral reefs worldwide under rapid climate change conditions. Increasing concentrations of carbon dioxide in the atmosphere can cause oceans to become more acidic, effectively reducing the rate of calcification until it reaches a limit when coral reefs will start to erode due to the

limited availability of carbonate ions in seawater. Local stresses on coral reefs such as overfishing, destructive fishing using dynamite and poisons, sedimentation, and pollution will exacerbate coral reef degradation. Economies relying heavily on reefs for fisheries and tourism will be greatly affected and millions of people might be displaced due to increased beach erosion as the coastal protection provided by coral reefs decreases, marine experts say. The study used conservative estimates

of carbon dioxide increase in the atmosphere.

Half of the world's reefs are located in the Southeast Asian region. The Philippines is among the top in coral reef biodiversity. About half of the country's population live along the coast and obtain their daily protein requirement and livelihood from the sea and reefs. Yet, the country's reefs have also been ranked among the most impacted in the world. Unless local stresses and greenhouse gas emissions are reduced, the Philippines faces a less than desirable future for coastal zones and communities.

Working against time, the young Filipino marine scientists in the GEF-CRTR Forum called on all Filipino youth to increase their vigilance and to help in the conservation of coral reefs. They also called upon local coastal resource managers and the national government to scale up management interventions to preserve one of the country's most important natural assets.

A co-author of the *Science* paper, Dr. Gomez said that although predictions for the future of coral reefs are very alarming, there is still time to act to avert the crisis if governments and ordinary citizens take prompt steps to reduce carbon dioxide emissions. "We are all 'future leaders,'" said Dr. Gomez. "It is our privilege and responsibility to do whatever we can to conserve and preserve our coral reefs for the youth of the future." (Rollan Geronimo, UPMSI-GEF CRTR Scholar)

CRTR Students

The table outlines the students linked to the CRTR Program either through funding support or through research attached to the scientific Working Groups and Centres of Excellence.

Albert. Simon, PhD	Australia	The University of Queensland	Scientific tools for community-based management in the Solomon Islands
Andrew. Jay,	Palau	PICRC	Training in techniques of coral culture using sexual propagation
Arboleda. Mark Dondi, Masters	Philippines	Marine Science Institute, University of the Philippines	Prokaryotic communities associated with healthy and diseased corals
Arnold. Suzanne, PhD	USA	University of Maine	Coral settlement and recruitment
Baria. Maria Vanessa, Masters	Philippines	UPMSI, Philippines	Spatial and temporal patterns of coral recruitment in Bolinao, Pangasinan
Bejarano. Sonia, PhD	UK	University of Exeter	Use of acoustic remote sensing to predict relative fish density and grazing intensity
Boch. Charles, PhD	USA	University of California Santa Barbara	Understanding coral mass spawning and the mechanisms for regulating and controlling reproduction
Bollozos. Iris, Masters	Philippines	Bolinao Marine Laboratory	Reef restoration
Bozec. Yves, Postdoc	France	CINVESTAV, Mérida	Analysis of reef dynamics
Cabaitan. Patrick, Masters	Philippines	University of the Philippines	Reef restoration
Canto. Robert, PhD	Australia	The University of Queensland	Benthic algal growth controls in coral reefs
Cleland. Deborah, BSc (hons)	Australia	Australian National University	Use of ABM for social objectives in a coral reef fishery
Colombo. Ma. Florencia, PhD	Mexico	Instituto de Ciencias del Mar y Limnología, UNAM	The effects of elevated temperature and pCO ₂ in the calcification mechanisms of hermatypic corals
Coronado. Cesar, PhD	Mexico	Centro de Investigación Científica y de Educación Superior de Ensenada	Water circulation in the Puerto Morelos Reef Lagoon
Couch. Courtney, Masters	USA	Cornell University	Cellular immune response of the sea fan <i>Gorgonia ventalina</i> to disease and environmental stress
Croquer. Aldo, Postdoc	Venezuela	University of Puerto Rico	Geographic assessment and monitoring of diseases in the wider Caribbean
De La Cruz. Dexter, Masters	Philippines	University of the Philippines	Coral nurseries as an intermediate step in coral restoration in Bolinao, Pangasinan, Philippines
Diaz-Almeyda. Erika, Masters	Mexico	Instituto de Ciencias del Mar y Limnología, UNAM	The role of Desaturases on the thermal sensitivity of Symbiodinium
Fisher. Paul, Postdoc	UK	Instituto de Ciencias del Mar y Limnología, UNAM	Coral response to temperature and light: perspectives for bleaching
Fogarty. Laurel,	Ireland	University College, London	Spatial extension of fundamental models
Fung. Tak, PhD	UK	University College, London	Modelling coral reef ecosystems and their interaction with human societies

CRTR Students cont.

Furaha Karisa. Juliet, Masters	Kenya	Moj University	The influence of area protection and site characteristics on recruitment, survival, and growth of coral species on the Kenyan coast
Geronimo. Rollan C., Masters	Philippines	University of the Philippines	Modeling marine protected area networks along the South China Sea
Gonzalez. Luis, Honors	Mexico	Instituto de Ciencias del Mar y Limnología, UNAM	Photoacclimation and thermal tolerance of Symbiodinium D1
Hogan. J Derek, PhD	Canada	University of Windsor	Scales of larval dispersal and connectivity among reef fish populations
Hook. Scott, PhD	Australia	The University of Queensland	The role of institutions in economic development: An empirical analysis of growth and development of small island states in the Pacific - A case study of the Fijian state in policy development and implementation
Idip. David, Masters	Palau	Palau International Coral Reef Center	Remote sensing techniques for coastal environments and biological cycles of coral species in Palau
Jones Chauka. Leonard, Masters	Tanzania	Institute of Marine Sciences, University of Dar es Salaam	Molecular and physiological study of Symbiodinium harboured by reef building corals of Tanzania
Jordán Garza. Guillermo, Masters	Mexico	Instituto de Ciencias del Mar y Limnología	Geographic assessment and monitoring of diseases on Mexico reefs
Kilfoyle. Kirk, PhD	USA	Nova Southeastern University	Establishing a standardised module intervention and monitoring program in Puerto Morelos, Mexico
Kongjandtre. Narinratana (Nong), PhD	Thailand	The University of Queensland	Taxonomy and connectivity of corals from the genus Favia in Thailand and on the southern Great Barrier Reef
Leiper. Ian, PhD	Australia	The University of Queensland	Mapping tropical marine communities for direct application purposes using remote sensing techniques
León Zubillaga. Ainhoa, Masters	Venezuela	Universidad Simón Bolívar, Caracas	Genetics and connectivity of Acropora palmata
Levy. Gideon (Gidi), PhD	Israel	Haifa University	Coral reef restoration
Lim. Alan, PhD	Canada	University of Waterloo	Use of remote sensing to detect ecological changes in coral reef environments using textural measures
Lumibao. Candice, Masters	Philippines	University of the Philippines	Genetic analysis of juvenile rabbitfish (Siganus spp) along the northwestern coast of the Philippines
Marcos Ma. Sheila Angeli, PhD	Philippines	National Institute of Physics, University of the Philippines	Signal processing, applied physics
Mbije. Nsajigwa, PhD	Tanzania	Institute of Marine Sciences, University of Dar es Salaam	Gardening concept as an applicable tool in reef restoration in Tanzania
Melbourne-Thomas. Jessica, PhD	Australia	University of Tasmania	Decision support systems for managing coral reefs at a regional scale
Mohammed. Mohammed Suleiman, PhD	Tanzania	Institute of Marine Sciences, University of Dar es Salaam	Distribution and dynamics of coral diseases and its relationship to coral health and local environmental factors in Tanzania
Mojica. Angela, Masters	Guatemala	Old Dominion University	Effects of herbivorous spiny crab (Mithrax spinosissimus) on coral reef community structure

CRTR Students cont.

Ortiz. Juan Carlos, PhD	Venezuela	The University of Queensland	Ecological dynamics of coral reefs in response to subtle disturbances
Padilla-Gamino. Jackie, PhD	Mexico	University of Hawaii	Coral ecophysiology and reproduction
Penafior. Eileen, PhD	Philippines	University of the Philippines	Remote sensing of coral bleaching
Porto Morales. Isabel, Masters	Colombia	Universidad de los Andes, Colombia	Coral genetics and connectivity
Pueblos. Miahnie Joy, Masters	Philippines	University of the Philippines	Coral-associated microbial communities during recovery from PUWS disease
Rangel Avalos. Marcos Alberto, Masters	Mexico	Instituto Tecnológico de Boca del Río, Mexico	Coral reef restoration
Ravago-Gotangco. Rachel, PhD	Philippines	University of the Philippines	Genetic connectivity of Philippine populations of <i>Siganus fuscus</i> at multiple spatio-temporal scales
Ridep-Morris. Alma, Masters	Palau	James Cook University	The dynamics and epidemiology of a coral disease outbreak in Nikko Bay
Rodrigues. Maria Joao, PhD	Mozambique	James Cook University	Impacts of over-fishing on coral reefs
Roelfsema. Chris, PhD	Australia	The University of Queensland	Integrating field and remotely sensed data: low cost, community-based assessment of tropical marine ecosystem health in developing nations
Rosell. Kathryn B., Masters	Philippines	Silliman University	The effects of the riverine discharges on coral disease prevalence
Saenz Agudelo. Pablo, PhD	Colombia	Ecole Pratique des Hautes Etudes, Paris, France	Study of coral reef fish connectivity using a genetic approach
Salas de la Fuente. Eva, Masters	Costa Rica	Universidad de Costa Rica	Population genetics of the Bicolor damselfish, <i>Stegastes partitus</i>
Schuttenberg. Heidi, PhD	USA	James Cook University	Understanding effective coral reef governance
Sweet. Mike, PhD	UK	University of Newcastle	Microbial ecology of coral surfaces
Ticzon. Victor, PhD	Philippines	University of the Philippines	Use of remote sensing to predict the density of keystone taxa
Van Dien. Tran, PhD	Vietnam		Develop tools for mapping and monitoring reef composition and condition in the turbid and clear coastal waters of Vietnam
Vergara. Mark Windell, Masters	Philippines	University of the Philippines	Coral community structure of the Bolinao reef system, NW Philippines
Vicentuan. Kareen, Masters	Philippines	University of the Philippines	The reproductive biology of scleractinian corals and in addition, the effects of fragmentation on their reproductive status
Villanueva. Ronald, Postdoc	Philippines	University of the Philippines	Long-term cost effectiveness and efficacy of restoration interventions and factors influencing natural recovery processes at Bolinao and Palau
Villegas Sanchez. Carmen, PhD	Mexico	CINVESTAV - Merida	Recruitment and genetic connectivity of coral reef fishes from the Mexican Caribbean



165

The number of media outlets (in 18 countries) which published or broadcast stories covering the launch of the CRTR Program's first 'synthesised' research output.

Promoting Scientific Learning
and Capacity Building

2
Component

Promoting Scientific Learning and Capacity Building

Component Two of the Program is aimed at capacity building outcomes through the promotion of scientific learning and linking scientific knowledge to management and policy. Sound management and policy tools will shape and change the way policy and decision-makers view and approach coral reef management. The Program is achieving this aim through:

- Building or enhancing the capacity of institutions across four regions to serve as regional Centres of Excellence and;
- Developing from the research, information, products and networks that can lead to better management and strengthened policies regarding coral reefs in the regions.

The four Centres of Excellence are based in major coral reef regions (three are in developing countries) around the world, and are hosted by leading research institutions in those regions:

- Southeast Asia: Marine Science Institute/Bolinao Marine Laboratory, University of the Philippines.
- East Africa: Institute of Marine Sciences, University of Dar es Salaam, Tanzania.
- Western Caribbean/Mesoamerica: Unidad Academia Puerto Morelos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México (UNAM).
- Australasia/South Pacific: Centre for Marine Science/Heron Island Research Station, The University of Queensland, Australia.

The Centres of Excellence are designed to be a regional resource. As such, they have a unique responsibility to engage stakeholders in the region and to serve as a hub for research, capacity building, information outreach and uptake by target users. This will be a long-term effort, but steps need to be taken at the outset to begin this process. The overarching objectives of the Centres of Excellence in Phase One are to:

- Engage regional institutions (either through training or joint research activities, or both);
- Disseminate information (in partnership with others);
- Link this to management and key decision-making opportunities (at the local, national and regional levels) affecting coral reef management;
- Feed into other relevant programs in the region (e.g. GEF, World Bank or otherwise);
- Set up a reference or stakeholder group with which the Centre of Excellence may engage to communicate information about the CRTR Program, receive input on how to make it relevant to capacity building and knowledge needs in the region, and add value to ongoing projects and programs.



Australasian Centre of Excellence

Centre for Marine Studies and Heron Island Research Station, The University of Queensland

Following the fire at Heron Island Research Station in March 2007, the Station has now been rebuilt and will officially re-open in early 2009. Improvements include new student accommodation, research laboratories, teaching labs and seminar rooms, along with a flow-through aquaria, library and ancillaries. Despite the damage sustained from the fire, it has had minimal impact upon the activities of the Centre of Excellence. In 2008 the CoE's research focus remained through activities with the Bleaching Working Group, however some discreet projects were also undertaken.

The Centre of Excellence has become a partner in the Integrated Marine Observing System (IMOS), which is being managed by the Australian Institute of Marine Science (AIMS). IMOS is designed to improve Australia's ability to monitor changes in its 16 million km² ocean territory, and includes the establishment of a wireless sensing network at Heron and One Tree Islands as part of its monitoring network. As the marine data and information gathered through the network are critical components to its success, the information will be stored in an eMII facility, providing a single integrative framework for data and information management for use by scientists, managers and the public.

Further to the partnerships developed with the Bleaching Working Group and the Australian network, the CoE has also undertaken project partnerships with partners in the region. Dr Ken Anthony is heading up a Packard-funded project, which is developing an information tool package to assist managers assess how coral reef communities will change in response to environmental stress. Over the past year Dr Anthony has made progress in the development of a community dynamics model that enables formal analysis of how changes in environmental pressures lead to shifts in the position of community equilibria. The framework includes basic concepts relating to overfishing, and incorporates effects from coral bleaching, sedimentation, nutrient enrichment and physical disturbance regimes. A key result of the analyses demonstrates that shifts from coral to algal abundance on reefs are driven as strongly by stress responses to increasing thermal regime and poor water quality as they are by overfishing. Three sets of tool packages are currently being developed targeting policy officials, marine park managers and reefs users. In addition, a package is also being developed for the curriculum of primary school users in Karimunjawa and Semarang.



Fish ecology training, Maldives. Photo: Melanie King

Further work in the region includes the Centre of Excellence's Local Government Initiative (LGI) in the Solomon Islands, involving a collaborative partnership with the European Union-funded 'Sustainable Forest and Conservation Project' and Aberystwyth University in the UK. The project is working with the Kahua local community and Kahua Association Council in the eastern Makira-Ulawa Province to develop an understanding of how to build adaptive capacity to lead to stronger marine management of their coastline. In October the project team undertook field visits to work with the Council to determine: economic drivers related to coastal resource use; levels of fishing effort and associated factors; the state of the coastal environment and future changes; and community perceptions of the environment. The project will now determine appropriate interventions for reducing local environmental impacts.

In addition to this project work, the Centre of Excellence continues to develop relationships and networks with regional partners and provide training and information exchange opportunities. During 2008 the CoE hosted two study tours – one from the Maldives and one from the Cook Islands, as well as supporting Pacific Island participants from Fiji, Papua New Guinea, and the Solomon Islands to attend the annual Coastal Resource Management course. The Maldivian study tour involved senior managers from the Ministry of Environment, Energy and Water and focused on the practical application of marine protected areas, management of tourism operations in sensitive environments, and the latest research in coral reefs and climate change impacts. The tour was part of a larger project looking at building capacity in ecosystem-based management. The Cook Islands contingent of government and community members was a collaboration with the Cook Islands Marine Resources Institutional Strengthening (CIMRIS) Project and was aimed at learning opportunities for considerations into potential partnership models between community, business and government in which to implement ecosystem-based management projects.

East African Centre of Excellence

Institute of Marine Studies, University of Dar es Salaam, Zanzibar

The East African Centre of Excellence continued to serve as a regional hub in the East African region for research and training workshops. The CoE has hosted numerous international and regional researchers and students throughout 2008, and continues to expand on its institutional capacity to host the CRTR activities, amongst others.

During 2008 the Centre of Excellence has been involved in a number of collaboratory activities at the national level, including technical and financial assistance to the Marine Parks and Reserve Unit (Fisheries Division) for coral reef assessments in the Dar es Salaam Marine Reserves. The CoE is also collaborating with Tanga Coastal Zone Resource Centre in the assessment of coral reefs using community-based coral reef monitoring techniques.

The local research project 'Mapping and Characterisation of Coral Reefs and Associated Threats' is continuing with the entry of coral reef threat data into the GIS database. Ranking of reef sites according to vulnerability level and quantification of threats started with the analysis of the data from the fisherfolks, which constitute the bulk of the data. The data indicates that dynamite fishing and fishing with drag-nets are by far the leading fishery related threats. Analysis of other data from the field surveys with other stakeholders will permit the research team to make the final ranking of sites according to vulnerability level and quantification of threats after taking into consideration of the non-fishery related threats such as land-based threats, shipping related threats, population dynamics etc.

Mapping of the coral reefs and the associated habitats commenced with the analysis of IKONOS imagery in 2005 with a special focus on the reef habitats surrounding Chumbe Island (located on the northern parts of the Menai Bay Conservation Area). To-date algorithms for mapping coral reef habitats have been developed and tested at Chumbe reefs and supplementary field ground surveys have been conducted at other reef sites around Unguja Island. The results obtained from the IKONOS imagery have demonstrated that this is the best approach for future mapping of the reefs along the coast of Tanzania.

The results of the 'Indigenous Knowledge on Coral Reefs Management in Tanzania' project which looked at income trends from fishing have been mixed. Approximately 46.5% of respondents stated that there was a decreasing trend of income from fishing due to: destruction of habitats; population increase in coastal areas and unemployment causing people to turn to fishing activities; unsustainable upland activities such as deforestation increasing sedimentation and runoff; and use of traditional fishing gear and vessels not allowing artisanal fishers to go to the open sea for fishing. However, 45.8% of respondents claimed that there was an increasing trend of income from fishing due to: use of dynamite enabling higher catches near shore; use of modern fishing gear and vessels; high demand for fish in cities and large towns due to population increases and increases in the price of fish as a result of tourism; and the presence of cold storage facilities enabling better collection and storage. Despite the increasing income trend from fishing activities, fishers claimed that the money obtained was not enough to fulfil daily basic requirements due to the increase in living standards.



Fishermen, Zanzibar. Photo: Melanie King

The CoE is continuing to work with local agencies and NGOs in providing technical expertise and information on coral reef habitats. Dr Muhando was involved in the assessment of biophysical environment and resources in the Dar es Salaam Marine Reserves. In another collaboration, the CoE through Dr Muhando has been working with WWF Tanzania to

update maps of the Tanzania Coastal habitats and resources, which will be useful sources of information for researchers and managers. In addition to these and other activities, the Centre has also been involved in coastal zone management issues along the Tanga coast. Researchers were involved in ecological surveys and mapping of habitats in collaboration with community members, ACEP-South Africa, Marine Parks and Reserve Unit, Fisheries Research Institute, Faculty of Aquatic Sciences, Tanga Fisheries and the Institute of Marine Sciences. CoE scientists are also working with Tanzania Fisheries Institute (Fisheries Division) and the Faculty of Aquatic Sciences in executing the MACEMP-funded project 'Fish stock assessment in trawlable and non-trawlable areas'.

Mesoamerican Centre of Excellence

Unidad Academica Puerto Morelos of the Instituto de Ciencias del Mar y Limnologia of the Universidad Nacional Autonoma de Mexico (UNAM)

The CoE has also been instrumental in addressing government authorities on climate change and coral bleaching in an effort to encourage them to take effective policies for social adaptation scenarios and policies that reduce greenhouse gas emissions. Research activities have also continued and seen a number of collaborations being undertaken. Collaborations with the Remote Sensing Working Group has led to a series of experiments aimed at resolving the possible relationship between the dose of solar radiation and the rate of dose, with the loss and recovery of photosystem II activity in coral samples under different degrees of thermal stress. The goal is to develop a physiology-based algorithm to improve the current NOAA DHW satellite product. Further research into the possible role of 'state transitions' in different coral species was undertaken with the potential resulting information key to understanding the effects of elevated temperatures on the early events leading to coral bleaching.

Significant progress against the two major local research priorities for the Centre of Excellence has also been made during the year. Under the Hydrodynamic Model for the Puerto Morelos Reef Lagoon project, the team is continuing to monitor the hydrological characters of the reef lagoon and the adjacent oceanic waters. To improve critical information on the description of the mass transfer between the lagoon and the oceanic waters and allowing for estimates to be made of the dispersal of pollutants or the transit of coral and fish larvae, changes have been made to the distribution of the Doppler profilers along the current. The high-resolution bathymetry has also been expanded to include 17kms of the coastline, which includes the entire Marine Protected Area. A numerical model of the internal circulation of the coastal lagoon has also been developed. In addition to this work, the project team has continued to analyse the energy dissipated by the reef during extreme meteorological events. The most significant result is the realisation that the energy dissipation capacity of the reef structure is dependent on the sea level. Modelling is now taking place on the direct effects of rises in sea level or losses in reef structure on the coastal zone protection capacity of the reef.

Work has also continued to progress on the groundwater and nutrient load on the Puerto Morelos lagoon project. The CoE is continuing with direct observations of the aquifer including flows, water quality and water table levels in order to calibrate the ground water circulation model, which was generated in 2007. The data is clearly indicating the main sources of pollutants in the area as being: (i) improper disposal of urban wastewater into the aquifer; (ii) an open air garbage dump site located three kilometres away from the coast; (iii) the improper disposal of waste water from the hotels.



Students participating in the Light and Photosynthesis of Coral Reefs course, Jan-Feb 2008, Puerto Morelos.

The Centre of Excellence has continued to build on its regional training courses and links to management in building local and regional capacity. During 2008 the CoE held two training courses: Light and Photosynthesis in Coral Reefs and Marine Protected Areas in the Caribbean Region. These two courses involved 37 students from Mexico, Puerto Rico, Colombia, USA, UK, Tanzania, Taiwan, Cuba, and the US Virgin Islands.

The CoE has also been engaged by local and federal government authorities and local NGOs to participate in the planning of the beach recovery program for Cancun. According to the Hotel Owners Association in Cancun and the municipal government, as a result of the loss of usable beaches in Cancun due to extreme weather events and poor construction practices, there is a net loss of income equivalent to USD\$380 million annually. In this context, and considering the relative importance of the income generated by the tourism industry in Mexico, developing a sustainable beach-recovery program that minimises the damage to the local reefs whilst returning local beaches to their 'original' state is urgent.

Science at Work

The local community, including local scientists and managers, were successful in employing the results of local research projects to temporarily cancel two large scale development projects threatening the Puerto Morelos reefs.

- I. In late 2007, a large Mexican corporation presented a project to construct a Port facility with the capacity to handle two of the latest-generation cruise ships, all in the vicinity of the local Marine Protected Area. For the last five years this Corporation has been lobbying local and federal governments for permission to construct port infrastructure in the area. The latest construction plans included the removal of a “Rock” at the entranceway to the proposed port to increase the navigational channel. The information generated by the Centre of Excellence on the hydrodynamics of the Puerto Morelos reef lagoon, was instrumental in highlighting the dangers of such infrastructure constructions and operations in the vicinity of a protected area. During the public consultation process, the CoE engaged the press and the public in promoting reef conservation in Mexico.
- II. In late February 2008, three weeks prior to the end of the administration, the municipal urban development agency presented a development plan for Puerto Morelos, which included transforming Puerto Morelos to a “sleeping town” or “dormitory city” for the workers employed by the construction and hotel industries in the Cancún and Playa del Carmen municipalities. The proposal included construction of several large-scale low income housing complexes for a projected increase in the local population in the next five years from approximately 12,000 to 180,000 inhabitants. Independent of the social problems that such uncontrolled population growth may produce, the project ignored the geological characteristics of the area and failed to identify flood risk areas. In addition to this, the proposal also neglected the construction of a water treatment plan and ignored the possible effects on the water quality of the beaches and on the reef itself.

The information generated by the CoE through the groundwater project was instrumental in highlighting the dangers of the development plan. As indicated in Figure 1, the most obvious danger is related to flooding in the proposed area of development due to its location in a natural depression. This scenario was further complicated by the proposed construction of a by-pass road that will create an effective barrier for rainwater. The data generated by the project indicates the fragility of the local watershed to pollution generated by suboptimal or inexistent facilities for the treatment of urban, including hotel operations, wastewaters. Furthermore the data indicates that this pollution is threatening not only the drinking water reserves for Puerto Morelos, but also the reef.

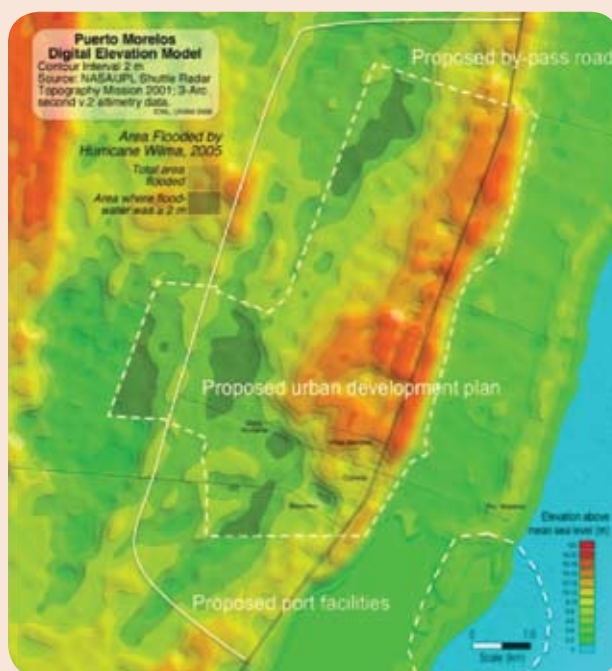


Figure 2. Digital elevation map showing the areas of proposed development in Puerto Morelos. Shaded areas indicate regions that were flooded during Hurricane Wilma on October 2005.

The information generated by the CoE was a key component to identifying the urban development plan as unsustainable and a threat to the main source of revenue for the local population, and the reef itself. During the consultation process, members of the CoE engaged local and national media, and the municipal governments about the linkages of coral reef natural services and the economic development of the area. In this context, the presentations were presented to the city councils of Cancún and Playa del Carmen on the importance of the reefs for the tourist industry. These events received good coverage by the local media and as a result, the CoE Chair was invited to present the CoE work as part of the World Tourism Day celebrations organised by the municipal governments of Cozumel and Playa del Carmen in late September 2008. During this period CoE members were also invited by the Association of Hotel owners of Cancún to present a talk on the role of the natural services that coral reefs provide to the tourist industry.

Southeast Asian Centre of Excellence

Marine Science Institute / Bolinao Marine Laboratory, University of the Philippines

The Southeast Asian Centre of Excellence has continued to progress towards achieving its objectives through local research projects, and a series of interactive information exchanges with a range of stakeholders. Within the local research projects, progress on the Coral Taxonomy project is continuing with the upgrading of the reference coral collections in the local museum and the development of local expertise for the identification of Indo-Pacific species. Demand for the training courses is increasing with more than 40 applications being received for the October 2008 training session. These courses are building on the earlier courses in developing the capacity of local researchers and managers in species identification. Work on the virtual museum is also continuing with approximately 80% of the late Prof Nemenzo type specimens now photographed, and the COENOMAP website has been 'amended' to ensure faster access and new links to the original descriptions of Philippine coral species by Dr Francisco Nemenzo and Dr J.E.N. Veron, among others.

The 'Identification and epidemiological clues of microbial coral diseases in the Lingayen Gulf' project is also progressing well with results to-date showing that isolates of *Vibrio* s. confirmed as causative agents of Porites Ulcerative White Syndrome (PUWS), which is the most visible infectious coral disease in the Lingayen Gulf. This has raised questions regarding the original source of the bacteria and monitoring of the Bolinao waters since 2004 suggests that intensive mariculture activity can raise the titer of *Vibrio* spp as the most common copiotrophic members of marine bacterial communities by several orders of magnitude. Repeated mesocosm experiments designed to demonstrate the infectious impact of fish cage water containing enhanced titers of presumptive vibrios have so far remained inconclusive.

"The program made strong in-roads into building the capacity of scientists and managers in developing countries."

The research project on connectivity studies to support conservation and management of reef ecosystems in Bolinao is also producing results indicating significant genetic differentiation with putative partitioning of the six populations of *S. fuscescens* studied into genetically distinct groups. On the other hand, analyses using landmark-based multivariate morphometric methods did not reveal distinct population differentiation among study sites, suggesting that these methods might not be powerful enough differentiate *S. fuscescens* populations.

Progress is also continuing on the common sampling project and on the Local Government Initiative. Under the common sampling project, 13 study sites have now been established at Bolinao and Batangas. Initial monitoring work has commenced with sites marked and photographed using standard protocols, and random transects at Bolinao being analysed for coral cover and composition. The project is currently acquiring materials for the fabrication of recruitment tiles and blocks for deployment in the two locations.

Local Government Initiative

The Local Government Initiative is also progressing well with numerous activities being undertaken. Following last year's formulation of draft operating procedures on coastal law enforcement, the project participated in the 'Coastal Resources Management Forum' in August 2008. This Forum served to foster and enhance inter-Local Government Unit (LGU) collaboration in western

Pangasinan through sharing of experiences and identification of common key actions. It focused on the challenges and opportunities related to the strengthening or scaling up of coastal resources management efforts undertaken by local government units. The three themes of the Forum were: i) sustainable mariculture development; (ii) coastal tourism; and (iii) management of marine protected areas. Local coastal resource managers, municipal fishermen,



Dr. Wilfredo Licuanan examining a new coral species record for the Philippines. Photo: Mark Vergara

people's organisations and the tourism sector all shared initiatives and plans in a collaborative effort. The CoE researchers supported the Forum by providing scientific information on the value and status of coastal ecosystems in the region, and results of pertinent research initiatives.

The project has also been providing technical assistance to the MPA establishment in Agno and MPA ordinance to the Barangay Council of Tupa, Agno. For the MPA establishment the CoE team collected data to determine the best site(s) for the MPA establishment in the municipality. After the completion of these underwater assessments, the project conducted community validation workshops. The workshops were held to disseminate information, gather and validate important information and to lobby support for the MPA establishment in the municipality. The municipal mayor of Agno attended the workshop and encouraged his constituents to support the initiatives. Under the MPA ordinance component, the project team provided technical assistance following a request by the council to improve the proposed local ordinance in terms of form and substance. Additional inputs pertaining to MPA establishment were integrated to the legal instrument being drafted by the Barangay council.

In the Bolinao area the project has been working with LGUs, MPA managers and the local coastal law enforcers to incorporate the MPA Enforcement Protocol Guide as part of their management plan. It was conceptualized to help improve the law enforcement activities covering the eight MPAs in the municipality and as a guide for the enforcers to discharge their duties and functions effectively. The LGU of Bolinao is now planning to initiate the formulation of the unified MPA management plan that would cover existing MPAs in the municipality. The plan will facilitate the coordination of all the initiatives at the municipal level and will harmonise all the rules and regulations pertaining to MPA management.

69

The number of events – training courses, workshops, media opportunities, meetings and conferences – the Program undertook or participated in during 2008.

Linking Scientific Knowledge
to Management and Policy

3
Component

Linking Scientific Knowledge to Management and Policy

During the year there have been some significant activities including the completion of the CRTR Program's Mid-term Review, the continuation of the ecological sampling project, Palau resilience project and the Bolinao aquaculture project (see Disease Working Group report).

Mid-term Review

In February 2008, the Mid-term Review of the Program was contracted out to an international team of five reviewers. The evaluation served two purposes:

- I. Development Grant Facility: the goal was to enhance the impact of ongoing and future global programs and partnerships by assessing and reporting on the outcomes achieved under the grant relative to its objectives, the effectiveness of implementation arrangements and other processes designed to deliver results, and to provide feedback to the major funders regarding key lessons learnt and effectiveness of the grant to inform the design of future partnerships, and;
- II. Global Environment Facility: the main purpose was to take stock of implementation this far; assess whether or not objectives are being met and outcomes are likely to be achieved given current institutional arrangements, funding levels and resource allocation; identify any course corrections and; agree on key benchmarks that may serve as triggers for a second phase.

The final report has now been accepted with the main findings demonstrating that the CRTR Program is relevant to international priorities for coral reef research, and that it has been able to increase knowledge on important areas such as coral reef protection and bleaching, with the Centres of Excellence found to be both relevant and in demand by local users. For the complete findings of the Review, Volume One is available for download from the Program's website (Publications) at www.gefcoral.org.

Benthic field methods to detect change and key processes structuring the coral communities at the Centres of Excellence

The ecological sampling, or 'common sampling' project as it is more commonly known is designed to implement a set of key monitoring techniques to assess the dynamics of coral populations and associated coral reef organisms by defining key ecological processes that regulate the populations, across the four regional Centres of Excellence which can be replicated across the globe. The project aims to establish and evaluate processes at localities that may lead to comparisons across spatial scales over time. In this project, the team is interested in the processes that influence the structure of coral communities at the various habitats in the vicinity of the Centres of Excellence.

All sites were re-examined in the past year with fieldwork being conducted in Zanzibar, Heron Island, Mexico and the Philippines. In the Philippines (which was established later than the other sites), all 13 sites have now been selected and established. Initial monitoring work has commenced with sites marked, photographed using standard protocols and random transects at Bolinao being analysed for coral cover and composition. The project is currently acquiring materials for the fabrication of recruitment tiles and blocks for deployment in the two locations – Bolinao and Batangas.

The Project now has three years of data from the Heron Island, Zanzibar and Mexico sites on rates of change in key state variables such as coral and macroalgal cover and size frequency distributions, and also data on vital processes such as recruitment, post-settlement mortality, coral growth, partial mortality (and complete mortality), and colony fission and fusion.

Palau Resilience Project

The Palau Resilience project is examining the role of herbivory as a key process in its control of algal abundance as a prime regulator of the recruitment of reef corals. In November 2007, a common garden experiment was set up in which grazing from large parrotfish was manipulated by using parrotfish exclusion devices (PEDs) that locally reduce herbivory in the microenvironment of settlement plates. If PEDs work in Palau as they have in Belize, the research team will see macroalgal tufts and anticipate concomitant reductions in coral recruitment. As was done at the sites in the Caribbean, the research team is revisiting the Palau sites (in January 2009) to examine the effects of the PEDs on the succession of organisms and coral settlement in this subcryptic nursery habitat (the plate undersides).

The research team are specifically manipulating herbivory by manipulating the most functionally important group of herbivores - the large parrotfish. Thus, they will be able to get beyond just the process effect (i.e. changing herbivory) by quantifying how it affects the recruitment potential of coral reef ecosystems. Importantly, by focusing on a manipulation of large scarids the results simulate the effects of moderate fishing pressure (which contrasts with the more acute - but less policy relevant - approach of using full cages to exclude all grazers). If the process of herbivory is a key driver of coral recruitment and the resilience of coral reefs, it should be evident among biogeographically distinct coral reef ecosystems that have no species in common. If the research can show that herbivory from large parrotfish controls algal development sufficiently to affect coral settlement, the research team will be able to make profound recommendations to managers of coral reefs. Specifically, these results could provide a clear and practical rationale for prohibiting the taking or killing of large parrotfish.



CRTR information stand at the 2008 International Coral Reef Symposium, Fort Lauderdale. Photo: Andy Hooten

11th International Coral Reef Symposium

CRTR Program members (researchers and students) participated in the 11th International Coral Reef Symposium at Fort Lauderdale on 7-11 July. The Program was well represented with Dr Roberto Iglesias-Prieto and Dr Drew Harvell participating as keynote speakers during the week. Many of the senior researchers and students from the Program participated in plenary presentations and poster presentations.

The Program was a major sponsor of the event and mounted a display of publications and tools, including the Disease Manual and Underwater Cards, the Restoration Guidelines manual, copies of the 'The Carbon Crisis' Science Magazine paper and Research Updates for the Working Groups and Centres of Excellence.



350

The percentage growth in the number of unique visitors visiting the CRTR Program website.

Program Management

4
Component

Program Management

As the Project Executing Agency The University of Queensland (Brisbane, Australia) is responsible for the management of the CRTR Program. Program management responsibilities include financial management and reporting; strategic communication and capacity building activities; information management; stakeholder liaison; and co-financing sources.

During Year Four, the Program has made steady progress towards meeting its approved activities and Phase One objectives with the following outlining the status of disbursements and procurement, as well as the Program's communication activity for the year.

Communication

During 2008 the Currie Communications team of Mr Mark Paterson, Dr Bruce Munday and Ms Gabrielle Sheehan executed internal and external communication activities designed to inform not only the Program members, but also the Program's audiences of coastal/coral reef managers, policy-makers and scientists with information based on the Program's research outputs. The key outputs from the communications team for the CRTR Program during 2008 included:

- The launch of a quarterly HTML e-newsletter for members, *CRTR E-News* in January
- The start of communications update, *Coralert!* to key CRTR Program people in April
- The release of three flagship products from the Disease Working Group in July
- A showcase of tools and publications at the International Coral Reef Symposium in July
- A major re-design of the program website, www.gefcoral.org, in September/October
- The development and production of a brief film/video profile for the program in October



Synthesis paper, *Science* Magazine, December 2007.

Communication activities for the year commenced in December 2007 with the media launch of the CRTR Program's first 'synthesised' research output, the scientific paper, 'The Carbon Crisis: Coral Reefs under Rapid Climate Change', published in the 14 December, 2007 issue of *Science* Magazine. The paper highlighted the urgent action required to protect coral reefs from rising concentrations of carbon dioxide in the Earth's atmosphere. Within 24 hours of the press conference, 165 media outlets in 18 countries had reported the paper's main message, that, in order to save coral reefs, there needs to be immediate action from world leaders to urgently cut CO₂ emissions, and from policy-makers and reef managers to stop over-fishing, pollution and unsustainable coastal development. Comments from the paper's CRTR Program authors were reported on the front pages of national newspapers, including *USA Today* and *The Australian*, and on international newswires Associated Press, Reuters, Bloomberg and Agence France Presse. The story featured as the number one science article monitored online by Google (Australia) on the day of the release.

Following on the heels of this event, the CRTR Program members participated in the 11th International Coral Reef Symposium at Fort Lauderdale on 7-11 July. The Program was well represented with many of the senior researchers and students from the Program participating in keynote addresses, plenary presentations and poster presentations. The Program was also a major sponsor of the event and mounted a display of publications and tools, including the Disease Manual and Underwater Cards, the *Restoration Guidelines* manual, copies of the 'The Carbon Crisis' *Science* Magazine paper and Research Updates for the Working Groups and Centres of Excellence.

Communication activities continued with the aim of promoting the Program's information to its wide membership and in working with Working Groups and Centres of Excellence in communicating their research outputs. In efforts to bring the researchers, students and management closer together despite the distances and different countries, the Communication Team commenced the year with the development and dissemination of two internal communication tools: a quarterly e-newsletter and a regular communication email update. The quarterly e-newsletter, *CRTR E-News*, is the main communications vehicle for keeping the CRTR Program 'family' in-touch with news, events and progress across the program. This newsletter was launched in January 2008 and is sent to 152 recipients every three months. CRTR Program members contribute many of the articles and images. A second newsletter, *Coralert!*, is sent to 82 key CRTR Program personnel every eight weeks, updating them on specific communications activity and outputs, as well as seeking their ideas for products, tools and activities.

Working with the Working Groups and Centres of Excellence has also produced a series of Research Updates, documenting the progress made by these groups during the past year, and discussions with Working Group chairs during ICRS have led to planning for future outputs from many of groups for 2009. During 2008, communications meetings were also held with the Centres of Excellence in East Africa, the Philippines and Mesoamerica. These sessions sought to identify the priority needs of the CoEs and determine their key outputs during the remainder of Phase One of the program. These discussions will be completed with CoE chairs at the Synthesis Panel meeting in Australia during November 2008. As a result of these meetings, local communications workplans and training workshops will be presented in each of the regions during 2009.

During 2008 the Program undertook or participated in 69 events – training courses, workshops, media opportunities, meetings and conferences. In addition to this Program members produced 174 publications, either journal articles, book chapters, conference papers, media articles or electronic products. These publications are classified as either fully or partially supported by the Program, or not supported but having an influence on, or being influenced by, the research being undertaken by the Program Working Groups and Centres of Excellence.

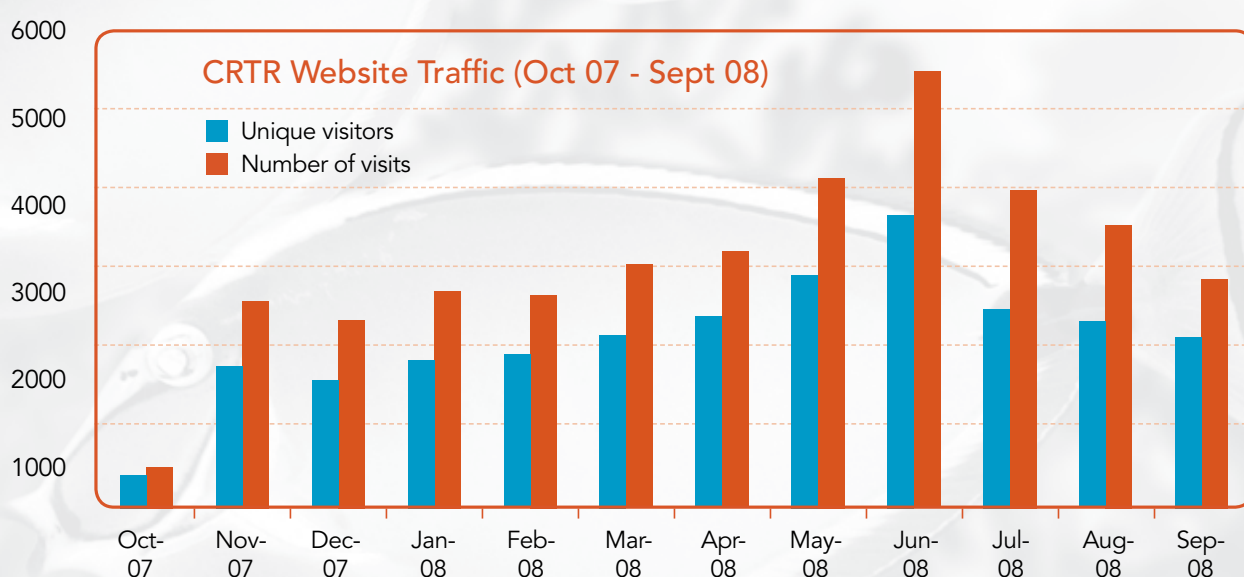


Website November 2008.

“The communications team will, with the support of scientists, maintain a flow of new information based on research and capacity building activities.”

Website

The number of unique visitors to the CRTR Program website has grown 350% in the past year. In 2008 (as at end of September), there have been 22,058 unique visitors; 31,812 visits; and 127,632 pages accessed, and; 786,724 hits. More time has been invested in maintaining the Latest News section, starting an Image Library and establishing an online facility to order Publications. Upon consideration of the growing traffic to the website, together with the rising tide of scientific know-how from the Program, a decision was made to further invest in the design and usability of this cost-effective channel. As a result, a fresher, easier-to-navigate site will be unveiled during November 2008.



Corporate Branding

The communications team is working on a video profile and stakeholder forum, two activities designed to raise awareness of the CRTR Program and increase understanding about its role. The video profile will be available to CRTR Program members and partners for use in presentations from November 2008 and will be featured on the website. The stakeholder forum, to be staged in partnership with the Great Barrier Reef Foundation at the University of Queensland on 3 November 2008, seeks to open dialogue between the program and Australian business leaders with an interest in marine conservation. Both activities seek to generate awareness that the condition of coral reefs is not simply an environmental issue, that their health is inextricably linked to the social and economic wellbeing of those countries, where the livelihoods of 100 million people rely upon them.

2009 'Harvest Year'

The communications team is calling the year, 2009, the 'harvest year' for phase one of the program. As the fifth and final year of the program's first phase, next year represents an opportunity to harvest (collate and summarise) the new knowledge generated by the program's investment to-date. The communications team will, with the support of scientists, maintain a flow of new information based on research and capacity building activities, together with targeted campaigns to raise awareness of the issues facing coral reefs, and the information available through the CRTR Program.

A large, stylized white letter 'A' is centered in the lower right quadrant of the page. The background is a solid orange color with a faint, repeating pattern of seaweed or coral-like structures.

Abbreviations

Abbreviations

ACEP - African Coelacanth Ecosystem Programme
AIMS – Australian Institute of Marine Science
BWG – Bleaching Working Group
CIMRIS – Cook Islands Marine Resources Institutional Strengthening
COENOMAP – A web-accessible, map-oriented database on the distribution of corals in the Philippines
CO₂ – Carbon dioxide
CoE – Centre of Excellence
CORDIO – Coral Reef Degradation in the Indian Ocean
COT – Crown of Thorns
CRTR – Coral Reef Targeted Research & Capacity Building for Management Program
CWG – Connectivity and Large-Scale Ecological Processes Working Group
CYBD – Caribbean Yellow band Disease
DGF – Development Grant Facility
DHW – Degree Heating Weeks
DWG – Disease Working Group
ECONAR Project – Ecological Connections Among Reefs Project
ESA – European Space Agency
GEF – Global Environment Facility
ICRS – International Coral Reef Symposium
IMOS – Integrated Marine Observing System
LGI – Local Government Initiative
LGUs – Local government units
MACEMP – Marine and Coastal Environment Management Project
MBRS – Mesoamerican Barrier Reef System
MERIS – Medium Resolution Imaging Spectrometer
MPA – Marine Protected Area
MDSWG – Modelling and Decision Support Working Group
NGO – Non-government Organisation
NORDECO - Nordic Agency for Development and Ecology
NOAA – National Oceanic and Atmospheric Administration
PEDs – Parrotfish exclusion devices
PICRC – Palau International Coral Reef Center
PTD – Project To Date
PUWS – Porites Ulcerative White Syndrome
RRWG – Restoration and Remediation Working Group
RSWG – Remote Sensing Working Group
SMs – Standardised Modules
SOPAC – Pacific Islands Applied Geoscience Commission
TNC – The Nature Conservancy
UNAM – Universidad Nacional Autonoma de Mexico
UNU-INWEH – United Nations University International Network on Water, Environment and Health
UPMSI – University of the Philippines Marine Science Institute
UQ – University of Queensland





The Coral Reef Targeted Research & Capacity Building for Management (CRTR) Program 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 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.