

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



Coral Reef Targeted Research & Capacity Building for Management Program

2007 Annual Report

(1 April 2007 - 30 September 2007)



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CRTR Synthesis Panel members

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- ❖ Ms Kristen Sampson, Finance Officer – Project Executing Agency
- ❖ Mr Kim Mitchell (Currie Communications) – Communication Coordinator
- ❖ Professor Ove Hoegh-Guldberg, Chair – Bleaching Working Group & Australasian Centre of Excellence
- ❖ Professor Peter Sale, Chair – Connectivity Working Group
- ❖ Professor Drew Harvell, Chair – Coral Disease Working Group
- ❖ Professor Peter Mumby, Chair – Remote Sensing Working Group
- ❖ Dr Alasdair Edwards, Chair – Restoration & Remediation Working Group
- ❖ Professor Roger Bradbury, Chair – Modelling & Decision Support Working Group
- ❖ Emeritus Professor Ed Gomez – Southeast Asian Centre of Excellence
- ❖ Dr Roberto Iglesias-Prieto – MesoAmerican Centre of Excellence
- ❖ Dr Alfonse Dubi – East African Centre of Excellence

Contributions have also been received from Working Group members in their individual reports to the Working Group Chairs.

Further Information

Information used in this report has been collated from the individual Working Group and Centres of Excellence 2006 Annual Reports, and from the communication products produced during the year. Additional information has been produced with the input of the Management Team.

Further information regarding this report and/or to request copies of the individual Working Group and Centre of Excellence Annual Reports can be requested from the Executive Officer, Melanie King (m.king4@uq.edu.au).

Abbreviations

BWG	Bleaching Working Group
CoE	Centres of Excellence
CRTR	Coral Reef Targeted Research Program
CWG	Connectivity Working Group
DWG	Disease Working Group
ECONAR	Ecological Connections Among Reefs
GEF	Global Environment Facility
ITMEMS	International Tropical Marine Ecosystems Management Symposium
MBRS	Mesoamerican Barrier Reef System
MPA	Marine Protected Area
MDSWG	Modelling & Decision Support Working Group
NGO	Non-government organisations
PEA	Project Executing Agency
RRWG	Restoration & Remediation Working Group
RSWG	Remote Sensing Working Group
UQ	The University of Queensland



Executive Summary

As the midway point for Phase 1 of the Coral Reef Targeted Research Program (CRTR), 2007 has seen an increase in the level of activity and research outputs as well as a significant number of capacity building activities aimed at increasing the knowledge and information exchanges for both developing and developed country scientists and managers of coral reefs.

There has been a significant range of research findings and 'world-firsts'. For example, the Bleaching Working Group are in the process of publishing a paper describing 1600 gene products. This is a world first as no other cDNA libraries of the key symbiont inhabiting reef-building corals have been published. The Remote Sensing Group were involved in the creation of first national marine habitat map of Palau, whilst the Restoration & Remediation Working Group, in another 'world-first' has established the timing of coral reproduction around Bolinao in the Philippines. Through this information, the effects of fragmentation on reproduction and survival are beginning to emerge which will provide important information for the field of coral restoration techniques.

Further research outputs which will provide an important source of information to the research, management and policy communities includes work on the impact of local environmental factors on coral health diseases. This area is a priority for the Disease Working Group which has a range of projects related to water quality and disease spread. Through their research it is believed that there are strong indications that poor water quality hastens the progress of various disease syndromes. Additionally, their research on the impacts of aquaculture is also showing that this may play a role as an incubator, conveyor and facilitator of disease into natural populations. The Group has also made significant discoveries in the Caribbean and Australia regarding the potential impacts of climate warming events on the outbreak of coral disease, and work continues in this area.

Collaborations between Working Groups also produced excellent results during the year with the Disease and Remote Sensing Working Groups collaborating on a project which is considering the various ways in which thermal stress could impact disease. This collaboration has led to the creation of new algorithms to predict outbreaks using a combination of monitoring data from Australia and the Caribbean and satellite temperature data. The model uses predicted sea temperature data

and can identify the potential efficacy of various management strategies for future scenarios. A model has also been developed to investigate the impacts of several scenarios on reef health including (i) indirect impacts of protecting herbivorous fishes, (ii) the effects of modest *Diadema* recovery, and (iii) direct disease-inhibitory effects of MPAs that have been reported from the Philippines.

In addition to the research outputs, there has been a significant number of tools and products designed for a range of audiences. The Modelling & Decision Support Working Group has developed the next generation of an agent-based participatory modelling game – ReefGame. This modelling game was reviewed by the target audience of fishing families, barangay captains, and government officials at a workshop held at the Marine Science Institute's Bolinao Marine Laboratory, with successful outcomes.

Through the Remote Sensing Working Group, new data products have been generated including a web-portal for directing users to sources of satellite data on factors affecting coral reefs and new bleaching metrics around Centres of Excellence. An on-line toolkit has also been developed for selecting suitable image data and mapping techniques for mapping and monitoring coral reefs, seagrass beds (from another project) and water quality. This toolkit shows managers, scientists and technicians working in coastal marine environments how remote sensing can map and monitor changes to indicators of coastal ecosystem health. The toolkit currently focuses on coastal water bodies, seagrass and coral reefs, and mangroves but future work will extend it to cover all other coastal ecosystems. The toolkit can be viewed at www.gpa.uq.edu.au/CRSSIS/tools/rstoolkit/.

The four Centres of Excellence have also been producing effective results through local research projects and on-ground capacity building activities. For example, the Australasian Centre of Excellence is providing new insights and projections into how benthic reef communities are likely to behave under multivariate environmental stressors, and the Mesoamerican Centre of Excellence has produced the first results from its hydrodynamic model for the circulation of the reef lagoon at Puerto Morelos, Mexico. These results were recently published in the February issue of *Coral Reefs*.

The Southeast Asian Centre of Excellence has produced two field guides in 2007: A 'Field Guide to the Bubble Corals of the Philippines' which will be used with non-scientist divers who are trained by the project to map the distributions of these corals in the Philippines, and; 'The

Guide to the Corals of Bolinao and Western Luzon' which has commenced with field surveys and taxonomic identification of the coral species photographed.

In terms of building capacity within developing countries, the Program is well on the way to strengthening the technical skills within the regions of scientists and managers. The Program currently directly sponsors or supports 64 masters, postgraduate students or post-doctoral fellows in 19 countries. In December 2007, these students will be meeting at the Australasian Centre of Excellence to build the network of the 'next generation' of coral reef scientists, and to learn new skills and techniques to enable them to effectively communicate their science to a range of audiences to ensure greater awareness raising and impact. Further to this support there have been a number of sponsorship opportunities for developing country participants to attend training workshops held by the Working Groups and Centres of Excellence.

Members of the Program have been responsible for the publication of approximately 420 publications and for over 120 events including training workshops (technical and other), conferences and meetings, since the commencement of Phase 1. Additionally, members are also regularly called upon to brief media, governments, NGOs and others on issues facing coral reef ecosystems.

In summary, 2007 has seen the effective consolidation of many activities and strategies for the Program and the Program is well positioned to make an impact in the final two years of Phase 2.

Component 1: Addressing knowledge and technology gaps

Component Summary

Over the past ten years, an increasing awareness of the importance of coral reefs has been evident, 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 some of the basic forcing functions affecting coral reefs remain. 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 responses
- Coral disease
- Coral reef connectivity and large scale ecological processes
- Remote sensing
- Coral restoration & remediation
- Modelling and decision-support¹

¹ For budgetary purposes, the Modelling & Decision-Support Working Group is funded under Component 3 – Linking scientific knowledge to management.

Bleaching 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, 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
Dr David Obura	CORDIO East Africa, Kenya
Dr John Bythell	Dept of Marine Sciences & Coastal Management, University of Newcastle, UK
Dr Ron Johnstone	Centre for Marine Studies, The University of Queensland, Australia



*Bleaching event, Great Keppel Is.
Australia (Photo: Ove Hoegh-Guldberg)*

During 2007, the Bleaching Working Group (BWG) continued to build scientific capacity in the next generation of coral reef researchers and managers both in developing and developed countries. The Group hosted or provided significant support for research workshops in Kenya (meso-scale effects of coral bleaching – benthic fish interactions), Zanzibar (coral reefs, population genetics and environmental change), Hawaii (2007 Edwin Pauley Summer Program in Marine Biology), and Australia (new frontiers in cellular interactions in cnidarian/dinoflagellate symbiosis). In addition to these training opportunities, the Working Group is also sponsoring and supporting a number of postgraduate students and post-doctoral fellows from Mexico, Kenya, Venezuela, Indonesia, Thailand, Tanzania, Iran, Columbia, Australia, U.K and USA.

The BWG is one of the most prominent groups working on the impacts of global warming on coral reefs and during 2007 its members were regularly asked to comment in media, on government committees and in non-government organisation (NGO) forums. In addition to these capacity building and information exchange activities the BWG has continued to make progress against its research agenda.

The BWG has conducted workshops and published several papers on the fundamental physiological mechanisms underpinning coral bleaching and mortality, and why some corals are more sensitive to thermal stress than others. In the first of these projects, a theoretical model for linking mortality to physiological parameters such as tissue protein and chlorophyll



Bleached corals, Great Keppel Is, Australia (Photo: Ove Hoegh-Guldberg)

World-first: cDNA libraries of the key symbiont inhabiting reef-building corals published

content has been established by the Professor Hoegh-Guldberg laboratory. The second project also under the Hoegh-Guldberg laboratory explored the underlying physiological behaviour of Symbiodinium in bleached corals. The first microarray experiments have revealed 100 gene candidates, the proteins of which underpin the response to thermal stress by reef-building corals and their resident Symbiodinium.

Research into the geographical diversity of Symbiodinium has found different strains in approximately 800 coral species from Zanzibar, Thailand and surrounding regions. Early results from DNA extractions, PCR-DGGE analyses and DNA sequencing of the 550 coral samples from the under-studied Thailand region indicate many new and unusual coral-algae symbioses. While a definitive assessment of how water quality affects these associations is premature, many of the same species of symbiont are being found at mainland and island locations. A conspicuous feature of the region is the occurrence of clade D species (a group that appears to be thermally tolerant) whose presence is not restricted to turbid inshore areas as previously thought, but which is also found on offshore islands where water clarity is greater.

The project looking at the functional diversity of Symbiodinium and its role in explaining differences in stress susceptibility among reef-building corals and their symbionts is preparing to publish a paper describing 1600 gene products. This is a very important step forward for the project as Working Group members are now focusing on a number of projects looking at genetic responses of corals to stress. It is also a world-first as no other cDNA libraries of the key symbiont inhabiting reef-building corals have been published.

The investigations into the significance of host-symbiont mutualism, close microbial associates and metabolic communication in the response of corals to rapid environmental change have also made significant progress during 2007. The studies have significantly advanced the debate concerning the importance of the close microbial associates of reef-building corals. One of the most significant discoveries is that symbiotic cyanobacteria were shown to fix atmospheric nitrogen. A paper on these findings is currently in press in Marine Ecology Progress series.

Connectivity Working Group

MEMBERS:

Prof. Peter Sale (Chair)	Biological Sciences, University of Windsor, Canada
Dr Carmen Ablan	Molecular Genetics Laboratory, The Worldfish Centre, Malaysia
Dr J. Ernesto Arias	Lab. Ecología de Ecosistemas de Arrecifes Coralinos, CINVESTAV-U, Mexico
Prof. Mark Butler IV	Department of Biological Sciences, Old Dominion University, USA
Prof. Robert Cowan	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, Université 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
Dr Simon Thorrold	Biology Department, Woods Hole Oceanographic Institution
Dr Mary Alice Coffroth	Department of Biological Sciences, State University of New York
Dr Ken Lindeman	Environmental Defense, Miami, USA
Dr Enric Sala	Center for Marine Biodiversity and Conservation, Scripps Institute of Oceanography

The Connectivity Working Group (CWG) has continued to build capacity and outreach to local management agencies and NGO personnel through training opportunities and production of appropriate documents. The annual training workshops on recruitment monitoring are being modified to include more senior managers as the focus shifts towards using connectivity and recruitment data in guiding management of protected areas. Preparation of reports in a format accessible to management agency personnel is a high priority.

The Working Group has continued to build scientific capacity through training opportunities and student scholarships. These have included workshops in Miami



Photo: Aden Guillermo Jordan Garza

Critical bottlenecks may be the primary determinant of patterns of coral connectivity.

(connectivity of Mesoamerican reefs); Honduras (connectivity, recruitment and protected area management on the Mesoamerican reef); and Townsville (connectivity and population resilience). The Working Group continues to support postgraduate students and postdoctoral fellows from Belize, Guatemala, Costa Rica, Canada, USA, Mexico, Colombia, and Venezuela.

Through the investigations into connectivity in bicolor damselfish, the Group is demonstrating several approaches to measuring connectivity in fish species that do not aggregate over large distances to spawn. Genetic assignment tests, otolith microchemistry, ecology of settlement patterns, and data collected during the ECONAR (Ecological Connections Among Reefs) project on hydrodynamics and habitat are being utilised to establish patterns of connectivity for populations of this common species in the Mesoamerican Caribbean.

Work under the 'post-settlement bottlenecks in coral recruitment' project is continuing to monitor the settlement of corals at five sites in Mesoamerica, while evaluating the demography of naturally occurring coral recruits for the critical early post-settlement months, including factors such as algal biomass that might affect settlement and early demography. The demography of juvenile corals is also being monitored using permanent transects and tracking of specific individuals - the rationale being that critical bottlenecks in the months between settlement and reaching a size of 1cm or so in diameter may be the primary determinant of patterns of coral connectivity. Factors responsible for these bottlenecks are being investigated.

The CWG's 'coral connectivity' project has collected data on coral larval behavior and competency period, and commenced pilot efforts to build this new information into dispersal models to provide an informed view of connectivity in important reef building species. The major effort to track larvae at Glovers Reef during the spawning season in Autumn 2007 was abandoned on account of Hurricane Felix, however its likely that some useful results will emerge.

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	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 University, Israel
Prof. Ernesto Weil	Department of Marine Sciences, Universidad de Puerto Rico Mayaguez, Puerto Rico

The Disease Working Group (DWG) has answered many pressing questions including which disease syndromes are infectious; which Centres of Excellence have the largest coral disease problems; which Centres of Excellence would be the most tractable for identifying local factors that might impact upon disease; and whether climate factors would affect coral disease levels.

At the end of Year 3 the DWG has published 15 peer-reviewed papers directly supported by the Program, and 15 partially supported. The Group is sponsoring or supporting five postgraduate students and one post-doctoral from Palau, Puerto Rico, Mozambique, Mexico, Philippines and the USA.

The DWG has made significant discoveries in the Caribbean and Australia regarding the potential impacts of climate warming events on the outbreak of coral disease. The Group considered the various ways in which thermal stress could impact disease, leading to a productive collaboration with the Remote Sensing Working Group (RSWG) to create new algorithms (see Figure 1) to predict outbreaks using a combination of monitoring data from Australia and the Caribbean and satellite temperature data. The model uses predicted sea temperature data and can identify the potential efficacy of various management strategies for future scenarios. The collaboration with the RSWG developed a model to investigate the impacts of several scenarios on reef health including (i) indirect impacts of protecting

The DWG & RSWG has created new algorithms to predict outbreaks of disease

herbivorous fishes, (ii) the effects of modest *Diadema* recovery, and (iii) direct disease-inhibitory effects of MPAs that have been reported from the Philippines.

Figure 1: Climate and Disease Outbreaks, a Disease Algorithm?

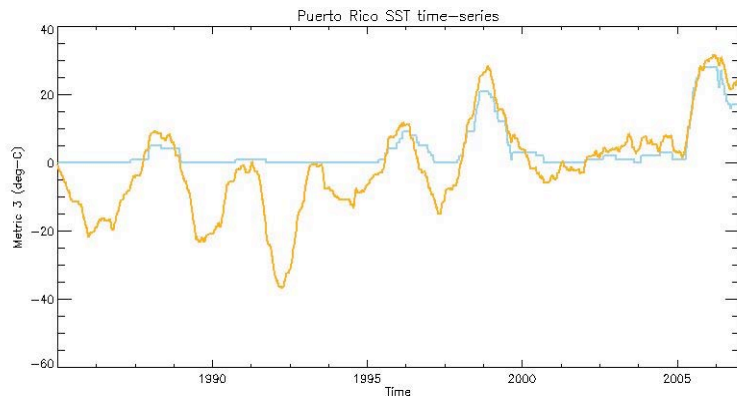


Figure 1. An example algorithm produced at the June 2007 joint modelling disease meeting between the DWG and RSWG. In orange are the time-series of metrics 1, 3, and 5 for Puerto Rico (18.0 N, 67.0 W) using CRW Pathfinder 0.5-degree (50-km). The metric WSSTA (Bruno et al., 2007) is shown in blue for comparison.

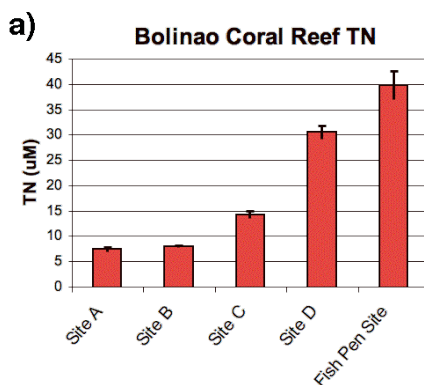
Strong indications poor water quality hastens the progress of various disease syndromes

Research is showing that aquaculture may play a role as an incubator, conveyor and facilitator of disease into natural populations

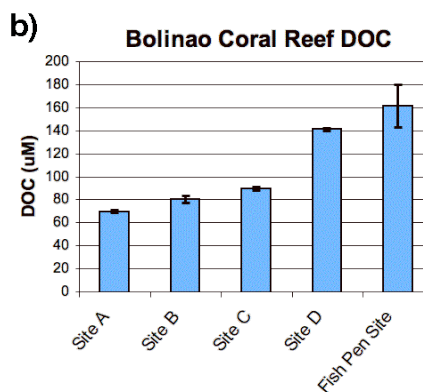
The impact of local environmental factors on coral health diseases are a priority for the Group which has a range of projects related to water quality and disease spread. There are strong indications that poor water quality hastens the progress of various disease syndromes.

The Group has highlighted disease surveys across water quality gradients, with a particular focus on fish farms as a source of poor water quality and potentially pathogenic micro-organisms. Preliminary studies have found that the fish pens in Bolinao Bay (Philippines) have a strong influence on the free living and attached bacteria population, nutrient input, primary production and the patterns of energy and carbon flux in the surrounding waters (see Figure 1 and 2). The Group will soon know the identity of specific bacteria exported from fish farms to reside on the surface of reef corals. Aquaculture may play a role as an incubator, conveyor and facilitator of disease into natural populations. Therefore, during 2008 the Group plans to focus additional efforts on this investigation and scale it up with a partnership with the Bolinao Center of Excellence and the Restoration & Remediation Working Group. The goal is to produce significant new scientific knowledge that might feed directly into policy relating to the sustainability of aquaculture adjacent to coral reef systems.

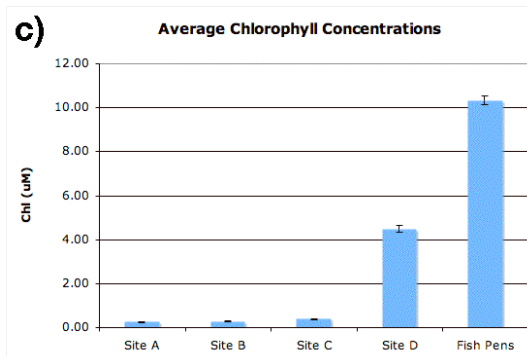
Figure 2: Coral Disease and Water Quality and Fish Farms



a) Total dissolved nitrogen



b) Total dissolved carbon



c) Chlorophyll concentrations

NB Error bars denote the standard error in all figures.

The DWG has continued investigating the processes of coral immune response to disease, and developed methods to induce cellular immunity of gorgonian sea fans in response to pathogens and temperature stress

and is in the process of developing these methods for scleractinians. The Group hopes to use cellular immune response as a tool to assess the conditions that compromise immunity in corals. Meanwhile the Group has gained further insight into how the bacterial communities of coral change when challenged with pathogens and environmental stress.

Surveys at the Centres of Excellence have provided invaluable empirical data on changes of coral community structure and the prevalence of disease syndromes and signs over time. They also allow the selection of a few syndromes to serve as models of how infectious diseases affect reef sustainability. The Group has worked with tractable syndromes in East Africa and has identified a number of Caribbean and Indo-Pacific and East African disease syndromes that are infectious, as well as identifying new causative agents. The Group is also confronting the reality that infectious disease is a moving target; it can be infectious at one time and not at others.

Two full years of consistent data from carefully paired reefs in Marine Protected Area (MPA) and non-MPA locales in the Philippines, show significantly fewer coral diseases on many of the MPA reefs compared to non-MPA reefs. The first year's data has been summarised into a report specifically for managers and disseminated to local managers. A future focus will be to understand what aspects of these MPAs result in lower levels of coral disease.

Modelling & Decision Support Working Group

MEMBERS:

Dr Roger Bradbury (Chair)	Tjurunga Pty Ltd, Australia & Australian National University
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
Dr Ernesto Arias	Lab. Ecología de Ecosistemas de Arrecifes Coralinos, CINVESTAV-U, Mexico
Dr Peter Campbell	Advanced Computer Applications Center, Argonne National Laboratory, USA
Prof. Craig Johnson	Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Australia
Dr Bohdan Durnota	Tjurunga Pty Ltd, Australia
Prof. Rob Seymour	University College London, U.K

The Modelling & Decision Support Working Group (MDSWG) has presented and contributed to the ITMEMS conference in Cozumel and a technical workshop in Akumal with Mesoamerican Barrier Reef System (MBRS) stakeholders. The Group is building capacity through local stakeholder workshops and is sponsoring or supporting six postgraduate or postdoctoral positions in Mexico, Australia, Philippines and the U.K.

Fieldwork in the Philippines and Mexico included socio-economic surveys of four towns in the Lingayen Gulf (Philippines) representing direct users of the Bolinao-Anda reef complex. This was followed by two feedback workshops for Local Government officials, some of whom are already using the results and recommendations. This study resulted in a series of manuscripts for publication and presentations to local and international symposia.

In Mexico, the Group has consolidated its database of coral and fish for 11 sites along the length of the MBRS, analysed the data, and developed and empirically validated a powerful tool to generate the geomorphological classes from easily available imagery. This has led to strong empirical relationships between such geomorphological classes and the structure of both coral and fish communities.

Next generation of ReefGame developed

The MDSWG's development of biophysical models has continued with work on the fundamental model structure including: continued refinement of the deterministic model; conversion of discrete deterministic model to a continuous model with differential equations; and continued development of the stochastic model. A spatial extension to the fundamental model is indicating that boundary interactions do not necessarily buffer a phase shift; rather they may strengthen the effect; and up to a threshold of interaction strength, a more healthy reef patch (with higher grazing) may help improve coral cover at a less healthy patch.

The Group now has a fully validated fundamental mathematical framework, local and regional models that interact with each other and a first instantiation for the MBRS of a coupled local/regional model. This can form a platform for the creation of development scenarios for the MBRS region because they capture the main biophysical drivers in the system.

The MDSWG has developed the next generation of an agent-based participatory modelling game – ReefGame – which was the basis of a workshop held at the Marine Science Institute's Bolinao Marine Laboratory.

The workshop was very well received by all participants, which included fishing families, barangay captains, and government officials. Early feedback indicates that the fishers found the day valuable, interesting and stimulating. The officials noted that the novelty of the process encouraged the fishers to share their ideas and experiences – much more so than traditional questionnaires. The MDSWG believes that these stakeholder workshops, describing and modelling how people behave, are the most powerful way to influence people and change their behaviour - when people are added to the models, they are immediately of more interest to management and policy.

The 4th sketch of the global model was made available to stakeholders and critiqued by the Group in Bolinao in September. A simplified instantiation of the model, 'Oceana', was agreed in Bolinao to test its broad dynamical behaviour, and this has also been released to stakeholders for comment and criticism.

The MDSWG held an international workshop in the Yucatan on the socio-economic dimensions of the coral reef problem identified research methods, priorities and socio-economic drivers across the CRTR study regions. The outcomes from this workshop included:

- inter-institutional relationships and preliminary

- cooperation agreements initiated;
- consensus on local and regional focus areas;
- consensus on the need for a plurality of social research methods in order to capture local complexities;
- consensus that effective management of the reefs relies on a comprehensive understanding of socio-economic and political drivers;
- constructive exchange on barriers to greater local participation in CRTR project, especially for academics and non-government actors working outside strictly bio-physical and economic disciplines;
- identification of possible strategic alliances with other proposed and ongoing research projects addressing sustainability in the Mesoamerican region.

Demand continues for “Reef Restoration Concepts and Guidelines”

Collaborations with international organisations and projects continued throughout 2007

Restoration & Remediation Working Group

MEMBERS:

Dr Alasdair Edwards (Chair)	School of Biology, University of Newcastle, U.K
Emeritus Professor Ed Gomez (Co-Chair)	Marine Science Institute, University of the Philippines
Dr Richard Dodge	National Coral Reef Institute, Nova Southeastern University
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 (JWRC), Japan

The Restoration & Remediation Working Group (RRWG) has supported and trained six post-graduate students from a number of countries during the past year. The Group has also provided support for a technician at Bolinao Marine Laboratory (BML) and met the fieldwork costs of four students from developed countries.

The publication of *Reef Restoration Concepts and Guidelines: making sensible management choices in the face of uncertainty*, both in printed and electronic form (available from www.gefcoral.org) has continued to provide policy guidance to governments, managers and NGOs. Over 600 hard copies have been distributed on-demand to a wide audience, whilst a targeted marketing campaign to key audiences is to be undertaken in early 2008 to ensure that the Guidelines reach all appropriate practitioners and managers. In addition to the hard copy distribution, approximately 700 electronic copies have been downloaded from the CRTR Program website during 2007.

Collaborations continued with projects and organisations including: 1) a pilot IEC activity to raise awareness of marine life among coastal dwellers dependent on coral reefs was held in three communities in Bolinao as a joint initiative of the CoE and the RRWG, in partnership with World Wide Fund for Nature and in cooperation with the local government units and the Philippines Department of Education. 2) A regional workshop on coral reef restoration was also held in collaboration with EC REEFRES project at the South-East Asia CoE with participants from Thailand, Indonesia, Vietnam, Malaysia, Singapore and Philippines as well as researchers from UK, USA, Israel and Italy.

The Group's research projects have also made progress during the year with work on the long-term efficacy and

First detailed data of coral reproduction timing at Bolinao



Sample fragment (*Acropora digitifera*) in tygon tubing placed at Ioul Luke's Reef in Koror, Palau for a growth and survivorship experiment. Background colony is *A. digitifera*. (Photo: Charles Boch)

cost-effectiveness of restoration interventions continuing at contrasting sites in Mexico, Palau and Philippines. Standardized Modules (SMs) are being monitored for treatments that include controls, artificial substrate pads, settlement plates, addition of grazing snails (*Trochus*), and addition of coral transplants at varying densities. Monitoring on the SMs and on the adjacent reef includes key processes linked to natural recovery: 'visible' coral recruitment, growth of corals, coral survival, fish herbivory, and algal growth. All sites were affected to some extent during the year due to impacts from Hurricane Dean (Akumal, Mexico), and bleaching and a crown-of-thorns starfish outbreak (Bolinao, Philippines). Despite these setbacks, the characterisation of the rates of key processes influencing recovery and ultimately the outputs will assist in modelling restoration scenarios.

Under the larval recruitment project based in Bolinao the Group is studying the effects of fragmentation and transplantation on reproduction in the corals by monitoring growth, fecundity and survival of both transplants and donor and control colonies. The timing of coral reproduction around Bolinao has now been established (this is the first detailed data for the Philippines), and the effects of fragmentation on reproduction and survival are beginning to emerge. Two sets of recruitment tiles have been retrieved with very different coral communities. Gravid *Acropora* colonies were also successfully spawned in the BML outdoor hatchery and spat were settled onto conditioned tiles in order to study how herbivory and spat density affect post-settlement survival.

The RRWG has assessed the cost-effectiveness of mass culture of juvenile corals on substrates with juveniles of the grazing snail, *Trochus niloticus*, in midwater nurseries, and efficacy of transplantation to the reef after one year. At Palau the Group has checked on growth and survival of juvenile corals cultured with grazing snails in cages in the mid-water nursery; transplanted the 1-year old cultured corals to pallet balls on Lukes Reef; carried out a second mass-culture experiment using sexual propagation; and monitored spat at around 12 months post-settlement. Survival rates of the juvenile *Acropora* were perhaps 2 orders of magnitude better than the wild. Costs of rearing based on the current experiments suggest ~US\$10 per 1-year juvenile colony ready for out-planting.

Work on enhancing recovery by transplantation of corals continued with monitoring of growth and survival of

transplants on the nine degraded bommies at Bolinao. Results show that *Porites cylindrica* has much better survival compared to *Montipora digitata* but that there do not appear to be any significant differences based on density and surface orientation of attachment. *Pavona danai* is now being tested at the two sites to further our understanding of which species are most suitable for transplantation under different conditions and why.

Work has also continued with the nurseries near Silaqui Island, Bolinao on enhancing recovery by *in situ* culturing of corals in nurseries. This research aims to discover which species are most suitable for nursery culture, how long they need to be cultured, what rearing techniques work best and are most cost-effective, and how well the farmed coral colonies can adapt when out-planted to degraded reef areas. Prior to the June 2007 bleaching event, survivorship in both nurseries was around 80-90%. The bleaching reduced survivorship to ~60% and provided further data on relative susceptibilities among species (e.g. *Acropora muricata* was wiped out). A new rope nursery of improved design was established for detailed experimentation on coral growth and survival of four species.

The Group is also using recently developed molecular markers to evaluate the genetic background of a limited number of coral species. The first set of DNA samples from four populations of *Pocillopora damicornis* was collected in late 2006 and extraction of high molecular weight DNA has been successfully completed. The next stage is to use microsatellites to evaluate the population genetics.

Remote Sensing Working Group

MEMBERS:

Prof. Peter Mumby (Chair)	Marine Spatial Ecology Lab, School of Biological Sciences, Hatherly Laboratory, University of Exeter, U.K
Dr Laura David (Co-Chair)	Marine Science Institute, University of the Philippines
Prof. Stuart Phinn	School of Geography, Planning and Architecture, The University of Queensland
Prof. Ellsworth LeDrew	Faculty of Environmental Studies, University of Waterloo, Canada
Dr Mark Eakin	Marine Applications Science Team (MAST), Coral Reef Watch Project, NOAA
Dr William Skirving	Coral Reef Watch Project, NOAA
Dr Alan Strong	Marine Applications Science Team (MAST), Coral Reef Watch Project, NOAA

Capacity building activities of the Remote Sensing Working Group (RSWG) consisted of personal training of CRTR students in remote sensing with special application to their research. Four students participated, resulting in two draft papers and the first national marine habitat map being created of Palau. Two full CRTR workshops for coral reef managers and technical staff were held in Puerto Morelos and Zanzibar (in collaboration with the Reef Restoration Working Group).

New data products were generated including a web-portal for directing users to sources of satellite data on factors affecting coral reefs and new bleaching metrics around Centres of Excellence.

Inter-working group activities have been strong, with the RSWG joining with the Disease Working Group (DWG) to identify new algorithms for coral disease prediction and new parameterisation for modelling. Collaboration with the Bleaching Working Group (BWG) developed new algorithms for coral bleaching. RSWG is involved in a study of reef recovery in Palau personnel from the Restoration and Rehabilitation (RRWG), Bleaching and Connectivity (CWG) Working Groups and a regional study of coral gene flow that also includes members of the DWG and CWG.

Coincident and satellite-image field data sets for coral reef environments, in Belize, Palau, Australia and Fiji have been used to develop techniques for rapid field surveys of benthic cover to produce spatial information for mapping and calibration/validation of image data sets of coral reefs. Techniques have also been developed for processing the field data to drive the image based mapping process for mapping benthic cover from high

Creation of first national marine habitat map of Palau

Web portal for directing users to sources of satellite data on factors affecting coral reefs generated

New algorithms for coral disease prediction and coral bleaching developed

On-line toolkit developed for mapping and monitoring coral reefs, seagrass beds and water quality



Photo: Laura David

Excellent results have been achieved through further validation experiments of the three-dimensional radiative transfer model

spatial resolution satellite images. The group is now in the final stages of applying these techniques to image and field sites. Standard and advanced image processing techniques are also being compared to assess the additional information and costs provided by more advanced data and processing approaches.

An on-line toolkit has been developed for selecting suitable image data and mapping techniques for mapping and monitoring coral reefs, seagrass beds (from another project) and water quality

(www.gpa.uq.edu.au/CRSSIS/tools/rstoolkit/). This toolkit shows managers, scientists and technicians working in coastal marine environments how remote sensing can map and monitor changes to indicators of coastal ecosystem health. This toolkit currently focuses on coastal water bodies, seagrass and coral reefs, and mangroves but future work will extend it to cover all other coastal ecosystems

(www.coastal.crc.org.au/cwhm/toolkit/).

Collaboration with other research organizations and agencies has resulted in a year-long deployment of thermistors where coral bleaching occurred in the northern Philippines so that data can be compared to the AVHRR thermal signatures of 2006-07.

The RSWG also had input to a workshop on use of RS-GIS as a tool for coastal planning was conducted for Bolinao and nearby coastal municipalities. Another tool that is being developed collaboratively for use by coastal managers is a technique of Rapid Reef Assessment where an under-boat towed video transect that can be analyzed unsupervised. Together through the RSWG, the development team has shown reliable assessment of living vs non-living components from a video stream using data obtained during the Palau field work last April 2006.

The same group is also currently honing the method to distinguish live coral, dead coral, algae, and abiotic. After refinement they plan to apply the same analysis to the more complex reef of Bolinao. If successful, this will give managers a hassle free quick assessment of the state of their reefs and reliably detect change. The group is also developing methods to determine reef rugosity, size and frequency of holes, and degree of bleaching.

The three-dimensional radiative transfer model has been subjected to further validation experiments with excellent results. This indicates that the formulation of the Radiative Transfer Equation in the 3D Model is correct and converges to the analytical solution very quickly, and that the software implementation is largely error-free.

The model is now considered conceptually complete but not ready for distribution to third parties. A manuscript describing the model is in preparation with the intention of submission to the Journal Applied Optics.

A major piece of work is a large scale modeling based sensitivity analysis for the ability to discriminate key coral reef benthic types under varying environmental conditions, and consequently provides specific advice on the design of remote sensing instruments for coral reef applications. Not only is this the first time the optical properties of actual coral reef waters have been utilized in such an analysis, the Group's substantial dataset allows consideration of spatial and temporal variability of optical properties across the reef environment.

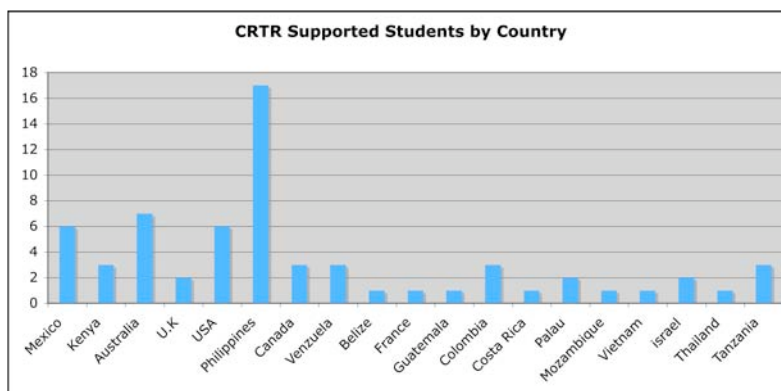
Two collaborative projects with members of the BWG are exploring the use of the Radiosity model to investigate spectral mixing processes on corals. These projects will seek to establish the light-fields around coral structures under differing solar and sea state conditions for both photobiology and remote sensing objectives.

Investigation of multiple light scattering effects within differing coral morphologies, at differing depths and under different illumination conditions, is beginning with construction of the basic model input parameters and evaluating model internal accuracy tests.

CRTR Students²

The CRTR Program through the Working Groups and Centres of Excellence are sponsoring or supporting 64 masters, postgraduate students or post-doctoral fellows in 19 countries. Further to this there have been a number of sponsorship opportunities for developing country participants to attend training workshops held by the Working Groups and Centres of Excellence.

Figure 3: CRTR Supported students by country



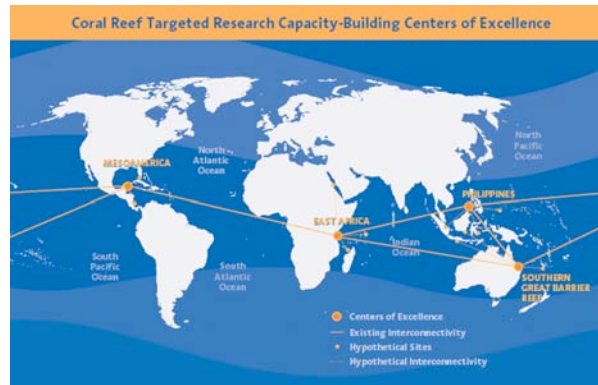
² This table only includes those students supported through scholarships or other assistance mentioned in Working Group or Centre of Excellence annual reports, and does not include those students working in CRTR member's laboratories nor students who received scholarships to training workshops.

NAME	COUNTRY OF ORIGIN	INSTITUTION	SCHOLARSHIP TYPE	TITLE / AREA OF STUDY
Jackie Padillo-Gamino	Mexico	University of Hawaii	PhD	Assessing the impacts of disturbance on reproduction of corals
Mebrahtu Ateweberhan	Kenya	Wildlife Conservation Society	Postdoc	TBA
Juliet Furaha	Kenya	Moj University	Masters	The influence of area protection and site characteristics on recruitment, survival, and growth of coral species on the Kenyan Coast
Shakil Visram	Kenya	CORDIO	Postdoc	TBA
Juan Carlos Ortiz	Venezuela	The University of Queensland, Australia	Postdoc	TBA
Nathaniel Alvarado	Belize	University of Maine, USA	BSc	Coral ecology
Angela Mojica	Guatemala	Old Dominion University, USA	MSc	Impact of grazing crabs on coral reefs and Postlarval lobster responses to settlement cues
Ainhoa León Zubillaga	Venezuela	Universidad Simón Bolívar, Caracas	MSc	Genetics and connectivity of Acropora palmata
Isabel Porto Morales	Colombia	Universidad de los Andes, Colombia	MSc	Coral genetics and connectivity
Eva María Salas De La Fuente	Costa Rica	Centro de Investigación en Ciencias del Mar y Limnología, Universidad de Costa Rica	MSc	Population genetics of the Bicolor damselfish, Stegastes partitus
Roger Theissen	Canada	University of Windsor, Canada	Masters	Population genetics and connectivity in reef fish
David Williamson	Australia	James Cook University, Australia	PhD	Connectivity in reef fishes
Derek Hogan	Canada	University of Windsor, Canada	Postdoc	Otolith chemistry approaches to fish connectivity
Pablo Saenz Agudelo	Colombia	Perpignan University, France	PhD	Genetic connectivity in reef fish
Suzanne Arnold	USA	University of Maine, USA	PhD	Coral settlement and recruitment
Carmen Amelia Villegas Sanchez	Mexico	CINVESTAV, Merida, Mexico	PhD	Coral connectivity
Aldo Croquer	Venezuela	University of Puerto Rico	Postdoc	Geographic assessment and monitoring of diseases in the wider Caribbean
Guillermo Jordán Garza	Mexico	Instituto de Ciencias del Mar y Limnología, Mexico	Masters	Geographic assessment and monitoring of diseases on Mexico reefs
Alma Ridep-Morris	Palau	James Cook University, Australia	Masters	The dynamics and epidemiology of a coral disease outbreak in Nikko Bay
Cathie Page	USA	James Cook University, Australia	PhD	TBA
Maria Rodrigues	Mozambique	James Cook University, Australia	PhD	Assessment of the prevalence of diseases on coral communities from the south-western Indian Ocean
Courtney Crouch	USA	Cornell University, USA	Masters	TBA
Kathryn Rosell	Philippines	University of the Philippines	Masters	The effects of the riverine discharges on coral disease prevalence
Tak Ching Fung	UK	University College, UK	PhD	Modelling coral reef ecosystems and their interaction with human societies
Rollan Geronimo	Philippines	University of the Philippines	MSc	Modeling marine protected area networks along the South China Sea
Jessica Melbourne-Thomas	Australia	University of Tasmania, Australia	PhD	Decision support systems for managing coral reefs at a regional scale
Yves-Marie Bozec	France	CINVESTAV, Merida, Mexico	Postdoc	Analysis of reef dynamics
Gilberto Acosta Gonzalez	Mexico	CINVESTAV, Merida, Mexico	Postdoc	TBA
Deborah Cleland	Australia	Australian National University, Australia	BSc (hons)	Summer Research Scholarship
David Idip	Palau	Canada (2/3) and Exeter (1/3)	MSc	Dedicated training in remote sensing: mapping reefs, bathymetry, wave exposure and beta diversity of Palau
Robert Canto	Philippines	The University of	PhD	Benthic algal growth controls in coral reefs

NAME	COUNTRY OF ORIGIN	INSTITUTION	SCHOLARSHIP TYPE	TITLE / AREA OF STUDY
Chris Roelfsema	Australia	Queensland, Australia The University of QLD, Australia	PhD	Integrating field and remotely sensed data: Low cost, community-based assessment of tropical marine ecosystem health in developing nations
Ian Leiper	Australia	TBC	PhD	Mapping tropical marine communities for direct application purposes using remote sensing techniques
Tran Van Dien	Vietnam	TBC	PhD	Develop tools for mapping and monitoring reef composition and condition in the turbid and clear coastal waters of Vietnam
Zolan Botin	Philippines	University of the Philippines	PhD	Data and computer hardware support
Ma. Sheila Angeli Marcos	Philippines	University of the Philippines	PhD	Field support in Palau and Bolinao
Sonia Bejarano	Colombia	University of Exeter	PhD	Use of acoustic remote sensing to predict relative fish density and grazing intensity
Alan Lim	Canada	University of Waterloo	PhD	Use of remote sensing to detect ecological changes in coral reef environments using textural measures
Victor Ticzon	Philippines	University of the Philippines	Masters	Use of remote sensing to predict the density of keystone taxa
Eileen Penaflor	Philippines	University of the Philippines	PhD	Remote sensing of coral bleaching
Kareen Vicentuan	Philippines	University of the Philippines	Masters	The reproductive biology of scleractinian corals and in addition, the effects of fragmentation on their reproductive status
Iris Boliozos	Philippines	University of the Philippines	Masters	TBA
Maria Vanessa Baria	Philippines	University of the Philippines	Masters	Spatial and temporal patterns of coral recruitment in Bolinao, Pangasinan
Patrick Cabaitan	Philippines	University of the Philippines	Masters	Coral reef restoration
Marcos Alberto Rangel Avalos	Mexico	Instituto Tecnológico de Boca del Rio, Mexico	Masters	TBA
Charles Boch	USA	University of California Santa Barbara, USA	PhD	Investigate the reproductive cycle of <i>Acropora</i> spp. to enhance our understanding of coral mass spawning and the mechanisms regulating and controlling reproduction
Li Shaish	Israel	Isreal Oceanographic and Limnological Research, Israel	PhD	Coral reef restoration & remediation
Gideon Levy	Israel	Isreal Oceanographic and Limnological Research, Israel	PhD	Coral reef restoration & remediation
Kirk Kilfoyle	USA	Nova Southeastern University Oceanographic Center, USA	Masters	Assessing the effectiveness of various artificial reef designs, monitoring changes in fish assemblages on coral reefs
Dexter De La Cruz	Philippines	University of the Philippines	Masters	A critical look at the use of the 'coral nursery' as a intermediate step in coral restoration in Bolinao, Pangasinan, Philippines
Heidi Schuttenberg	USA	James Cook University, Australia	PhD	Understanding Effective Coral Reef Governance
Narinratana Kongjandtre	Thailand	The University of Queensland, Australia	PhD	Taxonomy and connectivity of corals from the genus <i>Favia</i> in Thailand and on the southern Great Barrier Reef.
Scott Hook	Australia	The University of Queensland, Australia	PhD	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 State capacity to protect coastal regions in Fiji
Simon Albert	Australia	The University of Queensland, Australia	PhD	New tools to identify coral reef ecosystems at risk
Nsajigwa Mbije	Tanzania	University of Dar es Salaam, Tanzania	PhD	Assessing the applicability of the gardening concept, evaluate and develop the protocols for reef restoration
Leonard Jones Chauka	Tanzania	University of Dar es Salaam, Tanzania	PhD	Molecular and physiological studies of <i>Symbiodinium</i> harbored by reef building corals of Tanzania in relation to environmental stress
Mohammed Suleiman Mohammed	Tanzania	State University of Zanzibar	PhD	Distribution and Dynamics of Coral Diseases and its Relation to Coral Health and Local Environmental

NAME	COUNTRY OF ORIGIN	INSTITUTION	SCHOLARSHIP TYPE	TITLE / AREA OF STUDY
Cesar Coronado	Mexico	Centro de Investigación Científica y de Educación Superior de Ensenada. Mexico	PhD	Factors in Tanzania Water Circulation in the Puerto Morelos Reef Lagoon
Paul Fisher	UK	Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México	Postdoc	TBA
Mark Dondi Arboleda	Philippines	Marine Science Institute, University of the Philippines	PhD	Biology
Rachel Ravago-Gotangco	Philippines	Marine Science Institute, University of the Philippines	PhD	Marine Science
Mark Vergara	Philippines	Marine Science Institute, University of the Philippines	MSc	Marine Science
Candice Lumibao	Philippines	Marine Science Institute, University of the Philippines	MSc	Marine Science
Miahnie Joy Pueblos	Philippines	Marine Science Institute, University of the Philippines	MSc	Marine Science

Component Two: Promoting Scientific Learning and Capacity Building



Component Summary

Component Two of the CRTR 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 intends to achieve this aim through:

- helping to build or enhance the capacity of institutions in at least three developing country sites within the first phase of the Program, so that they can function as Centres of Excellence (CoE) for coral reef research;
- developing from the research, and in close consultation with managers and on-ground participants, opportunities, products and networks that can lead to better management and strengthened policies regarding coral reefs in the Project's chosen regional sites ,

The four CoEs for the first phase of the Program are based in major coral reef regions around the world:

- Southeast Asia: Marine Science Institute/Bolinao Marine Laboratory, University of the Philippines.
- Eastern Africa: Institute of Marine Sciences (IMS), of the University of Dar Es Salaam, Zanzibar, Tanzania.
- Western Caribbean/Mesoamerica: Unidad Académica Puerto Morelos, Instituto de Ciencias

- del Mar y Limnología, Universidad Nacional Autónoma de México (UNAM).
- South Pacific/Australasia: Heron Island Research Laboratory of the Centre for Marine Studies, The University of Queensland, Australia.



Photo: Ove Hoegh-Guldberg

New insights and projections of how benthic reef communities are likely to behave under multivariate environmental stressors

Australasian Centre of Excellence

Contact: Professor Ove Hoegh-Guldberg, Centre for Marine Studies, The University of Queensland

The major technical focus for the Centre of Excellence has been supporting the research and operations of the Bleaching Working Group through Professor Ove Hoegh-Guldberg's laboratory at the Centre for Marine Studies, UQ. A full report on the technical achievements and a listing of publications from the Hoegh-Guldberg laboratory is available under the Bleaching Working Group annual report. Further to this, the Australasian Centre of Excellence has continued to support the efforts of Centre for Marine Studies students during the year and these efforts have contributed towards the Bleaching Working Group research.

Dr Ken Anthony received a Packard Foundation grant to develop an information tool package that can help managers assess how coral reef communities will change in response to environmental stress. The project is using a combination of physiological niche modeling, Bayesian belief networks and community matrix models as the general framework. This approach will allow the Centre to combine environmental, biological and ecological information from multiple sources and across multiple scales to produce semi-quantitative estimates of reef resilience. Although precise predictions will not be feasible, this project will provide new insights and projections of how benthic reef communities are likely to behave (within a confidence envelope) under multivariate environmental stressors.

The Centre of Excellence is a partner in the Integrated Marine Observing System (IMOS) designed to improve Australia's ability to monitor changes in its 16 million km² ocean territory. A component of the IMOS project will establish a wireless sensing network that will be the basis of a sophisticated monitoring network at Heron and One Tree Islands. This has enabled funding for a superseded project to be redirected toward other capacity building exercises of the Australasian CoE.

Capacity building activities during the year included sponsorship of nine participants from the Pacific and Southeast Asia to attend the *Tropical Marine Invertebrates* course; the *Coastal Resources Management Course*, and the *Marine Neurobiology* course as part of the Great Barrier Reef Study Program. A second training opportunity involved sponsorship of participants to attend the *Responding to Mass Bleaching and Climate Change Workshop* organized by the Great Barrier Reef Marine Park Authority (GBRMPA) and the National Oceanographic and Atmospheric Administration

(NOAA) which presented a practical training package to coral reef managers that explores strategies to respond to the threat of mass coral bleaching and climate change.

The Centre has continued to establish and enhance networks throughout the region through various forums including meetings, conferences and information dissemination, and has progressed against its objectives through 2007 despite the setback experienced with the loss of laboratory and accommodation facilities at Heron Island.



Landing site where fish are landed after being caught, east coast of Unguja, Zanzibar (Photo: Narriman Jiddawi)

The CoE has been involved in providing technical advice to groups undertaking community-based coral reef monitoring programs

East African Centre of Excellence

Contact: Dr Alfonse Dubi, Institute of Marine Sciences, University of Dar es Salaam

The East African Centre of Excellence continues to serve as a hub for research and capacity building activities in the region. Facilities continued to be upgraded to support this effort during 2007, and the Centre of Excellence hosted numerous visiting researchers and training workshops.

During the year the Centre of Excellence has provided support to three postgraduate students and hosted researchers from the Bleaching, Remote Sensing and Restoration & Remediation Working Groups. The BWG assisted in assessing coral reef health in selected sites on the west and east coast of Unguja Island. A GIS and Remote Sensing training workshop, supported by recently acquired Ikonos Satellite images for Unguja, helped to update existing coral reef distribution maps and to describe in greater detail the health status of reefs.

The CoE has been called upon on a number of occasions to provide advice and technical assistance to a range of stakeholders. During the year, the CoE assisted KICAMP and Kinondoni Municipal Council in describing the location (mapping) and status of coastal resources on the Dar es Salaam coast as well as developing a searchable database for use in decision making. The Centre has also started to investigate how to inform and build capacity of Zanzibar Local Government and the community at large to adopt environmentally friendly practices for coral reefs.

The CoE reviewed coral reef monitoring programs in Tanzania, combining recent CRTR project data on coral health with that of previous coral reef monitoring. This review was presented during the Tanzania Marine Forum held in Dar es Salaam along with other papers from CoE personnel. The forum discussions benefited stakeholders from research and training institutions, private sector, community organizations, coastal management programs, public institutions and local communities.

The CoE has also been involved in providing technical advice to various groups undertaking community-based coral reef monitoring programs in Bagamoyo, Mkuranga, and Tanga. These activities have highlighted the need for a community-based monitoring manual to establish protocols and ensure consistency of data.

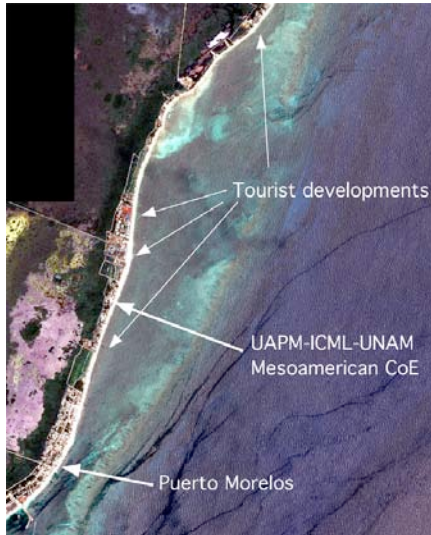


Image courtesy of Roberto Iglesias-Prieto

Products from the local research projects will benefit managers of the local marine protected areas

Mesoamerican Centre of Excellence

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

The Mesoamerican Centre of Excellence is continuing to work with the Bleaching, Disease, Remote Sensing, and Restoration & Remediation Working Groups in undertaking and hosting research. Further to the Working Group activities, the Centre is also conducting two local research projects looking at (1) the development of a hydrodynamic model for the circulation of the reef lagoon, and (2) an analysis of the local watershed to assess the influence of groundwater on the reef lagoon. Under the first project, activities are continuing on schedule and the first peer review paper describing the general characteristics of the water circulation in Puerto Morelos was published in *Coral Reefs* in February 2007. Under the groundwater project, activities related to the analysis of the nutrient distribution in the local watershed and in the reef lagoon were initiated and work on the physical properties of the local watershed continued as scheduled. The final products of these projects will benefit the managers of the local marine protected areas, with the early results already being incorporated into direct management actions. The CoE conducted Courses on *Light and Photosynthesis on Coral Reefs* (with 15 students from 9 countries) and *Marine Protected Areas* (with 28 students from 6 countries supported by 14 lecturers from several institutions in 3 countries).

The CoE has also continued to link the scientific results to local managers and policy decision-makers by participating in local, regional and national forums including the National Scientific Advisory Council on Coral Reefs for the Mexican Federal Government, of which Dr Iglesias-Prieto is the president, and in maintaining constant communication with the management community through the participation at advisory committees and workshops. The first workshop, attended by 16 managers from 2 countries, was divided in two sections. During the first part Dr. Al Strong from NOAA and the Remote Sensing Group presented a hands on workshop on the use of the satellite tools from NOAA, and in the second part the objectives and the scope of the CoE were presented by local members of most of the working groups.



Photo: Mark Windell Vergara

Impacts of mariculture and eutrophication on the health of the coral reefs in Bolinao is being investigated

Southeast Asian Centre of Excellence

Contact: Emeritus Professor Ed Gomez, Marine Science Institute, University of the Philippines

The past year has seen further development of the Southeast Asian Centre of Excellence based at the University of the Philippines' Marine Science Institute. Improved infrastructure has ensured a high standard of facilities for Working Groups, and visiting and local researchers. The CoE continues to directly support two doctoral students and three masters students plus two doctoral and four masters level students under various CRTR Working Groups. The GEF and CoE students and staff also participated in the training/workshops: 1) the short course on coral taxonomy; 2) the mini-symposium and workshop led by the Coral Disease Working Group (DWG); and 3) the Communications Training/Workshop.

The CoE successfully hosted the mini-symposium and workshop of the DWG attended by national government agencies, non-government organizations and the academe. This was followed by a workshop for Working Group members and students, investigating the impacts of mariculture and eutrophication on the health of corals/coral reefs in Bolinao.

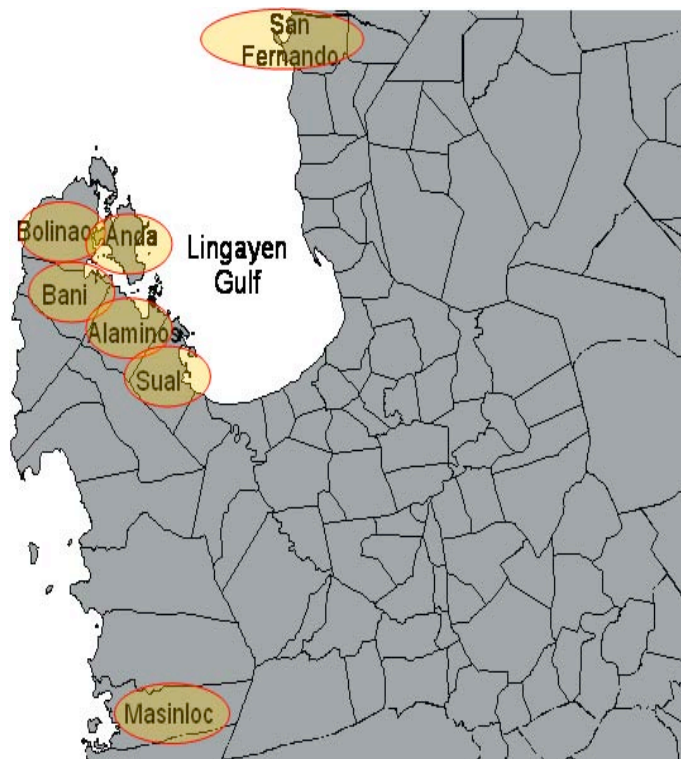
The three local projects continue to make progress:

1. The Coral Taxonomy project has updated, the on-line map library of Philippine corals now including information on coral distribution, species lists, virtual museum, taxonomic guides and featured species. Data from this research will contribute to a field guide to the corals of Bolinao and Western Luzon.
2. A Field Guide to the Bubble Corals of the Philippines has been developed. This will be used with non-scientist divers who are trained by the project to map the distributions of these corals in the Philippines.
3. The Guide to the Corals of Bolinao and Western Luzon has commenced with field surveys and taxonomic identification of the coral species photographed.

Under the Local Government Initiative (LGI), the CoE conducted a one-day workshop entitled *Rules of Engagement, Recording System and other SOPs in Coastal Law Enforcement*. The participants were law enforcers including MPA managers and local enforcers from the barangays with established coral reef marine protected areas. The LGI project will assist conservation of coral reef ecosystems by improving governance and

management of the coastal zone. An important outcome of the workshop was the formulation of draft operating procedures on coastal law enforcement. Follow-up meetings and workshops will develop an operational manual on the rules of engagement.

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Map of participating local municipalities – Philippines Local Government Initiative

Component Three: Linking Scientific Knowledge to Management & Policy

During the past year activity under the 'linking science knowledge to management and policy' has increased with significant inroads being made in the development of research outputs and results, which will be able to be applied to these audiences. Specific activities of note include:

'The Carbon Crisis: Coral Reefs under Rapid Climate Change'

Following on from the February 2007 synthesis meeting in San Diego, a panel of 17 CRTR researchers has developed a research paper titled "*The Carbon Crisis: Coral Reefs under Rapid Climate Change*" which will be published in the December 2007 issue of *Science*. The paper is the inaugural 'synthesis' product of the CRTR Program integrating elements of research from across the Program's research portfolio. The information contained in this paper will be developed into appropriate information products for management and policy communities.

Common Sampling Project

Strong progress continues on the ecological and environmental monitoring under the Common Sampling Project. Under the project, the interest is in the processes that influence the structure of reef communities (in the direct vicinity of the CoEs) to provide impetus, local ownership and capacity within each region. Momentum is building across the four regions in Mexico, Australia, Zanzibar and the Philippines, under the guidance of Professor Robert van Woelk with approximately 18 sites now set up at the four Centres of Excellence.



Members of the Common Sampling Project at the October 2007 Workshop in Florida, USA

CRTR Future Leaders Forum

From the 10-14 December 2007, the Australasian Centre of Excellence at The University of Queensland will host 55 of the Program's Masters and Postgraduate students, and Postdoctoral fellows from 17 countries. The Forum purpose of the Forum is to develop the network of the future leaders in marine and coral reef ecosystem research and management; assist in building their capacity to understand global issues impacting on these ecosystems, and; to develop new knowledge and skills to assist them in their current and future roles. Specifically, the aims are to:

- Empower the students/participants with the latest knowledge and skills to assist them in integrating a broad range of information into their future roles as coral reef and coastal ecosystem researchers and/or managers.
- Build peer networks, and strengthen existing regional and international networks amongst the participants in order to strengthen effective information and knowledge transfers.
- Bring together world-renowned international researchers and managers in marine ecosystems together with the students to provide mentoring and knowledge exchange to build on, and develop existing knowledge and skills.
- Transfer capacity building skills and expertise to strengthen the capacity and knowledge of the participants for governance, research and management of marine resources.
- Develop an understanding of effective techniques in communicating research outputs to various audiences in order to ensure effective uptake of the

- information to preserve the marine environment in developing countries.

Local Government Initiative

The Local Government Initiative (LGI) is continuing to proceed in all four regions where the Centres of Excellence are located. In the Philippines, the Centre of Excellence is progressing well with stakeholders meetings including law enforces, MPA managers and local enforcers from the barangays looking at assisting in the effort to conserve coral reefs by improving governance and management of the coastal zone.

The Australasian Centre of Excellence is undertaking a three-site study (Solomon Islands, Cook Islands and Fiji) with the main focus on the Solomon Islands. The CoE is focusing on working with a local community to explore the activities creating pressure on the local ecosystems, and to determine if there is enough local capacity to implement the necessary management responses to these pressures. The outcome will be the establishment of an action plan to combat some of these pressures and reduce the impact on the coral reef ecosystem.

In Mexico, Centro Ecologica Akumal is leading the LGI and will be focusing on informing coastal development decision-making with robust information about threats to coral reef health and how these affect ecosystem goods and services on which coastal communities rely, state and federal regulations and norms designed to protect vulnerable coastal habitats and resources, and to make decision-making more participatory by empowering civil society and other stakeholders with this information.

Lastly, the East African Centre of Excellence's LGI aim is to get local governments and key stakeholders e.g. WIOMSA, MACEMP, dive operators, boat operators and the public in general, to focus on the problems facing coral reefs, identifying those that are of highest priority and which they are committed to addressing, and coming up with possible solutions and plans to implement these with the help of the COE. The expected outcome will be improvements in the practices and policies of the Zanzibar Local Government, the public and other key stakeholders who influence pressures on coral reefs to promote the sustainability of coral reef ecosystems and result in greater benefits for Zanzibar society.



Participants at the MDSWG Workshop on socio-economic dimensions of the coral reef problem – Merida, Yucatan (May 2007).
Photo Credit: Rollan Geronimo

Synthesis Research Projects

Socio-economic Workshop – Modelling & Decision Support Working Group

In April 2007, the Modelling & Decision Support Working Group (MDSWG) organized and held a socio-economic workshop at CINVESTAV (Merida, Yucatan, Mexico). The socio-economic environment of coral reefs is increasingly seen as a major component to be taken into account by the CRTR program. Socio-economic drivers are often instrumental in modifying the resilience of the reefs, and they are also the ones the CRTR's outcomes will finally influence in order to preserve coral reefs while contributing to poverty alleviation in the concerned areas.

The CRTR Program requires coordinated research on socio-economic drivers and processes that affect Mesoamerican reefs, Western Philippines reefs, Eastern Africa reefs, and South Pacific reefs. As socio-economic environments are largely different from one benchmark site to another, it is essential to rely on common methodologies and research objectives across the different regions. The proposed workshop brought together selected experts from each region to address the following issues:

- To assess the current level of socio-economic knowledge for each benchmark site.
- To overlap the different methodologies in use across the benchmark sites.
- To select a given set of scale-dependent socio-economic issues that need to be addressed.
- To agree on common methodologies to address these issues.
- To produce a handbook synthesizing the above findings.

The results from the workshop are currently being incorporated into the MDSWG models, and a handbook synthesizing the findings is currently being developed.

Modelling the Impact of Coral Disease on Caribbean Coral Reefs

(Collaboration between the DWG and RSWG)

In June 2007, members of the Disease Working Group (DWG) and Remote Sensing Working Group (RSWG) met to discuss and simulate the effect of disease outbreaks on Caribbean coral reefs and evaluate the scope for mitigation using marine reserves. Marine reserves are heralded by some as a panacea for conservation yet their role in mitigating many key disturbances, such as bleaching and coral disease, are not clear. The workshop combined expertise and new empirical studies from within the CRTR Program to address this question. A more detailed summary of the workshop can be seen in the Disease Working Group section of this Report, however, some specific outputs from this meeting will include 1) a Scientific paper entitled 'The role of marine reserves in mitigating outbreaks of coral disease in Caribbean reefs', and 2) a CRTR Policy Brief on the use of marine reserves to mitigate coral disease.

Component Four: Program Management

The CRTR Program is managed by The University of Queensland (Australia) as the Project Executing Agency (PEA) on behalf of the World Bank. Management of the Program includes day-to-day management and administrative requirements; contracting of all projects and sub-grants; financial management; communication oversight, and; monitoring and evaluation reporting.

As the midway point for the CRTR Program, 2007 has seen an increase in research activities producing results and outputs, which have been communicated in many forums to various audiences. Commencement of the Program's communication strategy has also seen an increase in the flow of research results being developed and disseminated for specific audiences and this will increase in 2008 as the Working Groups and Centres of Excellence begin to consolidate four years of research.

By the end of Year Three, all procedures and processes have been implemented and are functioning effectively and there has been continued consolidation of activities and strategies for the Program. The Program is now well positioned to ensure the research outputs and subsequent information items have an effective outcome and impact in the remaining two years of Phase 1 and beyond into subsequent phases.

Disbursements

Disbursements have continued during 2007 with the Program on-track to meet its projections. Activities have continued to be funded under Components One, Two, Three and Four during the past year.

GEF Funding

2007 has operated smoothly in terms of funds disbursement against approved activities, and as mentioned, the Program is on-target to meet its projections. Research activities have continued to increase and the outputs are increasing in line with funds disbursement.

DGF Funding

2007 is the final year for the disbursement of DGF funds, with the third and final tranche of the DGF Grant being received. These funds continued to support the activities of the Centres of Excellence, and activities which are actively linking the scientific outputs to the management and policy communities. All activities and disbursements are on-target to meet the contractual due date of 31 March 2008 for all funds to be expended.

Procurement

The procurement for the Project for the year is listed below:

Consultancies

- Mr Andy Hooten, Synthesis Panel Executive Secretary & U.S Coordinator.
- Centro Ecologica Akumal (Mexico) for support for Miguel Angel to assist with monitoring exercises for the Working Groups.
- Mr Garrett Strang for video footage and editing of interviews with key CRTR members, and locality footage at the Centres of Excellence.

Executive Committee Honoraria

As mentioned in previous reports, Drs Knowlton and Muthiga have been placed on the Honoraria list for their work undertaken on behalf of the Project as Executive Committee members.

Sub-Grants

During the reporting period there were no new sub-grants contracted by the Project Executing Agency.

Monitoring & Evaluation

The Program commenced monitoring and evaluation of its activities under the revised performance indicators in 2007, and a report on this can be obtained in the separate Monitoring & Evaluation Annual Report.

Communication

In 2007 the Program continued to make effective inroads into its communication program, despite the Program suffering a setback with the passing of its Communication Coordinator, Mr Kim Mitchell in June. Despite this, the guiding frameworks already established and implemented by Mr Mitchell effectively ensured that the Program's communications focus could continue to function effectively. Under the Currie Communications team of Mr Mark Paterson and Dr Bruce Munday, the communication focus remains on developing and enhancing networks to facilitate the exchange of current research findings relevant to coral reef management, and to develop and disseminate research-based information resources to core internal and external stakeholders.

Discussions have continued with Working Groups and Centres of Excellence to develop future products for their research outputs, and the most appropriate audiences and dissemination pathways for this information. 2008 will see an increase in activity for communication products with the release due of Disease Cards; a Disease Guidelines for Managers; Modelling for Managers; a Restoration Manual; an update on what we know on coral bleaching, and; other information sources and products as they arise.

During 2007, the communication outputs have included:

Centres of Excellence

During 2007, the Communication Coordinators met with the Centres of Excellence to assist in the development of a localised and regional communication and outreach strategy for the Centres. Each Centre of Excellence will continue to focus on awareness raising, and on increasing their outreach to target audiences as the results from research and other activities begin to emerge. These results will be synthesised and developed into appropriate audience information products as they arise.

'The Carbon Crisis'

As mentioned previously in this report, in December 2007, the CRTR Program will release its inaugural 'synthesised' research output with the publication of the paper *"The Carbon Crisis: Coral Reefs under Rapid Climate Change"* in the December issue of *Science*. The messages and information contained within this paper will be refined and strategically distributed to key management and policy stakeholders to ensure an effective uptake of the information.

CRTR Website

The CRTR website was realigned to ensure a stronger and more effective 'information centre' for the Program under the guidance of Mr Mitchell and further introduction of new materials and viewing platforms is now in place. With this 'new look' website in place we have noticed a large increase in the number of visitors to the site. For example, in 2006 there were 3,226 unique visitors; 4,381 number of visits; 18,118 pages accessed, and; 179,274 hits. In 2007 (as at end October), this increased to 6,361 unique visitors; 8,775 visits; 107,770 pages accessed, and; 221,562 hits (see figures 4 and 5 below).

Work will continue into 2008 to maintain a constant update of new information based on research and capacity building activities, along with targeted campaigns to raise awareness of the issues facing coral reefs, and the information available through the CRTR Program.

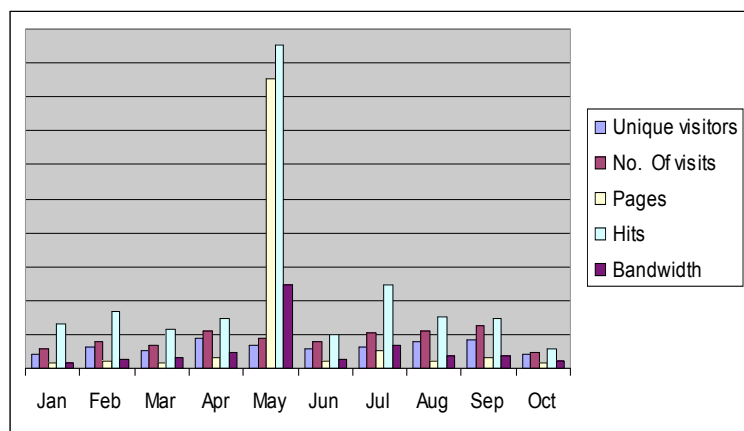


Figure 4: CRTR Website Monthly History by graph

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth (Mb)
Jan 2007	400	600	1660	12887	136.45
Feb 2007	648	805	2242	16686	273.19
Mar 2007	543	670	1760	11763	297.91
Apr 2007	880	1123	3200	14581	476.28
May 2007	663	904	85107	95308	2450
Jun 2007	594	795	2013	10168	284.44
Jul 2007	608	1050	5141	24546	701.54
Aug 2007	771	1103	2204	14977	370.23
Sep 2007	861	1248	2881	14636	381.33
Oct 2007	393	477	1562	6010	204.38
Total	6361	8775	107770	221562	5.50 GB

Figure 5: CRTR Website Monthly History showing figures

Publications

Members of the CRTR Working Groups and Centres of Excellence have continued to produce numerous papers, which have been published in a wide range of journals. Since the commencement of Phase 1, the Working Groups and Centres of Excellence have produced 490 journal articles; conference papers; manuals and guidelines; book chapters; media articles, and; books.

Events

The Working Groups and Centres of Excellence have been responsible for 120 events involving both developing and developed country participants since the commencement of Phase 1. These events include numerous training workshops; meetings; stakeholder workshops and sessions; presentations, and; conferences, and have led to an increase in awareness of the issues facing coral reef ecosystems, and improved technical skills in a range of applications.

Reef Restoration Concepts and Guidelines

The 'Reef Restoration Concepts and Guidelines' publication developed by Drs Edwards and Gomez continued to be an in-demand flagship product with the publication going into a second print run due to high demand. Over 600 hard copies have been distributed through demand-driven requests and approximately 700 electronic copies downloaded from the website. In early 2008, a targeted campaign will take place to ensure that key audiences are aware of the Guidelines and have access to them. Drs Edwards and Gomez, through collaboration with CRISP and ReefRes are in the process of developing a restoration manual which will be released in late 2008.



