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

Remote Sensing Working Group

The role of remote sensing in supporting coral reef management

Management Implications

The CRTR Remote Sensing Working Group (RSWG) is investigating the potential and limitations of remote sensing of coral reefs, so that the technology may be used for realistic and practical management objectives.

The Working Group has identified four main areas of targeted research.

1) Creation of decision-support and analysis software for monitoring the health of coral reefs using remote sensing

Until now, the remote sensing of coral reefs has been conducted on an ad-hoc basis with little consistency or general insight into its limitations. For example, we know that some aspects of reef health can be resolved on shallow reefs in French Polynesia but we cannot predict whether this would be a realistic expectation in say Jamaica, where reefs have a different flora and fauna, are located in deeper water, and where light penetration is slightly reduced because of higher suspended sediment concentrations in the water column. Without a generic understanding of the limitations of reef remote sensing, the technology may continue to be oversold or deployed for unrealistic management objectives, resulting in an inappropriate use of financial resources.

The RSWG will quantify the limitations of coral reef remote sensing by combining modelling and field experiments. Models predict the ability of a given remote sensing instrument to detect the subtleties of bottom reflectance that distinguish reef habitats or the cover of corals and macroalgae within habitats. Whilst the passage of light through the water column is relatively well understood, the interaction of light between reef organisms, many of which have complex structures, presents a research challenge. We address this problem using radiosity methods which were originally developed in the computer graphic industry. Coral structures are divided into thousands of individual patches, each of which behaves as a reflecting surface. On reaching the reef, sunlight is reflected and scattered in predictable directions, from which we can calculate the net light recorded by the sensor once it has passed back through the water and atmosphere. Computer models will be refined and tested in the laboratory and then tested under field conditions in a unique, large-scale remote sensing experiment.

A series of platforms, approximately 3m by 3m in size, will be suspended at various heights above the sea bed. Objects will be placed on these platforms to represent explicit combinations of coral structure and various levels of reef health. Hyperspectral sensors will then be flown above the experiment allowing us to replicate the experiment under different levels of surface wind.

WORKING GROUP GOAL

Build scientific capacity necessary to provide the information needed for management and policy, so that coral reef ecosystems under threat from climate change and multiple human stressors can be sustained for current and future generations.

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

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

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

The CRTR Program is a partnership between the Global Environment Facility, the World Bank, The University of Queensland (Australia), the United States National Oceanic and Atmospheric Administration (NOAA) and approximately 40 research institutes & other third parties around the world.

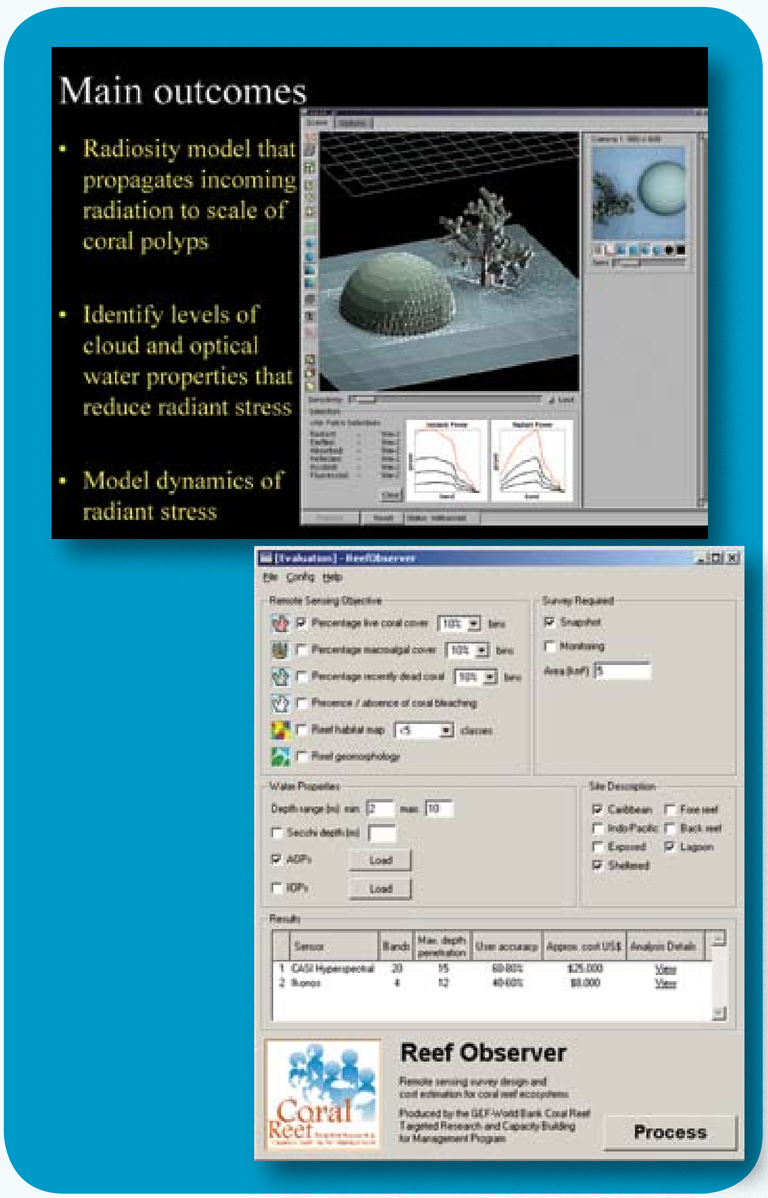
October 2006

2) Development of methods to detect changes in the coastal environment

Remote Sensing is also needed to identify the habitat type and possibly predict the cover of corals and algae on a reef. This requires high resolution imagery and direct field survey at the time of image acquisition and therefore have limited application to archived or low-resolution (30 m +) imagery. A wealth of satellite and photographic data are often available for reefs, sometimes archived as far back as World War II. We will conduct a number of activities to improve the way in which changes in reef condition can be predicted indirectly using remote sensing. These methods will highlight which areas of the coast have undergone the greatest change and help managers quantify the rate of change in reef habitats.

Three approaches will be taken to test the methods including (i) modelling spatial patterns of reef substrata and simulating changes, (ii) comparison of habitats within a sequence of images that have been intensively ground-truthed (Belize, Mexico, Philippines, Australia, Palau), and (iii) the acquisition of images before and after an acute disturbance event (e.g. bleaching event with high mortality) that occurs during the project lifetime.

The communication of coastal change can be difficult if using a map-based approach in communities that rarely use cartographic techniques. Previous work that made use of community based mapping and storytelling in central Java illustrated the difficulty that some cultures have with spatial constructs. Therefore, one component of this study will build upon change detection of environmental status and attempt to determine the best cartographic or narrative technique for communicating with local managers of coral resources.



3) Application of remote sensing to the inventory, monitoring and management of biodiversity

Recent remote sensing research has improved the detail of reef habitat maps but the interpretation and uses of these products for management has received relatively little attention. Specifically, what do habitat maps mean in terms of biodiversity and reef function and how should they be used for conservation planning? For example, many reserve selection algorithms require an extensive database of species' distributions which are costly and logistically difficult to establish. Remote sensing could largely replace intensive site-specific biodiversity surveys if the value of habitats as a surrogate for species (or functional) diversity were established in a variety of environments.

The CRTR Program provides an unrivalled opportunity for taxonomic capacity within its Centers of Excellence and to quantify the ecological basis of habitat maps. The species composition of habitats are being surveyed in Belize and Mexico and compared and assessed at a Caribbean-wide scale using comparable data from the Bahamas. Comparable surveys will take place in Palau and the Philippines but with less reliance on species-level identification. Emphasis will be placed on particularly important species (e.g. commercially-important or 'keystone' species) but much of the species-level information will be replaced with functional trophic categories.

A second biodiversity activity is quantifying the relationship between the topographic complexity of reef habitats (called rugosity) and the relative density of reef fish. Habitat complexity is being measured using acoustic remote sensing methods and related to the density and biomass of around 30 ecologically and economically important fish species. Outputs of this research will enable managers to monitor the effectiveness of reserves effectively by stratifying their sampling by both habitat type and local habitat complexity, both of which affect the densities of reef fish. Maps of habitat complexity may also identify the location and extent of critical fish habitat which will guide MPA site selection and help understand the connectivity of fish populations (e.g. areas with high adult stocks or high recruitment).

4) Creation of an Ocean Atlas and tools to manage coral bleaching

A wide variety of oceanographic and atmospheric remote sensing products are available for reef management but many are in disparate locations and user-unfriendly formats. A variety of US government agencies are establishing a national Ocean Atlas to collate a plethora of data sets relevant for coastal management within a single website. The RSWG will extend this initiative to an *international* Ocean Atlas for coral reef environments. The website will display a number of standard environmental products (e.g. wind speeds, wave heights, solar radiation) but also develop and test new products which are especially relevant to coral bleaching. Outputs will (i) enhance the credibility of managers by providing timely spatial information (e.g. now-casting mass bleaching events), (ii) support reef research throughout the Targeted Research Working Groups, (iii) provide educational and research tools by defining the climatology of specific reef areas (iv) enhance understanding of climate change by recording and predicting environmental trends worldwide and (v) improve management of coastal watersheds through identification of water quality dynamics. An important aspect of this project is that the Ocean Atlas will be used by managers, scientists and students interested in many other ecosystems and parts of the World.

Satellite (IKONOS) image of Heron Island, Australia, captured in April 2004, immediately following a period of coral reef bleaching. Heron Island is the small land mass (brown) to the bottom of the image, whereas most of the living reef structre can be seen as light brown. Note the living patch reefs (seen as small dots) in the center of the image. The bright white dots surrounding the edges of the reef are waves. The RSWG is using this and other images of coral reefs to determine the degree to which change detection may be possible over large areas.

Image: William Skirving and Allan Strong, NOAA

Remote Sensing Working Group

The role of remote sensing in supporting coral reef management

- RESEARCH UPDATE

Image: Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center

New sea surface temperature products that predict temperature at sub-surface levels will begin in the first year of the project with principal development in Palau and Heron Island. However, the products will be tested and made operational in all project sites including Zanzibar. Solar products (short wave, PAR, UV) will begin development in the second year of the project, winds in the third year, and turbidity in the fourth year depending on the availability of satellite data.

Coral bleaching is a major cause of concern for the future of coral reefs. The outputs from this project of an international Ocean Atlas for coral reef environments will enable managers to monitor the severity of environmental stress in the coastal zone.

However, this cannot as yet easily predict which areas are least likely to experience conditions that precipitate mass bleaching. Physical models, based on hydrological and tidal information, show great potential for predicting how sea temperature will vary across a reef system given a certain amount of heating (i.e. which regions tend to heat up fastest and which remain cool).

Such models will be developed and tested and after being merged with the outcomes of the CRTR Bleaching Working Group, will enable managers to identify reefs which have a natural degree of resistance to coral bleaching and those that are most at risk. The creation of 'bleaching risk maps' will be pioneered by NOAA in Palau, Heron Island and Puerto Morelos/ Belize and collaboratively with the University of the Philippines at Bolinao.

Further Information

Remote Sesing Working Group

Chair: Professor Peter J Mumby
University of Exeter, United Kingdom
Email: P.J.Mumby@exeter.ac.uk

Co-Chair: Dr Laura T David
University of the Philippines
Email: ldavid@upmsi.ph

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

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