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Coral Reef Targeted Research and Capacity Building for Management: Using Sound Science to Influence Policy and Improve Management of the World's Coral Reefs

2008 HAS BEEN DECLARED THE INTERNATIONAL YEAR OF THE REEF—TO CELEBRATE THE BEAUTY AND IMPORTANCE OF THESE MAGNIFICENT ECOSYSTEMS AND, AT THE SAME TIME, TO CALL ATTENTION TO THE SEVERE THREATS THEY FACE FROM HUMAN ACTIVITY LEADING TO DECLINES IN THEIR HEALTH AND PRODUCTIVITY IN MANY PARTS OF THE WORLD. THE CORAL REEF TARGETED RESEARCH AND CAPACITY BUILDING FOR MANAGEMENT (CRTR) PROGRAM IS A GLOBAL PARTNERSHIP SUPPORTED BY THE GEF, THE WORLD BANK DEVELOPMENT GRANT FACILITY (DGF), THE UNIVERSITY OF QUEENSLAND (UQ) AND US NATIONAL AND OCEANIC ATMOSPHERIC ADMINISTRATION (NOAA) TO IMPROVE OUR UNDERSTANDING OF HOW CORAL REEF ECOSYSTEMS ARE RESPONDING TO GLOBAL CHANGE, WHAT CAN BE DONE TO REDUCE THEIR VULNERABILITY TO NEAR AND LONGER-TERM THREATS AND TO PUT THIS INFORMATION IN THE HANDS OF DECISION-MAKERS TO PROMOTE NEEDED ACTION. THIS NOTE DRAWS ON FINDINGS RECENTLY PUBLISHED IN SCIENCE RELATED TO CLIMATE CHANGE IMPACTS ON CORAL REEFS. IT SEEKS TO DEMONSTRATE THE ROLE OF RESEARCH IN BUILDING CAPACITY, CREATING AWARENESS, INFORMING THE POLICY DEBATE AND PROMOTING URGENT MANAGEMENT ACTIONS TO CREATE A BRIGHTER FUTURE FOR THE WORLD'S CORAL REEFS.

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Coral Reef Targeted Research & Capacity Building for Management

EXPERIENCE OF THE GEF

GEF/WB: CORAL REEF TARGETED RESEARCH AND CAPACITY BUILDING FOR MANAGEMENT PROGRAM

GEFID: 1531 WORLD BANK: P078034

PROJECT DESCRIPTION

The Coral Reef Targeted Research and Capacity Building for Management (CRTR) Program was designed shortly after a massive global coral bleaching event, associated with the 1997-98 El Niño event that resulted in the death of 16% of the world's coral reefs. This was a wake-up call to the marine science and management community—a call that coral reefs were in dire trouble and fundamental gaps in our understanding of how coral reef ecosystems respond to climate change and other human pressures had forced us into a reactive rather than a proactive mode of management.

The CRTR partnership was formed to address these fundamental gaps, to build capacity for world class, management-driven research in countries where coral reefs are found, and to use this information to improve the management effectiveness of coral reefs and welfare of human communities that depend on them.

The Program is envisioned in 3 phases over a 15 year time horizon. The first and current 5-year phase involves three components: (1) addressing knowledge and technology gaps; (2) promoting learning and capacity building; and (3) linking scientific knowledge to management and policy. Research under the CRTR is carried out in four Centers of Excellence (see Map in Experience Note 2), by international working groups and researchers at the Centers of Excellence on 6 key themes. These include Coral Bleaching, Reef Connectivity, Disease, Remote Sensing, Reef Restoration and Remediation, and Modeling and Decision Support.

Experience Note No. 2 summarizes recent findings from the Coral Disease, Remote Sensing and Restoration and Remediation Working Groups. This note draws on findings recently published in *Science* magazine related to climate change and coral reefs. It is an example of how GEF supported targeted research is helping to build capacity, create awareness, inform the policy debate

Figure 1 Fishing canoes on reefs in Zanzibar.

surrounding climate change and the urgent actions needed if the world's coral reefs are to survive in the second half of this century and beyond.

Figure 2 Mapping biodiversity on reefs in Palau. © P. Mumby

THE EXPERIENCE

Issues and Challenges

CO_2 in the earth's atmosphere is rising rapidly. Conservative estimates under a business as usual scenario for CO_2 emissions, indicate atmospheric CO_2 exceeding 500 parts per million (ppm), with global temperatures rising by at least 2°C by 2050. These values far exceed those of at least the past 420,000 years under which most contemporary marine organisms evolved. And the rates of change are 2-3 orders of magnitude higher than any seen in records of the Vostock Ice Core study (see Fig. 3), from which we may infer CO_2 concentrations and mean sea temperature over that period. Given the rapidity and rarity of such rates of change in the fossil record, it is likely that these changes will exceed the ability of most marine organisms to adapt.

What does this mean for coral reefs? Under conditions expected in the 21st century, global warming will make coral bleaching more frequent—and potentially deadly, as corals have less time to recover between bleaching episodes. Ocean acidification from increased CO_2 dissolving into seawater will make it difficult, if not impossible, for coral reefs to continue to build the calcium carbonate skeletons which make them the only living structures visible from outer space. The 3-Dimensional structure of coral reefs provides essential living space to fish and the million or more species thought to inhabit them, making them one of the most productive and diverse ecosystems on earth. As a result of climate change, reef-building corals will become increasingly rare, leading to less diverse reef communities and ecosystem services that cannot be maintained.

The loss of reef integrity has severe implications not only for biodiversity, but for human communities who depend on these ecosystems for food and livelihoods, coastal protection, tourism and cultural and spiritual well-being.

Increasing temperatures and decreasing calcification rates create synergies with impacts on reefs from local human pressures such as pollution (e.g., from sediments and nutrient enrichment) and over-fishing of key species (including top predators and reef grazing herbivores). These local stressors are thought to undermine the innate resilience of healthy (coral dominated) reefs to periodic disturbances from storms, outbreaks of disease or other pests which are expected to become more frequent and intense with climate change. In this way, cumulative local stress aggravated by more frequent and intense events associated with climate change are driving reefs toward the tipping-point for functional collapse.

A review of the literature and results from CRTR supported research on climate change, local impacts and trophic interactions affecting coral reef ecosystem resilience, provides the basis for future scenarios of coral reefs. Three reef scenarios, representing changes anticipated at different concentrations of atmospheric CO_2 and corresponding increases in temperature and decreases

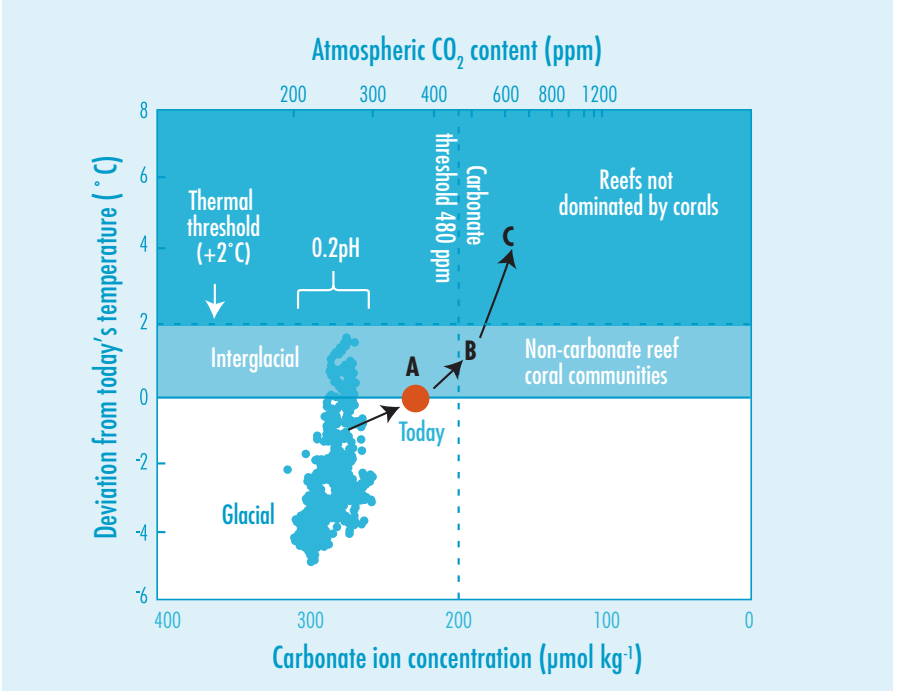

Figure 3 Temperature and carbonate ion concentrations related to calcification rates reconstructed for the past 420,000 yrs. A, B, and C refer to scenarios depicted in Fig. 4.

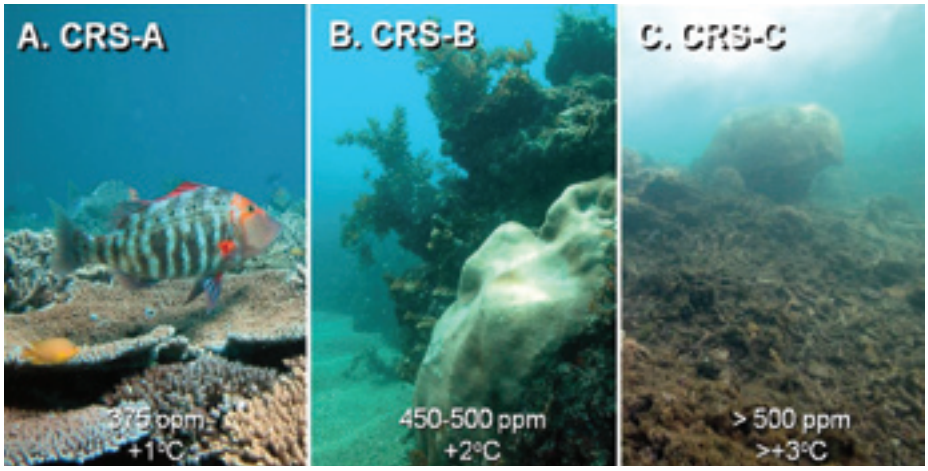

Figure 4 Future scenarios for coral reefs with increased [CO_2] atm. and mean temperature above today's associated with Climate Change.

in calcification rates noted in Fig. 3, are presented below in Fig. 4 (CRS-A, B and C, below). These scenarios, depicting current and future reef trends associated with climate change in combination with local stressors are drawn from extant examples in the Great Barrier Reef which serve as proxies. They indicate increasingly serious consequences for reef-associated fisheries, tourism, coastal protection and people. Without a two pronged approach that includes mitigation measures that aim to dramatically reduce CO_2 emissions and stabilize [CO_2] atm at 450 ppm or lower, ***and*** effective management to reduce local human stresses on coral reef ecosystems, the future for these magnificent marine systems is dire.

RESULTS AND LEARNING

While policymakers in the international arena grapple with formulas and cost effective means to bring down CO_2 emissions to well below 1990 levels over the next 50 years, local marine resource managers are in a position to buy time for coral reefs. A number of interventions can and must be taken now to address immediate threats to reef ecosystem health and thus increase the chances that they will be able to survive in ocean conditions altered by climate change but below thresholds that would spell disaster for reefs and vulnerable systems linked to them, including human communities.

These measures include maintaining reef community structure or biodiversity so that essential food webs and processes are sustained, particularly grazing of algae by herbivorous fish and marine invertebrates. Field work supported by the CRTR Program has demonstrated the singular importance of protecting parrotfish as natural grazers on reefs who also help cycle energy and nutrients between adjacent mangroves, seagrass beds and coral reefs. Maintaining this habitat connectivity within a reef system and between reefs, .e.g, through coastal zoning or possibly through a system of networked marine protected areas (MPAs), is important to ensuring recruitment of juvenile reef fish and many other keystone species that contribute to the functional integrity of reefs. These reef dwellers help maintain essential reef interactions which underpin reef productivity and resilience and the many ecosystem services provided by reefs (e.g., for tourism, food, coastal protection and biodiversity) that coastal economies have come to rely on.

Apart from protecting reef biodiversity in general and reef grazers in particular, maintaining good coastal water quality is equally important for sustaining healthy reef ecosystems, and something managers need to address urgently. Including tertiary treatment of waste water to remove phosphorous and nitrogen and treating industrial effluents to reduce high Biological Oxygen Demand (BOD) and toxic chemicals like Persistent Organic Pollutants (POPs) and heavy metals, are high priority investments for reefs adjacent to heavily populated areas or industry. In more rural settings, focusing on controlling non-point source pollution (including sediment) from agricultural run-off through improved watershed management is important. A "ridge to reef" approach may include changing tillage practices and minimizing cultivation on fragile lands, introducing integrated pest management to replace pesticides with heavy POP concentrations, rotating crops with cultivars that take up residual nitrogen, and planting buffer strips around riparian areas to minimize runoff into surface waters. In circumscribed areas of reef damaged by destructive fishing, severe bleaching events or ship groundings, it may be possible to enhance natural regeneration through active reef restoration, including coral transplantation (see Experience Note No. 2).

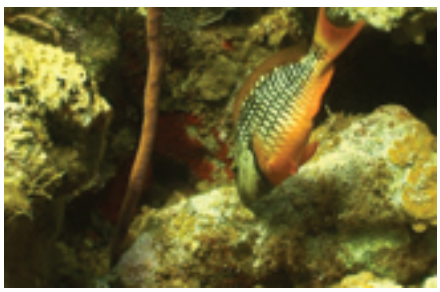

Figure 5 Parrot fish grazing on algae in the Caribbean.
© P. Mumby

Actions identified above are most likely to help reefs survive the inevitable stresses that increased CO_2 emissions accumulating over the last 100 years will impose on them, but ***only*** if immediate measures are taken to limit future CO_2 concentrations to levels below what are predicted to be catastrophic for coral reefs—500 ppm.

REPLICATION

The science identifying climate change and ocean acidification as among the most important threats to the future of coral reefs has been well documented. Similary, there is mounting evidence of cumulative local pressures that interact with them synergistically to undermine coral reef ecosystem resilience and increase their vulnerability to stress.

A dual strategy including mitigation and adaptation measures must be embraced. Scaling up and improving the effectiveness of local management measures to reduce near-term threats to reefs can help build resilience to future impacts from climate change, but only if parallel actions to limit CO_2 emissions below the tipping point for reefs are effective.

SIGNIFICANCE

The CRTR Program is working with stakeholders and local governments through its regional Centers of Excellence to increase awareness of the growing risks facing coral reefs from local and global sources, and the implications in economic and social terms for the tens of millions of people who depend on them for livelihoods, food security and coastal protection.

Through targeted research, the CRTR program is using robust science to help

Figure 6 A healthy reef and one impacted by coral bleaching and crown-of-thorn outbreaks near human population centers on the Great Barrier Reef. © O. Hoegh-Guldberg

measure these risks and better understand local coral reef ecosystem responses to these risks. Through its capacity building and efforts to link science to management, it is translating these findings into an action agenda for managers and policy makers that can make a difference to the future of the world's reefs and all who value them.

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