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IN THE AMOUNT OF US\$11 MILLION  
TO  
THE UNIVERSITY OF QUEENSLAND  
BRISBANE, AUSTRALIA  
FOR A GLOBAL PROJECT:  
CORAL REEF TARGETED RESEARCH AND CAPACITY BUILDING FOR MANAGEMENT  
August 4, 2004

**Environment Department**  
**Environmentally & Socially Sustainable Development Network**

## CURRENCY EQUIVALENTS

(Exchange Rate Effective 13 July 2004)

Currency Unit = Australian Dollar

AUS\$1 = US\$0.7208

US\$1 = AUS\$ 1.3873

## FISCAL YEAR

2005 -- 2009

## ABBREVIATIONS AND ACRONYMS

AO	Administrative Officer
BML	Bolinao Marine Laboratory, Philippines
BWG	Bleaching (and Local Ecological Responses) Working Group
CMS	Centre for Marine Studies
COE	Center of Excellence
CRTR	GEF Coral Reef Targeted Research
CWG	Connectivity (and Large-scale Ecological Processes) Working Group
DCCO	Data integration, Communication and Capacity building Officer
DWG	Disease Working Group
EO	Executive Officer
FO	Finance Officer
GEF	Global Environmental Facility
GBR	Great Barrier Reef
IMS	Institute of Marine Science, Zanzibar
IOC	Intergovernmental Oceanographic Commission
MDSWG	Modeling and Decision Support Working Group
PDF B	Project Development Facility, Phase B Planning Grant
PEA	Project Executing Agency
PIP	Project Implementation Plan
PM	Puerto Morelos
RRWG	Restoration and Remediation Working Group
RSWG	Remote Sensing Working Group
SOP	Standard Operating Procedures
UNAM	Universidad Nacional Autónoma de México
UPMSI	University of Philippines, Marine Science Institute
UQ	University of Queensland
UNESCO	United Nations Educational, Scientific & Cultural Organization
WB	World Bank

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**WORLD**  
**CORAL REEF TARGETED RESEARCH AND CAPACITY BUILDING FOR MANAGEMENT**

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Coral Reef Targeted Research and Capacity Building for Management

## GEF Project Document

East Asia Environment and Social Development Unit (EASES)  
Environment Department (ENV)

<b>Date:</b> August 4, 2004 <b>EASES Sector Director:</b> Maria Teresa Serra <b>ENV Acting Director:</b> James Warren Evans <b>Project ID:</b> P078034 <b>Focal Area:</b> I - International waters	<b>Team Leader:</b> Marea Eleni Hatziolos <b>Sector(s):</b> General agriculture, fishing and forestry sector (100%) <b>Theme(s):</b> Biodiversity (P), Other environment and natural resources management (P)
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### Project Financing Data

Loan       Credit       Grant       Guarantee       Other:

#### For Loans/Credits/Others:

**Amount (US\$m):** 11.0 M

Financing Plan (US\$m):	Source	Local	Foreign	Total
RECIPIENT		0.00	2.50	2.50
AUSTRALIA, STATE GOV. OF QUEENSLAND		0.00	2.60	2.60
DEVELOPMENT GRANT FACILITY (WB)		0.00	3.00	3.00
GLOBAL ENVIRONMENT FACILITY		0.00	11.00	11.00
FOREIGN UNIVERSITIES		0.00	3.20	3.20
<b>Total:</b>		0.00	22.30	22.30

**Recipient:** THE UNIVERSITY OF QUEENSLAND, BRISBANE, AUSTRALIA  
on behalf of Mexico, Tanzania and the Philippines

**Responsible agency:** THE UNIVERSITY OF QUEENSLAND, BRISBANE, AUSTRALIA  
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### Estimated Disbursements ( Bank FY/US\$m):

FY	2005	2006	2007	2008	2009				
<b>Annual</b>	2.20	2.50	2.40	2.40	1.50				
<b>Cumulative</b>	2.20	4.70	7.10	9.50	11.00				

**Project implementation period:** Five years

**Expected effectiveness date:** 12/12/2004    **Expected closing date:** 11/30/2009

## A. Project Development Objective

### 1. Project development objective: (see Annex 1)

**The Global Environment Objective** is to fill critical gaps in our global understanding of what determines coral reef ecosystem vulnerability and resilience to a range of key stressors—from localized human stress to climate change—and to inform policies and management interventions on behalf of coral reefs and the communities that depend on them. **The Project Development Objective** is to align, for the first time, the expertise and resources of the global coral reef community around key research questions related to the resilience and vulnerability of coral reef ecosystems, to integrate the results, and to disseminate them in formats readily accessible to managers and decision-makers. A related objective is to build much-needed capacity for science-based management of coral reefs in developing countries, where the majority of reefs are found. These objectives will be achieved through targeted investigations involving networks of scientists, in consultation with managers, and the dissemination of knowledge within and across regions to decisionmakers.

### 2. Key performance indicators: (see Annex 1)

The Targeted Research Project is being designed as part of a long term effort that will be implemented in phases. The initial five- year phase will support the establishment of an applied research framework and build capacity for science-based management of coral reefs in areas with significant coral reef resources and Bank/GEF investments. These include sites in Mesoamerica, East Africa, Southeast Asia, and the Southwestern Pacific. While the impacts of this project are expected to be realized well beyond the five year time frame of the initial phase, expected outcomes include a coordinated processes to fill critical knowledge gaps, improved capacity for science-based management of coral reef ecosystems, and development and uptake of new knowledge products to enhance decision-making. Evidence of these outcomes would include, *inter alia*, new management tools in the hands of users, decision-support systems to aid local decision-making, publications co-authored by developed and developing country scientists and policy briefs outlining actions to promote coral reef sustainability. These outcomes will serve as benchmarks for the Project's long term goals, which are more effective management and informed policies leading to the sustainability of coral reef ecosystems. Key indicators of project success during phase 1 include the following:

1. Formerly fragmented research efforts are coordinated and targeted for the first time around key sustainability themes in four coral reef regions. A coalition of scientists and research institutions from developed and developing countries is built to support this effort.
2. Major partners from different sectors are aligned with this initiative, building momentum toward a critical mass of resources and a sustained effort.
3. Institutional and human capacity for science-based management of coral reef ecosystems is built in countries where coral reefs are found
4. Research results are peer reviewed by members of the scientific and management community and include knowledge products (see Box 1 in section C.2) and decision support systems relevant to managers and policymakers
5. Coral reef managers are empowered with knowledge and tools to make better decisions.
6. Research findings are mainstreamed into World Bank and IOC country dialogue and assistance strategies for countries with coral reefs.
7. Policies to protect coral reefs or mitigate impacts from key stressors are strengthened as a result of new information.
8. Coral reef management projects under early implementation or in preparation—many with GEF

support—incorporate TR findings into project design.

9. The GEF uses results to guide future resource allocations for coral reef management and as a model for large-scale targeted research to address cross cutting issues in Climate Change, International Waters and Biodiversity.

## **B. Strategic Context**

### **1. Sector-related Country Assistance Strategy (CAS) goal supported by the project: (see Annex 1)**

**Document number:** n/a **Date of latest CAS discussion:** n/a

The TR Project supports two main thrusts of the Bank's Environment Strategy: (1) Improving quality of life, and (2) Protecting the Global Commons. Of the 184 member countries within the World Bank, over 100 possess coral reefs within their national boundaries, and rely upon them as natural assets. Coral reefs are not only global assets of exceptional biodiversity value, they are significant drivers of economic growth in the more than 60 developing countries where they occur. Cesar et al 2003, have calculated the net present value of healthy coral reefs at \$800 Billion annually. This figure derives primarily from the contribution of reefs to (i) tourism --the fastest growing economic sector in the world and (ii) fisheries, which, like tourism, is a major employer and source of foreign exchange to many of the Bank's clients. In terms of the Bank's target beneficiaries, many impoverished coastal communities depend on reefs directly for food, livelihoods and environmental security. Coral reefs are an essential source of nutrition, income and subsistence for the poorest of the poor--those marginalized communities who turn to the sea as a last resort to meet their basic needs. A major study by DFID on Poverty and Reefs (2003) estimates that of the 30 million small scale fishers in the developing world, most are dependent in some form on coral reefs. More than half the protein and essential nutrients in the diet of 400 million poor living in tropical coastal areas is supplied by fish, the majority of which is marine and a large proportion of which is dependent on healthy reefs. Thus, from an economic growth perspective, as a source of nutrition and and the basis of livelihood for millions of the world's poor, coral reefs are closely linked to the Bank's poverty and environment agenda. Their continued productivity and health should be a key objective of natural resource management and an essential part of any poverty reduction strategy in those countries where coral reefs are found.

The Tanzania PRS and in the FY04-06 CAS emphasize the strong links between sustainable management of natural resources and poverty reduction. Tanzania has a large and rapidly growing coastal population which includes two of the four most impoverished provinces in the country. Tanzania also borders the largest area of shallow coral reef in East Africa (DFID 2003) and it is estimated that 93,000 coastal dwellers in Tanzania are employed in fisheries or aquaculture. In Zanzibar alone, some 23,000 artisanal fishers depend directly on the surrounding coral reefs for their livelihood and protein. Tanzania is currently preparing a \$55M Marine and Coastal Environmental Management Project, with primarily IDA support, which will benefit directly from the research and capacity building components of the proposed Targeted Research (TR) initiative. In the Philippines, where more than 1 million small scale fishers depend directly on coral reefs for their livelihoods; 50% of all animal protein consumed in the Philippines derives from marine fisheries and aquaculture. To ensure linkages with the TR initiative, the Philippines Country Team will be represented on an internal Bank Working Group comprised of Task Team Leaders of coral reef and coastal management projects which will liase directly with the TR Project governance structure. The internal Working Group will ensure that research results feed into ongoing AAA, rural and environment sector strategies, and country dialogue (see section C3 below). In Indonesia, the launch of a \$75M follow-on (Phase II) Project for Coral Reef Rehabilitation and Management (COREMAP) is expected later this year, to strengthen governance of Indonesia's 2.6 million ha of coral reefs, which have the potential to provide hundreds of millions of dollars annually through tourism and fishing to the Indonesian economy

and to directly affect the livelihoods of some 10,000 coastal communities scattered throughout Indonesia. Links have also been built between COREMAP II and the TR Project to support the research and science-based management capacity of the former. On the Caribbean Coast of Mexico and Belize, reef-based tourism is a major economic sector, and is being developed with Bank support in Honduras. The Fisheries Sector is also a key sector in the sub-region, with nearly 300,000 people employed in fisheries and aquaculture. The productivity of the fisheries sector (shrimp, lobster, conch, and other high valued species) in Mexico, Belize and Honduras is directly dependent on the health of the adjacent Barrier Reef, the longest in the hemisphere. The CASes in all three countries emphasize the importance of governance of natural resources to sustain rural economic growth. Here again, the TR Project is designed to link closely with the ongoing regional project for the Conservation and Sustainable Use of the Mesoamerican Barrier Reef System--by providing crucial information on ecosystem connectivity, larval transport, disease, and vulnerability to El Nino events. All of these feed directly into Project objectives, which include improving management effectiveness of marine protected areas, assessing the health of the MBRS, and assessing resilience to climate change.

### **1a. Global Operational strategy/Program objective addressed by the project:**

Coral reef ecosystems are open and trans-boundary in nature by virtue of the of flow of nutrients, pollutants, larvae, and adults of migratory species across ecosystem boundaries, and often national frontiers. Pollutants entering the system are primarily land based, emphasizing connections between drainage basins and shallow, coastal receiving waters, where most coral reefs are found. Coral reefs are a major feature of Large tropical Marine Ecosystems. They are extraordinarily diverse and generate an array of environmental goods and services which are dependent on reef integrity and the maintenance of ecosystem processes. Effective governance of transboundary aquatic resources is a hallmark of the IW Focal Area. The Targeted Research Project responds to the strategic priority for the International Waters Focal Area identified in the GEF FY03-FY06 Business Plan to: "Expand global coverage to other water bodies of cross-cutting foundational capacity building and innovative demonstration projects."

Through a series of highly integrated investigations in four coral reef regions of the world, the TR Project seeks to fill the most significant gaps in our global understanding of the relationship between major stressors and the structure and function of coral reefs. The Project will explore the role of ecosystem processes, such as connectivity, community dynamics and structure, in responses to stress, e.g., in the form of differential bleaching, rates of disease incidence, and recovery to determine what factors may confer resilience and sustainability in response to major forms of stress. By bridging knowledge gaps related to impacts of climate change and localized human stress on the sustainability of trans-boundary aquatic ecosystems, the project fits within the Integrated Land and Water Operational Program, OP 9. However, by virtue of its cross-cutting investigations, which will shed light on the relationship between the effects of climate change on coral reef ecosystem integrity, including biodiversity and connectivity between reefs, as well as between watersheds and aquatic ecosystems, the project will have benefits in several different focal areas and operational programs, e.g., GEF OPs 2, 8,10 and 12. It may also form the basis for a study on inter linkages and future joint program of work between the GEF Focal Areas of Climate Change, International Water and Biodiversity within the Bank.

As noted above, the Project will support capacity building across GEF Focal Areas, by creating a robust scientific framework within developing countries to investigate the basis for ecosystem vulnerability and resilience to climate change and localized human pressures. Impacts on ecosystem structure and Biodiversity will also be examined as part of these investigations. The model for establishing global networks of researchers to jointly investigate topics of high priority for coral reef ecosystem management, and to link the results to policy and decision-making, is eminently transferable to other focal areas and

themes. This cross-cutting outcome for capacity building is also identified in the GEF FY03-06 Business Plan as a priority for the third replenishment phase:

..."Cross-cutting capacity building projects will support capacity building activities outside the scope of any one focal area but common to achieving the goals of all focal areas. Such activities, particularly focusing on LDCs and SIDS, will include: (i) foundational capacity building, to establish the basic capacity of a country to meet its global environmental and sustainable development goals."

The joint investigations and targeted learning that result from collaborative, applied research, involving networks of developed and developing country scientists, will build the foundation for knowledge-based management and policies. The research findings and cutting edge tools developed will be disseminated periodically through a series of management and policy briefs aimed to improve our global capacity to manage coral reef ecosystems.

## **2. Main sector issues and Government strategy:**

Despite their global significance as environmental and economic assets, coral reefs are in decline worldwide. The main threats to coral ecosystem sustainability stem from localized impacts of human pressure and accelerated climate change. Human impacts include (i) over-fishing and destructive fishing techniques, which alter trophic levels and destroy the ecological integrity of reef communities; (ii) land-based sources of pollution (e.g., sedimentation from deforestation and other poor land-use practices, pesticides, eutrophication from agricultural run off and municipal waste, and Persistent Organic Pollutants (POPs)); (iii) habitat loss from land reclamation and construction, (iv) marine-based threats, including maritime transport, the cruise line industry. Impacts associated with climate change include (i) increased sea surface temperature, sea-level rise and storm frequency and severity, and (ii) changes in ocean chemistry, all of which undermine reef growth and the physical integrity of coral reef ecosystems.

The 1997/98 massive coral bleaching episode tied to an El Niño event, in which an estimated 30% of the world's coral reefs were affected, was a wake-up call to coral reef scientists and managers alike. Science magazine devoted an entire issue (August 15, 2003) to the spectre of coral reef decline. In a lead review article, entitled *Climate Change, Human Impacts and the Resilience of Coral Reefs*, the authors identify a range of human stressors on reefs whose intensity and frequency have resulted in a global threat to coral reefs. The cumulative impact of this threat is exacerbated by historically high rates of climate change and climate variability, which together place enormous stress on the ability of reefs to adapt. The Global Status of Coral Reefs 2002 Report, lists two thirds of the world's reefs as under severe threat from the cumulative impacts of economic development and associated impacts of climate change. Calls for protection and more sustainable use of coral reef ecosystems have been a familiar theme in global fora, from the International Coral Reef Initiative (launched in 1995, in which the Bank played a key role), to the Convention on Biological Diversity (1995), the International Tropical Marine Ecosystems Management Symposia (ITMEMS I and II, 1998 and 2003, respectively), and most recently, the World Summit on Sustainable Development (2002). The WSSD Plan of Implementation identifies coral reefs as unique and vulnerable ecosystems that play a crucial role in the economies of SIDS and other developing states, and urged partners to: (i) implement the Framework for Action of the International Coral Reef Initiative (ICRI); (ii) implement the Jakarta Mandate on Marine Biodiversity of the Convention on Biological Diversity; and (iii) strengthen capacity globally to manage these ecosystems through science-based management and information sharing.

### 3. Sector issues to be addressed by the project and strategic choices:

Addressing these challenges will require a new research paradigm. Based on agreed priorities identified in extensive consultations with coral reef scientists and managers during the Block A phase, this project seeks to coordinate and target research for the first time in this community's history. It will establish a global network of eminent coral reef scientists working together across disciplines and regions so that (i) key knowledge gaps can be systematically addressed to reduce uncertainty in the context of management, (ii) targeted research is multidisciplinary, drawing on a blend of biophysical and social sciences, (iii) the research is integrated across space and time to allow for a synoptic view of coral reef ecosystem dynamics in response to stress at local, regional and global scales and (iv) research findings are effectively communicated to decision-makers. (vi) These findings will be followed up at the policy level, by the Bank in country dialogue with clients with coral reefs, as to appropriate policy actions and investments.

Strategic choices involve the design of a global project for targeted research vs. a series of regional or national-level projects to support science based management of reefs. Other strategic choices involve the institutional arrangements and flow of funds for a global project which will be implemented across four sub-regions. Another key strategic choice has been to focus capacity building on creating the investigative framework and robust methodology to prioritize and test hypotheses in the field that will *inform* management, rather than to focus on management *per se*. Other initiatives, like the International Coral Reef Action Network (ICRAN) and NGO supported community-based management efforts are designed to focus on the latter. This strategic choice has clear implications for the fundamental nature and design of the Targeted Research Project.

## C. Project Description Summary

### 1. Project components (see Annex 2 for a detailed description and Annex 3 for a detailed cost breakdown):

Below are summarized the overall components of the TR project, the structure of the participating elements, the key reforms to be sought, the benefits and target population, and the institutional and implementation arrangements.

Project components are organized around the following major themes:

#### Component I. Addressing Knowledge and Technology Gaps (\$US 11.2 M)

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. This targeted research framework will systematically define those information gaps, and prioritize them in an order of strategic importance to management, so that the resulting information and tools developed can lead to credible outcomes. The project is organized around six key themes and research questions, which will be investigated by interdisciplinary teams of developing and developed country scientists. These themes were identified through extensive consultation with the scientific and management communities over the course of project preparation to encompass the kinds of knowledge and management tools that underpin sustainability science for coral reefs. They are the focus of investigations by distinct working groups and include the following:

**i. Bleaching and Local Ecological Response:** The physiological mechanisms and ecological

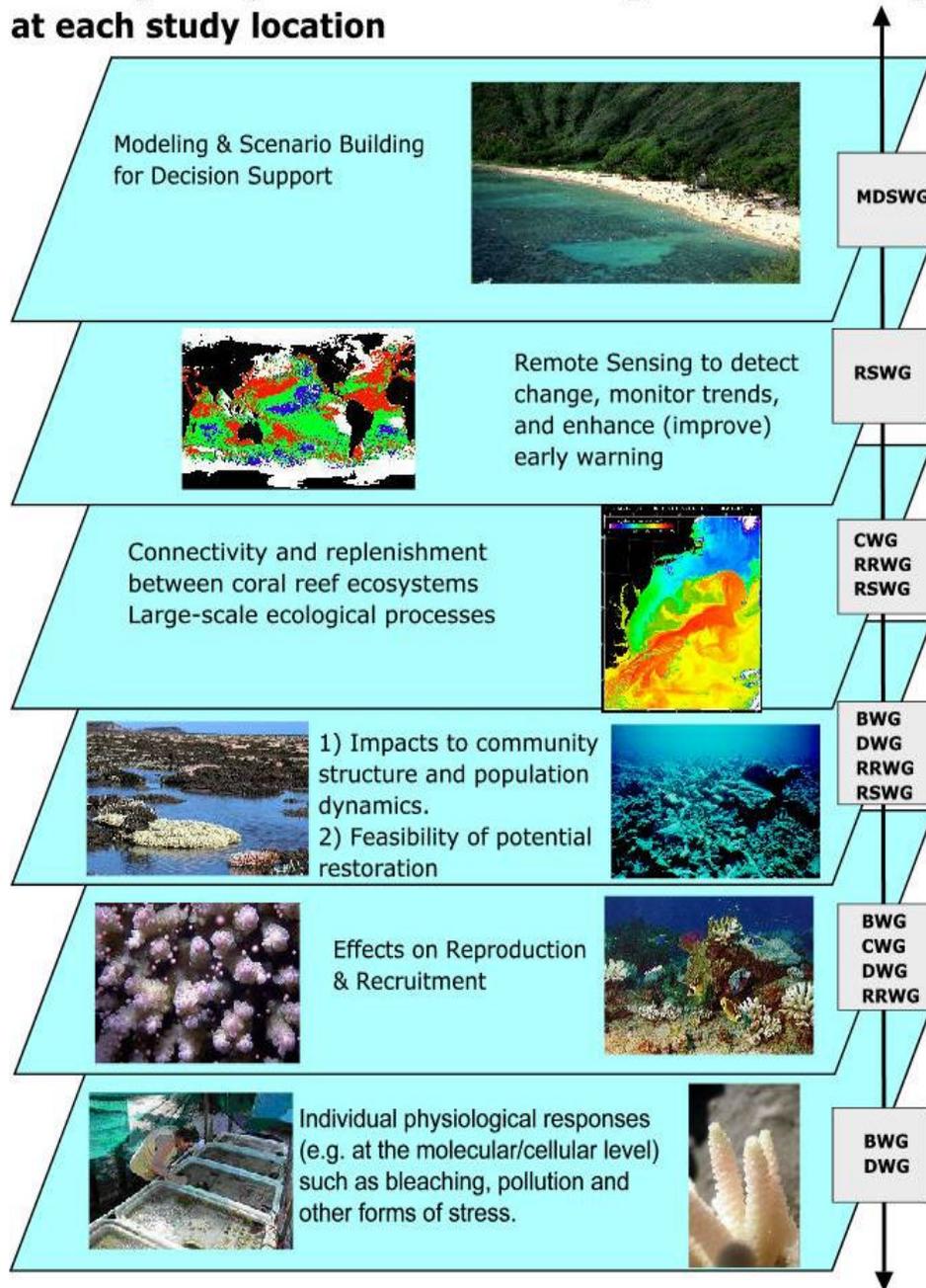
consequences of large area (or massive) coral reef bleaching, particularly in response to sea surface temperature anomalies, like the El Niño/Southern Oscillation episodes; to nutrient and sediment influxes; and the potential consequences of changes in frequency of coral taxa in response to such stressors on coral reef integrity and function;

- ii. **Disease:** The nature, severity and spread of coral reef diseases, some of which may be responsible for major shifts in the structure, function, health and sustainability of coral reefs;
- iii. **Connectivity:** The importance of physical and biological connections (or “connectivity”) between coral reefs, whether within or between different regions of International Waters. This also has direct bearing on the environmental conditions and key design factors needed to establish and sustain effective Marine Protected Areas (MPAs);
- iv. **Restoration and Remediation:** The tools, technologies and efficacy of restoring coral reefs that have been severely degraded or destroyed, and the key organisms and environmental conditions to consider when rehabilitating a given coral reef environment, and the circumstances under which such restoration may be cost-effective;
- v. **Remote Sensing:** The application of remote sensing to refine information and enhance the rate and scale at which knowledge can be generated and applied. This includes the need to modify remote sensing applications and related technologies so that they can be practically deployed and sustained within developing countries;

A sixth theme focuses on the development of Decision Support Tools to help managers and policymakers understand the likely pressure/response behavior of coral reef ecosystems to a range of local and climate change related stressors, and the types of interventions that could mitigate these effects. This theme is addressed by the Modeling and Decision Support Working Group and is described in Component III, below, on Linking Science to Management.

Figure 1 shows the intent of a thematic integration and coordination between the working groups at a given site. Given resources limitations, not all working groups can begin targeted investigations in all 4 regions initially. However, the intent is to have all working groups engaged in at least two of the four all locations within the project's first phase. Figure 2 shows the locations and stages in the project at which the working groups will engage within each region. Standard operating procedures are being developed to ensure statistical rigor and comparability of results across field sites. Working Groups will work with researchers from the Centers of Excellence to set up sampling, permanent plots and experimental work that can be initiated jointly and monitored between visits by Working Group members. The Modelling and Decision Support Working Group will pull together results from other groups and their own collection of socioeconomic data to create models of the system and each site that can be disturbed by various stressors. Outcomes, including their social and economic implications, will help elucidate tradeoffs of various policies to decisionmakers.

## Working Group Collaboration & Integration of Findings at each study location



*Figure 1 - Major coral reef research themes and the integration of research across working groups. By employing this layering approach, there is greater leverage in relating information across themes and within the initially limited number of study sites. Sites may increase in replication as this model evolves over the course of the Targeted Research program.*

**Initial status of Working Group activities within each of the four regions and Centers of Excellence**

<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5 or later phases</b>	Four Targeted Research Regions and the stages in which each Working Group executes specific activities. Based on fiscal limitations several of the WG's will start in a limited number of sites, and will gradually expand to the other regions. In the meantime cross-cutting meetings of WG member are designing standard operating procedures to assist one another with data collection. See notes below <sup>1</sup> .
<b>Puerto Morelos / Akumal (Mexico)</b>					
<b>BWG</b>	BWG*	BWG*	BWG*	BWG*	
<b>DWG</b>	<b>SP</b>	DWG*	DWG*	DWG*	
<b>CWG</b>	CWG*	<b>CWG</b>	<b>CWG</b>	CWG*	
RSWG*	MDSWG*			RRWG*	
RRWG*				RSWG*	
				MDSWG*	
<b>Zanzibar (Tanzania)</b>					
<b>SP</b>	BWG*	BWG*	<b>BWG</b>	BWG*	
RRWG*	RSWG*	DWG*	<b>DWG</b>	DWG*	
DWG*			<b>RSWG</b>	RSWG*	
			CWG*	MDSWG*	
			MDSWG*	RRWG*	
<b>Bolinao (Philippines)</b>					
RRWG	<b>RRWG</b>	<b>RRWG</b>	RRWG*	BWG*	
CWG*	BWG*	<b>BWG</b>	CWG*	DWG*	
	DWG*	<b>DWG</b>		RSWG*	
	RSWG*	<b>RSWG</b>		MDSWG*	
	MDSWG*				
<b>Heron Island (Australia)</b>					
BWG*	<b>BWG</b>	BWG*	BWG*	BWG*	
	<b>DWG</b>	DWG*		DWG*	
RSWG*	<b>RSWG</b>	RSWG*		RSWG*	
		MDSWG*	<b>SP</b>	MDSWG*	

1. **BWG:** Bleaching and Local Ecological Factors
2. **CWG:** Connectivity Working Group
3. **DWG:** Disease Working Group
4. **MDSWG:** Modeling and Decision Support
5. **RRWG:** Restoration and Remediation
6. **RSWG:** Remote Sensing
7. **SP:** Synthesis Panel

<sup>1</sup>Working Group letters in larger **Bold** font refer to a full working group meeting held at a given COE for the year indicated.  
 \*representatives from these groups will be visiting & working with the COEs during these periods, or holding smaller meetings

Figure 2 - Study Site locations and the stages at which working groups will engage.

## **Component II. Promoting Scientific Learning and Capacity Building (US \$4.2 M\*)**

Currently, most coral reef research is based in universities and research institutes in the developed world, while most coral reefs are located in developing countries. Rectifying this global discrepancy is a key mission of this project. To accomplish this, the research themes outlined above will be explored in different regions. This will serve both to ensure that the information ultimately used by managers is regionally appropriate, and to provide collaborative training opportunities with local scientists so that they can respond to future developments.

The Targeted Research investigations will focus around four “Centers of Excellence” (COE) in four major coral reef regions of the world:

- Western Caribbean/Mesoamerica: Puerto Morelos Laboratory of the Universidad Autónoma Nacional de México
- Eastern Africa: Institute of Marine Science, of the University of Dar es Salaam, Zanzibar, Tanzania
- Southeast Asia: Marine Science Institute in Bolinao of the University of the Philippines
- South Pacific/Australasia: Heron Island Marine Research Laboratory of University of Queensland, on the Great Barrier Reef, Australia

These sites were selected on the basis of significant ongoing GEF and other donor investments in coral reef management, and where considerable baseline data already exist. Although the three developing country nodes are not yet Centers of Excellence, they do count on a core of coral reef scientists and infrastructure, essential to carrying out the research. One of the objectives of the Project will be to transform these research institutions into real Centers of Excellence--to serve as regional resources for coral reef scientists and managers.

Each of these Centers will play an important functional role within the overall Targeted Research program. The Centers will host the majority (but not all) of the research of the Working Groups (as some will be carried out at satellite sites) and promote the participation of local scientists and graduate students in this or similar research. Funds will be made available to each COE to support regionally relevant coral reef research, identified as a high priority, which links to the Targeted Research carried out by the various Working Groups, and can benefit from the expertise of these visiting researchers. This scientific mentoring will help build capacity for world class research that will eventually be designed and sustained by local scientists in the region. Such apprenticeship-type arrangements were piloted at the Centers of Excellence during project preparation, in which world renown, seasoned researchers were paired with younger post-doctoral and graduate students in a supporting environment. This model also presents an opportunity for the scientific community to learn and benefit from the knowledge of local stakeholders, especially with those who may possess traditional knowledge. It will be replicated in all four Centers of Excellence over the course of the project to promote north-south and intergenerational learning between scientists, as well as a greater appreciation of the need to make research relevant to local and regional needs.

Second, the Centers of Excellence will serve as magnets for regional and local scientists to improve their technical skills, such as:

- taxonomic classification to assist visiting regional and international researchers
- experimental design and implementation
- communication workshops to more accurately convey research results to an array of audiences

- writing workshops to improve the quality of papers to be accepted in international scientific journals

The Targeted Research Project will support a series of workshops each year which will bring researchers in the various working groups together to orient field research, brief each other on findings and based on these results, modify and design the next phase of investigation.

In addition, researchers will explore together with other stakeholders (e.g, NGO representatives, government agency representatives and regional and local businesses) how such research findings can be applied in practice (see section c. below). At least once during the life of project, a symposium will be convened involving all project participants and representatives of relevant GEF IW and Marine Biodiversity Projects to presents findings, demonstrate their application to improving management (e.g., through new tools and decision support systems) and public awareness about cause and effect relationships between human impacts and coral reef health.

If successful, this model may be easily replicated in other regions, e.g., the Red Sea and Central Pacific, as the Project expands into a second phase.

\*Support for this component will be reinforced by graduate student scholarships to developing country students and research training conducted at the Centers of Excellence in conjunction with the research undertaken by the various Working Groups, identified above in Component I.

### **Component III. Linking Scientific Knowledge to Management and Policy (US \$ 4.0 M)**

A guiding Synthesis Panel has been established to give direction to the targeted research program and ensure that the whole is greater than the sum of its parts. In addition to overseeing the quality of the research, the Synthesis Panel synthesizes results across Working Groups and Centers of Excellence to interpret these findings and make policy recommendations where appropriate. Periodic symposia will be convened throughout the project to engage key stakeholders, public policy makers, and experts in economics, social development and law in dialogue about the relevance and implications of research outcomes. With input from these groups and from regular independent reviews, the Synthesis Panel will modify the focus of investigations as needed to benefit management and policy. The Panel consists of the heads of each of the six scientific working groups, representatives from each of the Centers of Excellence, the Executive Officer from the Project Executing Agency, and several outside experts representing the scientific, management, natural resource economics and environmental policy communities. Efforts are currently underway to engage a manager from South East Asia (possibly Indonesia), to fill a vacancy recently created by a former member from this region. The Synthesis Panel will be aided in its role by a coordinator based in Washington, D.C. who will serve as an Executive Secretary to the Synthesis Panel and interlocutor with the PEA. Terms of reference for the Coordinator have been drafted and will be included in the Project Implementation Manual.

Another important element of this component will be the work of a sixth scientific Working Group, on Modeling and Decision Support. Its task will be to integrate bio-physical data and other information about coral reef ecosystem boundaries and drivers with economic and social data from human communities in and around the Center of Excellence. Modeling the response of coral reefs to these ecosystem drivers, incorporating disturbance from both human stressors and climate change, can help decisionmakers visualize the results of various policy decisions on coral reef structure and function. Among the types of stress/response system behavior modeled could be the effects of eutrophication and sedimentation on recruitment of coral reef organisms, effects of pollution or increased sea surface temperature on the frequency of disease outbreaks on coral reefs, effects of increases in sea surface temperature on coral

reproduction and calcification rates, and the effects of overfishing and changes in food web structure on the abundance and distribution of reef building corals. Such models will help translate ecosystem response to changes in the productivity of ecosystem goods and services. These changes will be translated, in turn, into economic and social impacts on local stakeholders as well as on coral reef dependent economies in the region.

In addition to hosting the research, each Center of Excellence will serve as the conduit of information to satellite sites in the region, and to various user/stakeholder groups. These user groups include other GEF projects (including those in OP2 as well as Large Marine Ecosystem Projects), programs such as the Global Coral Reef Monitoring Network (GCRMN) and the International Coral Reef Action Network (ICRAN) of the International Coral Reef Initiative (ICRI), and Coral Reef Degradation in the Indian Ocean (CORDIO), a multi-donor program (see Fig. 3 below). Thus, in addition to strengthening scientific capacity in the region, the Centers of Excellence will be responsible for building management capacity locally among coastal resource managers (including coastal developers, managers of watersheds draining into coral reefs, community-based groups and NGOs promoting conservation and sustainable use of coral reefs) by: (1) overseeing training in monitoring and the application of new management tools developed by the Working Groups to emerging management initiatives, (2) incorporating traditional knowledge into the training and data collection methods, and (3) translating research findings into user friendly information and tools for decisionmakers. This will include demonstrations of the visualization tools developed by the Modeling and Decision Support Working Group.

The Centers of Excellence will also serve as conduits of information to decision-makers at the national and regional levels in the design of national development plans and policies where tourism and fisheries are concerned, in the implementation of international conventions and negotiating access agreements to coastal resources. NGOs active in the region, represent a particularly cost-effective means to communicate findings to managers and help convert them into low-tech solutions for direct application to developing country management needs. These include tool kits for managers, such as the one TNC has prepared for building resilience into MPA design, as well as those involving bio-indicators to assess stress in key reef species. The Project has also been identified as a source of new knowledge for an innovative Learning Partnership--the Tropical Marine Protected Area Network--initiated recently by Conservation International, The Nature Conservancy, Wildlife Conservation Society and World Wildlife Fund. This learning network will operate in the same regions where the TR Project Centers of Excellence are located and will help disseminate project findings for uptake by MPA managers.

### Example of Knowledge Products and Tools from Targeted Research

- Review of the state of knowledge in each focal area of investigation
- Simple biomarkers of ecosystem stress to be used in routine reef monitoring by local communities and resources managers
- Early warning tools to predict bleaching in corals in response to specific stressors (e.g., heat, light, contaminants) in corals in response to specific contaminants or certain pollutants related to specific Early warning tools to predict bleaching in corals
- Development of simple disease diagnostic kits to measure prevalence of disease, identify syndromes and test for certain pathogens
- Techniques to measure connectivity between coral reefs to support spatial management (e.g., setting MPA boundaries and designing functional networks of MPAs)
- Remote Sensing techniques to measure changes in coral reef community structure and biodiversity over space and time
- Primer on restoring and rehabilitating damaged coral reefs, and conditions under which such restoration may be cost-effective
- Decision support tools, including scenario building and other visualization techniques, to demonstrate likely outcomes of development decisions and economic policies and

High level audiences will be kept abreast of research findings through the work of the Synthesis Panel. In addition to overseeing the direction and quality of the Targeted Research, the Synthesis Panel integrates the research findings and serves as a formal interlocutor with other disciplines, such as development economics and law, to enhance the relevance and uptake of results by policymakers and to recommend key policy and institutional reforms stemming from the targeted research. In addition to publishing findings in the peer reviewed scientific literature, the Synthesis Panel will periodically develop and disseminate a series of management and policy briefs, or précis, in a form easily internalized by different audiences. These audiences include Bank Country Directors, GEF project teams, policy-makers, and member of regional and global fora (e.g, the IPCC, CSD, ICRI, SBSTTA, Regional Seas Conventions).

To inform the Bank's country dialogue with strategic clients with coral reef resources, an internal working group composed of Bank Task Team Leaders of relevant coral reef and coastal resource management projects has been formed. This working group will liaise closely with the Synthesis Panel and relay project findings and recommendations to country teams (both SMUs and CMUs). Country Directors will be briefed periodically on the results to inform country dialogue on needed policy reforms, as well as feed into AAA work, preparation of CASEs, PRSPs and sector strategies.

Finally, to disseminate and promote the uptake of Project results, the TR will also make use of the IW:Learn Project (a GEF/UNDP/UNEP/WB Knowledge Management Project for International Waters) to help disseminate research findings. Electronic fora and roundtable discussions focusing on key themes emerging from the targeted investigations may be supported through the IW:Learn Project and open to the relevant community of practice. Over the course of project implementation, the information and tools produced will be disseminated as knowledge products to enhance the management of coral reefs. These products may range from in-situ diagnostics (for example, disease assessment and bio-indicators of specific forms of stress and metabolic response in coral reef organisms, to markers for larval recruitment indicating source and sink reefs) to remote sensing products and applications to assess the state of coral reef health. In addition to these tools, a series of management and policy briefs will be developed periodically by the

Synthesis Panel, and released to targeted audiences.

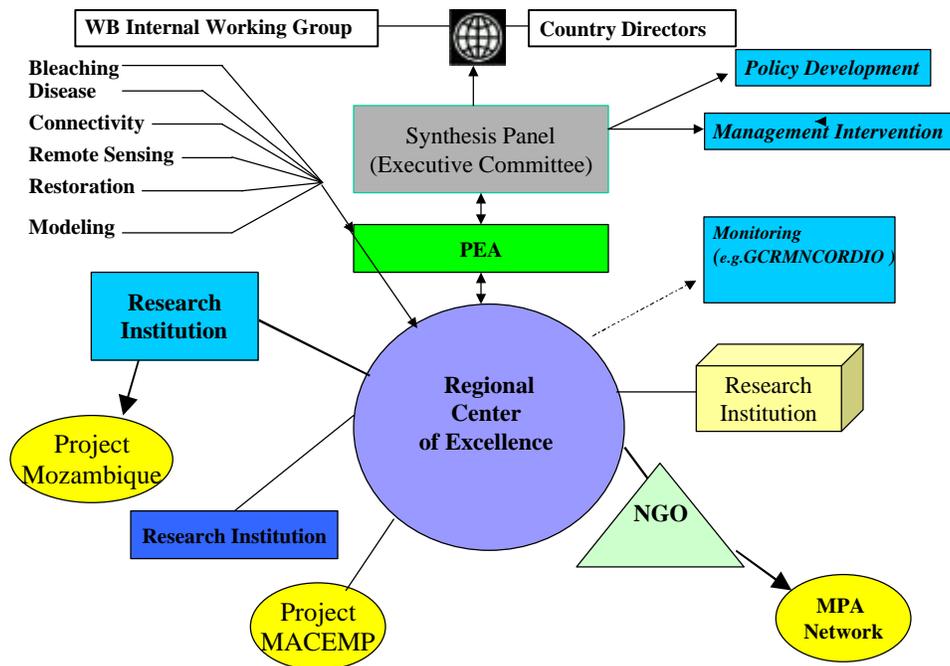


Figure 3 - Illustration of the institutional linkages involved in designing, implementing and disseminating the results of the targeted investigations. Institutional Nodes, or Centers of Excellence, will provide the quality control and research rigor required to carry out the experimental design formulated by the working groups and endorsed by the Steering Committee. Capacity building is the result of collaboration between a COE and other research facilities in selected locations with coral reef ecosystems, through formal exchanges, targeted learning and collaborative research. Research results are channeled to management projects and activities to inform decision making, and to policymakers to introduce needed reforms. Similar clusters of node and satellite institutions are envisioned in each region and some of the working groups may overlap in their use of field sites and clusters to carry out investigations.

#### Component IV. Project Administration (US\$ 2.9 M)

This component involves overall coordination and management of Project implementation (see section C 4. on Institutional Arrangements.) A Project Coordination Unit will be set up in the Center for Marine Studies of the University of Queensland, which will serve as the Project Executing Agency (PEA). The PEA will be staffed by an Executive Officer, a Financial Management Officer/Procurement Officer, and a Project Coordinator to assist the EO in overseeing activities at the Centers of Excellence. As part of its in-kind contribution to the Project partnership, UNESCO/Intergovernmental Oceanographic Administration (IOC) will second one of its technical staff from Headquarters to serve as a full time Communications and Outreach Officer based in Brisbane at the PEA. His primary role will be to liaise with the COEs, to link the targeted research to IOC programs to build capacity for better management of ocean resources, and to facilitate a knowledge network among COEs with support from the PEA. The PEA will also be responsible for Data Management and for disseminating and archiving research results in formats and channels acceptable to the institutions involved and for the benefit of target audiences. The Project Implementation Manual will document procedures for data ownership, management and dissemination.

Component	Indicative Costs (US\$M)	% of Total	GEF Financing	% GEF Financing	Bank Financing -DGF (US\$M)	% of Bank/DGF Financing	Direct and In-Kind Co-Financing	Parallel Financing [1]
1. Knowledge & Technology Gaps	11.2	48	8	72	0	0	0	3.2 (2)
2. Promoting Learning and Capacity Building	4.2	22	1.2	11	1.7	57	0	1.3 (3)
3. Linking Scientific Knowledge to Management	4.0	18.5	1.4	13	1.3	43	0	1.3
4. Project Administration	2.9	11.5	0.4	4	0		2.5	0
<b>TOTAL</b>	<b>22.3</b>	<b>100</b>	<b>11</b>	<b>100</b>	<b>3</b>	<b>100</b>	<b>2.5</b>	<b>5.8</b>
[1] Administered outside the PEA								
[2] Research Institutions								
[3] Smart State Grant to Heron Island								

Component	Indicative Costs (US\$M)	% of Total	Other financing (US\$M)	% of Bank/DGF financing	GEF financing (US\$M)	% of GEF financing
1. Filling Key Knowledge Gaps	11.20	50.2	3.20	28.3	8.00	72.7
2. Promoting Learning and Capacity Building	4.20	18.8	3.00	26.5	1.20	10.9
3. Linking Scientific Knowledge to Management	4.00	17.9	2.60	23.0	1.40	12.7
4. Project Administration	2.90	13.0	2.50	22.1	0.40	3.6
<b>Total Project Costs</b>	<b>22.30</b>	<b>100.0</b>	<b>11.30</b>	<b>100.0</b>	<b>11.00</b>	<b>100.0</b>
<b>Total Financing Required</b>	<b>22.30</b>	<b>100.0</b>	<b>11.30</b>	<b>100.0</b>	<b>11.00</b>	<b>100.0</b>

## 2. Key policy and institutional reforms supported by the project:

### Key Policy and Institutional Reforms

The key policy reforms to be sought will be (i) better information and knowledge transfer of those practices that can most effectively alleviate localized human stress that may contribute to increased vulnerability of coral reefs to the effects of climate change; (ii) development of institutional and human resource capacity to support coordinated, long-term investigations into the nature of stress/response interactions determining coral reef sustainability in the face of cumulative stress from natural and human-induced causes; (iii) facilitating the linkages between science and management to visualize future scenarios (e.g., of resource state and provision of goods and services ) based on current patterns and trends, identify appropriate regulatory and incentive-based interventions, and build support for sustained conservation of coral reefs.

Although this framework is designed to address targeted research globally, the Project aims to shape policy

decisions affecting the sustainability of coral reef ecosystems at national and local levels. It aims to do this by developing accurate stress/response and ecosystem dynamic models and decision support that will significantly improve our understanding of coral reef ecosystem resilience, vulnerability to different forms of stress (from local, human-induced stress, to climate change impact), and the steps that can be taken to reduce uncertainty in designing management interventions. Scenario building, which will allow the forecasting of reef ecosystem response to stress under different management/use options (including upstream or offsite development), will provide decision-makers with the basis for significantly improved management interventions and the design or strengthening of relevant policies that contribute to the sustainability of coral reef ecosystems for generations to come.

What is needed is a change in the way coral reef science is pursued in support of management and in the way development decisions which may affect coral reefs are made. This involves a commitment by the public sector to sustained, targeted and high quality empirical work directed at resolving key unknowns as a fundamental priority. Once these key, targeted gaps in knowledge are filled, the dissemination of this information to policymakers, the scientific community, industry, coastal managers and the general public will have positive impacts on management interventions and policy. Ultimately, the Targeted Research will support policies related to mitigating the causes and effects of climate change, improve those practices and technology that most effectively reduce land based sources of pollution to reefs, over-fishing, and the application of tools to enhance natural resilience and recovery of reefs to stress. (This includes better zoning of coastal landscapes and seascapes, and terrestrial corridors contiguous with reefs, adoption of improved field techniques to assess reef health or factors such as disease, light, heat and other stressors which may elicit coral bleaching; or may facilitate artificial restoration.)

### **3. Benefits and target population:**

#### **Benefits and Target Population**

The benefits of this project are primarily global, however, there will also be regional and local benefits as a result of many of the findings. The targeted research is directed at filling critical gaps in our understanding of how coral reef ecosystems around the world respond to different types of threats, how to mitigate these threats, and how best to enhance natural resilience to and recovery from major disturbances. Only with systematic investigations designed to identify the nature of ecosystem response to such threats and to discriminate significant trends in coral reef ecosystem response from natural variability (background noise), can science provide the guidance needed to managers and stakeholders who rely on coral reef ecosystem goods and services for livelihoods, or value their biological, cultural and intrinsic worth.

The major benefits of the TR will be:

- networks of developed and developing country scientists collaborating on the testing of strategic, priority hypotheses related to determinants of coral reef vulnerability and resilience under various forms of stress and coordinating their research across regions;
- capacity and long-term commitments for targeted learning within and across regions strengthened
- a rigorous framework in place for science based management of coral reef ecosystems in four key regions of the world;
- informed decision making backed by solid science that reduces uncertainty, and guidance to GEF and other partners on the range of options and most cost-effective investments to improve the condition of coral reefs globally.

Development benefits include a globally coordinated scientific community skilled in developing

investigative frameworks designed to reduce uncertainty regarding key issues related to ecosystem sustainability within and between regions, and to develop cost-effective tools and knowledge that will significantly improve coral reef management at the local level. Because of the global nature of this research effort, the opportunity to coordinate with a number of ongoing or planned coral reef initiatives in various regions of the world with support from bilateral agencies (such as US NOAA and the U.S Coral Reef Task Force, the Agence Francaise de Developpement, which is about to launch a coral reef research initiative in the South Pacific) and scientific research institutions (like the U.S. National Science Foundation, Woods Hole Oceanographic Institution and the National Science and Engineering Research Council of Canada). Project beneficiaries include (i) the community of established coral reef scientists, who will have the opportunity to collaborate on a global scale on agreed priorities essential to effective, long-term management, (ii) the emerging generation of new coral reef researchers who will be trained in cutting edge investigative techniques by the best scientists in the field, to answer these and other questions, as they emerge, related to the survival of coral reef ecosystems, as we know them, around the world.

Managers (from the public sector, NGOs and CBDs) and policy-makers will also benefit from this Targeted Research as the recipients of knowledge and key information that will help them make the case for better practices and policies aligned with conservation and sustainable use of coral reef ecosystems. The Targeted Research preparation has consulted extensively with on-going scientific and management efforts related to coral reefs. Current coral reefs management initiatives, such as ICRAN, which is now an operational network of ICRI, will benefit by strengthening management recommendation and options as a result of this project. NGO program, such as the Nature Conservancy's "Transforming Coral Reef Conservation for the 21st Century" will also use results, and is collaborating with this project to further conservation objectives. Important indirect beneficiaries are the hundreds of millions of people who either rely on coral reefs for environmental security and economic livelihoods; enjoy reefs for their recreational, cultural and spiritual value; or stand to gain from biodiversity and ecological services that have yet to be assessed.

The GEF and its implementing agencies, including the World Bank, will also benefit significantly from the guidance emerging over the course of this targeted research program, to assess the cost-effectiveness and long-term impact of current interventions and improve upon them; the need to re-orient strategic assistance, and how to achieve synergy across related focal areas (e.g., international waters, biodiversity and climate change).

#### 4. Institutional and implementation arrangements:

A major study to identify the most appropriate institutional arrangements and flow of funds for the implementation of the project was completed as part of project preparation. The results of the study recommended the establishment of a global implementing agency (the Project Executing Agency or PEA) with overall responsibility for project execution and administrative accountability to the Bank. An arrangement whereby The University of Queensland, Australia, serves as recipient of the Grant funds on behalf of project beneficiaries, and as Executing Agency, in partnership with UNESCO-IOC, has been determined to offer an optimal combination of financial accountability, technical expertise, capacity building and long-term institutional commitment (including substantial co-financing), to serve as the global executing agency. The PEA will have a fully dedicated staff to oversee project implementation, outreach and communication activities, and future planning (including development activities to identify future co-financing and new partnerships). Such a staff will include, at a minimum, a senior level Executive Officer, a Project Coordinator, an Outreach and Communications Specialist, and a Financial Manager with responsibility for sub-project grants and the limited procurement of goods and consultant services that will be undertaken by the PEA. These will be full time positions, working out of the same centralized project office. In addition, the PEA will hire, as necessary, short term consultants to work with the Synthesis Panel to: 1) design a communication strategy for the Project 2) produce and disseminate knowledge products (including periodic publications in peer reviewed journals, policy and management recommendations, videos and other educational materials to reach a range of user groups); (3) organize multi-disciplinary symposia to help interpret research findings for policymakers, and (4) periodically evaluate the performance of Working Groups and Centers of Excellence. A dedicated Executive Secretariat will assist the Synthesis Panel in carrying out these tasks.

At the field site level, the four Centers of Excellence will be responsible for hosting the research, helping to organize training workshops and information outreach activities. They will work closely with the 6 scientific working groups, who will be directly in charge of organizing and leading the research program. The Working Groups will be responsible for planning detailed work programs around key research question in their area of concern and translating these into research proposals that will be reviewed for funding. The research outlined in these proposals must satisfy criteria of scientific rigor, relevance to management, feasibility and cost effectiveness. Input of the management community in shaping the research agenda and on interpretation of research findings will be obtained *inter alia*, through inclusion of managers in each Working Group and in the independent peer review of proposals, through reference groups of end users associated with each Working Group, through workshops and multi-disciplinary symposia designed to interpret the application of results, and, in the case of Modeling and Decision Support Working Group, through ongoing consultations with decisionmakers at the local and higher levels.

Chairs of the Working Groups and representative of the Centers of Excellence will be responsible for developing and submitting annual work plans to the PEA and reports on performance relative to annual benchmarks. These will be reviewed, in turn, by the Synthesis Panel, and by independent reviewers as appropriate. A sub-committee of the Synthesis Panel, the Executive Committee, will be derived from the external members of the Synthesis Panel (e.g., those not affiliated with a Working Group or Center of Excellence) and a representative of the University of Queensland not directly associated with the PEA office. These "financially disinterested" members will review annual work programs and budgets submitted by the Working Groups and Centers of Excellence and make decisions about resource allocations consistent with performance and research priorities agreed by the group as a whole. The Executive Committee will also take into account the recommendations of independent peer reviewers who will be selected from the coral reef research and management communities to provide an arms length review of the annual reports and work plans of each Working Group and Center of Excellence. Procedural details for the

functioning of the Synthesis Panel and the Executive Committee have been developed, along with guidelines and criteria for the approval of sub-project grants, and are included in the Project Implementation Manual.

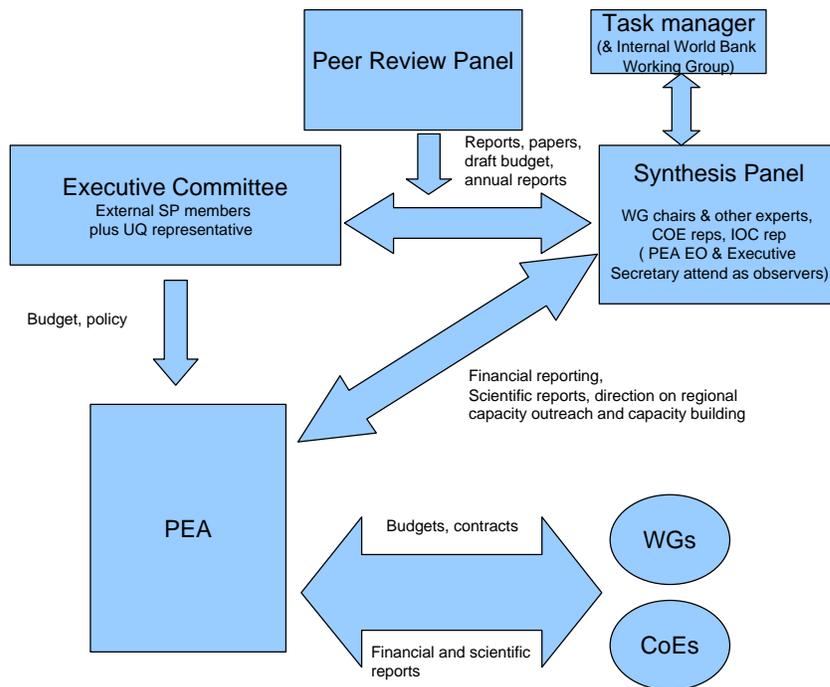


Figure 4. Diagram of relationship between the various administrative and oversight bodies of the TR Project. The PEA submits semi-annual Project progress reports and research and budget proposals on behalf of the WGs and COEs to the Synthesis Panel for their review. The Synthesis Panel makes its recommendations to the Executive Committee, which reviews these and input from independent peer reviewers to make final decisions on resource allocations. Policy Briefs and other technical communications emerging from the Synthesis Panel are also reviewed by the Executive Committee and independent reviewers prior to being released.

## D. Project Rationale

### 1. Project alternatives considered and reasons for rejection:

Previous studies of large-scale environmental impacts have shown that organizing response, damage assessment and restoration programs in a reaction-based mode results in significant financial and societal costs to both the affected and responsible parties. An alternative approach is to support management with targeted research that is proactive in its focus and strategic planning. The global knowledge creation and capacity building that is part of this program is consistent with the GEF's new strategic emphasis on targeted learning to build indigenous capacity within its clients for strategic and effective environmental decision-making. This involves asking the right questions, e. g., to identify major bottlenecks or drivers to sustain coral reef ecosystem goods and services, or to improve the cost-effectiveness of applications of existing tools, like Marine Protected Areas and coastal and ocean zoning, and the use of remote sensing and modeling. Targeted research may also lead to development and application of new tools, such as

biotechnology, in the design of bio-indicators of reef stress or resistance to bleaching, and in the identification of pathogens and their pathways of transmission. At the macro scale, this might involve the development of new tools like genetic markers to reveal connectivity between reef systems or techniques to enhance natural recovery and restore reefs damaged from blast fishing or cyanide. This new knowledge, disseminated and linked to decision-making, has the capacity to dramatically increase the effectiveness of current and future management interventions. It also lends credibility and accountability to decision-making and has the potential to generate the political will needed to make tough trade-offs between conservation and intensive use.

An alternative to this approach is the no-project alternative, which would perpetuate the problems of uninformed/reactive management rather than science based/pro-active management, and isolated, country-specific research. The latter which, while valuable, would not have the spin-off and global learning impact of the networked research and integrated problem solving that is the hallmark of this Targeted Research and Capacity Building Program. Without a better understanding of ecosystem processes and how they interact with the range of stressors facing coral reefs today, management interventions will continue to be hampered by inadequate science. The proposed project will, therefore, link the results of the Targeted Research to the Bank’s portfolio of ongoing and pipeline coral reef projects, many in partnership with the GEF.

**2. Major related projects financed by the Bank and/or other development agencies (completed, ongoing and planned).**

Please refer to the Map annex to see where many of these Projects are located in relation to the Centers of Excellence.

Sector Issue	Project	Latest Supervision (PSR) Ratings (Bank-financed projects only)	
		Implementation Progress (IP)	Development Objective (DO)
<b>Bank-financed</b> Improving management of highly threatened, economically important environmental goods and services in the epicenter of marine biodiversity.	Coral Reef Rehabilitation and Management Project (COREMAP): Phases I-II	S	S
	Conservation and Sustainable Use of the Mesoamerican Barrier Reef System	S	S
	Gulf of Aqaba Environmental Action Plan	S	S
	Red Sea Strategic Action Plan Implementation (Bank, UNEP and UNDP)	S	S
	Coral Reef Monitoring Network in Member States of the Indian Ocean Commission (COI), within the Global Reef Monitoring Network (GCRMN)	S	HS
	Coastal and Marine Biodiversity Management Project, Mozambique	S	U

	Coastal and Marine Biodiversity Conservation in Mindanao, Philippines	U	S
	Marine Biodiversity Protection and Management (MSP), Samoa	S	S
	Hon Mun MPA Pilot Project (MSP), Vietnam	HS	S
	CORALINA Project, San Andres, Colombia	HS	HS
	Coastal Zone Integrated Management Program, Benin (Pipeline)		
	Guinean Coastal Zone Integrated Management and Preservation of Biodiversity (Pipeline)		
	Coastal and Biodiversity Management Program, Guinea Bissau (Pipeline)		
	Marine and Coastal Biodiversity Conservation, Senegal (Pipeline)		
	Sustainable Coastal Livelihoods, Tanzania (Pipeline)		
	Mainstreaming Adaptation to Climate Change in Caribbean (Pipeline)		
<b>Other development agencies</b>			
Selected UNDP Activities	Tanzania: Development of Mnazi Bay Marine Park Comoros: Conservation of Biodiversity and Sustainable Development in the Federal Islamic Republic of the Comoros Mauritius: The Management and Protection of the Endangered Marine Environment of the Republic of Mauritius India: Management of Coral Reef Ecosystem of Andaman and Nicobar Islands Maldives: Conservation and Sustainable Use of Biodiversity Associated with Coral Reefs in		

	<p>the Maldives  Vietnam: Coastal and Marine Biodiversity Conservation and Sustainable Use in the Con Dao Islands  Philippines: Conservation of the Tubbataha Reef National Park  Philippines: Biodiversity Conservation and Management of the Bohol Islands  Papua New Guinea: Milne-Bay Province Marine Integrated Conservation  Belize: Conservation and Sustainable use of the Barrier Reef Complex  Cuba: Priority Actions to Consolidate Biodiversity Protection in the Sabana-Camaguey Ecosystem  Reversing Degradation Trends in the South China Sea and Gulf of Thailand  Integrating Watershed and Coastal Area Management in Small Island Developing States of the Caribbean  Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa  Reduction of Environmental Impact from Tropical Shrimp Trawling through Introduction of By-catch Technologies and Change of Management</p>		
<p>UNEP Activities</p>			
<p>Other Donors</p>	<p>International Coral Reef Initiative (ICRI)  International Coral Reef Action Network (ICRAN)</p>		

IP/DO Ratings: HS (Highly Satisfactory), S (Satisfactory), U (Unsatisfactory), HU (Highly Unsatisfactory)

In addition to projects related to conservation and sustainable use of marine biodiversity (exemplified by the examples given above), there are a growing number of Large Marine Ecosystem (LME) Projects under preparation (Caribbean LME, Gulf of Mexico LME, and Agulhas and Somali Current LME) and early implementation (Pacific SIDS, South China Sea), which complement and may benefit from the overall research agenda of the Targeted Research Project. The UNDP/GEF Caribbean LME project

concept highlights the need to fill critical data gaps related to preparation of the TDA/SAPs for the wider Caribbean. There is also a capacity building component of the LME Project, focusing on improving governance and institutional arrangements for management of shared resources of the Caribbean LME, as well as a science component which focuses on transboundary, pelagic fisheries management. The TR Project can contribute information on stress/response pathways in coral reefs of the Western Caribbean associated with major land based threats, as well as from Climate Change. There is broad scope for linking the Working Groups on Connectivity and Remote Sensing under the TR, with research groups under the Caribbean LME Project, especially on the topics of spawning aggregations and larval and adult phase dispersal (major axis of connectivity within LMEs), and assessing marine ecosystem health. The latter will be crucial to the objectives of enhancing governance of transboundary coastal and marine resources. Discussions with UNEP Regional Seas staff in the Caribbean on how to use results from the TR to accelerate ratification of the Land Based Sources of Marine Pollution (LBS) Protocol in member countries have also taken place. Use of the GIS-based coral reef visualization and decision support tools to be developed by the Modeling WG, represent the potential application of TR research outputs to management and policy in the Wider Caribbean.

Similar opportunities exist for the TR Project to liaise with the UNEP/GEF South China Sea Project, which has a sub-component and regional working group on Coral Reefs, some of whose members overlap with those in the TR Project. Opportunities for close collaboration between the two projects lie within the area of Reef Restoration and Rehabilitation, Connectivity and Decision Support and Modeling. The International Coral Reef Action Network (ICRAN), a partnership hosted by UNEP and the World Conservation Monitoring Center, will also be able to use the results from the Targeted Research investigations to contribute to a suite of demonstration sites within UNEP's Regional Seas Programmes, including South East Asia and the Caribbean. Peer-to-peer learning exchanges are also planned, which could be facilitated through the nodes. As a result of these information and learning exchanges, feedback will also be provided to participants in the Targeted Research to help ensure that it is client-driven.

Although Agulhas and Somali Current LME project is still in the concept phase, there has been significant progress in scoping out needs and activities within the Eastern African/Western Indian Ocean Marine Eco-region of the LME through a consortium of NGOs (WWF is taking the lead) and research institutions, including the Institute of Marine Sciences in Zanzibar. Focus on coastal resources, such as coral reefs, fisheries and mangroves, and improving management tools such as spatial planning (MPAs and ICM) and remote sensing, offer excellent opportunities for collaboration between the TR Project and this effort and building ownership for an ecosystem based management approach to governance of shared living marine resources of the LME.

To ensure broad dissemination of research results across LMEs, facilitate uptake of new management tools and promote replication of research activities in new regions during subsequent phases of the Project (e.g., the Pacific SIDS, the Gulf of Mexico, and the Red Sea LMEs), the Targeted Research Project will coordinate closely with the IW:LEARN Project, about to enter its second phase. The Bank led activities under this jointly implemented UNDP/UNEP/WB IW Full Sized Project, will include hosting learning exchanges on coral reefs through the IW:Learn website ([www.IWLearn.net](http://www.IWLearn.net)) with links to the TR website at [www.GEFCoral.org](http://www.GEFCoral.org). These learning exchanges may feature, among other things, techniques to assess ecosystem boundaries (relevant to classification of marine ecoregions within the LMEs), and new diagnostic tools to predict coral bleaching and disease paths in corals, or techniques to enhance recovery of damaged reefs, a high priority for reefs in the South China Sea. In addition to the virtual learning that can take place through links to the IW:Learn portal, IW Project Teams and representatives from these projects will be invited to attend periodic training workshops in the regions hosted by the Centers of Excellence. Resources will be set aside for participation by government counterparts involved in these LME Projects, to ensure cross project learning and encourage adoption of better management policies. Similarly, funds

will be set aside to ensure that TR principals attend the biannual IW Conferences, to report on research results and application to management of transboundary water resources.

### **3. Lessons learned and reflected in the project design:**

Historically, research components of GEF projects dealing with coastal and marine ecosystems have focused on assessing and monitoring baseline conditions. Several have documented declines in the resource base, but few, if any, have supported experimental research that would improve our understanding of ecosystem function or factors that regulate ecosystem response to various kinds of threats. A recent Consultative Group meeting of the WB/GEF MesoAmerican Barrier Reef System Project held in Belize (October 03), flagged the Targeted Research Project as a much needed complement to the work the MBRS Project is undertaking in sustainable fisheries, monitoring of ecosystem health and policy harmonization in coral reef related sectors in the four participating countries. This includes: (i) managing spawning aggregations of commercially valuable reef fish (and links to the TR Connectivity Working Group), (ii) implementing the first regional Synoptic Monitoring Program of Reef Health for the MBRS (with links to the TR Remote Sensing Working Group and to the the Disease and Bleaching Working Groups); and (iii) technical input to the MBRS Policy Working Groups on harmonizing policies and good practice related to shared resources of the MBRS (with links to the TR Modeling and Decision Support Working Groups). Similarly, the COREMAP II Project Team and NGOs (TNC) working alongside, have indicated very strong interest in collaboration with the TR Working Group on Reef Restoration and Rehabilitation, to test new tools for restoring dynamited and cyanide damaged reefs in the region. Given the emphasis on ecosystem-based management endorsed by the GEF, the WSSD and others for favoring a holistic approach to natural resources management, there is a need to understand the nature and pathways of ecosystem drivers to identify bottlenecks in ecosystem function and how best to address these.

Lessons learned from past experience with public sector financed-research have been incorporated into the design of the Targeted Research, as follows: (i) target research on strategic priorities which will significantly enhance knowledge required for effective management, (ii) identify near-to-medium term products and tools that can be applied in the interim to demonstrate the benefits of a committed, targeted research program; (iii) ensure transparency and full-fledged participation in partnerships between developed and developing countries, and (iv) disseminate knowledge as widely as possible, taking care to tailor messages to different target audiences.

Historically, the coral reef scientific community has been fragmented in its approach to conducting investigations in a coordinated manner, and over both space and time. The TR framework presents the first opportunity for the coral reef scientific community to pool its intellectual resources and energies—in a collaborative mode with developed and developing country scientists—to design targeted investigations that will address key unknowns and ultimately contribute to improving human welfare. The research framework has emphasized the need to prioritize gaps in knowledge, sequence investigations to build on knowledge obtained by one or more working groups, analyze and synthesize results (with the help of the Steering Committee), and disseminate these as discrete knowledge products and innovative tools to stakeholder groups. As the results from these investigations come on line, the Steering Committee will be in a position to collectively address how the information may best be used to affect management options, influence policy, contribute to the accuracy of economic models involving coral reefs and dependent communities, and improve the quality of life through enhancing the sustainability of strategic resources.

#### **4. Indications of recipient commitment and ownership:**

This project is global in scope, and will involve more than 70 international scientists and a host of scientific institutions from around the world. The proposal has the strong support of the nodal agencies in the four countries involved (Mexico, Tanzania, the Philippines and Australia), as evidenced by the letters of endorsement from these institutions. The coral reef community in these and other countries in the regions who will benefit from direct involvement in the research or from the management information that will be generated by it are also enthusiastic about this global effort. A strong role for the COEs is envisioned in terms of engaging other institutions in the region in the research, building capacity among the next generation of coral reef scientists and serving as an information clearing house to a range of stakeholders (from local communities to national and regional level policy-makers). These activities are consistent with the missions of the COEs, and their roles in providing technical advice for the formulation of national and regional policies. To create local buy-in, each Center of Excellence will serve as the conduit of information to satellite sites and various user/stakeholder groups and projects within each region. NGOs active in the region will help to communicate findings to managers and help convert them into low-tech solutions for direct application to developing country management needs. These include tool kits for managers, such as the one The Nature Conservancy has prepared for building resilience into MPA design, as well as those involving bio-indicators to assess stress in key reef species.

#### **5. Value added of Bank and Global support in this project:**

Of the 184 member countries of the World Bank, more than 90 countries rely on coral reefs as natural economic assets. However, most of these reefs and associated resources are components of larger transboundary marine ecosystems, which require multi-country approaches to manage and conserve. The Bank has considerable experience in transboundary water resources management through a growing portfolio of Regional Seas and International Waters programs. More recently, experience in promoting regional cooperation in the conservation and sustainable use of the world's second longest barrier reef system—the Mesoamerican Barrier Reef System—has provided a model for regional coordination, involving multinational technical and policy working groups, on which the TR Project can build.

The Bank is in a unique position to provide global leadership on needed policy reforms that may be implicated by the TR findings. World Bank Country and Sector Directors will be apprised periodically of the research results and their implications for the Bank's clients, by an internal Project working group of Bank Task Team Leaders of coastal and marine resource management projects. Result can form the basis for ESW, flagging the value of goods and services provided by coral reefs and what is at stake, or feed directly into the Country Dialogue with clients with coral reefs, and the Country Assistance Strategy and the PRSP process. Where appropriate, new investment projects may be identified to reduce stress on coral reefs and the threat to reef-dependent communities, as in Tanzania, where a Sustainable Coastal Livelihoods Projects is being designed as a follow up to the PRSP.

### **E. Summary Project Analysis** (Detailed assessments are in the project file, see Annex 8)

#### **1. Economic (see Annex 4):**

- Cost benefit      NPV=US\$ million; ERR = % (see Annex 4)
- Cost effectiveness
- Incremental Cost
- Other (specify)

The activities and costs subsumed under this Project are entirely incremental, as they support global learning and capacity building for science-based decision-making. Baseline research activities in client counties consist mostly of coral reef monitoring and localized investigations. Apart from monitoring

activities, these efforts are not systematically networked at the national or regional level, nor are they designed to shed light on specific stress response relationships, or the variability in response (i.e., in resilience or vulnerability) that reef ecosystems may display depending on the type, intensity and cumulative nature of the stress. In contrast, the GEF Targeted Research Project is designed to focus on strategic questions directly related to the sustainability of coral reef ecosystems at different sites, under varying stress regimes, and to compare these results across regions. The interdisciplinary nature of the working groups, the geographic and temporal scale of the research program (across four distinct coral reef regions, over 15 years), and the networked nature of the research, will require a degree of cooperation and support that cannot be sustained by any one country. The transboundary nature of coral reef ecosystems, the threats to their sustainability, and the fundamental gaps in our understanding of system behavior and recovery potential, require a multinational effort that spans a range of variability within and between systems. Multinational working groups and cross regional learning and capacity building will ensure that this is a truly global effort, extending well beyond the boundaries of the research sites and countries involved.

No other organization is presently undertaking such a coordinated and targeted program of research to inform managers and policymakers on cost-effective options for coral reef conservation and management. This program would simply not be possible without GEF funding. The GEF serves as an organizing force around which a significant proportion of the community of practice for coral reef research is being united for the first time. The preparation activities have galvanized partner participation, and have resulted in resources and efforts to be realigned, but the GEF support will be catalytic in launching this Targeted Research. The GEF will also serve as a powerful catalyst to leverage funds from an array of partners and collaborators who are committed to supporting one or more aspects of the research. The critical mass of investigators and supporting institutions who are being brought together as a result of this initiative will have an unprecedented impact on the way ecosystem research is conducted in the future.

An incremental cost analysis has been prepared and is attached as Annex 4. The total Project Cost is estimated at US \$28.8 million. GEF is asked to contribute \$11 million, or approximately half the cost of implementing this first phase of the overall Targeted Research Program. Over \$12 million has been identified as in-kind co-financing, and at least \$8 million in cash co-financing is being sought from a number of sources to implement the work program presented here. These include: collaborating research institutions such as the University of Queensland, US NOAA and others (e.g. NSF and comparable institutions), as well as from the Bank's Development Grant Facility (which will meet in April to review a proposed request for \$3M over three years in support of the Project's Partnership), and Bilaterals such as the Japanese, who have expressed a strong interest in supporting coral reef research in the Pacific. In addition to cash, participating research institutions are expected to contribute substantial in-kind resources, in terms of access to field laboratory facilities, services, and staff time. The team is approaching a number of Private Foundations, which have specific programs for marine conservation, scientific research or climate change, as well as corporations with an interest in promoting marine tourism and travel. The latter have already pledged significant in-kind co-financing in the form of reduced hotel and air fares for Project researchers. Working Groups have also been seeking co-financing directly through national research funding agencies and collaborating institutions (e.g., US NOAA). An additional \$10-20 Million in leveraged cash and in-kind resources (including personnel and equipment), not directly under the Project's control, will be raised from collaborating institutions. New partnerships are expected to emerge once GEF financing is committed and the Project gains momentum on the ground. (see section on Finance below).

## **2. Financial (see Annex 4 and Annex 5):**

NPV=US\$ million; FRR = % (see Annex 4)

The Project Executing Agency shall be the principal recipient of GEF funds, other donor funds and funds

to be contributed by the participating governments. The PEA shall be fully accountable for all project funds and shall ensure timely disbursement of funds to participating project implementing institutions. PEA shall be responsible overall project management and coordination including procurement, financial management and project administration. Figure 4, below, illustrates the Flow of Funds model to accommodate the diverse source of funds (e.g. from the GEF, the Bank, Bi-laterals, and the recipient) and the potential for new co-financing expected to emerge throughout Project implementation.

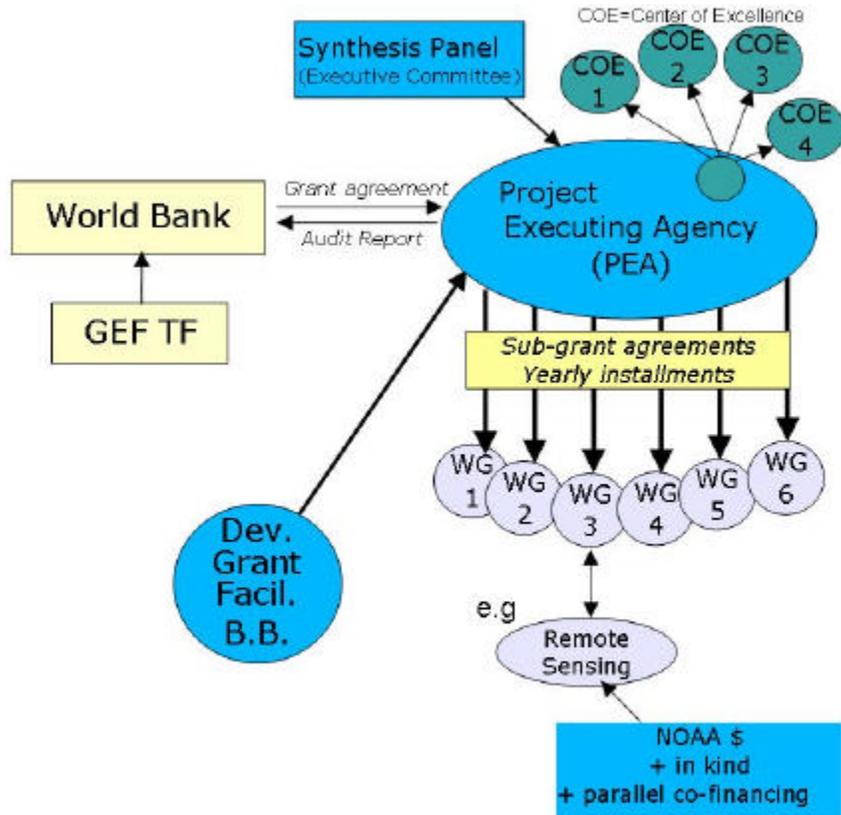


Figure 4 - Diagram of Funds Flow Model for the Targeted Research.

**Fiscal Impact:**

N/A (no loans involved)

**3. Technical:**

The six targeted research working groups will coordinate investigations and results through use of complementary study designs and locations, and through targeted learning exchanges. By coordinating the targeted investigations, the working groups are building an information base that can directly relate findings across space and time (see Figure 1). Such complementary data collection not only strengthens findings but also enhances correlations at different spatial scales. Investigations within many of the Working Groups will also contribute to specific model development to support their respective areas of inquiry, and to contribute to the decision support. The standard operating procedures developed under the Project will contribute to more effective technical exchange by ensuring consistent application of methods and protocols. This has tremendous implications for extending technical capacity and standard approaches

within the client countries. Combined with targeted learning exchanges, this technical approach allows a broad spectrum of researchers within both developed and developing countries to present and debate relevant issues about priority hypotheses, the logistics required to implement targeted research, and to share various experiences. This model is proving to be highly effective in knowledge sharing, and in transcending previous communication barriers. While certain locations will continue to experience limitations in infrastructure (i.e. Internet throughput--which is largely based on given Country's telecommunications infrastructure), these focused exchanges will help to mitigate this constraint within Centers of Excellence in each region.

In concert with the Synthesis Panel, the working groups members and supporting staff will design, plan and disseminate policy briefs and guidelines for the application of relevant findings into management and policy operations. These will be made available directly to clients, Bank country teams and sector units, the GEF, NGO community and to relevant international fora.

#### **4. Institutional:**

##### **4.1 Executing agencies:**

Project execution will be carried out through a series of mutually reinforcing institutional arrangements. A partnership arrangement between the University of Queensland, Australia and UNESCO-IOC, has been determined to offer an optimal combination of financial accountability, technical expertise, capacity building and long-term institutional commitment (including substantial co-financing), to serve as the global executing agency. At the field site level, four nodal agencies will be responsible for hosting the research, helping to organize training workshops and information outreach activities. They will work closely with the 6 scientific working groups, who will be directly in charge of organizing and leading the research program. Liaison with local and international NGOs with projects in the region, and with other projects and research institutions who have expressed interest in collaborating in some aspect of the TR Program will be facilitated through this layered structure of project execution.

As a result of the Block A consultations which engaged both scientists and managers, a conscious decision was made to limit the research to 3-4 key coral reef regions of the world during the initial five year phase. These regions were selected on the basis of where there were already significant GEF and other investments in coral reef management; where there was the beginning of a critical mass of coral reefs scientists and infrastructure to support establishment of a regional node (which could evolve into a Center of Excellence for coral reef research), and with support from the Project could facilitate research and capacity building at a number of satellite sites. The research nodes in these regions were carefully selected in coral reef ecosystems where considerable baseline data was already available and where resident researchers were engaged in research that could both contribute to and benefit from the targeted research objectives.

Under ideal circumstances and significantly larger financial resources, this project would have greater spatial replication and site representation within each of the regions identified, and would reflect some sort of stratified random sampling design. However, there will never be enough financial resources to conduct the kind of spatial replication that would be required to generate rigor and power in a statistical context (i.e. drawing inference over a sampling universe within a given region). As an alternative, this project has approached the targeted research with a case-study model, whereby a limited number of study sites have been identified, in which a suite of investigations around key themes is carried out and the information integrated at each site. Results will be compared across sites, where possible, to assess what impact/response relationships may be global in scope as opposed to regional (in terms of cumulative

impacts) or even local in scope. It is legitimate and necessary to focus at the outset on a smaller number of sites until the effectiveness of the research model(s) can be demonstrated.

It is the project's intention to expand the number of sites as the Project progresses through successive phases and the working groups move toward filling critical information gaps through time. This is why the Targeted Research has been conceived as a 15 year program. Sequencing is essential in light of the human and financial resources available and to allow consolidation of results and reformulation of hypotheses before expanding into new regions and sites. (See Figures 1 and 2)

#### 4.2 Project management:

Day to day administration of the TR Project will be the responsibility of the Project Executing Agency (PEA). The PEA will have a fully dedicated staff to oversee project implementation and performance, outreach and communication activities, and future planning (including development activities to identify future co-financing and new partnerships). Such a staff will include, at a minimum, a senior level Executive Officer, an Administrative Assistant (to help with Sub-grant administration and procurement), a Data, Outreach and Capacity Building Officer, a Research and Education Coordinator and a Financial Manager. These will be full time positions, preferably working out of the same centralized project office. In addition, the PEA will hire, as necessary, short term consultants as required.

The PEA will receive technical oversight and programmatic direction from a Synthesis Panel and Executive Committee (see section on institutional arrangements). The PEA will report technical and financial progress of the Project semi-annually to the Bank with copies to the Synthesis Panel and Executive Committee for comment. A full briefing on Project progress will be made to the Synthesis Panel during the annual meetings of the Synthesis Panel and Executive Committee. In addition to the progress reports, the PEA will submit a financial audit and annual work plans for the WGs, COEs and Synthesis Panel, approved by the Executive Committee, to the Bank. The Bank will provide financial and technical oversight through supervision missions and an internal Bank Working Group, consisting of staff with relevant projects.

#### Project Monitoring and Evaluation

Project monitoring and evaluation will be the shared responsibility of the Project Executing Agency and the Synthesis Panel. M&E of progress by the Working Groups and Centers of Excellence will be an ongoing task of the PEA, whose responsibility includes reviewing outputs against agreed workprograms and a series of performance indicators that will be included in the subgrant agreements between the PEA and recipients. These will reflect outputs and outcomes described in Annex 1 of the PAD and the agreed goals and objectives of the specific Working Groups or Centers of Excellence. WG Chairs and COE representatives will also be responsible for developing and submitting work programs for the next year to the PEA. These will be reviewed initially by the Synthesis Panel and recommendations for funding made to the Executive Committee. An independent peer review of proposals will be commissioned periodically by the Synthesis Panel to provide an arms length assessment of the merit of the sub-project proposal. These recommendations along with those of the Synthesis Panel will be passed on to the Executive Committee for review and final allocation of resources to the various subproject proposals.

The full Synthesis Panel will convene physically at least once a year to take stock of the year's outcomes, discuss any outstanding issues related to the direction of the science, agree on publications to be developed for the coming year, and review proposals of the WG and COEs. In between meetings, the Synthesis Panel will communicate regularly through conference calls and e-mail. Extraordinary meetings of the Synthesis Panel may be convened if necessary, although efforts will be made to convene these around other conferences or meetings which Synthesis Panel members may be attending.

Results of these meetings will be documented in official minutes by the executive secretariat and communicated to the PEA. The minutes of the meetings and follow up actions will be included in semi-annual technical and financial progress reports submitted to the Bank. These semi-annual reports will also include the results of supervision missions by PEA staff to research sites. Prior to being submitted to the Bank, the semi-annual technical and financial progress reports will be reviewed by the Executive Committee, which will have responsibility for approving the following year's research work program and budget for each of the six working groups and the four COEs. The scientific output of the Project will be continuously evaluated through publications in peer reviewed journals and presentations at international fora. A Mid-Term Review of the Project at the end of Year 3 will coincide with an evaluation of the key outcomes of the Development Grant Facility financed components (2 and 3). These evaluations will assess progress against performance benchmarks in Annex 1 toward meeting the GEF and Project Development Objectives.

#### 4.3 Procurement issues:

No issues were identified during the appraisal mission. The executing agency has been assessed to be at very low risk by the Bank. The University of Queensland's procurement procedures mirror those of the Bank and these will be used for the limited procurement to be carried out by the PEA. A procurement plan for these goods and services has been agreed. The majority of the Grant funds will be disbursed through subgrants which will not require a Bank approved procurement plan.

#### 4.4 Financial management issues:

These are discussed in the section on Financial Management arrangements in Annex 6.

### **5. Environmental:** Environmental Category: C (Not Required)

#### 5.1 Summarize the steps undertaken for environmental assessment and EMP preparation (including consultation and disclosure) and the significant issues and their treatment emerging from this analysis.

The Project is designed to enhance environmental sustainability. There are no negative environmental issues/impacts associated with this project. It is primarily a technical assistance project to build capacity for science based management of coral reef ecosystems. The approach is one of trying to create the investigative framework that will help reef scientists and managers understand the basis for ecosystem vulnerability or resilience in the face of key environmental stressors, such as climate change, land-based sources of pollution, disease, etc., and to develop tools that may be most cost-effective in reducing risk and enhancing sustainability. A Category C Environmental Rating has been assigned to the Project by the Bank's Environmental Safeguards Team.

#### 5.2 What are the main features of the EMP and are they adequate?

n/a

#### 5.3 For Category A and B projects, timeline and status of EA:

Date of receipt of final draft:

n/a

#### 5.4 How have stakeholders been consulted at the stage of (a) environmental screening and (b) draft EA report on the environmental impacts and proposed environment management plan? Describe mechanisms of consultation that were used and which groups were consulted?

n/a

#### 5.5 What mechanisms have been established to monitor and evaluate the impact of the project on the environment? Do the indicators reflect the objectives and results of the EMP?

n/a

## 6. Social:

6.1 Summarize key social issues relevant to the project objectives, and specify the project's social development outcomes.

Building capacity for science-based management of coral reefs in countries where they occur will increase the potential for appropriate and cost-effective management interventions, heighten accountability to the public re: important conservation/development tradeoffs and create the basis for risk management in the context of environmental uncertainty. All of these outcomes have substantial social benefits, particularly for those communities dependent on coral reefs. For tourism dependent countries, strengthening the information base to safeguard coral reefs will have enormous economic benefits as well.

6.2 Participatory Approach: How are key stakeholders participating in the project?

Participation of stakeholders will be via workshops, collaborative research, exchange of graduate students and post-docs, publications, symposia and application of research results to policy and management of coral reefs.

6.3 How does the project involve consultations or collaboration with NGOs or other civil society organizations?

The results of the research will feed directly into a variety of management activities already in place. Many of these are sponsored by NGOs and CBOs, working with communities to conserve coral reefs and ensure their continued production of environmental goods and services (see figure 1 in C). Among the NGOs with which the Project will be working are: The Nature Conservancy, Conservation International, WWF, The Wildlife Conservation Society, Environmental Defense, Centro Ecológico Akumal, Western Indian Ocean Marine Science Association (WIOMSA), Society for the Conservation of Reef Fish Spawning Aggregations (SCRFA); The project will also work with NGOs to disseminate information, educate the general public and provide material for their advocacy work for marine conservation.

6.4 What institutional arrangements have been provided to ensure the project achieves its social development outcomes?

The Synthesis Panel will serve as the interface between science and management and science and policy. The SP will ensure that research is carried out in a cost-effective and rigorous way to ensure credibility of results, and will channel findings to various stakeholder groups in appropriate formats to promote the visibility and uptake of the results in decision-making.

6.5 How will the project monitor performance in terms of social development outcomes?

This will be worked out in project preparation.

## 7. Safeguard Policies:

7.1 Are any of the following safeguard policies triggered by the project?

Policy	Triggered
Environmental Assessment (OP 4.01, BP 4.01, GP 4.01)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Natural Habitats (OP 4.04, BP 4.04, GP 4.04)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Forestry (OP 4.36, GP 4.36)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Pest Management (OP 4.09)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Cultural Property (OPN 11.03)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Indigenous Peoples (OD 4.20)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Involuntary Resettlement (OP/BP 4.12)	<input type="radio"/> Yes <input checked="" type="radio"/> No
Safety of Dams (OP 4.37, BP 4.37)	<input type="radio"/> Yes <input checked="" type="radio"/> No

<b>Projects in International Waters (OP 7.50, BP 7.50, GP 7.50)</b>	<input type="radio"/> Yes <input checked="" type="radio"/> No
<b>Projects in Disputed Areas (OP 7.60, BP 7.60, GP 7.60)*</b>	<input type="radio"/> Yes <input checked="" type="radio"/> No

## 7.2 Describe provisions made by the project to ensure compliance with applicable safeguard policies.

N/A - this is a technical assistance project focused on targeted research and learning. None of the activities identified under this project are likely to trigger any of the Bank's Safeguard Policies.

## F. Sustainability and Risks

### 1. Sustainability:

The Project is envisioned as the first phase of a long-term effort which will be sustained through a coalition of partners, built around a common agenda and measurable outcomes. GEF support is being requested for this initial phase, which will serve as a proving ground for the targeted research model and a platform for scaling up and replicating the model in subsequent phases. The requested level of GEF support in this early phase is critical in that it will serve as the primary catalyst to (i) build a broad coalition of partners (within the scientific, NGO and management communities) committed to this effort over the long term, (ii) mobilize the necessary human and financial resources to undertake it, (iii) re-align ongoing and potential investments of partners in a coordinated effort that will bring focus and cutting edge science to a common research agenda, and (iv) facilitate the uptake of new knowledge and tools derived from the targeted research into the design and implementation of GEF-supported activities related to coral reefs.

A long-term approach is needed because coral reefs are influenced by processes over a wide range of temporal and spatial scales. Research in other marine environments has consistently identified the need to establish long-term studies and management trials (over at least 10 to 15 years) to better understand the dynamics and drivers of these systems. This is especially true of coral reef ecosystems. Existing research indicates that coral reefs fluctuate on several decade-long time scales, hence the need to sustain this effort over a multiple phases. The results generated have the potential to eliminate much of the uncertainty characterizing coral reef management efforts to date and to transform management of highly threatened ecosystems from a reactive, empirical mode to a pro-active one. This has important implications for resource allocation, with a focus on preventive measures to manage risks to coral reefs.

Despite the long-term nature of these investigations, information products will be staged for delivery at periodic intervals to provide interim benefits and tools for managers. Outreach workshops to communicate the relevance of investigations and their outputs to local communities and to those responsible for coastal and marine resources management will be organized annually by the Centers of Excellence. Tools and guidance described in a box in Section C2, will be disseminated through knowledge networks within the coastal resources management community, and policy briefs will be circulated by the Synthesis Panel for key audiences in the public policy and development communities. This periodic update of management relevant results will help sustain the commitment that will be required to reap the benefits of targeted investigations over the longer term. As this program of research develops, the Centers of Excellence become stronger, and the working groups generate visible benefits for management and policy, it is hoped that the project's partnerships will expand and that additional financing from research institutions, governments and private foundations will be forthcoming, eliminating the need for further GEF support. Linking the TR to Bank investments, as in Phase 2 of the Indonesia Coral Reef Rehabilitation and Management Project (COREMAP, which includes GEF support) and to a Poverty Reduction Strategy Credit for Sustainable Coastal Livelihoods in Tanzania, will contribute the sustainability of the TR and the uptake of results in follow-up actions.

GEF support during preparation and the promise of support for this initial phase have been absolutely essential to securing the buy-in of key partners thus far. In addition to the direct Project co-financing, significant investments in related activities have also been leveraged, to coincide with this initial phase of the Project. While these leveraged investments lie outside the Project, the results will contribute important knowledge toward filling gaps and strengthening networking with scientists engaged in the Targeted Research, thus also contributing to capacity building. Extending the TR effort to subsequent phases will depend on the success of this initial phase in achieving measurable outcomes and enlisting the necessary financial and institutional support for future investments. As in other examples of regional Bank/GEF initiatives, these initial investments will serve to attract new resources by a range of partners, helping to institutionalize collaboration and sustain the Project through successive phases. It is anticipated that partnerships will expand and additional financing from research institutions, governments and private foundations will become the major source of funding in the subsequent phases of the program.

**1a. Replicability:**

Because the TR Project is structured around discrete research themes and networks of scientists it presents infinite opportunities for replication and scale up. In this initial phase, the Project investigations will be centered around four nodes and Centers of Excellence. Consistent with the availability of resources, the research design calls for the 6 Working Groups to focus their investigations at these sites to lend power to their research through integration of information across themes, in a case-study or demonstration project approach. The research agendas of each of the Working Groups, however, provide broad scope for replication at satellite sites in the region, expanding collaboration with other scientists and institutions around the node. Similarly, the opportunity exists to expand to new nodes and Centers of Excellence in subsequent phases, as demand and resources dictate. Successful implementation in Phase 1 will set the stage for scale up and replication in subsequent phases. The focus in subsequent phases or regions may shift away from filling basic knowledge gaps to strengthening capacity in coral reef countries and tools and interventions for better decision-making. Modeling and decision-support are among the tools that may be refined as knowledge gaps are filled and effort shifts to the application of knowledge to management. By the end of this five year phase, the Project will have documented a model for Targeted Research with wide transferability to other GEF Focal Areas.

**2. Critical Risks** (reflecting the failure of critical assumptions found in the fourth column of Annex 1):

Note “With respect to project objectives, there are no significant risks of failure of critical assumptions”.

<b>Risk</b>	<b>Risk Rating</b>	<b>Risk Mitigation Measure</b>
<p><b>From Outputs to Objective</b> The research findings do not lead to demonstrable improvements in management or policies affecting coral reefs.</p>	<p>S</p>	<p>The project is designed to couple the research with the management and policy communities. The Centers of Excellence have a role to play in disseminating information locally to coastal resources users/managers, and to feed it up to policy makers at the national and regional level through periodic symposia and briefings. The Synthesis Panel has a similar role to play at the level of international public policy.</p>
<p><b>From Components to Outputs</b> Project Components 1-3. Continued support for the project by researchers in developing and developed</p>	<p>M</p>	<p>Centers of Excellence and associated academic institutions within host countries will need to be well integrated into the project, the benefits of</p>

<p>country institutions is not sustained due to lack of political will or other priorities.</p> <p>Project implementation (disbursements) will be affected by complexity and scope of the Project.</p>	<p>M</p>	<p>their participation clear and tangible, and the importance of their work recognized by management.</p> <p>The University of Queensland has substantial experience in executing complex projects. It has sound financial management and follows international standards in procurement and grant administration. As partners in project execution, UNESCO/IOC will work closely with the Centers of Excellence to provide technical support and liaison with the PEA. The Bank Project Team will include representation from each country team where there is a Center of Excellence, and field based staff will carry out regular supervision missions.</p>
<p><b>Overall Risk Rating</b></p>		

Risk Rating - H (High Risk), S (Substantial Risk), M (Modest Risk), N(Negligible or Low Risk)

M

### 3. Possible Controversial Aspects:

None

## G. Main Grant Conditions

### 1. Effectiveness Condition

Approval by the Bank of the Project Implementation Manual, which is currently available in draft. The PEA has been established and adequately staffed.

### 2. Other [classify according to covenant types used in the Legal Agreements.]

n/a.

## H. Readiness for Implementation

- 1. a) The engineering design documents for the first year's activities are complete and ready for the start of project implementation.
- 1. b) Not applicable.
- 2. The procurement documents for the first year's activities are complete and ready for the start of project implementation.
- 3. The Project Implementation Plan has been appraised and found to be realistic and of satisfactory quality.
- 4. The following items are lacking and are discussed under loan conditions (Section G):

N/A

## I. Compliance with Bank Policies

- 1. This project complies with all applicable Bank policies.
- 2. The following exceptions to Bank policies are recommended for approval. The project complies with all other applicable Bank policies.

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Marea Eleni Hatziolos  
**Team Leader, ENV**

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Maria Teresa Serra  
**Sector Director, EASES**

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James Warren Evans  
**Acting Director, ENV**

## Annex 1: Project Design Summary

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

Hierarchy of Objectives	Key Performance Indicators	Data Collection Strategy	Critical Assumptions
<p><b>Sector-related CAS Goal:</b> The strategic goal of this Program is to enhance the sustainability of coral reef ecosystems as global commons, whose goods and services support the livelihoods and security of millions of people.</p>	<p><b>Sector Indicators:</b></p> <ol style="list-style-type: none"> <li>1. Conservation of coral reefs and the goods and services they provide are priorities for reef countries, as reflected in economic development plans and support from the international community.</li> <li>2. The CASes, PRSPs and CEAs of countries with significant coral reefs include discussion of the status of reefs, and their contribution to livelihoods and environmental/ economic security in that country.</li> </ol>	<p><b>Sector/ country reports:</b></p> <ol style="list-style-type: none"> <li>1. Global Status of Coral Reefs Report (produced every two years by GCRMN).</li> <li>2. National economic development plans, regional plans, integrated coastal management plans, etc.</li> <li>3. Commission on Sustainable Development Reports; progress reports on follow up to WSSD targets on coral reefs.</li> <li>4. Scorecards/performance reports of ICRI members.</li> </ol>	<p><b>(from Goal to Bank Mission)</b> Continued commitment by countries and donors to conserve and manage coral reef ecosystems for sustainable use.</p>
<p><b>GEF Operational Program:</b> International Waters: OP 9, Multiple Focal Area: To build capacity for science-based management of transboundary marine ecosystems under threat from climate change and multiple human stressors, through targeted research and learning across regions.</p>	<p><b>Outcome / Impact Indicators:</b></p> <ol style="list-style-type: none"> <li>1. Formerly fragmented coral reef research efforts are coordinated and targeted for the first time around key science and technology gaps. --A coalition of scientists and research institutions from developed and developing countries is built to support this effort.</li> <li>2. Major partners from different sectors are aligned with this initiative, building momentum toward a critical mass of resources and sustained commitment to the targeted research beyond the initial phase. --Increase in number of partners contributing -- Increased in amount of</li> </ol>	<ol style="list-style-type: none"> <li>1. Number and management-relevance of publications and reports arising from national research agencies</li> <li>2. Project progress reports.</li> <li>3. National reports, quantitatively improved, with higher standards of confidence presented to meetings of the International Coral Reef Initiative (ICRI)</li> <li>4. Annual reports from research institutions and management agencies associated with the management of coral reefs.</li> </ol>	<ol style="list-style-type: none"> <li>1. Implementation of project on a global scale does not prove too complex to achieve objectives.</li> <li>2. Sustained co-financing beyond first phase is forthcoming.</li> </ol>

resources leveraged since start of Project

3. Results of research are peer reviewed annually for quality control and product delivery against agreed benchmarks; synthesized; interpreted and disseminated to different audiences.
4. Results are linked to management such that coral reef managers are empowered with knowledge and tools to make better decisions
5. Institutional and human capacity for science-based management of coral reef ecosystems is built in participating countries where coral reefs are found.  
--COEs fully engaged in hosting research and training by EOP.
6. Policies in participating countries to protect coral reefs or mitigate impacts from key stressors are strengthened as a result of new information.  
--At least 1 example of policy adoption or reform in favor of coral reefs documented by EOP.
7. Research findings are mainstreamed into World Bank country dialogue and assistance strategies for countries with coral reefs.
8. Coral reef management projects under early implementation or in preparation — many with GEF support — incorporate research findings and links to TR in project design.
9. The GEF uses results to guide future resource allocations to address cross

	cutting issues in Climate Change, International Waters and Biodiversity in the context of transboundary water resources mgt, and to guide clients in the design of large-scale targeted research.		
<p><b>Global Objective:</b></p> <p>To fill critical science and technology gaps that currently impede effective management and informed decision-making on behalf of coral reefs. To build such capacity in countries where coral reefs occur, and thereby improve the prospects for sustainability of reefs and the goods and services they provide to millions of people.</p>	<p><b>Outcome / Impact Indicators:</b></p> <p>Evidence of mainstreaming new knowledge and tools (e.g., into NGO toolkits produced for MPA and coral reef managers, and into policy briefings for decision-makers) by EOP.</p>	<p><b>Project reports:</b></p>	<p><b>(from Objective to Goal)</b></p>
<p><b>Output from each Component:</b></p> <p>1. Addressing knowledge and technology gaps:  --Uncovering critical unknowns that contribute to improved management.  --Developing new tools and techniques for assessing coral reef stress, and for rehabilitating damaged reefs.</p>	<p><b>Output Indicators:</b></p> <p>1. a. Five international working groups established and conducting research under sub-project agreements at at least 1 COE by Yr 1.  --State of knowledge of each WG focal area summarized in a TR publication by end of Year 1 to serve as knowledge baseline.  --At least 3 diagnostic tools</p>	<p><b>Project reports:</b></p> <ol style="list-style-type: none"> <li>1. Project reports</li> <li>2. Publications</li> <li>3. Website content and visitation frequency</li> <li>4. Formal feedback from workshops</li> <li>5. Feedback from project participants (e.g., recorded on website forum area)</li> </ol>	<p><b>(from Outputs to Objective)</b></p> <p>Coral reefs continue to provide a major source of protein and income to millions of poor people living in the tropical coastal areas, and thus management of coral reef resources continues to be a high priority in developing countries with significant coral reef resources.</p>

<p>2. Promoting scientific learning and capacity building: Scientists and students with enhanced capacity to engage in targeted research. Institutions with increased capacity to engage in targeted research.</p> <p>3. Linking scientific knowledge to management</p>	<p>on line by end of year 2. --At least 2 policy briefs prepared and disseminated to environmental policy community by EOP -- At least five major knowledge products (see Box in PAD C 2) generated and disseminated by EOP.</p> <p>2. Developing country graduate students and early career researchers included in the research activities of all working groups by Year 2 (At least 20 graduate or post-doctoral fellowships supported by the Project by EOP); b. Active collaboration between developed and developing country scientists in research activities; improved research and technical capabilities of developing country institutions; c. Regular exchanges of academic staff and students between developing and developed country institutions by EOP d. Multiple publications of research results in peer reviewed journals by developed and developing country scientists for each WG. Enhanced publishing by COE staff in peer-reviewed journals (e.g., rate more than doubles by EOP).</p> <p>3. a. Synthesis Panel meets at least once/yr and agrees on agenda and outputs for year 1 (Secretariat established by project effectiveness)</p>	<p>2. a. Publications in peer reviewed journals and Staff Profile of TR Project</p> <p>b. Project progress reports.</p> <p>c. Project progress reports. Project website.</p> <p>d. Peer reviewed journals</p> <p>a. Project progress reports.</p>
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<p>4. Project Administration</p>	<p>(process) model developed and implemented for Project to guide direction from Synthesis Panel.  3g. At least one major symposium hosted at each COE to disseminate and interpret research findings for policymakers and managers in the region.  3h. World Bank internal Working Group is briefed frequently by the SP on key findings and other issues relevant to policy.  3i. At least one example of policy dialogue between a World Bank Country Director and client on action to reduce/mitigate stress on coral reefs documented by EOP.</p> <p>4.a. PEA fully staffed and operational within 6 months of effectiveness.  b. Sub-project agreement negotiated and first year sub-grants disbursed to all WG by 1st quarter of CY05.  c. Periodic site visits made to COEs as needed  c. Knowledge management system up and running by Year 2.</p>	<p>3i. Country Assistance Strategies</p> <p>Project reports  Bank supervision reports</p>	
<p><b>Project Components / Sub-components:</b>  1. Addressing key knowledge and technology gaps.   2. Promoting scientific learning and capacity building.</p>	<p><b>Inputs: (budget for each component)</b>  1. \$11.2M   2. \$4.20M</p>	<p><b>Project reports:</b>  Progress reports and disbursement/ expenditure reports   Project Reports on no. of graduate and postdoctoral students trained between WG institutions and COEs;</p>	<p><b>(from Components to Outputs)</b>  Continued support for the project by partners and by researchers in developing and developed country institutions.</p>

3. Linking scientific knowledge to management.	3. \$4.0M	and WG institutional reports. Project Reports and number of policy briefs produced, participating NGO annual reports; refereed publications credited to the TR.	
4. Project Administration	4. \$2.9M	Semi-annual technical and financial progress reports	

## Annex 2: Detailed Project Description

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

Coral reefs play a key role for the functioning of tropical coastal ecosystems and for the large coastal populations that depend on reef resources for their daily livelihoods. Complex and productive, coral reefs include an overall biodiversity that is critical for the ecosystem's natural ability to respond to environmental change. Coral reefs also provide critical resources (e.g. fish, tourism, coastal protection, etc) for some 500 million people that depended either totally or partially on reefs (Wilkinson, 2002). Coral reefs are under pressure from a wide array of human influences. Recent evidence also reveals that coral reefs are sensitive to environmental changes like climate change (Hoegh-Guldberg 1999; IPCC 2001). As a result of such pressures, coral reefs are in decline in almost every region of the world. Recent estimates put the rate of decline at somewhere between 40 and 60% of the world's coral reefs over the next 50 years unless appropriate steps are taken (GCRMN 2000). This has huge ramifications for a large number of human societies and endeavors as well as the inherent aesthetics of our coastal ecosystems.

Understanding how these changes will manifest themselves and how the impact on human and reef communities can be eliminated or minimized is an urgent priority. Despite significant progress over the last two decades, there are many key gaps in our basic understanding of coral reef function and dynamics. The Coral Reef Targeted Research and Capacity Building program has been established to address these fundamental information gaps in our understanding of coral reef ecosystems, so that management options and policy interventions can be strengthened globally. For the first time in history, this project will join the collective effort of many of the World's leading coral reef scientists to coordinate research efforts and address key outstanding questions about the health of coral reefs. The program is being developed in phases over 15 years, and through focused and systematic research, is working to effectively support management and policy and to better integrate resulting information with other disciplines, such as economics and law. The program will also *enhance the capacity of researchers, students and managers within developing countries*, so that a global network can effectively share the most up-to-date research to benefit regional, national and local management actions and policy.

The Program is coordinated across four geographic nodes, representing key coral reef regions of the world, and focused around six key themes which will address essential science and technology gaps in our understanding of what drives coral reef ecosystem sustainability. The Targeted Research Program framework consists of three strategic elements:

1. Addressing knowledge and technology gaps
2. Promoting Learning and Capacity Building
3. Linking scientific knowledge to management
4. Project Administration and Coordination

#### By Component:

##### Project Component 1 - US\$11.20 million

##### I. Key Knowledge Gaps (GEF = US\$ 8.0) (Other Cofinancing = US \$ 3.2)

##### A. Targeted Investigations and Working Groups

To address these science and technology gaps, 6 Working Groups, comprised of developed and developing country scientists who are internationally regarded in their fields, have been formed to focus and coordinate research around key themes. A guiding Synthesis Panel has been formed to play a crucial role in overseeing the quality and direction of the research, and to integrate research findings such that the whole is greater

than the sum of its parts.

Under Component 1, targeted investigations of five of the six Working Groups will be supported. The research of the sixth Working Group, "Decision Support and Modeling," will be supported under Component 3 (Linking Science to Management) as the main objective of this WG is to link science to management by helping to integrate the results of the other five Working Groups into a descriptive model of the coral reef ecosystem that is being investigated. The model is intended to serve as a scenario building tool for managers and policymakers to help them visualize the ecological and socio-economic impacts of their decisions on coral reefs.

**(1) Coral Bleaching and Local Ecological Responses Working Group (BWG):** Ove Hoegh-Guldberg, Chair, University of Queensland, Australia *Members:* Yossi Loya, Co-Chair, University of Tel Aviv, Israel, Bill Fitt, (Cellular responses, USA); Helen T. Yap (Local ecological responses, Philippines); John Bythel (Local ecological responses, UK); Rob van Woesik (Local ecological responses, Japan/USA); Roberto Iglesias-Prieto (Molecular mechanism/markers, Mexico); Ruth Gates (Cellular responses, USA); Barbara Brown (Cellular responses, UK); Michael Lesser (Cellular responses, USA); Ron Johnstone (Local ecological responses, Australia); Tim McClannahan (Local ecological responses, Kenya) Nyawira Muthiga (Local ecological responses Kenya) David Obura (Local ecological responses, Kenya); Ole Vestergaard, Coordination (IOC/UNESCO, France)

The Bleaching Working Group was founded by the UNESCO/Intergovernmental Oceanographic Commission (IOC) in April of 2001. The group's initial terms of reference included the development of indicators specifically for coral bleaching. Subsequently, it expanded its mandate to examine specific physiological mechanisms for coral bleaching as well as the local ecological factors that precipitate bleaching and its after-effects, and differences between direct human stresses with those related to climate change.

The Working Group has prioritized hypotheses at various levels of interaction related to stress tolerance and the basis for vulnerability and resilience corals reefs to bleaching. Examples include the following:

- ***Molecular-level Hypotheses:*** i) The basis of heat stress tolerance in corals rests in the molecular mechanisms that reduce photoinhibition. ii) Failure of the primary steps of photosynthesis leads to a build-up of oxygen radicals, which then cause cellular damage. iii) Both coral host and zooxanthellae have a series of coral bleaching specific markers that may be useful as bio-markers.
- ***Cellular and Physiological Hypotheses:*** i) Coral bleaching and mortality is driven by the primary variable elevated temperature but is influenced by light, flow and other factors. ii) Thermal stress will reduce growth rates, coral metabolism, and regenerative capacity iii) Seasonal fluctuations in the density and quality of zooxanthellae are important to understanding coral bleaching.
- ***Within-Reef Ecological-level Hypotheses:*** i) Climate change will reduce reef resilience by: increasing whole colony mortality on coral reefs, changing differential mortality patterns (species, size) reducing recruitment (loss during larval phase failure of settlement), having a greater effect on larval survival compared to the adult phase, causing a change in relative abundance of populations, size frequency distributions, and causing a functional shift. ii) Other stressors (natural and/or anthropogenic) will have a compounding effect on the tolerance of corals and zooxanthellae to thermal stress.

**(2) Connectivity and Large-Scale Ecological Processes Working Group (CWG):** Peter F. Sale, Chair University of Windsor, Canada (fish ecology, recruitment)

*Members:* Menchie Ablan (fisheries genetics, Malaysia/Philippines); Ernesto Arias (fish and coral ecology, Mexico); Mark Butler (lobster biology, recruitment, USA); Bob Cowen (fisheries oceanography, larval

biology, USA); Geoff Jones (fish ecology, recruitment, Australia); Serge Planes (fish genetics, France); Barry Ruddick (physical oceanography, Canada); Bob Steneck (coral reef ecology, coral recruitment, USA); Alina Szmant (coral biology, recruitment, USA); Simon Thorrold (fish otolith microchemistry, USA); Yvonne Sadovy (fisheries ecology, China); Bret Danilowicz (fish recruitment, stock discrimination, Ireland/USA); Ken Lindeman (fish ecology, USA); Enric Sala (grouper biology, USA); Mary Alice Coffroth (coral genetics, USA)

Coral reefs are patchily distributed in an ocean that provides the possibility of transport among them.

Presently, the design of Marine Protected Areas (MPA) containing coral reefs and their implementation uses educated guesses to decide appropriate spatial scales and patterns of placement, and there is little information to determine whether these guesses are even approximately correct. As levels of direct exploitation of coral reef resources rise, and as other pressures on reefs and increased use of coastal environments intensify, it becomes increasingly important that the establishment of spatially explicit management is done at correct spatial scales – ones compatible with known patterns of “connectivity” of target populations.

Connectivity can be defined as the flux of items between locations. It exists for nutrients, sediments, and pollutants, but in the context of coral reef management, connectivity in the form of the effective transfer of individuals (usually pelagic larvae) between local populations is the most important, and also the most difficult to measure. While the transfers of non-living materials are likely to be determined primarily by local and regional hydrodynamics, we know that the transfer of organisms (demographic connectivity) is more complex since passive transport due to hydrodynamics is modified by the sensory and behavioral capabilities of marine larvae. Effective transfer also involves successful establishment as a part of a breeding population, so connectivity among populations is not simply measured by focusing on dispersal patterns, but must include successful recruitment to the receiving population.

At present we lack quantitative data on demographic connectivity, yet these data are essential if we are to improve our ability to design and implement networks of MPAs and other spatially explicit management systems. The use of MPAs presupposes connectivity. Either MPAs are established at a size believed large enough to encompass all phases of the life cycle of species being sustained, or they are established at a size, and in spatial arrangements with respect to un-protected sites, that will foster enhanced recruitment of species to these surrounding sites due to dispersal beyond MPA boundaries.

The Connectivity Working Group is targeting these fundamental gaps in our knowledge. It is beginning its work in selected areas within the various regions of the program with the aim to develop specific tools and techniques necessary to address these critical questions. The Group’s initial focus involves the following research:

**Larval biology and behavior.** By studying several organisms simultaneously? ranging from spiny lobster with very lengthy larval phases, to corals with much shorted larval durations, to fishes with active larval swimming behavior? the CWG will provide critical knowledge of the potential of connectivity in furthering management and conservation.

**Hydrodynamic and biophysical models to predict dispersal.** The spatial and temporal patterns in abundance of new recruits must be driven initially by patterns of dispersal from source locations in a region. Using biophysical models to track dispersal through larval life from selected source locations, it should be possible to generate maps of 'settlement intensity' to compare with observed recruitment patterns. Congruence will suggest that models are sufficiently precise to describe patterns of connectivity among locations. Deviations will drive further work to improve hydrodynamic models, and to explore capabilities

for active movement. The nature of the deviations will provide cues to factors that may be important in determining connectivity patterns for various species.

**Genetics.** Flux experiments on corals and fish will use genetic data to reliably identify progeny from particular mass spawnings and dispersals. Coral studies will also use genetic patterns expressed in cohorts of differing age to determine if there have been measurable changes in patterns of connectivity in recent decades (during a time when Caribbean coral populations have suffered serious declines).

**Otolith chemistry (inner ear bones within fishes).** Work with fish will take advantage of the possibility that otoliths of larvae can be given a unique tag by administering a chemical to the females immediately prior to spawning. A second 'marking' method will rely on collection of sufficient genetic information from the spawning aggregation that a 'paternity analysis' can be used to screen collected recruits. The fish flux experiments will also tag the aggregating adults externally so that the 'catchment area' of the aggregation can be established using tag returns to locate animals after they have dispersed.

**Recruitment monitoring.** Studies of recruitment will be substantially extended by targeted research on early post-settlement survivorship and growth of selected species. The underlying hypothesis driving this work is that there are major bottlenecks to successful recruitment of corals that occur after completion of the larval phase. Understanding the causes of these bottlenecks, and therefore the conditions under which connectivity may or may not be achieved is clearly fundamental to a full description of coral reef connectivity.

Built into this targeted research, the CWG will be working with local managers and scientists in undertaking these experiments, so that genuine transfer of tools and techniques will take place, and so that a joint understanding of the findings will have direct application towards improved management.

**(3) Coral Disease Working Group (DWG):** C. Drew Harvell, Chair, Cornell University, Ithaca, NY, USA

*Members:* Garriet Smith, Co-Chair, (USA); Farooq Azam (USA), Eric Jordan (Mexico), Esther Koh (Singapore), Eugene Rosenberg (Israel), Ernesto Weil (Puerto Rico), Bette Willis (Australia), Laurie Raymundo, (Philippines/Guam).

Over the last 20 years, unprecedented increases in disease on coral reefs have contributed significantly to coral reef degradation. Disease-related damage of coral reefs has been well documented in the Caribbean, but recent observations of coral disease in other regions of the world are just beginning, and disease occurrence in these other regions may be a potential harbinger for increasing outbreaks and impacts associated with increased climate warming. What has prompted this rapid emergence of coral disease?

The Disease Working Group is targeting investigations to address this question, to understand this emergent problem and to develop tools and responses that can be used for management. The Disease Working Group is basing its work program around the following major tasks and hypotheses:

- **Identify major coral diseases.** What diseases are global in their distribution?
- **Infectious disease significantly reduces coral reef biodiversity.** Can some diseases enhance biodiversity?
- **Coral disease (and pathogenic organisms) are higher during bleaching events and in more bleached locales.** Are bleached corals more sensitive to super-infection with other pathogens?
- **Coral Disease prevalence and severity are higher in high nitrogen eutrophic situations.** Does

- chronic stress (such as eutrophication) result in higher incidences of disease?
- **What is the host range of known coral pathogens?**
- **Remediation for coral disease.** Can antimicrobial agents limit infections?

**(4) Coral Restoration and Remediation Working Group (RRWG):** Alasdair Edwards, Chair, University of Newcastle, U.K.

*Members:* Edgardo D. Gomez, Co-Chair (Philippines), Loke Ming Chou (Singapore), Andrew Hayward (Australia), Richard E. Dodge (Caribbean), Johann Bell (Malaysia), Baruch Rinkevich (Israel), Aileen Morse (USA), Tadashi Kimura (Japan), Abdul Azeez Abdul Hakeem (Maldives).

The world-wide degradation of coral reefs, particularly in the last two decades, has prompted greater attention to remediation and restoration. This has resulted in a wide range of initiatives broadly classified as improving the existing condition of impacted coral reefs (mainly through human influence). Early initiatives have focused more on artificial reefs where “reefs”, or more accurately “fish-aggregating devices” are created on non-coral reef platforms, mainly to enhance fisheries production. While this approach is still being expanded more recent activities have been directed specifically at restoring degraded coral reefs.

The diversity and scale of remediation/restoration activities vary tremendously. They cover habitat modification, coral transplantation, species re-introduction, and recruitment potential enhancement. Some of these interventions involve large-scale sub-tidal structures designed to facilitate natural colonization of reef-related species, while others use simpler and less costly approaches that are more readily replicated.

Reef remediation and restoration will continue to have an increasingly important role and efforts are likely to expand in the future. However, viable approaches and technologies are in relatively early stages of development, and in most cases are currently difficult to implement on large spatial scales.

Reef remediation/restoration should not replace reef protection as the first management option. However, large areas of degraded reefs make it unavoidable to ignore remediation and restoration action. The loss of biological and economic services from degraded reefs continually emphasize the need for maintaining the ecosystem, and where degraded, to restore it to a level where significance can once again be realized.

The Restoration and Remediation Working Group is examining the state of restoration and remediation techniques and is targeting investigations to test the efficacy of a range of potential applications. The research includes the following considerations:

- the scientific protocols necessary to design and implement restoration strategies
- baseline data for developing effective criteria
- the efficacy and feasibility of restoration and remediation techniques
- prospects for enhancing natural recovery
- opportunities to combine reef remediation with small and micro-enterprise at the local level.

The Restoration and Remediation Working Group will coordinate its investigations with other Targeted Research Working Groups to consider implementing joint research into remediation or restoration options, especially with the Bleaching, Disease and Connectivity Working Groups.

**(5) Remote Sensing Working Group (RSWG):** Peter J. Mumby, Chair, University of Exeter, U.K.

*Members:* Laura David, Co-chair (Philippines), Ian Gillett (Caribbean, Belize), Jack Hardy (Caribbean, Indo-Pacific, USA); Eric Hochberg (Caribbean, Indo-Pacific, USA), Ellsworth LaDrew (Caribbean, Indo-Pacific, Canada), William Skirving (Indo-Pacific, Australia); Al Strong (Caribbean, Indo-Pacific,

USA); Mary Vasquez (Caribbean, Belize).

The Remote Sensing Working Group will be developing and testing a wide range of remote sensing tools, including satellite, airborne, acoustic and in situ methods. Prior to this Targeted Research effort, 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 radiative transfer 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. While 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 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 specialized 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.

The RSWG will also provide tools to identify various coral reef habitat types and possibly predict the cover of corals and algae on a reef. These tools require high resolution imagery and direct field survey at the time of image acquisition and therefore have limited application to archived or lower-resolution 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 coral reef habitats.

Recent remote sensing research has improved the detail of reef habitat maps but the interpretation and uses of these products for management and measuring and evaluating biodiversity 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 Targeted Research framework provides an unrivalled opportunity for taxonomic capacity within its Centers of Excellence and to quantify the ecological basis of habitat maps.

In addition to improving the capability of remote sensing to help assess coral reefs, this working group will also provide technical assistance to the other working groups that might benefit from the use of remote sensing products to complete their investigations. Finally, the RSWG will organize a wide variety of oceanographic and atmospheric remote sensing products into an International Oceanographic Atlas and will make them available for reef and coastal management within a single website.

## **B. Research Workshops and Academic Mentoring by Working Group Members**

As part of the research to be led by each Working Group, workshops will be organized by the Working Group chairs at each Center of Excellence to host the research. This will serve to bring together the various members of the Working Group(s) to launch the research and to orient local scientists and researchers in the region about the targeted investigations to be carried out at the Center of Excellence. The workshops will be a combination of knowledge sharing and field work, demonstrating the techniques to be used and introducing graduate students, post docs and resident scientists to the research that will be carried out. Support for collaborative research on local research priorities that will benefit from the expertise and guidance of Working Group Members will be provided under Component 2, Promoting Scientific Learning and Capacity Building.

Research scholarships for developing country graduate and post-doctoral students will be a major component of all the Working Group research. Wherever possible, developing country students will be recruited into the research laboratories of Working Group members to carry out investigations as part of the TR Program and to complete degree programs under Working Group member supervision. The level of involvement will be fully defined during the startup of each research component and will depend on the availability of suitable students. This could range from full scholarships to undertake work in the institute(s) of developed country Working Group members, to joint supervision between developed and developing country WG members. This would involve a proportion of the time spent in training within the developed country institute(s), or simply the incorporation of a component of a local student's research project into the local activities of the group, with the student benefiting from the advice and interactions of working group members during field visits. A definitive list of developing country student involvement is not yet available, but initial plans envisage up to 23 masters and PHD students, and 8 Postdocs being supported under the project. The sharing of at least four of the postdoctoral fellowships may be supported in partnership with the International Society of Reef Studies.

The senior scientists involved in each working group all have excellent publication records and a concerted effort will be made to publish results with developing country counterparts in peer-reviewed journals. The chance to publish with some of the most senior figures in each field will constitute an important capacity building component for both students and early career scientists in all groups. The publications will be supplemented by other reports and information briefs written for more general audiences.

### **Project Component 2 - US\$4.20 million**

#### **II. Scientific Learning and Capacity Building (GEF = US\$ 1.2 M; DGF = US\$ 1.7 M; other Co-finance = US\$ 1.3 M)**

Each of the Targeted Research Working Groups will carry out the majority of their field work in developing countries. Four regional nodes have been selected that reflect the biological diversity of coral reefs throughout the world, and have the capacity to serve as Centers of Excellence (COE).



The four nodes occur within three major coral reef regions? the western Pacific, including Southeast Asia (which is the center of coral reef biodiversity), the Indian Ocean (which has suffered extensively from recent episodes of coral bleaching associated with climate change), and the western Atlantic (whose reefs are substantially different from Pacific and Indian Ocean reefs). The locations have been selected on the basis of significant ongoing investments in coral reef management, and where considerable baseline data already exist, along with a critical mass of coral reef scientists and infrastructure—essential to carrying out coordinated research. In each of these four areas, a Center of Excellence (COE) has been identified

- Western Caribbean: Universidad Nacional Autónoma de México
- Eastern Africa: University of Dar Es Salaam, Marine Science Institute, Zanzibar, Tanzania
- Southeast Asia: Marine Science Institute, University of the Philippines
- South Pacific/Australasia: University of Queensland, Australia

During the first years Mexico, Heron Island and the Philippines will be the most active sites. Palau<sup>1</sup> and Belize will also be involved to a lesser extent at this time. The Synthesis Panel will hold its Year 1 meeting in Zanzibar, with the intent to begin working group collaboration there in years 2 or 3. Other potential sites will be brought into the program in a progressive manner, possibly toward the end of phase 1, depending upon the success of working group integration at the core sites and the need for spatial replication.

<sup>1</sup> The Government of Palau, through the International Coral Reef Center, is exploring partnership arrangements with the TR Project to host some of the WG research as a satellite site

**Activities:**

**A. Institutional Strengthening of Centers of Excellence (US \$2.9 M)**

Four regional nodes with the capacity to develop into Centers of Excellence for Coral Reef Research will host the research of the Working Groups. They will serve as a convening location for the Working Groups to meet and discuss the research priorities with regional and local scientists in a collaborative spirit. Furthermore, they will also serve as convening locations at specific periods to work with regional and local managers to consider how the findings can be applied within management contexts. Research plans, standard methods and development of capacity are being coordinated to maximize the level of effort between as many of the sites and working groups as possible. Each of the working groups will conduct core elements of their investigations in at least two of the four locations during the first phase of the Program.

As hosts for the investigations, the COEs also serve as the focal points for scientific learning exchanges,

led by the various Working Groups under Component 1. The project will support a series of workshops each year which will bring researchers from the various working groups together to orient field research, brief one another on findings and, based on these results, modify and design the subsequent phases of targeted research. Through the Centers of Excellence, working group members will engage with other researchers from within the region, as well as other working groups, and will jointly conduct investigations, share knowledge and engage in training opportunities with doctoral and post-doctoral students from participating developing countries. Based on experiences during the project development phase, apprenticeship-type models proved to be highly successful by combining world-class, seasoned researchers with younger post-doctoral and graduate students in a supportive working environment. This brings International expertise in the development and use of various techniques and investigative strategies that will provide opportunities for regional and local researchers to benefit. The involvement of post-graduates is supported through stipends and research scholarships. Each Center will identify a representative to serve on the Synthesis Panel (see Component III below), who will be responsible for coordinating the research to be carried out by the various Working Groups and oversee training in research techniques and the application of new management technologies for participants in the region. Support for equipment (e.g. microscopes, instruments, boats, etc.) and other upgrades (such as high speed internet communication and reference materials) will be provided to each COE, along with support for a technical assistant to the COE Representative

Co-financing support for graduate scholarships will also occur for developing country students enrolled at Universities (i.e. affiliated with the COEs), to collaborate on coral reef research at the four Centers of Excellence. This will support research and training in state-of-the-art techniques in coral reef research for developing country scientists affiliated with networks of marine laboratories and research institutions within the regions.

**B. Support for participation by regional scientists in Targeted Research Activities. (US \$0.150 M)**

A major role of the COEs is to facilitate access to the research training and management tools developed under the Project, by other scientists or managers in the region, not formally affiliated with the COEO. These opportunities for developing country scientists from the region, outside the COE, to participate (These would include personnel involved in other GEF-financed Coral Reef Management activities (e.g., Indonesia COREMAP, the MBRS Project in Mesoamerica, the Marine and Coastal Ecosystem Management Project (MACEMP) in Tanzania), and other donor financed initiatives.

**C. Support for Local Research Priorities (US \$1.0 M for 3 COEs), which can be informed by Working Group expertise. Participation of other local scientists as researchers/collaborators in specific experiments.**

Resources will also be set aside to support coral reef research that addresses local and regional priorities (e.g., Bolinao connectivity work). Thus, researchers at the COEs and at participating satellite sites (e.g. other research facilities which are part of a regional network of marine laboratories) will have the opportunity to engage in related research that is tailored to the specific needs of that region, while at the same time, benefiting from the expertise and mentoring by WG members and opportunities to reinforce institutional collaboration among scientists. Such collaboration will also access local knowledge and expertise and help ensure the near-term application of findings to local/regional management issues.

**D. Ongoing Outreach Activities (US \$0.115 M)**

Connecting with local stakeholders; developing communication and educational materials, e.g., for schools, and other knowledge products that can inform regional coral reef management activities. In addition to the

major workshops involving all working groups mentioned above, the Centers of Excellence, in cooperation with the WGs, will hold additional meetings and small workshops to familiarize local participants and stakeholders with the proposed work. This will also involve training of local personnel to carry out ecological surveys and certain experiments/measurements which require regular attention. Among those expected to participate would be technical staff and graduate students from local supporting institutions. For example, in years 1 & 2 the Disease Working Group will be training local Philippine personnel to carry out surveys for disease and to take samples for isolation and identification of pathogens.

#### **Project Component 3 - US\$ 4.00 million**

### **III. Linking Scientific Knowledge to Management (GEF = US\$ 1.4 M), DGF = US\$ 1.3 M) Other Co-finance = US\$ 1.3 M**

#### **A. Role of Synthesis Panel**

A guiding Synthesis Panel helps gives direction to the Targeted Research program and interprets and disseminates its findings. This experts Panel consists of the heads of each of the six thematic working groups, representatives from each of the Centers of Excellence, the Executive Officer from the Project Executing Agency, and several outside experts representing coral reef scientists, economists, and managers.

In order to maximize the impacts of the project on managers, scientists, environmental NGOs and government agencies in coral reef countries, the results of the program will be disseminated in a variety of formats and using a range of media. Peer reviewed papers will represent the highest level of scientific output and will ensure a high level of quality control on the results and conclusions. Non-technical summaries of the major findings will also be created by a contract science writer with experience working in developing countries. These will be further distilled into short briefs outlining the major results, setting out the policy implications, and listing possible management actions and policy options for consideration by relevant government agencies. The World Bank, as implementing agency, will use these policy briefs to inform its Country Dialogue with client countries and the preparation of country assistance and other strategies to guide its lending and non-lending operations. Such information will be used to promote reform in those economic sectors as well as macroeconomic policies which are responsible for local stress on coral reefs.

During the first year the Synthesis Panel will finalize policies on intellectual property and information access that will provide maximum flow of data and information while giving reasonable protection to researchers who need to publish their work before it enters the public domain.

The activities of the Synthesis Panel include the following:

**(1) Periodic Meetings** to Review, synthesize and interpret research results and provide direction re: scope and budget for proposed follow on investigations. This will be part of an annual review process that evaluates research findings and approves proposals for continuing research. An Executive Committee will approve funding allocations for renewal of research subgrants on an annual basis.

**(2) Occasional Symposia** to bring interdisciplinary perspectives to bear on research findings and to discuss implications for policy (to be held periodically in Washington for benefit of Bank staff and other public policy makers, e.g. U.S. Coral Reef Task Force, GEF STAP, National Academy of Sciences, Bilateral and Multilateral officials, NGO community.)

**(3) Publications and Communications** in the form of peer reviewed journal articles, Policy Briefs, and Occasional Technical Papers (These will be part of a TR series—output of the project), and periodic press releases. As part of the latter, one or two international workshops for journalists will be supported (with

Australian and DGF funds?) Work with Journalism and Public Policy Department of the University of Queensland to develop this. (Science writer hired to work with Synthesis Panel to draft briefs and journal articles, and to work with Working Groups and COEs to distill findings re: new tools or insights to be published in a variety of media (NGO newsletters, magazines, popular press, etc.)

**(4) Special Studies (including DGF Evaluation at end of Year 3)**

**(5) Short Term Consultancies to support the work of the Synthesis Panel**

- (a) Washington-based Coordinator to serve as Executive Secretariat
- (b) Honoraria for external Synthesis Panel members
- (c) Independent Peer Reviewers (up to 4 reviewers/yr)

**B. Modeling and Decision Support Working Group**

Roger Bradbury (Chair), Australian National University, Canberra, Australia

*Members:* John McManus, (USA) Porfirio Aliño (Philippines); Ernesto Arias (Mexico, Team Leader for MBRS); Antonio Badan (Mexico); Herminia Carnigal (Philippines); Robert Cowen (USA); Laura David (Philippines, Team Leader for Philippines), Bohdan Durnota (Australia); Felimon C. Gavanilo, Jr. (Philippines/USA); Craig Johnson (Tasmania); Richard Pollnac (USA); Ramon Sampang (Philippines); Rob Seymour (U.K), Rodrigo Garza (Mexico); Eloy Sosa (Mexico); Liana Talaue-Mcmanus (USA/Philippines); Cesar Villanoy (Philippines); Scott Woolridge (Australia).

The Modeling and Decision Support Working Group (MDSWG) is focused on the development of a set of novel, state-of-the-art tools to improve coral reef management and education. It integrates the work of the other five working groups, and combines this with a broad range of social, economic, ecological and physical information in a land-to-sea, watershed-based framework. The research is centered on the development of Dynamic Decision Support Systems (DDSS), which will augment Geographic Information Systems with best-practice guides, expert systems, and scenario-testing models. The set of spatially-explicit models will serve as layers in the GIS designed to provide analyses of the potential impacts of various management interventions on the coral reef and associated local economic and social systems. The layers will be interlinked in flexible ways, to provide for interdisciplinary analyses of potential cause and effect relationships. The models will not be aimed at simple deterministic prediction, but rather at identifying ranges of potential outcomes of management actions classified as high, medium and low probability.

The Modeling and Decision Support Working Group has been designed to focus on the development of advanced, highly innovative decision support tools for management, which will include scenario-testing, agent-based interdisciplinary modeling capabilities integrated with Geographic Information Systems (GIS). Some major project design goals include:

1. Long-term field efforts to parameterize the models based on studies of the targeted research working groups and associated human societies (in at least two of the COEs) can be carried out cost-effectively.
2. The decision support systems are based on needs that are of high priority in developing nations.
3. There is a strong local capacity to maintain and improve the systems after initial development.
4. Current expertise in Australia and the US on agent-based modeling, supplemented by partners in Europe, is built upon and combined with the considerable body of knowledge of reef ecology and hydrodynamics accumulated by scientists in Mexico and the Philippines.

**C. Meetings for Decision-makers at COEs**

Participation of local NGO's and coral reef managers in planning and awareness workshops to disseminate results and to discuss their management and policy implications. Based on preliminary discussions during the Block B phase, and further discussions during the early part of year 1 a number of active NGOs and management agencies will be invited to participate in workshops at those active stations which will present the objectives and management relevance of the proposed research and seek input on site locations, participation in some of the survey work, and plans for interpreting and disseminating the results of the research in terms relevant to managers and local NGO staff. This will be followed in year 4 with a major symposium, coinciding with the 11th International Coral Reef Symposium to discuss the results and consider their incorporation into management plans and policy recommendations globally for coral reefs. In the intervening years, smaller meetings will be held between selected working groups and managers/NGO staff.

#### **Project Component 4 - US\$2.90 million**

#### **Component IV. Project Administration (GEF = US\$ 0.4 M; Co-financing = US\$ 2.5 M)**

##### **A. PEA Coordination and Oversight (Financial Management and Reporting)**

##### **B. Liaising with other partners**

- **Networking with UNESCO/IOC to link TR activities to IOC Programs for science-based management of Ocean resources.** As part of its in-kind contribution to the Project partnership, UNESCO/Intergovernmental Oceanographic Administration (IOC) will second one of its technical staff from Headquarters to serve as a full time Data, Outreach and Capacity Building Officer based in Brisbane at the PEA. His primary role will be to liaise with the COEs, to link the targeted research to IOC programs to build capacity for better management of ocean resources, and to facilitate a knowledge network among COEs with support from the PEA.
- **Program Sustainability & Fundraising**

##### **C. Communication and Outreach**

**In collaboration with the Synthesis Panel and Centers of Excellence.** In order to maximize the impacts of the project on managers, scientists, environmental NGOs and government agencies in coral reef countries, the results of the program will be output in a variety of formats and using a range of media. Peer reviewed papers will represent the highest level of scientific output and will ensure a high level of quality control on the results and conclusions. Non-technical summaries of the major findings will also be created by a contract science writer with experience working in developing countries. These will be further distilled into short briefs outlining the major results, setting out the policy implications, and listing possible management actions and policy options for consideration by relevant government agencies. The World Bank, as implementing agency, will use these policy briefs to inform its Country Dialogue with client countries and the preparation of country assistance and other strategies to guide its lending and non-lending operations. Such information will be used to promote reform in those economic sectors as well as macroeconomic policies which are responsible for local stress on coral reefs. IOC will, similarly, use policy briefs and recommendations to inform its programs with member states to improve ocean governance and sustainable use of coral reef ecosystems.

The Project Executing Agency staff will maintain communication with key contacts in each participating country during the course of the research. Formal and informal dialogues between stakeholders and working group members will take place on an ongoing basis. In association with each working group, the PEA will produce an annual non-technical report on the results and

management relevance of the group's progress and achievements.

**D. Information Management (PEA)**

The PEA will also be responsible for Data Management and for disseminating and archiving research results in formats and channels acceptable to the institutions involved and for the benefit of target audiences. To the extent possible, data and information arising from the project will be entered into a central database together with a meta-database of all raw data holdings. (It is recognized that in some cases data and results may be more appropriately linked to rather than stored at PEA.) This will form the core of a specialized online information system. In addition a comprehensive bibliography of papers relating to all aspects of the research program will be compiled and made available in print and electronic form to all members and interested stakeholders. A selection of these will be made available as online documents for downloading and sharing among members. Information will be cross referenced and searchable to the extent possible using keywords. Photographs and remote sensing images obtained as part of the project will be stored in the database and made available for download using similar query and search interfaces. The Project Implementation Manual will document procedures for data ownership, management and dissemination.

### Annex 3: Estimated Project Costs

#### WORLD: Coral Reef Targeted Research and Capacity Building for Management

Project Cost By Component	Local US \$million	Foreign US \$million	Total US \$million
I. Filling Knowledge and Technology Gaps		11.20	11.20
II. Promoting Scientific Learning and Capacity Building	0.00	4.20	4.20
Linking Scientific Knowledge to Management	0.00	4.00	4.00
Project Administration	0.00	2.90	2.90
<b>Total Baseline Cost</b>	0.00	22.30	22.30
<b>Physical Contingencies</b>	0.00	0.00	0.00
<b>Price Contingencies</b>	0.00	0.00	0.00
<b>Total Project Costs</b> <sup>1</sup>	0.00	22.30	22.30
<b>Total Financing Required</b>	0.00	22.30	22.30

<sup>1</sup> Identifiable taxes and duties are 0 (US\$m) and the total project cost, net of taxes, is 22.3 (US\$m). Therefore, the project cost sharing ratio is 62.78% of total project cost net of taxes.

**Annex 4: Incremental Cost Analysis**  
**WORLD: Coral Reef Targeted Research and Capacity Building for Management**

See Annex 11 - Incremental Cost Analysis

### Annex 5: Financial Summary

#### WORLD: Coral Reef Targeted Research and Capacity Building for Management

In US\$ Millions	Source of Finance	Component 1 Knowledge & Tech. Gaps	Component 2 Promoting Scientific Learning & Capacity Building	Component 3. Linking Scientific Knowledge to Management	Component 4. Project Administration	TOTAL
<b>Year 1</b>	GEF	2	0	0.15	0.1	<b>2.25</b>
	Bank/DGF	0	0.6	0.4	0	<b>1</b>
	Other	0	0.2	0.2	0.5	<b>0.7</b>
<b>Year 2</b>	GEF	2.2	0	0.1	0.075	<b>2.4</b>
	Bank/DGF	0	0.7	0.4	0	<b>1.1</b>
	Other	0	0.4	0.2	0.2	<b>0.8</b>
<b>Year 3</b>	GEF	2.1	0	0.1	0.08	<b>2.3</b>
	Bank/DGF	0	0.4	0.5	0	<b>0.9</b>
	Other	0.9	0.3	0.2	0.6	<b>2.0</b>
<b>Year 4</b>	GEF	1.2	0.6	0.7	0.08	<b>2.6</b>
	Bank/DGF	0	0	0	0	<b>0</b>
	Other	1.3	0.4	0.2	0.6	<b>2.5</b>
<b>Year 5</b>	GEF	0.5	0.6	0.25	0.08	<b>1.4</b>
	Bank/DGF	0	0	0	0	<b>0</b>
	Other	1.0	0.15	0.5	0.6	<b>2.3</b>
<b>Total by Financiers</b>	<b>GEF</b>	<b>8</b>	<b>1.2</b>	<b>1.4</b>	<b>0.4</b>	<b>11.0</b>
	<b>Bank/DGF</b>	<b>0</b>	<b>1.7</b>	<b>1.3</b>	<b>0</b>	<b>3.0</b>
	<b>Other</b>	<b>3.2</b>	<b>1.3</b>	<b>1.3</b>	<b>2.5</b>	<b>8.3</b>
<b>PROJECT TOTAL</b>						<b>22.3</b>

## **Annex 6(A): Procurement Arrangements**

### **WORLD: Coral Reef Targeted Research and Capacity Building for Management**

#### **Procurement**

##### **Technical Annex: Procurement Arrangements**

#### **Project Components**

The Targeted Research Project is part of a longer term effort to support the establishment of an applied research framework and build capacity for science-based management of coral reefs in areas with significant coral reef resources and Bank/GEF investments. The project will provide grants to research institutions designed to: (i) define knowledge and technology gaps on the importance of coral reefs through key themes and research questions which will be investigated by interdisciplinary teams of developing and developed country scientists; (ii) promote scientific learning and capacity building ; and (iii) link scientific knowledge to management policy.

#### **Procurement**

Procurement for the proposed project would be carried out in accordance with the World Bank :Guidelines: Procurement Under IBRD Loans and IDA Credits” dated May 2004; and “Guidelines: Selection and Employment of Consultants by World Bank Borrowers” dated May 2004, and the provisions stipulated in the Legal Agreement.

A procurement capacity assessment was carried out for the University of Queensland which in this case is the project executing agency. The University has long established procedures for its own procurement which mirror the Bank’s shopping procedures for goods valued at \$100,000 or less and for the hiring of individual consultants. Given that the UQ procurement procedures are acceptable to the Bank and that the majority of the project consists of grants to research institutions who will handle the very small procurements in accordance with their established commercial procedures, the procurement risk is assessed as low.

Procurement under the grants will be done by the institutions themselves following standard commercial practices which are acceptable to the Bank. The grants will be used mainly to fund approved research activities, provide scholarships, organize seminars to disseminate research results, procure small amounts of laboratory equipment and supplies and fund travel costs of scientists and researchers to participate in the working groups involved in the research. As recipients of the grants, the research institutions are expected to follow standard commercial practices and to seek the best evaluated prices as it is in their own best interest and will maximize the utilization of scarce resources.

The University of Queensland, acting as Project Executing Agency (PEA) will be responsible for the management and administration of the project. Funds will be used by the PEA for the hiring of individual consultants, organize seminars and meetings, provide for the travel of participants, communications costs and arrange for the publication and dissemination of the research material. Individual consultants will be selected by comparing CVs of qualified candidates. Other incidental costs will be procured on the basis of statements of expenditures following UQ’s own procedures.

Because of the above, the preparation of a normal procurement plan is not meaningful. Grants will be provided on an annual tranche by the PEA which will prepare an annual program based on

recommendations of a synthesis panel which will receive grant proposals.

**Procurement methods (Table A)**

Apart from the grants to the Working Groups and the Centers of Excellence, however, some goods and services will be procured by the Synthesis Panel and for Project administration.

**Table A: Project Costs by Procurement Arrangements**  
(US\$ million equivalent)

Expenditure Category	Procurement Method <sup>1</sup>			N.B.F.	Total Cost
	ICB	NCB	Other <sup>2</sup>		
<b>1. Works</b>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<b>2. Goods</b>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<b>3. Services</b>	0.00	0.00	0.30	0.60	0.90
Consultant Services	(0.00)	(0.00)	(0.30)	(0.00)	(0.30)
<b>4. Miscellaneous ((including, subgrants, services, incremental operating costs, and travel related to meetings and project administration)</b>	0.00	0.00	15.60	5.80	21.40
	(0.00)	(0.00)	(15.60)	(0.00)	(15.60)
<b>Total</b>	0.00 (0.00)	0.00 (0.00)	15.90 (15.90)	6.40 (0.00)	22.30 (15.90)

<sup>1/</sup> Figures in parentheses are the amounts to be financed by the Bank Grant. All costs include contingencies.

<sup>2/</sup> "Other" category includes services of contracted staff of the project management office, goods purchased through national shopping under subgrants, training, technical assistance services, and incremental operating costs related to (i) managing the project, and (ii) administration of sub-grants.

**Table A1: Consultant Selection Arrangements (optional)**  
(US\$ million equivalent)

Consultant Services Expenditure Category	Selection Method							Total Cost <sup>1</sup>
	QCBS	QBS	SFB	LCS	CQ	Other	N.B.F.	
<b>A. Firms</b>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<b>B. Individuals</b>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.90 (0.90)	0.00 (0.00)	0.90 (0.90)
<b>Total</b>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.90 (0.90)	0.00 (0.00)	0.90 (0.90)

<sup>1)</sup> Including contingencies

Note: QCBS = Quality- and Cost-Based Selection  
 QBS = Quality-based Selection  
 SFB = Selection under a Fixed Budget  
 LCS = Least-Cost Selection  
 CQ = Selection Based on Consultants' Qualifications  
 Other = Selection of individual consultants (per Section V of Consultants Guidelines), Commercial Practices, etc.  
 N.B.F. = Not Bank-financed  
 Figures in parentheses are the amounts to be financed by the Bank Grant.

No prior review for procurement of consultants or other procurement categories will be required under the project.

## **Annex 6(B): Financial Management and Disbursement Arrangements**

### **WORLD: Coral Reef Targeted Research and Capacity Building for Management**

#### **Financial Management**

##### **1. Summary of the Financial Management Assessment**

###### **Summary Project Description**

The Coral Reef Targeted Research Project (The TR Project) will fund global research activities for science based coral reef management and capacity building. The project implementation is undertaken by six technical working groups organized around key research themes and four centers of excellence, three of which are based in beneficiary developing countries. A Synthesis Panel composed of the chairpersons of the six working groups plus additional outside experts and representatives of the regional centers of excellence will provide overall guidance and direction to project implementation.

A major study was carried out to identify the most appropriate institutional arrangements and flow of funds for the project. The study recommended establishment of a global implementing agency with overall responsibility for project execution and financial accountability to the Bank. The University of Queensland (UQ), a leader in the field of coral reef research and management, was selected as the host organization for the Project Executing Agency (PEA). The scientific Working Groups (WG) and Centers of Excellence (COE) established under the overall direction of the Global Synthesis Panel will carry out the field level implementation of the project. The PEA will operate independently under the guidance of the Synthesis Panel who will meet annually to review Project progress, performance of the PEA and the host organization and approve the annual budget. UQ shall be responsible for oversight and providing management support to the Project Executing Agency. The PEA shall be the principal recipient of GEF funds, other donor funds and funds to be contributed by the participating governments. The PEA shall be fully accountable for all project funds and shall ensure timely disbursement of funds to participating project implementing institutions. PEA shall be responsible for overall project management and coordination including procurement, financial management and project administration.

###### **Implementing Entity -Financial Management Assessment**

A financial management assessment of the host organization was carried out in accordance with the Guidelines for Assessment of Financial Management Arrangements of Bank financed Projects. The results of the assessment are summarized below.

The University of Queensland was established in 1909 and is a leader among the Australian universities and recognized internationally. The UQ is governed by the University of Queensland Act of 1998. The Act provides for the establishment of the governing body (the Senate) and defines its financial and corporate powers and responsibilities.

The Finance Administration and Audit Act of the Queensland state government prescribes the accounting and audit requirements of UQ. UQ financial policies, systems and procedures are described in a Financial Management Practice Manual that is prepared in accordance with the requirements of the Act. The Financial Management Practice Manual is based on a Financial Management Standard that was issued in July 1997 pursuant to Section 46L of the Financial Administration and Audit Act. This standard specifies the financial administrative requirements for statutory authorities (which includes the University) and also outlines the basic accountability and internal control procedures the Queensland Government requires to be adopted. The prescribed accounting standards are consistent with generally accepted accounting principles and Australian Accounting Standards.

The UQ finance function is organized under a Chief Financial Officer with a decentralized finance staff providing financial services to the various faculties and schools of the UQ. UQ operates on the principle of delegated authority with heads of faculties and schools responsible for operation, control and financial

accountability of their respective sections. A Business Manager (Head of Financial Services) supports the heads of faculties and schools and is responsible for all decentralized financial management functions. The Chief Financial Officer provides centralized financial services and oversight.

The PEA for the project will be located within the Centre for Marine Studies (CMS) of UQ. The CMS is an independent financial accountability unit within the Faculty of Biological and Chemical Sciences. PEA will be headed by an Executive Officer and will be supported by financial and technical staff. UQ has already appointed a project accountant who will be responsible for the project financial management. The project accountant will follow the UQ accounting policies and practices in maintaining project accounts, financial reporting and audit. The CMS financial staff will provide support, as required, in the discharge of the PEA finance services. The CMS financial staff and the central finance staff will provide guidance and oversight of the project accountant.

**The proposed financial structure and the accounting and financial policies and practices are acceptable to the Bank.**

### **Risk Assessment**

Overall financial management risks are considered minimal given strong financial management and control environment in the host organization. The host organization will take responsibility for establishment of the financial management unit of the PEA and ensure that competent staff is appointed to the unit.

***Inherent Risks*** are considered minimal due good financial management environment, qualified staff, training and continuous oversight by well organized finance department of the host organization.

***Control risks*** are also considered minimal due establishment of sound financial management policies and procedures, clear lines of authority and reporting and availability of well-qualified staff.

## **2. Audit Arrangements**

### **Independent Audit**

The Auditor-General (Queensland Audit Office) of the Queensland Government, in accordance with the Finance Administration and Audit Act, currently audits UQ financial statements. PEA shall have the project financial statements audited by an independent external auditor acceptable to the Bank. The Queensland Audit Office is an acceptable independent auditor. The audit report together with the annual financial statements shall be submitted to the Bank within 6 months after the close of the financial year. UQ has an internal audit function and it is expected that the internal auditors will include the PEA, as a unit within CMS, in their annual internal audit program. In addition, consideration could be given for field internal audits if significant risks are revealed in administration of research grants during project implementation.

## **3. Disbursement Arrangements**

### **Funds Flow and Disbursement Arrangements**

***Fund Flow from Bank to PEA.*** All project funds, GEF, donors and participating governments, shall be deposited with the PEA. GEF funds shall be deposited in accordance with the disbursement arrangements described below. The deposit of funds from parallel co-financiers shall be in accordance with separate bi-lateral agreements with each of the parallel co-financiers. PEA shall establish a separate bank account (Project Special Account) denominated in US dollars for deposit of GEF and World Bank funds. Project Special Bank Account (SA) shall be established with a commercial bank acceptable to the Bank. The initial deposit in the amount not exceeding US\$ 1 million will be deposited to the SA on receipt of the first withdrawal application. The replenishment of the Special Account shall be based on Statement of Expenditures (SOE) to be submitted monthly or whenever the SA is drawn below half of its initial deposit.

All GEF portions of project eligible expenditures shall be paid out of the Special Account in accordance with agreed accounting policies and procedures. PEA shall maintain separate accounts and supporting documents to report on the operation of the Special Account.

***Fund Flow from PEA to project executing agencies.*** A major portion of project funds will be disbursed as grants (herein after called sub-grants) to project participating institutes and Centers of Excellence to fund approved research and capacity building activities. Disbursement of funds from the SA to sub-grantees would be based upon signed sub-grant agreements following UQ policies and procedures for administration of research grants.

UQ has considerable experience in managing research grants and has a separate organizational unit that provides administrative and legal support to the administration and management of grants. Sub-grant applications will be in a standard form and will be initially reviewed and approved by the scientific Working Groups and submitted to the PEA for funding. The PEA with the support of appropriate UQ units will review applications for completeness and enter into a sub-grant agreement with the recipients. The sub-grant agreement shall specify, *inter alia*, purpose of the grant, objects of expenditure, disbursement schedule and reporting and monitoring arrangements. UQ accounting policies for management of research grants are given in the Financial Management Practices Manual. Based on these policies, PEA will prepare guidance describing the preparation, administration and management of Project sub-grants to be included in the Project Implementation Manual.

All other project related expenditures would be disbursed following UQ financial practices by the PEA. PEA shall maintain all documentation supporting disbursement from the Special Account.

To accommodate any eligible expenditures leading up to Project start up between July 1 and Project Effectiveness, retroactive financing of up to US\$1 Million (or 10% of the GEF Grant funds), shall be allowed. Such eligible expenditures include preparation and publication of manuals by the Working Groups, field work, meetings and travel that have been approved by the Synthesis Panel for the operation of the Working Groups.

### **Financial Management System**

***Organization and staffing.*** PEA shall establish a project accounting unit staffed with qualified and experienced personnel. A Project Accountant (PA) with qualifications and experience acceptable to the Bank has already been appointed as head of the unit. The Project Accountant shall be under the direct supervision of CMS Head of Financial Services and report functionally to the Head of the PEA and shall be supported by an adequate number of assistant and support staff. The number of staff and their responsibilities shall be decided based on the volume of work with due regard to segregation of duties and internal control processes.

***Internal Control.*** UQ has well defined administrative, accounting and operational procedures for various level of authority. Internal control processes of UQ are assessed as satisfactory and the PEA finance unit will operate in this environment. A sound organization and staffing, clear accounting and control procedures, independent oversight of the finance unit by the finance managers of UQ and training of project staff by the Bank should contribute to a good internal control environment.

***Accounting Policies and Procedures.*** PEA shall follow accounting policies of UQ in recording and reporting project transactions. It is agreed that separate project accounts shall be maintained within the UQ accounting system. PEA shall design a chart of accounts that would facilitate reporting of project expenditures in the format agreed for Financial Monitoring Reports. The chart of account shall facilitate recording of financial transactions for GEF and other donors, the project components and geographic locations. A Sub-grant Administration manual (to be included in the Project Implementation Manual) shall include policies and procedures for accounting and reporting at the level of field entities such as Technical

Working Groups and Centers of Excellence for research grants received from the Project.

*Planning and budgeting.* UQ currently has a sound budgeting process and it is agreed that similar budget policy be established for project activities. PEA shall require that all field project entities prepare annual work plans and budgets within the overall PAD expenditure estimates. The work plans and budgets, covering GEF and other donor funded activities, shall include both financial and physical targets. The annual budget shall also include a procurement plan. The annual plan, following review by the PEA, shall be submitted to the Synthesis Panel for approval. The approved budget shall be submitted for Bank review no less than 30 days prior to the beginning of the fiscal year. Following Bank’s no objection, the budget shall be the basis for project financial management.

*Reporting and Monitoring.* PEA shall prepare half-yearly and annual financial statements to report on project activities to the Bank and other stakeholders. The semester financial statements shall be based on agreed Financial Monitoring Reports and shall include (i) project financial statements compared with budgets and (ii) physical progress report compared with targets. The quarterly FMRs shall be agreed at negotiations. PEA shall also prepare annual project financial statements in accordance with agreed accounting principles and policies.

**Allocation of grant proceeds (Table C)**

**Table C: Allocation of Grant Proceeds**

<b>Expenditure Category</b>	<b>Amount in US\$million</b>	<b>Financing Percentage</b>
Sub-grants	10.30	93.7
Consultant Services	0.30	2.7
Incremental Operating Costs	0.40	3.6
Goods	0.00	0
<b>Total Project Costs with Bank Financing</b>	11.00	
<b>Total</b>	11.00	

**Use of statements of expenditures (SOEs):**

**Special account:**

## Annex 7: Project Processing Schedule

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

Project Schedule	Planned	Actual
Time taken to prepare the project (months)	24	60
First Bank mission (identification)	11/23/1998	11/23/1998
Appraisal mission departure	04/01/2004	04/13/2004
Negotiations	07/01/2004	07/19/2004
Planned Date of Effectiveness	12/01/2004	

**Prepared by:**

**Preparation assistance:**

**Bank staff who worked on the project included:**

Name	Speciality
Marea E. Hatziolos	Task Team Leader / Sr. Environmental Specialist
Anthony J. Hooten	Consultant / Coral Reef Ecologist
Hanneke van Tilburg	Senior Counsel / Legal
Maurice Le Blanc	Consultant / Procurement Specialist
Wijaya Wickrema	Consultant / Financial Management Specialist
Tundy Agardy	Consultant / Marine Resource and MPA Specialist
Agustinus Samson Kaber	Program Assistant / Bank and GEF Project Processing
Robin Broadfield	GEF Regional Coordinator

## Annex 8: Documents in the Project File\*

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

#### A. Project Implementation Plan

Project Implementation Manual (in Draft)

#### B. Bank Staff Assessments

#### C. Other

List of Project-related Publications of authors in the Working Groups or Centers of Excellence (in print, in press or in preparation)

##### Bleaching Working Group

**T.P. Hughes, A.H. Baird, D.R. Bellwood, M. Card, S.R. Connolly, C. Folke, R. Grosberg, O. Hoegh-Guldberg, J.B.C. Jackson, J. Keypas, J.M. Lough, P. Marshall, M. Nystrom, S.R. Palumbi, J.M. Pandolfi, B. Rosen, and J. Roughgarden.** 2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. *Science* Vol. 301 (August 15): 929-933.

Nature, Vol 45, 28 Feb 2002: "Reef under threat from 'bleaching' outbreak"

**R.P. Cooney, O. Pantos, M.D. Le-Tissier and J.C. Bythell:** 'Comparison of the molecular microbiology of black band disease in corals between the Great Barrier Reef and Caribbean' (Submitted).

**LaJeunesse, Todd C., William K. W. Loh, Robert van Woesik, Ove Hoegh-Guldberg, Gregory W. Schmidt, and William K. Fitt:** Low symbiont diversity in southern Great Barrier Reef corals relative to those of the Caribbean (*Limnology & Oceanography*, Vol. 48(5), September 2003, *in press*)

**Ove Hoegh-Guldberg, Ross J. Jones, Selina Ward & William K. Loh:** Is coral bleaching really adaptive? *Nature* **415**, 601 – 602, Feb 2002

**B.E. Brown, R.P. Dunne, M.S. Goodson, A.E. Douglas:** Experience shapes the susceptibility of a reef coral to bleaching. *Coral Reefs* (in press).

**Gian-Reto Walther, Eric Post, Peter Convey, Annette Menzel, Camille Parmesan, Trevor J. C. Beebee, Jean-Marc Fromentin, Ove Hoegh-Guldberg, Franz Bairlein:** Ecological responses to recent climate change. *Nature* **416**, 389 – 395, Mar 2002.

##### Remote Sensing Working Group

**Tiit Kutser, Arnold G. Dekker, William Skirving:** Modeling spectral discrimination of Great Barrier Reef benthic communities by remote sensing instruments. *Limnology & Oceanography*, **48**, 497–510, Aug 2003.

**P.J. Mumby** and eight co-authors. A Review of Remote Sensing for Coral Reefs. Submitted *Marine Pollution Bulletin*

**Hedley JD, Mumby PJ, Joyce KE, Phinn SR** (2003) Spectral unmixing of coral reef benthos under ideal conditions. *Coral Reefs* (in press)

**Hedley JD, Mumby PJ** (2003) Spectral unmixing and the resolution of depth from remotely sensed data of aquatic systems. *Limnology & Oceanography* **48**: 480-488

**Mumby PJ, Edwards AJ** (2002) Mapping marine environments with IKONOS imagery:

enhanced spatial resolution does deliver greater thematic accuracy. *Remote Sensing of Environment* 82: 248-257

### **Disease Working Group**

**Drew Harvell, Charles E. Mitchell, Jessica R. Ward, Sonia Altizer, Andrew P. Dobson, Richard S. Ostfeld, Michael D. Samuel:** Climate Warming and Disease Risks for Terrestrial and Marine Biota, *Science*, 296, 2158-2162, June 2002.

**C. D. Harvell and seven co-authors.** In prep. New Perspectives on International Impacts of Coral Disease.

**Mullen, Harvell, Jordan, Ward, Alker, Smith, Petes.** submitted. Host range and anti-fungal resistance of aspergillosis in three seafan species of the Yucatan. *Marine Biology*.

**Ward, Lafferty, Harvell.** in prep. Proxies Reveal Increasing Impacts of Disease in the Ocean.

**Ward, Harvell, Smith, Bruno, Rypien, Jordan.** in prep. A Test of the Disease as a Driver of coral Biodiversity Hypothesis.

**Harvell, Pates and Peters.** in prep. Mechanisms of Coral Resistance to Disease. (Chapter contributions for a book edited by Eugene Rosenberg, in prep. *Global Coral Health and Disease*.)

**Weil and Smith.** in prep. Local and geographic variability in disease prevalence at the species level in the Wider Caribbean.

**Willis, Smith, Ritchie and Paige.** Prevalence of Coral Disease in Australia.

**Raymunodo and Kacsmarsky.** Prevalence of newly described Philippine Coral Diseases.

### **Restoration and Remediation Working Group**

**L.M. Chou and ten co-authors.** A preliminary guide to coral reef restoration and remediation options for managers. Planned for December, 2003.

\*Including electronic files

## Annex 9: Statement of Loans and Credits

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

29-Apr-2004

Project ID	FY	Purpose	Original Amount in US\$ Millions			Cancel.	Undisb.	Difference between expected and actual disbursements <sup>a</sup>	
			IBRD	IDA	GEF			Orig	Frm Rev'd
P073195	2001	Critical Ecosystem Partnership Fund	0.00	0.00	25.00	0.00	20.90	62.30	0.00
Total:			0.00	0.00	25.00	0.00	20.90	62.30	0.00

WORLD  
STATEMENT OF IFC's  
Held and Disbursed Portfolio  
Mar - 2004  
In Millions US Dollars

FY Approval	Company	Committed				Disbursed			
		IFC				IFC			
		Loan	Equity	Quasi	Partic	Loan	Equity	Quasi	Partic
2002	AIG GEM II	0.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	AIM-ACCION	0.00	3.00	0.00	0.00	0.00	0.64	0.00	0.00
2004	BTC Pipeline	125.00	0.00	0.00	125.00	84.50	0.00	0.00	84.50
2002	CIPEF IV	0.00	30.00	0.00	0.00	0.00	0.67	0.00	0.00
2000/02/03	IMI	0.00	4.58	0.00	0.00	0.00	4.58	0.00	0.00
1994	Index Fund	0.00	9.02	0.00	0.00	0.00	9.02	0.00	0.00
2003	Novica	0.00	1.50	0.00	0.00	0.00	1.25	0.00	0.00
2004	Olam	0.00	15.00	0.00	0.00	0.00	15.00	0.00	0.00
2003	ShoreCap Intl	0.00	2.50	0.00	0.00	0.00	0.42	0.00	0.00
1999	Solar Dev. Cap.	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00
1997	TCW (GEM) Fund	0.00	5.44	0.00	0.00	0.00	5.44	0.00	0.00
	Total Portfolio:	125.00	120.84	0.00	125.00	84.50	37.02	0.00	84.50

FY Approval	Company	Approvals Pending Commitment			
		Loan	Equity	Quasi	Partic
2003	Ascent Fund	0.00	0.00	10.00	0.00
2002	GWRF	0.00	0.00	10.00	0.00
2003	Global MEF	0.00	4.00	0.05	0.00
2004	Schwarz Group	151.73	0.00	0.00	0.00
2004	TCW GEM VII	0.00	0.00	30.00	0.00
	Total Pending Commitment:	151.73	4.00	50.05	0.00

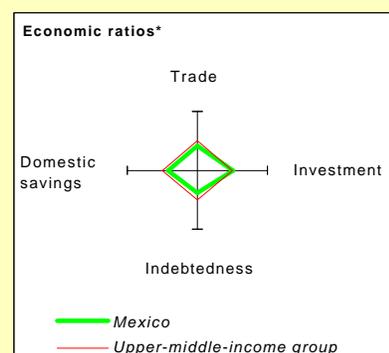
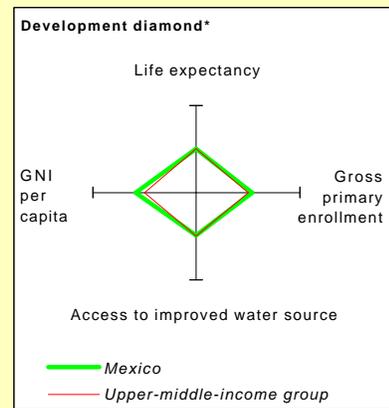
## Annex 10: Country at a Glance

### WORLD: Coral Reef Targeted Research and Capacity Building for Management

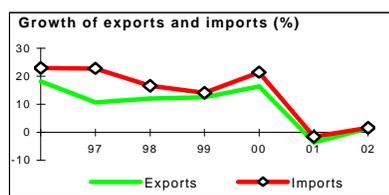
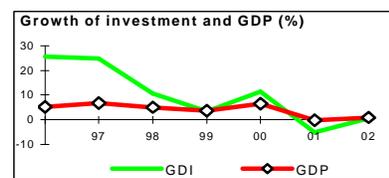
# Mexico at a glance

9/3/03

POVERTY and SOCIAL	Mexico	Latin America & Carib.	Upper-middle-income	
<b>2002</b>				
Population, mid-year (millions)	100.9	527	331	
GNI per capita (Atlas method, US\$)	5,920	3,280	5,040	
GNI (Atlas method, US\$ billions)	597.0	1,727	1,668	
<b>Average annual growth, 1996-02</b>				
Population (%)	1.4	1.5	1.2	
Labor force (%)	2.4	2.2	1.8	
<b>Most recent estimate (latest year available, 1996-02)</b>				
Poverty (% of population below national poverty line)	..	..	..	
Urban population (% of total population)	75	76	75	
Life expectancy at birth (years)	74	71	73	
Infant mortality (per 1,000 live births)	25	27	19	
Child malnutrition (% of children under 5)	8	9	..	
Access to an improved water source (% of population)	88	86	90	
Illiteracy (% of population age 15+)	8	11	7	
Gross primary enrollment (% of school-age population)	113	130	105	
Male	114	131	106	
Female	113	128	105	
<b>KEY ECONOMIC RATIOS and LONG-TERM TRENDS</b>				
	<b>1982</b>	<b>1992</b>	<b>2001</b>	<b>2002</b>
GDP (US\$ billions)	173.7	363.6	623.9	637.2
Gross domestic investment/GDP	22.9	23.3	20.9	20.3
Exports of goods and services/GDP	15.3	15.2	27.4	27.2
Gross domestic savings/GDP	27.9	18.3	18.6	18.3
Gross national savings/GDP	21.5	16.6	17.9	18.0
Current account balance/GDP	-3.4	-6.7	-2.9	-2.2
Interest payments/GDP	4.5	1.6	1.9	1.7
Total debt/GDP	49.6	30.9	25.4	24.2
Total debt service/exports	52.3	33.8	26.3	18.8
Present value of debt/GDP	..	..	..	..
Present value of debt/exports	..	..	..	..
	<b>1982-92</b>	<b>1992-02</b>	<b>2001</b>	<b>2002</b>
<i>(average annual growth)</i>				
GDP	1.9	3.2	-0.3	0.9
GDP per capita	-0.1	1.6	-1.8	-0.6
Exports of goods and services	5.1	13.4	-3.6	1.4



STRUCTURE of the ECONOMY	1982	1992	2001	2002
<i>(% of GDP)</i>				
Agriculture	8.1	6.7	4.1	4.0
Industry	33.4	28.1	27.1	26.6
Manufacturing	21.7	20.2	19.6	18.9
Services	58.4	65.2	68.7	69.4
Private consumption	61.6	71.8	69.6	70.0
General government consumption	10.5	9.9	11.8	11.8
Imports of goods and services	10.3	20.3	29.7	29.2
	<b>1982-92</b>	<b>1992-02</b>	<b>2001</b>	<b>2002</b>
<i>(average annual growth)</i>				
Agriculture	0.7	1.7	3.3	-0.4
Industry	2.5	3.7	-3.5	0.0
Manufacturing	3.0	4.3	-3.7	-0.6
Services	2.0	3.1	0.7	1.4
Private consumption	2.7	2.9	2.7	1.2
General government consumption	2.1	1.5	-1.2	-1.3
Gross domestic investment	2.5	4.7	-5.2	0.5
Imports of goods and services	11.2	11.8	-1.5	1.6

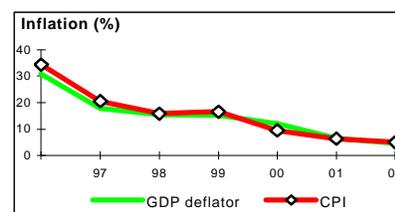


Note: 2002 data are preliminary estimates.

\* The diamonds show four key indicators in the country (in bold) compared with its income-group average. If data are missing, the diamond will be incomplete.

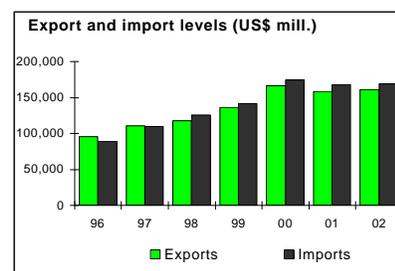
## PRICES and GOVERNMENT FINANCE

	1982	1992	2001	2002
<b>Domestic prices</b> (% change)				
Consumer prices	58.9	15.5	6.4	5.0
Implicit GDP deflator	60.9	14.4	6.5	4.6
<b>Government finance</b> (% of GDP, includes current grants)				
Current revenue	27.4	23.7	21.8	22.6
Current budget balance	-6.0	5.0	1.9	0.2
Overall surplus/deficit	-14.1	1.4	-0.7	-1.2



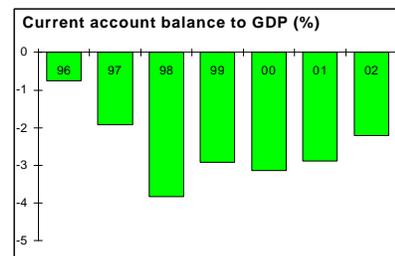
## TRADE

(US\$ millions)	1982	1992	2001	2002
<b>Total exports (fob)</b>	24,055	46,196	158,443	160,813
Oil	16,477	8,307	12,799	14,475
Agriculture	1,233	2,112	3,903	3,998
Manufactures	5,843	35,420	141,353	141,951
<b>Total imports (cif)</b>	17,011	62,129	168,396	168,949
Consumer goods	1,517	7,744	19,752	21,178
Intermediate goods	10,991	42,830	126,149	126,778
Capital goods	4,502	11,556	22,496	20,992
Export price index (1995=100)	127	91	103	106
Import price index (1995=100)	74	91	103	104
Terms of trade (1995=100)	171	100	101	102



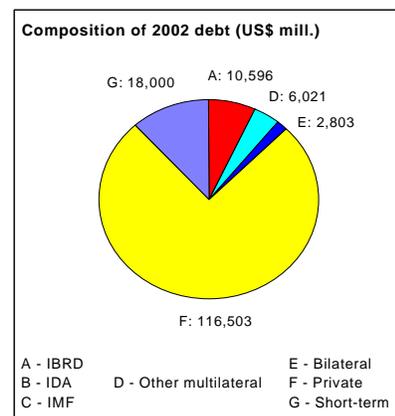
## BALANCE of PAYMENTS

(US\$ millions)	1982	1992	2001	2002
<b>Exports of goods and services</b>	28,169	55,387	171,103	173,374
<b>Imports of goods and services</b>	22,841	73,617	184,614	185,419
Resource balance	5,328	-18,230	-13,511	-12,045
Net income	-12,261	-9,595	-13,835	-12,282
Net current transfers	1,043	3,386	9,338	10,268
<b>Current account balance</b>	-5,890	-24,438	-18,008	-14,058
Financing items (net)	2,316	26,184	25,347	19,851
Changes in net reserves	3,574	-1,745	-7,339	-5,793
<b>Memo:</b>				
Reserves including gold (US\$ millions)	914	18,975	44,814	50,607
Conversion rate (DEC, local/US\$)	5.64E-2	3.1	9.3	9.7



## EXTERNAL DEBT and RESOURCE FLOWS

(US\$ millions)	1982	1992	2001	2002
<b>Total debt outstanding and disbursed</b>	86,081	112,315	158,291	153,923
IBRD	2,692	11,966	10,883	10,596
IDA	0	0	0	0
<b>Total debt service</b>	15,684	20,751	48,729	35,254
IBRD	328	1,874	2,178	2,093
IDA	0	0	0	0
<b>Composition of net resource flows</b>				
Official grants	76	14	..	..
Official creditors	1,577	615	-669	-432
Private creditors	6,391	-531	3,198	-3,932
Foreign direct investment	1,655	4,393	25,334	13,627
Portfolio equity	0	4,783	151	-104
<b>World Bank program</b>				
Commitments	540	1,313	860	1,322
Disbursements	408	1,352	749	1,247
Principal repayments	133	981	1,314	1,356
Net flows	275	371	-565	-108
Interest payments	195	892	864	737
Net transfers	80	-522	-1,429	-845



# Philippines at a glance

9/2/03

## POVERTY and SOCIAL

### 2002

	Philippines	East Asia & Pacific	Lower-middle-income
Population, mid-year (millions)	79.9	1,838	2,411
GNI per capita (Atlas method, US\$)	1,020	950	1,390
GNI (Atlas method, US\$ billions)	81.5	1,740	3,352

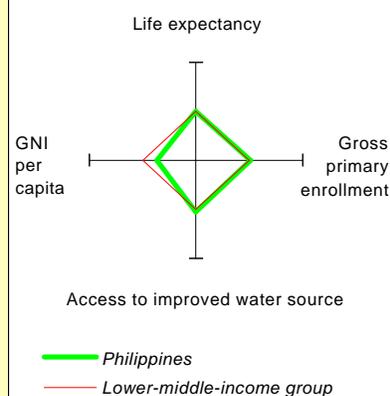
### Average annual growth, 1996-02

	Philippines	East Asia & Pacific	Lower-middle-income
Population (%)	2.2	1.0	1.0
Labor force (%)	2.3	1.2	1.2

### Most recent estimate (latest year available, 1996-02)

	Philippines	East Asia & Pacific	Lower-middle-income
Poverty (% of population below national poverty line) 1/	28	..	..
Urban population (% of total population)	60	38	49
Life expectancy at birth (years)	70	69	69
Infant mortality (per 1,000 live births)	29	33	30
Child malnutrition (% of children under 5)	32	15	11
Access to an improved water source (% of population)	86	76	81
Illiteracy (% of population age 15+)	5	13	13
Gross primary enrollment (% of school-age population)	113	106	111
Male	114	105	111
Female	113	106	110

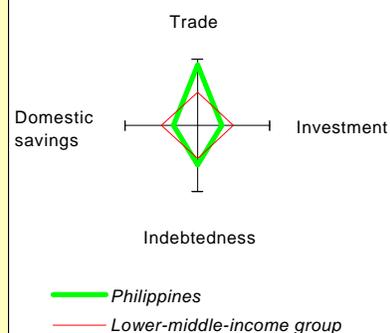
### Development diamond\*



## KEY ECONOMIC RATIOS and LONG-TERM TRENDS

	1982	1992	2001	2002
GDP (US\$ billions)	37.3	53.0	71.4	77.1
Gross domestic investment/GDP	27.9	21.3	17.6	16.6
Exports of goods and services/GDP	20.3	29.1	48.5	48.9
Gross domestic savings/GDP	22.1	16.4	19.0	17.7
Gross national savings/GDP	..	19.7	25.5	24.8
Current account balance/GDP	-8.6	-1.6	1.9	5.4
Interest payments/GDP	2.5	2.5	4.0	6.4
Total debt/GDP	65.4	62.3	80.9	77.7
Total debt service/exports	42.6	24.5	21.6	24.8
Present value of debt/GDP	..	..	77.4	..
Present value of debt/exports	..	..	132.7	..
	<b>1982-92</b>	<b>1992-02</b>	<b>2001</b>	<b>2002</b>
(average annual growth)				<b>2002-06</b>
GDP	1.6	3.7	3.2	4.6
GDP per capita	-0.8	1.4	1.0	2.4
Exports of goods and services	5.5	5.9	-5.2	3.3

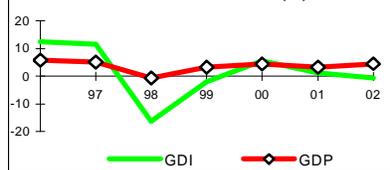
### Economic ratios\*



## STRUCTURE of the ECONOMY

	1982	1992	2001	2002
(% of GDP)				
Agriculture	23.3	21.8	15.1	14.9
Industry	38.8	32.8	31.6	31.6
Manufacturing	25.1	24.2	22.8	22.9
Services	37.8	45.3	53.3	53.5
Private consumption	68.8	73.9	68.2	69.5
General government consumption	9.1	9.7	12.8	12.8
Imports of goods and services	26.1	34.0	47.0	47.8

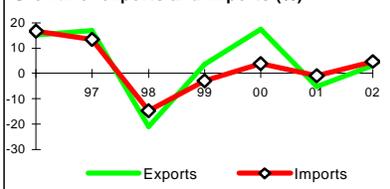
### Growth of investment and GDP (%)



### (average annual growth)

	1982-92	1992-02	2001	2002
Agriculture	1.5	2.0	3.7	3.5
Industry	0.1	3.5	2.3	4.1
Manufacturing	1.3	3.5	2.9	3.3
Services	3.1	4.6	3.7	5.4
Private consumption 2/	2.8	3.9	1.9	7.1
General government consumption	1.9	3.9	0.3	1.8
Gross domestic investment	0.4	2.4	1.3	-0.6
Imports of goods and services	7.0	5.1	-0.8	4.9

### Growth of exports and imports (%)



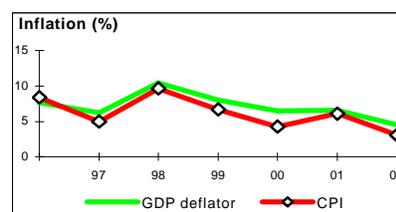
Note: 2002 data are preliminary estimates.

\* The diamonds show four key indicators in the country (in bold) compared with its income-group average. If data are missing, the diamond will be incomplete.

1/ Government poverty estimate is 34 percent for CY 2000. 2/ Includes statistical discrepancy

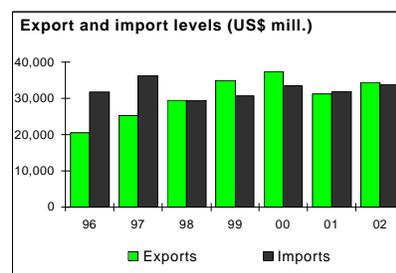
## PRICES and GOVERNMENT FINANCE

	1982	1992	2001	2002
<b>Domestic prices</b> (% change)				
Consumer prices	..	8.9	6.1	3.1
Implicit GDP deflator	8.7	7.9	6.6	4.5
<b>Government finance</b> (% of GDP, includes current grants)				
Current revenue	..	18.0	15.5	14.3
Current budget balance	..	2.1	-2.3	-5.3
Overall surplus/deficit	..	-1.2	-4.0	-5.3



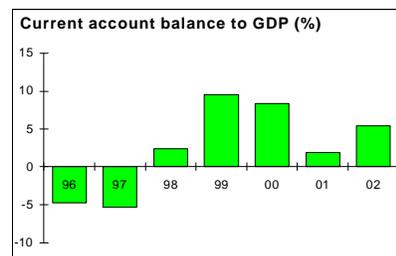
## TRADE

	1982	1992	2001	2002
<i>(US\$ millions)</i>				
Total exports (fob)	..	9,824	31,243	34,383
Electronics/Telecom	..	2,753	16,699	18,583
Garments	..	2,140	2,403	2,391
Manufactures	..	7,293	28,340	31,181
Total imports (cif)	..	14,519	31,986	33,975
Food	..	599	1,348	1,384
Fuel and energy	..	2,050	3,372	3,273
Capital goods	..	4,023	11,438	13,532
Export price index (1995=100)	..	..	..	..
Import price index (1995=100)	..	..	..	..
Terms of trade (1995=100)	..	..	..	..



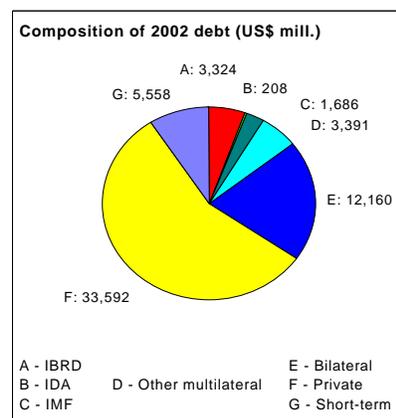
## BALANCE of PAYMENTS

	1982	1992	2001	2002
<i>(US\$ millions)</i>				
Exports of goods and services	6,825	14,566	34,391	37,439
Imports of goods and services	9,467	16,834	37,184	38,295
Resource balance	-2,642	-2,268	-2,793	-856
Net income	-1,044	593	3,669	4,550
Net current transfers	486	817	447	503
Current account balance	-3,200	-858	1,323	4,197
Financing items (net)	2,471	2,350	-1,131	-4,857
Changes in net reserves	729	-1,492	-192	660
<b>Memo:</b>				
Reserves including gold (US\$ millions)	..	4,338	15,658	16,180
Conversion rate (DEC, local/US\$)	8.5	25.5	51.0	51.6



## EXTERNAL DEBT and RESOURCE FLOWS

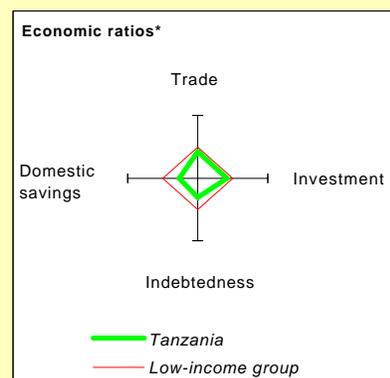
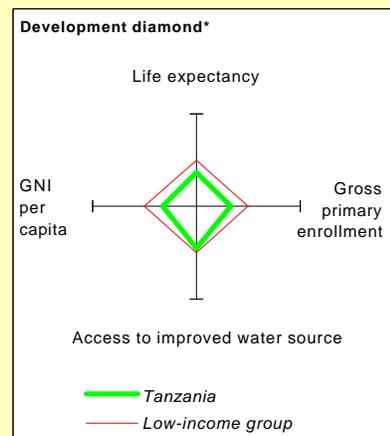
	1982	1992	2001	2002
<i>(US\$ millions)</i>				
Total debt outstanding and disbursed	24,413	33,005	57,758	59,919
IBRD	1,519	4,179	3,250	3,324
IDA	49	166	204	208
Total debt service	3,513	4,302	9,004	11,271
IBRD	174	640	491	479
IDA	0	2	6	7
Composition of net resource flows				
Official grants	70	208	112	74
Official creditors	469	1,457	-258	-39
Private creditors	1,138	-1,330	2,883	1,057
Foreign direct investment	16	228	1,142	1,026
Portfolio equity	0	360	1,050	1,912
World Bank program				
Commitments	541	630	90	200
Disbursements	259	578	120	177
Principal repayments	61	325	312	327
Net flows	197	254	-192	-150
Interest payments	113	317	185	158
Net transfers	84	-63	-377	-308



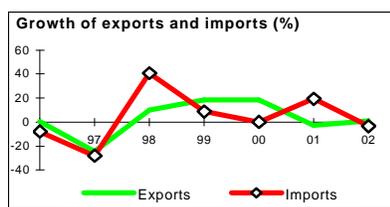
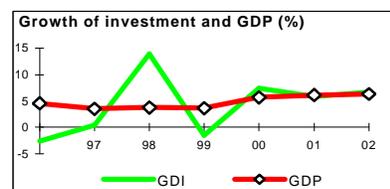
# Tanzania at a glance

8/20/03

POVERTY and SOCIAL	Tanzania	Sub-Saharan Africa	Low-income		
<b>2002</b>					
Population, mid-year (millions)	35.2	688	2,495		
GNI per capita (Atlas method, US\$)	280	450	430		
GNI (Atlas method, US\$ billions)	9.9	306	1,072		
<b>Average annual growth, 1996-02</b>					
Population (%)	2.4	2.4	1.9		
Labor force (%)	2.5	2.5	2.3		
<b>Most recent estimate (latest year available, 1996-02)</b>					
Poverty (% of population below national poverty line)	..	..	..		
Urban population (% of total population)	34	33	30		
Life expectancy at birth (years)	43	46	59		
Infant mortality (per 1,000 live births)	107	105	81		
Child malnutrition (% of children under 5)	29	..	..		
Access to an improved water source (% of population)	68	58	76		
Illiteracy (% of population age 15+)	23	37	37		
Gross primary enrollment (% of school-age population)	63	86	95		
Male	63	92	103		
Female	63	80	87		
<b>KEY ECONOMIC RATIOS and LONG-TERM TRENDS</b>					
	<b>1982</b>	<b>1992</b>	<b>2001</b>	<b>2002</b>	
GDP (US\$ billions)	..	4.6	9.3	9.4	
Gross domestic investment/GDP	..	27.2	17.0	17.4	
Exports of goods and services/GDP	..	12.4	15.3	16.7	
Gross domestic savings/GDP	..	0.3	8.4	10.5	
Gross national savings/GDP	..	6.2	7.3	10.1	
Current account balance/GDP	..	-15.5	-7.9	..	
Interest payments/GDP	..	1.2	0.4	0.6	
Total debt/GDP	..	145.1	71.5	77.2	
Total debt service/exports	23.6	42.2	10.3	7.8	
Present value of debt/GDP	..	..	14.4	..	
Present value of debt/exports	..	..	89.9	..	
	<b>1982-92</b>	<b>1992-02</b>	<b>2001</b>	<b>2002</b>	<b>2002-06</b>
(average annual growth)					
GDP	..	4.0	6.1	6.3	..
GDP per capita	..	1.3	3.8	4.1	..
Exports of goods and services	..	6.6	-2.7	1.0	..



STRUCTURE of the ECONOMY	1982	1992	2001	2002
(% of GDP)				
Agriculture	..	48.0	44.8	44.4
Industry	..	16.2	16.0	16.3
Manufacturing	..	8.2	7.4	7.6
Services	..	35.8	39.2	39.3
Private consumption	..	80.0	79.9	77.1
General government consumption	..	19.6	11.7	12.5
Imports of goods and services	..	39.4	23.9	23.6
	<b>1982-92</b>	<b>1992-02</b>	<b>2001</b>	<b>2002</b>
(average annual growth)				
Agriculture	..	3.6	5.4	5.0
Industry	..	5.3	6.9	9.3
Manufacturing	..	4.3	5.0	7.8
Services	..	3.7	5.5	6.2
Private consumption	..	3.9	24.0	2.3
General government consumption	..	1.9	-32.6	13.6
Gross domestic investment	..	0.7	5.8	6.7
Imports of goods and services	..	2.3	19.5	-3.3



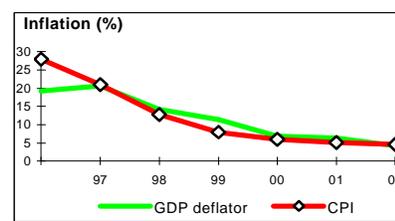
Note: 2002 data are preliminary estimates.

This table was produced from the Development Economics central database.

\* The diamonds show four key indicators in the country (in bold) compared with its income-group average. If data are missing, the diamond will be incomplete.

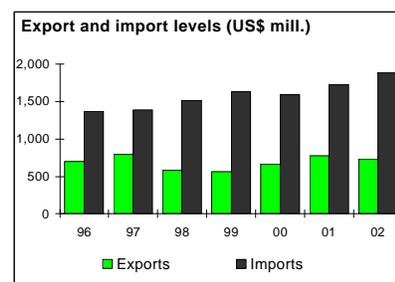
## PRICES and GOVERNMENT FINANCE

	1982	1992	2001	2002
<b>Domestic prices</b> (% change)				
Consumer prices	28.9	21.8	5.2	4.6
Implicit GDP deflator	..	25.4	6.2	4.2
<b>Government finance</b> (% of GDP, includes current grants)				
Current revenue	..	12.7	11.4	11.5
Current budget balance	..	0.8	-0.7	-1.4
Overall surplus/deficit	..	-1.6	-5.0	-5.7



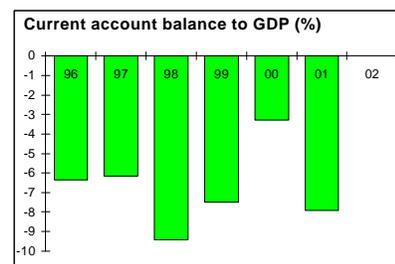
## TRADE

	1982	1992	2001	2002
<b>TRADE</b> (US\$ millions)				
Total exports (fob)	411	414	772	737
Coffee	134	60	57	70
Cotton	56	98	33	41
Manufactures	43	64	56	38
Total imports (cif)	1,128	1,357	1,726	1,889
Food	106	25	169	..
Fuel and energy	256	142	106	..
Capital goods	527	639	755	813
Export price index (1995=100)	86	75	151	156
Import price index (1995=100)	77	101	102	110
Terms of trade (1995=100)	112	74	148	141



## BALANCE of PAYMENTS

	1982	1992	2001	2002
<b>BALANCE of PAYMENTS</b> (US\$ millions)				
Exports of goods and services	645	548	1,430	1,569
Imports of goods and services	1,201	1,885	2,232	2,224
Resource balance	-556	-1,337	-802	-656
Net income	-85	-187	-85	-45
Net current transfers	24	456	-19	10
Current account balance	-523	-714	-738	..
Financing items (net)	524	817	909	..
Changes in net reserves	0	-102	-171	-347

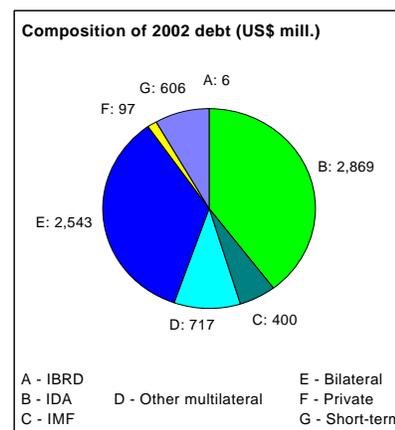


## Memo:

Reserves including gold (US\$ millions)	..	..	..	..
Conversion rate (DEC, local/US\$)	9.3	297.7	876.4	966.6

## EXTERNAL DEBT and RESOURCE FLOWS

	1982	1992	2001	2002
<b>EXTERNAL DEBT and RESOURCE FLOWS</b> (US\$ millions)				
Total debt outstanding and disbursed	6,202	6,675	6,679	7,238
IBRD	211	171	8	6
IDA	414	1,618	2,588	2,869
Total debt service	152	235	154	128
IBRD	25	45	4	3
IDA	4	19	35	22
Composition of net resource flows				
Official grants	309	697	927	..
Official creditors	231	263	93	179
Private creditors	31	-45	-21	-21
Foreign direct investment	17	12	224	..
Portfolio equity	0	0	0	..
World Bank program				
Commitments	71	60	355	57
Disbursements	107	235	119	148
Principal repayments	10	39	23	8
Net flows	97	196	96	140
Interest payments	18	25	17	17
Net transfers	79	171	80	123



Note: This table was produced from the Development Economics central database.

8/20/03

## **Annex 11: Incremental Cost Analysis**

### **WORLD: Coral Reef Targeted Research and Capacity Building for Management**

#### **Context and Broad Development Goals**

1. Context. Although they occupy only 0.1% of the ocean's surface, coral reefs are the world's richest repositories of marine biodiversity, and are the largest living structures on earth. Like their terrestrial counterparts, the rainforests, coral reefs support an array of environmental goods and services, whose ecological, cultural and economic value exceed our current capacity to quantify. Yet, despite their global significance, coral reefs are in decline worldwide.

2. The Global Status of Coral Reefs 2002 Report, lists two thirds of the world's reefs as under severe threat from the cumulative impacts of economic development and associated impacts of climate change. Even more recent reporting from the Scientific community (*Science VOL 301 15 AUGUST 2003*) stresses the now-global extent of coral reef decline.

3. The root causes of the deterioration of coral reefs have historically been attributed to direct human impacts, such as over fishing and destructive fishing practices, and chronic forms of near shore pollution; including sewage and sedimentation from poor land use practices. However, over the last several decades trends in climate-related episodes have begun to have significant impacts on coral reef ecosystems, and the combination of such events, combined with chronic forms of stress, are likely acting synergistically in the deterioration of coral reefs. The cumulative impact of threats to coral reef ecosystems is exacerbated by these historically rapid rates of changes in climate globally, which places enormous stress on the ability of coral reefs to adapt. That the negative trends appear to be observed in all coral reef regions of the world clearly indicate the global scope of the problem.

4. Calls for more effective conservation and more sustainable use of coral reef ecosystems have been a familiar theme in global forums, from the International Coral Reef Initiative, to the Convention on Biological Diversity (1995), the International Tropical Marine Ecosystems Management Symposia (ITMEMS I and II, 1998 and 2003, respectively), and most recently, the World Summit on Sustainable Development (2002). The WSSD Plan of Implementation identifies coral reefs as unique and vulnerable ecosystems that play a crucial role in the economies of Small Island Developing States (SIDs) and other developing states, and urges partners to: (i) implement the Framework for Action of the International Coral Reef Initiative (ICRI); (ii) implement the Jakarta Mandate on Marine Biodiversity of the Convention on Biological Diversity; and (iii) strengthen capacity globally to manage these ecosystems through science-based management and information sharing.

5. Many coral reef conservation and management initiatives have been launched in response to these challenges. As examples, the World Bank, in partnership with the GEF and others currently has over \$270 Million in active or pipeline projects in which coral reefs are a significant focus of conservation/sustainable use management effort. The United Nations Foundation, through UNEP, has catalyzed the launch of the International Coral Reef Action Network, and several International Non-Governmental Organizations (e.g. the World Wildlife Fund, The Nature Conservancy, Conservation International) have launched programs in an attempt to reverse coral reef decline. However, the effectiveness of these interventions is undermined by a paucity of information about what determines ecosystem sustainability and resilience to major disturbance events in an environment of increasing and variable stress. This information can only come from robust empirical observation and research on stress/response interactions, analysis of ecosystem drivers and threshold points. From such research it is

possible to produce knowledge and to help national and local coral reef managers apply this knowledge by developing the tools and approaches needed to manage with credibility and effectiveness. Such systematic research must be targeted to management needs and of sufficient temporal and geographic scale to discriminate long-term trends from background noise and local ecosystem response from larger scale, potentially global effects.

6. Project Scope. Without the understanding of key ecosystem processes and how they interact with the range of stressors facing coral reefs today, management interventions, short of complete removal of the sources of stress, will continue to be largely guesswork. The precautionary principle is currently our best tool to counteract threats from economic development and climate change whose impacts we do not fully understand. This is, however, a blunt instrument which is both economically and socially costly, and hence rarely applied.

7. The alternative approach, which this project embodies, is to support coral reef management with World-class targeted research. This involves scientists asking the right questions whose answers can benefit management and then providing managers with the best available science-based answers to them, e. g., to identify major drivers or bottlenecks in sustaining coral reef ecosystem goods and services, or to improve the cost-effectiveness of applications of existing tools, like Marine Protected Areas and coastal and ocean zoning, and the use remote sensing and modeling to support decisions. Such targeted research may also lead to development and application of new tools, such as biotechnology, in the design of bio-indicators of reef stress or resistance to bleaching, and in the identification of pathogens and their pathways of transmission. At the macro scale, this might involve the development of new tools like genetic markers to reveal connectivity between reef systems or techniques to enhance natural recovery and restore reefs damaged from blast fishing or cyanide. This new knowledge, when disseminated and linked to decision-making, has the capacity to dramatically increase the effectiveness of current and future management interventions as well as improvements to policies at the national level. It also lends credibility and accountability to decision-making and has the potential to generate the political will needed to make tough trade-offs between conservation and intensive use. These are the development objectives of this project.

8. This Coral Reef Targeted Research Project will be the first phase of a long term coral reef targeted research program. The program will be implemented in phases; this Project's first five-year phase will initiate research in areas of the world with significant coral reefs and Bank/GEF investments. These include sites in Mesoamerica, East Africa, Southeast Asia, and the Southwestern Pacific. Research nodes will be established at existing institutions that have the capacity to develop into Centers of Excellence in the region, and that may serve as resources and information clearing houses to satellite sites (involved in collaborative research or management), within and between regions.

9. The Project has the following four main objectives and components:

a. Addressing Knowledge and Technology Gaps

10. Over the past ten years, awareness of the importance of coral reefs has increased sharply, especially in light of their rapid decline in many regions, and their significance to developing countries. However, significant gaps remain in our understanding of some of the basic forcing functions and processes affecting coral reefs—to the extent that current management options are severely limited. The Project will systematically define information gaps, and prioritize them in an order of strategic importance to management, so that the resulting information and tools developed can lead to credible outcomes. Furthermore, policies developed at regional and national levels will also be strengthened to improve legislation to sustain the products and services provided to SIDS and coastal communities by coral reefs.

11. This component of the Project is organized around six key themes and major research categories, which will be investigated by interdisciplinary teams of developing and developed country scientists. These themes were identified through extensive consultation over the course of project preparation to encompass the kinds of knowledge and management tools that underpin sustainability science for coral reefs. They include:

- The physiological mechanisms and ecological consequences of large area (or massive) coral reef bleaching, particularly in response to sea surface temperature anomalies, like the El Niño/Southern Oscillation episodes, and the potential consequences of their changes in frequency;
- The nature, severity and spread of coral reef diseases, some of which may be responsible for major shifts in the structure, function, health and sustainability of coral reefs;
- The importance of larger-scale ecological processes, and the physical and biological connections (or “connectivity”) between coral reefs, whether within or between different regions. This also has direct bearing on the environmental conditions and key design factors needed to establish and sustain effective Marine Protected Areas (MPAs);
- The tools, technologies and efficacy of restoring coral reefs that have been severely degraded or destroyed, and the key organisms and environmental conditions to consider when rehabilitating a given coral reef environment;
- The application of advanced technology, particularly remote sensing, to refine information and enhance the rate and scale at which knowledge can be generated and applied. This includes the need to modify technology so that it can be practically deployed and sustained within developing countries;
- The need to develop decision support tools and scenario building which integrate economic development with bio-physical and other forcing functions to determine coral reef ecosystem response to (different kind and rates of) change or stress. Included in this type of analysis may be the impact of human stress on altering trophic relationships on coral reefs, particularly the relationship between nutrients, overfishing, and the overgrowth of corals by seaweeds and the reversibility of transitions between coral dominated and algal-dominated states. The development of models will incorporate the economic value of coral reefs, the socio-economic factors that affect the sustainable use of coral reefs, and the factors that inhibit translation of science into management.

b. Promoting Scientific Learning and Capacity Building

12. Currently, most coral reef research is based in universities and research institutions in the developed countries, while most coral reefs are located in developing countries. Rectifying this global discrepancy is the key mission of this project component.

13. In order to achieve this objective, the Targeted Research investigations will focus around four “Centers of Excellence” (COE) in four major coral reef regions (Western Caribbean (Universidad Nacional Autónoma de México), Eastern Africa (Marine Science Institute, University of Dar es Salaam, Zanzibar, Tanzania), Southeast Asia (Marine Science Institute, University of the Philippines), and the central south Pacific (University of Queensland, Australia).

14. These COEs will serve as nodes for targeted learning and capacity building between developed and developing country scientists -- to ensure that the information ultimately used by managers is regionally appropriate, and to train local scientists so that they can respond to future developments. Through twinning arrangements between various universities and research institutions, coral reef scientists will exchange with partner institutions to share cutting edge techniques e.g., the identification of coral pathogens,

measurements of metabolic stress linked to specific environmental stressors, the use of genetic markers to track larval dispersal and connectivity, and application of agent-based modeling techniques to simulate coral reef ecosystem response to various forms of stress. The Targeted Research Project will support a series of workshops each year which will bring researchers in the various working groups together to orient field research, brief each other on findings and based on these results, modify and design the next phase of research.

### c. Linking Scientific Knowledge to Management and Policy

15. A third major objective and outcome of this Targeted Research Project will be to improve global predictive capability in assessing impacts to coral reef ecosystems, in the face of cumulative stress from increasing coastal populations, changes in climate and other uncertainty. The targeted investigations are designed to feed into decision support systems for managers, policy makers, and other stakeholders.

16. The results generated from the targeted investigations will be formulated for application into management and policy contexts. Over the course of project implementation, the information and tools produced will be disseminated as knowledge products to enhance the management approaches and interventions. These products may range from in-situ diagnostics (for example, disease assessment and bio-indicators of specific forms of stress and metabolic response in coral reef organisms, to markers for larval recruitment indicating source and sink reefs) to remote sensing products and applications to assess the state of coral reef health. In addition to these tools, a series of management and policy briefs will be developed periodically by the Synthesis Panel and released to targeted audiences. These audiences include the World Bank Country Directors and Country Assistance Strategy (CAS) and Poverty Reduction Strategy (PRS) teams, GEF project teams, policy-makers, and member of regional and global fora (e.g. the IPCC, CSD, ICRI, SBSTTA, Regional Seas Conventions).

17. Links will be made between research results and management efforts in the four regions. Each Center of Excellence will serve as the conduit of information to satellite sites and various user/stakeholder groups (including NGOs and others involved in MPA management, coastal zone management and marine regulation, national and community-based coral reef management activities, and ecosystem monitoring efforts. NGOs active in the region, represent a particularly cost-effective means to communicate findings to managers and help convert them into low-tech solutions for direct application to developing country management needs. These include tool kits for managers, as well as those involving bio-indicators to assess stress in key reef species. At the other end of the spectrum, high level audiences will be kept abreast of research findings through publications of each of the working groups; through Synthesis Panel briefings, and in the form of periodic management and policy briefs.

18. The project component's main stakeholder and beneficiary groups will be both developing and developed country scientists who—for the first time in history for this scientific community—will have an opportunity to collaborate on address problems at a regional and global perspective that would not have been possible up until this point in time. It is anticipated that this project will result in a considerably strengthened institutional and human resource capacity, awareness and an improved, global information base from which the Centers of Excellence, visiting country scientists, managers, and academic institutions and agencies will benefit.

19. Additional target beneficiaries are members of the global community who also benefit from the biodiversity of coral reef ecosystems and services. It is anticipated that the project will result in significant gains in biodiversity conservation and sustainable development knowledge, information, awareness, income and non-monetary economic benefits. Finally, the GEF will also be a beneficiary of this project by gaining new insights into the best application of future GEF funding as applied to specific management and

conservation options for coral reefs and related marine resources within its member countries.

d. Project Execution and Administration

20. Given the global extent and the multidisciplinary nature of this undertaking, a carefully designed project execution and administration component is a critical part of the overall framework. The project involves renowned researchers from over 50 institutions who will carry out integrated, coral reef targeted research projects in four regions around the world. In addition, these scientists will work together to ensure that local capacity in the regions in which they work will be built over time, so that local scientists can benefit.

21. The successful execution of the project will be contingent on an implementing arrangement with committed individuals and institutions, a good governance structure, fiscal and managerial responsiveness, and sound financial management. This involves the coordination between the various working groups, and the related field work, the Synthesis Panel, the Centers of Excellence, the distillation of relevant information and its appropriate communication in the contexts of scientific peer review, management application, policy and sustainable development. As part of the project's preparation a range of institutional models have been considered and evaluated. A model has been chosen that balances the need for speed and efficiency in supporting the on-the-ground targeted research, with the need for technical and fiscal accountability in reaching the project objectives and goals.

22. The project will be managed by a Project Executing Agency (PEA), which will liaise with all of the Technical Working Groups, regional Centers of Excellence, and individual project staff when necessary. The PEA will have a fully dedicated staff to oversee project implementation, outreach and communication activities, and future planning (including development activities to identify future co-financing and new partnerships). Such a staff will include, at a minimum, a senior level Executive Officer, a Project Coordinator, an Outreach and Communications Specialist, and a Financial Manager. These will be full time positions, preferably working out of the same centralized project office. In addition, the PEA will hire, as necessary, short term consultants to 1) design workshops to integrate the research efforts of the scientific Working Groups, 2) oversee capacity-building efforts within the regions, and 3) disseminate synthesized results of targeted research to recipients involved in coral reef management, such as decision-makers, non-governmental organizations, and donor organizations.

23. In addition to the core management group that works together out of a centralized location, one or more data managers will be necessary. Such staff will not only manage the databases, but also develop and implement mechanisms for accessing such data -- for the scientists involved in the project and for the public at large. The need for such a position will of course increase through the life of the project.

24. The scientific Working Groups will be responsible for planning detailed research activities in each specialty, including choices regarding individual projects and institutions, as well as budgetary decisions involving resource allocations and procurements. Chairs of the scientific Working Groups will develop and submit annual work plans to the PEA, to be reviewed and approved by the Synthesis Panel. Each chair will also be responsible for evaluating progress made towards the stated goals of the scientific Working Group which he/she heads.

## Baseline Scenario

25. *Current Situation.* In the absence of GEF assistance for this project, the scientific community will pursue various coral reef targeted research investigations within limited and uncoordinated subject areas and geographic scope and using a variety of methodologies. There will be some collaboration between developed and developing country scientists, and a poor to modest amount of additional scientific capacity will be developed in the countries and regions where most coral reefs are located. Some of this baseline work may receive other forms of support from public and private foundations and academic institutions, and some would be undertaken (in the case of developing countries) through government institutions' own limited financial resources. In effect, the baseline work is largely compartmentalized within a country or sub-region and will focus on disparate scientific aspects of this global problem, using a variety of methodologies. While some scientific progress will continue to be made, little coordination of the research and little systematic dissemination of the information it produces, within a multi-disciplinary context, would occur.

26. Given the uncoordinated aspects of current research among investigators, their institutions and countries, and the inadequacy of resources to address problems with a multidisciplinary approach, it is almost certain that coral reefs within each of the target regions will continue to be degraded and global biodiversity values will continue to be lost unless significant, targeted actions are taken within a coordinated operational framework to supplement the current baseline.

27. *Scope of the Project's Baseline Scenario.* Based on an analysis of current plans for investigative activities under the baseline scenario, the following table illustrates where specific resources and activities are most likely to take place. Baseline expenditures on conservation-related activities are largely regionally focused, and so the baseline expenditures primarily generate limited local benefits, not global ones.

**TABLE A 4.1 – SUMMARY OF BASELINE CORAL REEF RESEARCH ACTIVITIES**

NO.	NATURE OF INVESTMENT	GEOGRAPHIC FOCUS	Budget amounts over 1-5 years (US\$Millions)
a.	Regional Environmental Monitoring and Information System	Mesoamerican Barrier Reef System (Mexico, Belize, Guatemala, Honduras)	4.4
b.	NOAA Coral Reef Watch Program	Caribbean, Northwest Pacific – US	8.0
c.	Ecology of Infectious Disease within Coral Reefs (NSF Grant)	Caribbean	0.25
d.	University of Queensland. Coral Reef Climate Change-related investigations. Development of specific indicators related to coral bleaching.	South Pacific, Mexico	1.2
e.	Remote Sensing – methods testing for field sampling and risk mapping	Caribbean, Palau	0.175
	<b>Total</b>		<b>14.0</b>

28. *Costs.* Over a five year project period, the total expenditures under the Baseline Scenario would be approximately USD\$14 Million. These are constituted as follows:

a. Regional Environmental Monitoring and information management system in the Mesoamerican Barrier Reef System.

Through a project funded by the GEF and World Bank the Mesoamerican region is developing a long term program for protection and sustainable use of the barrier reef system bordering Mexico, Belize, Guatemala and Honduras. As part of the project a sub- regionally focused monitoring and information management system is being developed to ensure that:

- monitoring techniques are appropriate, cost-effective and responsive to the information needs and monitoring capacity of each country, and that
- monitoring protocols are compatible within the region to allow for cross-country comparisons and integration of data into a regional assessment of ecosystem health over time.
- only a small proportion of resources are allocated to targeted research and field investigations, with the bulk of effort going toward monitoring and reporting.

b. NOAA Coral Reef Watch Program

The US National Oceanic and Atmospheric Administration has developed a program that focuses on technological applications for coral reef management. NOAA Scientists have developed experimental algorithms using satellite sea surface temperature imagery to identify regions of concern for coral bleaching events. With the experimental algorithms, NOAA provides a rendering of sea surface temperatures interpreted experimentally for the study of coral bleaching. In addition to this work, NOAA provides a number of websites and information products focusing on coral reef database management, integrating biological data from the reefs with interrelated chemical, biological, and physical data of surrounding marine areas. These data include measurements of coral reef taxa occurrences, numbers, life stages, pathology, productivity, sea water chemistry, turbidity, temperature, salinity, currents, bio-optical data, and substratum features. NOAA provides significant support to the United States Coral Reef Task Force and its domestic agenda for the protection of state and territorial coral reefs, but a significant amount of its work and resources also focus on the Caribbean basin and the Pacific Ocean, with an increasing interest in supporting international efforts.

c. Ecology of Infectious Diseases

Based on a five year grant from the (US) National Science Foundation, a number of investigators, some of whom are working group members, have received grant funding to further study the nature and extent of diseases affecting hard corals, and particularly sea fans, within the Caribbean Basin. The results from this work will contribute to more specific knowledge on the cause and effect of specific diseases or syndromes within this region.

d. Coral Bleaching, Climate Change and Development of Indicators

The University of Queensland has received grant funding from a number of sources to conduct a range of studies related to coral reef bleaching and the consequences of thermal stress on coral reefs within the Pacific and to a lesser extent, the western Caribbean (Yucatan Peninsula in Mexico). Results from this work will lead to the development of some indicators, but this work would be geographically limited in research and application of results. It would not have the potential to influence policy decisions which may impact on coral reefs

e. Remote Sensing methods for field sampling and risk mapping

Academic institutions, such as the University of Waterloo (Canada), University of Exeter (U.K.) the Australian Institute of Marine Science and others have committed resources to field test a number of approaches for coral reefs using remote sensing technology. In particular, the prospects of developing maps for areas that may be at higher risk to coral bleaching is being developed using Landsat imagery to proxy local bathymetry is being examined. Also, field testing of the potential plot sizes for long term monitoring using remote sensing is being developed.

29. *Benefits.* The benefits of the Baseline Scenario can be characterized as modest. At least some ongoing research and progress will be made with respect to various scientific investigations. However, these will be uncoordinated within any adaptive science framework (such as this project), and will be of limited benefit, especially if results remain within the confines of only one or two regions. Furthermore, results will be of limited global benefit within any management or policy context given the isolated nature and lack of information coordination of results. Of the activities defined, work within the Mesoamerican Barrier Reef System) would likely have the greatest spatial impact with respect to management application.

**Global Environmental Objective**

30. The Project's Development Objective and the Global Environment objective are to fill critical gaps in our understanding of what determines coral reef ecosystem vulnerability and resilience to a range of stressors--from climate change to chronic and acute forms of localized human impacts-- and to use this knowledge to strengthen management and policy globally for the benefit of coral reefs and the communities that depend on them. This will be achieved through targeted investigations involving networks of scientists, in consultation with managers, and the dissemination of knowledge within and across regions. The use of four major coral reef regions is an important aspect of this work, as it provides the opportunity to examine—and potentially replicate the findings—whether the factors affecting coral reefs are more local in nature or are global in extent, and how results can be used to strengthen future management options. The results generated over the life of this project will also significantly contribute to the GEF's ability to apply the best use of its limited resources in future conservation efforts where coral reefs and associated ecosystems are involved. A related objective is to build capacity for science-based management of coral reefs in developing countries where the majority of reefs are found.

**GEF Alternative**

31. *Scope.* The proposed GEF Alternative aims to develop a global adaptive science framework to allow scientists to investigate key unknowns regarding ecosystem drivers and how they interact with various forms of anthropogenic stress and climate change to determine vulnerability or resilience of coral reef ecosystems to these major forms of environmental “disturbance.” The targeted research has been carefully designed in specific areas of study by the various working groups, to test hypotheses relevant to management decision-making and to inform end-users of the implications of the results so that they can be readily applied. The project scope of the GEF Alternative includes the project components summarized above.. The GEF alternative will mark the first time in history within this scientific discipline that a strategic and coordinated set of investigations—designed within an adaptive framework— will be organized and executed on a global scale. The four major coral reef regions were selected based on the prospects of establishing Centers of Excellence within important areas where investigations can be successfully staged, and where there are significant opportunities for sharing knowledge and extending scientific capacity and learning.

32. *Costs.* The total additional expenditures associated with the GEF Alternative are estimated to be

about US\$20.00 million; these are summarized in Table A4.2 The GEF Alternative would involve expanded and new activities as described in the project components section above, and are summarized below:

Component	Indicative Costs (US\$M)	% of Total	Co-financing (US\$M)	% of Co-financing	GEF financing (US\$M)	% of GEF Financing
1. Knowledge & Technology Gaps	11.20	50.0	3.20	28.0	8.00	72.5
2. Linking Scientific Knowledge to Management	4.20	19.0	3.00	27.0	1.20	11.0
3. Promoting Learning and Capacity Building	4.00	18.0	2.60	23.0	1.40	12.5
4. Project Administration	2.90	13.0	2.50	22.0	0.40	4.0
<b>Total Project Costs</b>	<b>22.30</b>	100.0	<u>11.30</u>	100.0	<u>11.00</u>	100.0

This Incremental Cost table pools all co-financing to show the relationship of incremental GEF support. The Project Cost Table (Section C1 of this PAD) provides a further break down of co-financing type and percentage. This does not include in-kind contributions for investigator salaries and significant technology contributions from NOAA as a direct result of this project, and so is conservative in the amounts presented.

33. *Benefits.* The GEF Alternative will achieve all the benefits from the Baseline Scenario, but will enable further global benefits to be achieved, which can then be applied regionally and locally within appropriate management contexts to achieve additional regional/local benefits. In addition to the Baseline benefits, incremental benefits to the global community include the ability to conserve and sustain globally significant and representative biodiversity within each of the four regions, and to understand globally important drivers and trends in coral reef ecosystem health and to test and apply management options that may be broadly applied to mitigate impacts at the local and broader scales.

34. The GEF Alternative also provides institutional benefits that remove a number of the barriers to long term biodiversity conservation in these ecosystems. These institutional benefits include the following:

- *Strengthened links between science and policy for substantive and sustained change in behavior(public sector, corporate and local governance) in favor of coral reef ecosystems f Coral Reef Ecosystems.* The involvement of the Bank in promoting policy reforms based on reliable science, through country dialogue with clients and through its convening power in international for a will advance this outcome.
- *Development of protocols for the design of more effective MPA networks and other decision support tools.* Under the Baseline, “on-the-ground” experimental work, field testing of tools and interventions to enhance management in light of research findings, and decision support tools to help policymakers visualize the results of various development options is unlikely to occur. Under the GEF Alternative, by contrast, the communication and outreach activities designed to directly link science to management will educate stakeholders and help ensure that decisions are informed, and tradeoffs clearly spelled out. This will discourage short-term decision-making and increase the prospect for consistency in policies across sectors which have potential impacts on coral reefs.

35. *Domestic Benefits.* It is estimated that incremental domestic benefits of about US\$4.00 million will be realized in the GEF Alternative case. These benefits are associated largely with the Centers of Excellence, and with direct interventions supported through the targeted initiatives in the GEF Alternative. Other indirect benefits may also be realized through improved project review and determination of future components, based on the knowledge gained from the findings. Also, ecosystem management (e.g.,

improved watershed management, enhanced local existence values) but any incremental economic benefits from these improvements have not been estimated or included here; they are acknowledged to be one of the justifications for some level of Baseline support as a whole and for some further contributions towards the incremental costs identified under the GEF Alternative.

### Incremental Costs

36. The total expenditure under the Baseline Scenario is estimated to be US\$14.0 million while the total expenditure under the GEF Alternative is estimated to be approximately US\$36.0 million. The incremental expenditures (costs) under the GEF Alternative are therefore US\$22.0 million for the first phase project.

37. Of the incremental expenditures (costs) of US\$22.0 million, the GEF is requested to fund US\$11.0 million; the balance will be funded by other donors and stakeholders.

**Table A4.3 – coral reef targeted research and capacity building  
Incremental Cost Determination**

(US \$ million) [2003\$]

Component	Category	Cost	Regional / Local Benefit	Global Benefit
<b>A. Knowledge &amp; Technology Gaps</b>	Baseline	US\$10.75	Specific areas of inquiry (not necessarily tied to adaptive or applied science) will continue. Some regions and localities will benefit from the findings.	Some benefits based on information products or tools that might be applied in more than one region (e.g. NOAA SST data products, indicators from Disease Research, UQ)
	With GEF Alternative	US\$21.95	Improved coordination of priority unknowns (using similar methods) targeted within four regions and cross-referenced where possible. Sharing of methods, investigative techniques and information products.	Strategic uncovering of priority unknowns through an adaptive scientific approach related to the sustainability of coral reef ecosystems through improved management and policy options.
	<b>Incremental</b>	<b>US\$11.20</b>	–	–
<b>B. Linking Scientific Knowledge to Management</b>	Baseline	US\$2.3	Improvement of monitoring and information across a specific region (i.e. the MBRS region in the Caribbean)	–
	With GEF Alternative	US\$6.5	Improved communication of targeted information across multiple regions and disciplines. Working Groups to specifically work with management interests to improve management options and approaches.	Improved protection of key globally and regionally threatened ecosystems. Translation of targeted research to management and policy. Enhanced opportunities to engage in meaningful discussion with other disciplines (economics, law, sustainable development).
	<b>Incremental</b>	<b>US\$4.20</b>	<b>US\$0.00</b>	Not estimated.
<b>C. Promoting Learning and Capacity Building</b>	Baseline	US\$1.00	–	–
	With GEF Alternative	US\$5.00	Enhanced monitoring and information exchange permitting adaptive management. Efficient delivery of project funds, and evaluation of progress. Demonstration of financing models that potentially will be transferable to other protected areas, with concomitant efficiency gains.	Enhanced information exchange between developed and developing country scientists. Efficient coordination of implementing institutions, and monitoring of progress.
	<b>Incremental</b>	<b>US\$4.00</b>	<b>US\$</b>	–
<b>D. Project Administration</b>	Baseline	US\$0.00	–	–
	With GEF Alternative	US\$2.90	Establishment of Centers of Excellence within four regions to serve as learning centers and magnets for each Region.	Coordination of global efforts, adaptive science to benefit management and policy. Efficient delivery of project funds, and evaluation of progress.
	<b>Incremental</b>	<b>US\$2.90</b>	<b>US\$</b>	–
Totals	Baseline	US\$14.0		
	With GEF Alternative	US\$36.3		
	<b>Incremental</b>	<b>US\$22.30</b>	<b>US\$0.00</b>	–

**Annex 12: STAP Roster Technical Review**  
**WORLD: Coral Reef Targeted Research and Capacity Building for Management**

*“World investigation of localised stress and compounding effects on climate change on sustainability of coral reef systems” a targeted research project submitted by the World Bank*

**Sent to GEF on September 9, 2003**

The STAP and the GEF Targeted Research Committee is very pleased to have had the opportunity to review the World Bank’s Coral Reef Targeted Research Proposal scheduled for submission to the GEF Council in November 2003<sup>1</sup>. The Research Committee realizes that this project should have been at the time of pipeline-entry/PDF-B stage and appreciates the opportunity of being able to review it at this stage. In the future, the Research Committee very much hopes the process is successfully in place to support their capacity as committed scientists and reviewers of GEF targeted research proposals at the appropriate stage. The Research Committee trusts that its concerns on this coral reef targeted proposal will be addressed in the final documentation. Some members of the Research Committee would like to reserve the right to send in more details comments at a later stage, whilst others have incorporated them here..

Overall, this is a well-conceived targeted research (TR) that is addressing the stresses that are affecting the coral reefs of the world. Its basic approach is well stated and the outcomes it is seeking have the potential to advance our understanding of the various stresses and their impacts on coral reefs. However, as written, we have a few concerns that make us uncertain as to whether the TR will deliver what is being promised. We have summarised our concerns below and they cover aspects of choice of the sites, institutions and individual scientists, scientific management and leadership, the transfer of the scientific information into management actions and comments on the proposed work by each of the Working Groups. Where possible, we have made suggestions that could be implemented to overcome these. We very much hope they can help strengthen the proposal and achieve the needed outcomes of this TR.

1. **The choice of the specific sites is not clear and should be clarified.** It is not clear as to why the specific sites mentioned were chosen for the research (and neither is the choice of individuals/institutions – see below). In an ideal world, the project would be carried out in sites that were representative of different coral reef systems, types of sediments, eutrophic impacts, stresses, spatial characteristics (eg. region and current systems) and biodiversity. Why are some regions excluded, eg. the insular Caribbean?
2. **The synergies between the Working Groups, and the way stresses are being addressed at any of the selected site, need to be clarified.** From the documentation presented, the synergies between the Working Groups are not clear. It appears that the multiple stresses that the project emphasises are not being addressed at all the sites. We would have assumed that this would have been one of the priorities and strengths of the project. From Appendix 6 it is hard to see what is going to be researched at what site. It would be extremely useful to present a site/activity table. This would really bring out if many of the stresses are indeed going to be addressed at the various sites. We realise that the technical appendices do provide more details for much of the work, but essentially address the issues in that working group and not across the working group.
3. **Plans should be developed to expose the project to a wider scientific scrutiny and seek their collaboration where needed.** In addition to the selection of sites, how and why certain individuals (especially team leaders) were chosen is not clear. The project should ideally have involved a wide range of scientists and institutions from developing and developed countries and at least attempted

to involve the best experts in those regions. We appreciate that this is not an easy task (both due to difficulties in identifying the best experts and the possibility of not being able to attract their interest and time). Given the stage of the project, we would like to encourage the proposed activities be reviewed more extensively by internationally recognised experts involved in coral reef research and seek their collaboration/involvement when necessary. A possible mechanism might be through a workshop in conjunction with a web-based discussion or a large international coral reef conference, so there is a wider exposure of the proposed activities and an extensive review. The STAP can also suggest experts from the developing and developed world.

4. **The different working groups work needs to be brought together under strong scientific leadership.** From the present draft, it is not clear that the Synthesis Panel and its chair would be able to bring the multiple stresses and the work at the various sites together even with an external chair. The Working Groups state that the other working groups would provide the information, data or expertise, but again, from the description given, it is not clear how this is going to be done – what are the questions that would be addressed and how would the information be brought together. Thus, the role and the value added of the Synthesis Panel needs to be clarified, in addition to the synergies between the Panel and the Working Groups.
5. **The project should state how it is building on existing information.** It is not clear from the proposal on how the Project will interact and benefit from the existing GEF interventions which includes a coral reef management component. This should be further elaborated in the proposal. It is even more intriguing that there is little or no mention of how the project will build on what has already been done by institutions such as, ICRAN, ICRI, ICN, NOAA, others involved in the insular Caribbean and the Cooperative Research Centre for Reefs in Australia. These institutions and others can also become potential collaborators and their existing resources and networks can become part of information dissemination, e.g., as part of the learning exchanges process, the data generated can also be distributed via nodes such as SIDSNET, which already has nodes in the Caribbean and the Pacific.
6. **There appears to be lack of consultation, needs analysis and engagement of the potential managers.** We do not see evidence that the management action will result from the scientific findings. Is there evidence that the managers are looking for ‘science-based’ solutions? Have they been consulted (i.e. user needs assessment done) and if so what were the outcomes? Have the managers had information presented to them by individuals or institutions involved before and have the managers taken action? There is no clear mechanism presented on how the scientific information will result in management actions.
7. **Management implications/outcomes are weak in all the working groups and need to be strengthened.** Linkages to other working groups are weak, including data/information and methodology transfer. Further information has to be presented to really demonstrate the mechanism for the transfer of the information to the managers and its subsequent use. Section D, project rationale, does not mention the underlying causes. The management options should surely have to consider these before any “new” management strategies are put into place.
8. **We encourage the project to incorporate the *active* involvement of local communities from the beginning.** The approach taken at each of the sites appears to be very top down. We have seen little or no mention of the local communities that do manage and rely on many of the coral reefs of the world. In some cases, we hope that they have people who have already been doing work on the

ground as otherwise it is going to be very hard for the scientists and managers to walk in and do the work (e.g. in Papua New Guinea). Therefore, an initial stakeholder analysis would help in identifying and engaging the local communities.

9. **We are concerned about the participation of developing country scientists and the funds that will be allocated to them.** It would be helpful to indicate what is the ratio of experts from developing countries participating in the research, and what is the proportion of funds being allocated to developing countries.
10. **There appears to be a lack of post-intervention follow-up** and needs to be stated clearly. In terms of GEF global environment impacts, it is important to identify follow-up strategies. It seems to be missing entirely in the documentation. Further clarification is needed on what entities would follow up after the interventions? How would the follow-up occur?
11. **Some of the assumptions being made need clarification and testing,** (e.g. disease and the interaction with water quality is too simplified and generalised) and the appropriate Working Groups need to add that this will be tested. We feel that the project should point out the challenges and also the assumptions that apply to the replicability and transferability of the results.
12. **The summary of the proposed work by some of the Working Groups (see below) is excellent, but some others need to be strengthened both in terms of the methodology and perhaps the experts involved.** In particular we would like to highlight our concerns about Modelling and Decision Support Working Group and within that “Field validation”. Field validation is a critical aspect and needs to be considered in more detail than in the cursory manner presented here with (both within the main project proposal and in the Technical Annex 1). There is no indication as to how field validation will be undertaken, and no consideration of temporal and spatial scales etc.

### **More specific comments on the Working Groups**

Our comments are based on the Annexes in the main document but we have also checked in the six Scientific Annexes provided. The quality of the documentations in these annexes seems to vary considerably. Again a strong scientific leadership for the whole project could help overcome this.

Some comments across the working groups are:

- a) Scaling issues: Some of the information (e.g. IPCC scenarios) are available mostly at the global level, and yet the coral abundance, reef biodiversity etc is a t local and at best regional level. How would these be incorporated into the models?
- b) Some of the modelling work mentioned in various work in the appendix is hard to do on land let alone an “open” system as that of coral reefs. We are not convinced that enough thought has been given to this critical section in all the working groups.
- c) Only \$3.0 million are allocated to "linking scientific knowledge to management", the same amount that is allocated to project administration. If the former is an important goal of the project, is this level of funding proportionately adequate? Perhaps the team might wish to revisit this funding allocation.

### **Specific comments on each of the working groups proposed work:**

1. Bleaching Working Group: has some weaknesses. Some parts of the summary of the proposed work are excellent, however, other portions of the summary are less thorough, and give the impression that little or no work has been done in the three activities listed in the first paragraph.

We can only assume that since some of the processes involved, eg. changes in physiology to individuals reef systems, globe, are long-term that data needed on this would be somehow (through individuals and institutions involved?) be incorporated in the project.

2. Diseases Working Group: overall good.
3. Connectivity – various issues need to be improved, such as:
  - a. There is not enough evidence to indicate that what is proposed is achievable in the defined time frame.
  - b. It is not clear as to what techniques will have to be developed and which ones will be further expanded.
  - c. How long would it take to do develop the tools to identify and monitor stress and would these techniques be easily and quickly transferable to the other regions?
  - d. Is any of the information transferable to other regions and coral reefs with different history, biodiversity and set of stresses?
  - e. Are the researchers concentrating on “keystone species” so they may obtain a good understanding of the critical processes?
  - f. Is there a logic for choosing to concentrate on lobsters, groupers and snappers?
4. Restoration Working Group: well presented summary of the intended work, although again it would have been useful to say if pilot or other work suggests that the experimental work being suggested can be done over the spatio-temporal scale of the project.
5. Remote sensing Working Group: this seems to promise a great deal and we are not sure if it can deliver. Some of the techniques are a challenge in land-based systems and we are not convinced that these can be done in the coral reef systems. Further information on how the project team plans to address this would be useful.
6. Modelling and Decision support Working Group: this is the weakest WG in terms of the information presented. We are not sure if there is sufficient data available to develop an expert system. What are some of the challenges and can they be overcome? How will field validation be done? This is not trivial and should be clarified (see point 13 above). 12 major sets of models are being proposed and it is not clear how they will be integrated; there will be challenges in terms of information available and their spatio-temporal scales and yet this does not come across in the summary presented. We are not convinced that the research will lead to definite management implications

#### **Some minor points on the main project proposal**

- Section B, page 2 onwards. It would be worth mentioning climate variability as well as climate change is being considered; is “unprecedented” bleaching and not “unprecedented mortality” on page 3. The section does need to mention the temporal aspects and the potential time lags that might be of relevance to the coral reef systems
- Would the TR really lead to a “new generation of trained scientists” (page 20) in 5 years?

## Response to STAP Roster technical reviewer's comments

*(in italics)*

**1. The choice of the specific sites is not clear and should be clarified.** It is not clear as to why the specific sites mentioned were chosen for the research (and neither is the choice of individuals/institutions – see below). In an ideal world, the project would be carried out in sites that were representative of different coral reef systems, types of sediments, eutrophic impacts, stresses, spatial characteristics (eg. region and current systems) and biodiversity. Why are some regions excluded, eg. the insular Caribbean?

*As a result of the Block A consultations which engaged both scientists and managers, a conscious decision was made to limit the research to 3-4 key coral reef regions of the world during the initial five year phase. These regions were selected on the basis of where there were already significant GEF and other investments in coral reef management; where there was the beginning of a critical mass of coral reefs scientists and infrastructure to support establishment of a regional node (which could evolve into a Center of Excellence for coral reef research), and with support from the Project could facilitate research and capacity building at a number of satellite sites. The research nodes in these regions were carefully selected in coral reef ecosystems where considerable baseline data was already available and where resident researchers were engaged in research that could both contribute to and benefit from the targeted research objectives. (See Brief Section E.4.1)*

*Under ideal circumstances and significantly larger financial resources, this project would have greater spatial replication and site representation within each of the regions identified, and would reflect some sort of stratified random sampling design. However, there will never be enough financial resources to conduct the kind of spatial replication that would be required to generate rigor and power in a statistical context (i.e. drawing inference over a sampling universe within a given region). As an alternative, this project has approached the targeted research with a case-study model, whereby a limited number of study sites have been identified, in which a suite of investigations around key themes is carried out and the information integrated at each site. Results will be compared across sites, where possible, to assess what impact/response relationships may be global in scope as opposed to regional (in terms of cumulative impacts) or even local in scope. It is legitimate and necessary to focus at the outset on a smaller number of sites until the effectiveness of the research model(s) can be demonstrated.*

*It is the project's intention to expand the number of sites as the Project progresses through successive phases and the working groups move toward filling critical information gaps through time. This is why the Targeted Research has been conceived as a 15 year program. Sequencing is essential in light of the human and financial resources available and to allow consolidation of results and reformulation of hypotheses before expanding into new regions and sites.*

**2. The synergies between the Working Groups, and the way stresses are being addressed at any of the selected site, need to be clarified.** From the documentation presented, the synergies between the Working Groups are not clear. It appears that the multiple stresses that the project emphasises are not being addressed at all the sites. We would have assumed that this would have been one of the priorities and strengths of the project. From Appendix 6 it is hard to see what is going to be researched at what site. It would be extremely useful to present a site/activity table. This would really bring out if many of the stresses are indeed going to be addressed at the various sites. We realise that the technical appendices do provide more details for much of the work, but essentially address the issues in that working group and not across the working group.

*The suggestion of a site/activity table to lay out what investigations will occur at each site and where potential synergies between WGs lie is an excellent idea and will be incorporated into the Project Brief prior to final submission in November (see Section C1 addressing knowledge and technology gaps). As*

*noted above, however, the need to concentrate investigations in a limited number of sites and to sequence the work in line with proof of concept, resources and logistics, has determined the initial scope and geographic focus of the research in phase one. As a result, not all Working Groups will be working at all sites simultaneously in the initial phases until demonstrations can be completed and then scaled to other locations. Nevertheless, there is significant scope for synergy between the various working groups, and maximizing these opportunities and integrating information (especially at different scales) is a foundation of the model, and will be one of the main responsibilities of the Synthesis Panel to see that this occurs. This is a major strength of the proposed investigations and an example of the high value added of this approach to targeted research.*

*The Synthesis Panel has only been able to meet twice thus far during the Block B phase, but a third meeting is being planned in December 2003 to coordinate field work and to confirm procedures for the sharing of results in real time. In the meantime, there have been many working group meetings in which representatives from other working groups have attended. This has led to a more coordinated approach to the development of the WG research agendas and the sequencing of fieldwork, as reflected in the draft technical annexes. The construction of a table to clearly indicate who is doing what where, will help define this more clearly in the Brief and in the Project Implementation Plan.*

**3. Plans should be developed to expose the project to a wider scientific scrutiny and seek their collaboration where needed.** In addition to the selection of sites, how and why certain individuals (especially team leaders) were chosen is not clear. The project should ideally have involved a wide range of scientists and institutions from developing and developed countries and at least attempted to involve the best experts in those regions. We appreciate that this is not an easy task (both due to difficulties in identifying the best experts and the possibility of not being able to attract their interest and time). Given the stage of the project, we would like to encourage the proposed activities be reviewed more extensively by internationally recognised experts involved in coral reef research and seek their collaboration/involvement when necessary. A possible mechanism might be through a workshop in conjunction with a web-based discussion or a large international coral reef conference, so there is a wider exposure of the proposed activities and an extensive review. The STAP can also suggest experts from the developing and developed world.

*This comment suggests that the STAP was not aware of the considerable consultation and vetting within the scientific community that went on prior to and during the Block A Phase. The need for a Targeted Research program for coral reefs was first conceived in response to the 1997-98 El Nino-mass bleaching event, and presented at the first Inter-tropical Marine Ecosystems Management Symposium (ITMEMS) in November of 1998. After positive initial feedback and, following a favourable concept review by the STAP Research Committee in place at that time, a PDF Block A grant was obtained. The PDF A was to support systematic consultations with the scientific and management communities in conjunction with major coral reef fora, such as the International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring and Restoration, 1999 in Fort Lauderdale, Florida, USA; the International Workshop on Coral Reef Bleaching in Riyadh, Saudi Arabia, 1999; the 9th International Coral Reef Symposium in Bali in 2000 and the ICRI meetings in New Caledonia in 2000, and the Philippines in 2001. These consultations resulted in the prioritisation of research themes, identification of the best scientists in the field to undertake this research, and the narrowing down of field sites in line with existing knowledge, research infrastructure, GEF investments and anticipated budget.*

*The Working Group Chairs, selected to lead the effort in the key thematic areas, are pre-eminent in their fields. They are highly respected scientists with international reputations. These chairs were then invited by the World Bank's team to form working groups based on the following criteria:*

1. *That demonstrated scientific excellence and rigor be a defining quality of working group composition*

2. *That where possible, the working group include developing country scientists who clearly meet the first criterion in the field of investigation*
3. *That size of the working group not exceed a critical threshold beyond which it is difficult to act efficiently and with consensus*
4. *That the working group members be individuals who are willing to commit to an atmosphere of team work and coordinated investigations, and who are willing to share knowledge and approaches with others in developing capacity at every opportunity.*

*Further communication of the concept and of the emerging working groups was made to the external scientific community during a number of workshops supported with Block B funds. These exemplified the consultation and learning exchanges that the TR Project espouses, and will continue to be a hallmark of the targeted research model through involvement of the Centers of Excellence (See Brief Section E.4.1). Examples of these include two workshops, which were held in:*

- *Heron Island, Southern Great Barrier Reef, University of Queensland, 25 Feb – 18 March 2002, attended by 48 researchers and students,*
- *Puerto Morelos, Mexican Caribbean, Universidad Nacional Autónoma de México, 9-22 September 2002, attended by 25 researchers and students.*

*At these meetings, Working Group members engaged with other senior researchers (invited as distinguished guests) to share their knowledge and exchange ideas with young doctoral and post-doctoral students from participating developing and developed countries. This has allowed researchers to collectively discuss, peer-review, design and implement research priorities jointly at two of the four COEs, while at the same time share information and results across a broad generational gradient (i.e. an apprenticeship model). At the end of these exchanges, reports have been generated that have resulted in furthering post-workshop application of the information. The TR workshop concept also serves as a good mechanism within each of the COEs for integrating science into management considerations by facilitating regional discussions and learning exchanges among scientist, managers, policy-makers, NGOs and public sectors.*

*The scientific members throughout the working groups are already well connected within their community of practice, and most, if not all of the WG members are also members of the International Society for Reef Studies (ISRS), and National Chapters of other scientific organizations. The ISRS hosts a quadrennial symposium on reef studies, and the next of these (the 10th ICRS) will take place in Okinawa, Japan in the summer of 2004. This project, and its working group representatives have already applied for –and have been accepted by the organizing committee of the ISRS—to host mini-symposia on this global project, and to seek ways in which the targeted research can be strengthened. In addition, the Targeted Research will support 2 ISRS research scholarships per year, to be awarded to outstanding scientists from developing countries who will carry out research hosted by the TR Project.*

**4. The different working groups work needs to be brought together under strong scientific leadership.** From the present draft, it is not clear that the Synthesis Panel and its chair would be able to bring the multiple stresses and the work at the various sites together even with an external chair. The Working Groups state that the other working groups would provide the information, data or expertise, but again, from the description given, it is not clear how this is going to be done – what are the questions that would be addressed and how would the information be brought together. Thus, the role and the value added of the Synthesis Panel needs to be clarified, in addition to the synergies between the Panel and the Working Groups.

*While we agree that strong scientific leadership is required to bring the working groups together in a*

*coherent way, we take strong exception to the notion that such scientific leadership does not exist within the Project structure we have laid out. As noted before, the Chairs of the Working Groups and other members of the Synthesis Panel are world class scientists (see technical annexes posted on the website for lists of WG Chairs & members). Nevertheless, the Project Team welcomes recommendations from the STAP of additional scientists whom they feel can contribute to, and provide periodic review of project results and its process.*

*The role of the Synthesis Panel as part of the larger Steering Committee, is crucial in reviewing scientific results, to provide a check and balance of priority hypotheses across the working groups, and relating them across the various disciplines to distil emerging trends, discriminate global from regional or local patterns of response and steer the research in ever more promising directions. The recognition of strong coordination has already been acknowledged, and this has been addressed in the revised section of the Brief on institutional arrangements. This has been informed by the results of a major study which was not complete at the time of the STAP review.*

**5. The project should state how it is building on existing information.** It is not clear from the proposal on how the Project will interact and benefit from the existing GEF interventions which includes a coral reef management component. This should be further elaborated in the proposal. It is even more intriguing that there is little or no mention of how the project will build on what has already been done by institutions such as, ICRAN, ICRI, ICN, NOAA, others involved in the insular Caribbean and the Cooperative Research Centre for Reefs in Australia. These institutions and others can also become potential collaborators and their existing resources and networks can become part of information dissemination, e.g., as part of the learning exchanges process, the data generated can also be distributed via nodes such as SIDSNET, which already has nodes in the Caribbean and the Pacific.

*The TR Project Team has consulted extensively with staff from the institutions and projects referenced above. ICRI has been briefed on the status of project development since its inception, at the first ITMEMS, and then regularly at ICRI Steering Committee (CPC) Meetings and Symposia. The project has the full endorsement of this group, and in fact, it was the result of a presentation to the ICRI CPC in Maputo in December of 2001 that the East African Node was added, at the insistence of delegates from the region, including scientists and managers. The existence of several GEF and other donor-supported projects supporting ecosystem-based coastal resources management in the MBRS region, active scientific research and a strong commitment of governments and NGOs to conserve the world's second longest barrier reef, was a major factor in the selection of this sub-region, as well as in identifying a demand and opportunity for channelling results. The MBRS Project, COREMAP, ICRAN and other global NGO marine conservation initiatives have repeatedly expressed their desire to use the research results generated from the TR Project to underpin and inform the interventions that are being promulgated under these management projects. Here, existing networks like ICRAN and SIDSnet can help to disseminate research information to the management community. In contrast to these management efforts, the primary objective of the TR is not to implement better management, or even good governance. It is, rather, to create a robust framework for good science (and extend that quality through targeted, scientific learning) which will lead to new tools, insights about how systems in different places respond to various kinds of stress and prospects for their recovery in a changing environment, how they are connected in space and time, and how this information can be related to allow managers and policymakers to anticipate with greater accuracy the impacts of their decisions and have a sounder basis on which to intervene. (See Brief Section C.3. Benefits & Target Population).*

*Institutions such as NOAA and a new Center for Coral Reefs and Climate Change at the University of Queensland are already enlisted as partners under the project and are providing significant co-financing (NOAA at approximately \$10 million in direct and related co-financing; University of Queensland at*

approximately US \$3 million in direct co-financing.) The TR is also building effectively on the investigations of its Working Group members, many of whom are engaged in cutting edge research in the field. For example, within the Connectivity WG, their proposed research will benefit from the following foundational work of its members:

1. GP Jones has published **one of the only two studies** to empirically document retention of larval reef fish (Jones, G.P., Millicich, M.J., Emslie, M.J., Lunow, C. 1999. Self-recruitment in a coral reef fish population. *Nature*. 402, 802-804.) There are **zero comparable studies** on corals or other reef creatures.
2. RK Cowen is responsible for an important modelling contribution to connectivity thinking: Cowen, R.K., Lwiza, K.M.M., Sponaugle, S., Paris, C.B., Olson, D.B. 2001. Connectivity of marine populations: open or closed? *Science*. 287, 857-859.
3. S. Thorrold is one of the 2-3 leaders in use of otolith microchemistry to document sources of larval fish.
4. R. Steneck is a leading expert on the processes surrounding coral settlement and recruitment
5. M. Butler is a leading expert on spiny lobster settlement, recruitment and juvenile ecology in the Caribbean.

**6. There appears to be lack of consultation, needs analysis and engagement of the potential managers.** We do not see evidence that the management action will result from the scientific findings. Is there evidence that the managers are looking for 'science-based' solutions? Have they been consulted (i.e. user needs assessment done) and if so what were the outcomes? Have the managers had information presented to them by individuals or institutions involved before and have the managers taken action? There is no clear mechanism presented on how the scientific information will result in management actions.

*Please see the response to comment #3 above. The ability to link the scientific findings to management and facilitate its uptake is both a key objective and a major challenge of the Targeted Research Project. The Project team recognizes the strategic importance of promoting these linkages in: (i) the prioritization of research questions, (ii) formulation of hypotheses in ways that suggest management-relevant outcomes if the hypothesis is accepted or rejected, (iii) testing of research tools (such as remote sensing, fish larval dispersal markers, and field assays to diagnose stress in indicator species and diseases in corals), (iv) cost effective reef restoration techniques and (v) designing decision support tools to enhance management. All of these are core elements of the research. Managers were in fact consulted during project preparation (during the Block A and later in the Block B, although a formal assessment of managers' needs was not undertaken) in professional meetings and side events at international conferences dedicated to this purpose, through ICRI, ICRAN, and GEF project teams, with NGOs such as The Nature Conservancy and WWF—all of whom have identified a demand for knowledge and products among their constituents of the kind the TR is being designed to generate. An example is the growing interest among MPA managers in the notion of connectivity within and between ecosystems, its importance to maintaining the integrity of marine ecosystems and their supply of goods and services (e.g., in the context of fisheries recruitment and recovery of damaged coral reefs), how to measure it in the areas they manage, and how to use this information to design effective and resilient networks of MPAs. Without the science to explore this properly, estimates of connectivity between reefs will continue to be based on flawed concepts of surface currents, passive transport, and dispersal potential for one or two species. The result will be a continuation of the trial and error approach to management—a costly approach given what is at stake for coral reefs and those who depend on them.*

*To help managers ask the right questions of scientists and to sharpen the focus of the TR on management issues of local importance as well as global interest, the Centers of Excellence will need to play a strong role in bridging these two communities. The COEs can facilitate a combination of adaptive management*

and applied science by maintaining a dialogue between local managers and scientists in the region who are engaged in the TR. Similarly, creating opportunities for periodic consultation and outreach to local communities and incorporation of traditional knowledge in the process of addressing unknowns will be a responsibility of the COEs. They will be represented on the Capacity Building Sub-Committee along with other members of the Steering Committee, to help strengthen the linkages between science and management and ensure that local benefits are generated from the research undertaken. In a recent site visit to one of the proposed Centers of Excellence, the local representative immediately recognized the value of this approach. Upon learning of the plans for this proposal, he stated: “We need to stop shouting at one another based on emotion and rhetoric. We need answers from helpful, adaptive, science”. NGO collaborators in the TR, such as TNC and their affiliates, also have a strategic role to play in ensuring that the research findings are interpreted for various stakeholders and channelled effectively to these groups. Through their “Toolkit for MPA Managers” which aims to include measures to assess coral bleaching and guidance on how to minimize MPA vulnerability, and to enhance recovery from these and other disturbance events (including pollution, disease and blast fishing) the TR Project will have a ready conduit for the uptake of relevant findings from the various working groups as they emerge.

**7. Management implications/outcomes are weak in all the working groups and need to be strengthened.**

*(Please see technical annexes, as well as a separate file on project website: <http://www.gefcoral.org> that discusses management implications.)* Linkages to other working groups are weak, including data/information and methodology transfer. Further information has to be presented to really demonstrate the mechanism for the transfer of the information to the managers and its subsequent use.

*See discussion of CoE’s role in information dissemination to managers; see Brief section E.4.1 and section D.5 regarding policy dialogue between Bank and Clients).*

Section D, project rationale, does not mention the underlying causes. The management options should surely have to consider these before any “new” management strategies are put into place.

*Please see the response to point 6 above. Examples of more specific management outcomes include the following (in this case, from the Connectivity Working Group):*

- a. *Development of novel chemical methods for tracing sources of larval fish*
- b. *Development of novel genetic methods for tracing sources of larval fish and corals*
- c. *Use of data on recruitment variation in a novel way to test the realism and precision of models of dispersal of fish and lobster*
- d. *Use these novel approaches to provide estimates of connectivity in Mesoamerica for a) one breeding population of Nassau grouper, b) one or two representative reef fish species, c) one or two species of coral, and d) spiny lobster.*
- e. *Application of these same methods (modified as necessary depending on discoveries in Mesoamerica) to fish populations in the Philippines and coral and fish populations in Palau. (Thus capturing instances of connectivity in a continental Caribbean, a continental Pacific, and a mid-Pacific location.)*
- f. *Educating graduate students in each region in the course of carrying out the research.*
- g. *Engaging the management and NGO communities as participants in the research, as a deliberate way to enhance understanding of the problem, and its importance for management.*
- h. *Development, through a series of workshops, a clear appreciation in each local region of how the data obtained can be used to make better management decisions than would otherwise be possible.*

**8. We encourage the project to incorporate the active involvement of local communities from the**

**beginning.** The approach taken at each of the sites appears to be very top down. We have seen little or no mention of the local communities that do manage and rely on many of the coral reefs of the world. In some cases, we hope that they have people who have already been doing work on the ground as otherwise it is going to be very hard for the scientists and managers to walk in and do the work (e.g. in Papua New Guinea). Therefore, an initial stakeholder analysis would help in identifying and engaging the local communities.

*The STAP review raises a valid point and one the Project Team has been giving more thought to as the role of the COEs as interlocutors with local stakeholders and as centers for outreach and capacity building has become better defined. The centers in Puerto Morelos, Bolinao, Zanzibar and The Great Barrier Reef will not only serve as regional resource centers, but as focal points for engagement of the local community in research that will have an impact on their livelihoods and security. Rapid ecological appraisal promoted by NGOs such as TNC and partners for use by local communities, could provide a modus operandi as well for local community involvement in some aspects of the research. This would also be an opportunity for researchers to solicit local and traditional knowledge to help frame research questions in ways that are more meaningful to local groups. Thus, the findings could also be more readily interpreted and disseminated.*

*A workshop in Mexico being planned for early in Year by the Connectivity WG will bring together individuals from management agencies already committed to the Synoptic Monitoring Program (SMP) designed to monitor the health of the Mesoamerican Barrier Reef, under the MBRS project, to teach them how to monitor recruitment of fish, corals and lobster, and encourage the inclusion of these measurements within their SMP activities, while also teaching them how recruitment information is needed for study of connectivity, and how it can be used to inform management actions. This may be the first of an on-going dialogue with the management community that will build their capacity, while assisting in the data collection required for aspects of the connectivity project. This and other vehicles for active participation of local communities and managers will be explored during the early stages of project implementation. (See Brief Section E.4.1)*

**9. We are concerned about the participation of developing country scientists and the funds that will be allocated to them.** It would be helpful to indicate what is the ratio of experts from developing countries participating in the research, and what is the proportion of funds being allocated to developing countries.

*From the outset it has been a fundamental principle of the TR Project that support for developing country participation in the project would be a high priority. Working Groups agreed that support for students and post-docs would be **earmarked for individuals from the regions** in which they would be working, (i.e. Mesoamerica, Eastern Africa, South East Asia and Melanesia), not from developed countries, and that, wherever possible, these students would be **enrolled in institutions in the region**, even if they were seconded to developed country labs for portions of their education. The fact that Working Group membership is skewed toward developed country representation is a simple reflection of the current skills distribution in the areas of investigation targeted by the project (see complete list of Working Group members on project website: <http://www.gefcoral.org>). In spite of this and the limitations imposed by the budget on the total number of members in each group, the Working Group Chairs have done an excellent job of having developing country scientists represented within their groups. The current percentage of developing country scientists involved in the WGs are as follows:*

<i>Bleaching and Local Ecological Responses WG:</i>	<i>30%</i>
<i>Connectivity and Large-scale Ecological Processes WG:</i>	<i>20%</i>
<i>Disease WG:</i>	<i>37%</i>

<i>Restoration and Remediation WG:</i>	27%
<i>Remote Sensing WG:</i>	25%
<i>Modelling and Decision Support WG:</i>	43%

*We fully expect to see these percentages increase as the project moves forward. As a case in point, with respect to the Connectivity Working Group, faculty from CINVESTAV-Merida, and at ECOSUR-Chetumal (Mexico) will be added to participation in the research, as well as additional faculty from the node at UNAM.*

**10. There appears to be a lack of post-intervention follow-up** and needs to be stated clearly. In terms of GEF global environment impacts, it is important to identify follow-up strategies. It seems to be missing entirely in the documentation. Further clarification is needed on what entities would follow up after the interventions? How would the follow-up occur?

*The TR project is being designed as a 15 year program, thus follow up after the initial five year phase is being anticipated in a second and third phase. This will depend on the achievement of outputs and progress against performance indicators in the initial phase. GEF funds would represent a substantially smaller percentage of the overall project cost, as new partners are recruited and the research infrastructure (human and physical) becomes mainstreamed into institutions supported by the TR. (See sections on sustainability and replication in the Executive Summary and in Section F of the Project Brief).*

**11. Some of the assumptions being made need clarification and testing**, (e.g. disease and the interaction with water quality is too simplified and generalised) and the appropriate Working Groups need to add that this will be tested. We feel that the project should point out the challenges and also the assumptions that apply to the replicability and transferability of the results.

*The Working Groups are keenly aware of the assumptions involved in this adaptive research model, and of the associated problems and trade-offs. The tables that accompany each of the technical annexes have attempted to organize the information for each of the priority hypotheses so that the latter could be evaluated along with the assumptions, and then ranked for each Working Group. The Scientific Committee would review these with the help of the Synthesis Committee to determine which ones should be approved and how they should be ranked in order of importance. Replicability of investigations (and their inherent assumptions) is dependent upon their place within the investigative hierarchy and whether the results should be interpreted (i.e. molecular or physiological responses to stress) globally or in a more local context, if they prove to vary considerably over space (e.g. different ecological responses of populations in different regions). Communications between the Working Groups and their chairs, and the Synthesis Panel's oversight and synthesis of the findings will help determine the transferability of the results.*

**12. The summary of the proposed work by some of the Working Groups (see below) is excellent, but some others need to be strengthened both in terms of the methodology and perhaps the experts involved.** In particular we would like to highlight our concerns about Modelling and Decision Support Working Group and within that "Field validation". Field validation is a critical aspect and needs to be considered in more detail than in the cursory manner presented here with (both within the main project proposal and in the Technical Annex 1). There is no indication as to how field validation will be undertaken, and no consideration of temporal and spatial scales etc.

*We accept this comment, and are working to see that methods and approaches are standardized and coordinated between working groups. As a case in point, an upcoming joint meeting in the Philippines in*

*October--as part of the on-going Block B phase--will examine the issue of recruitment on coral reefs, and the ways and means in which working groups can coordinate their methods--to ensure that consideration is being given to variation in temporal and spatial scales, that common assumptions are carefully examined, and that there will be cooperation to help validate proposed models. As for additional experts, we feel confident that the Working Group chairs have carefully considered the caliber of researchers involved. However, we welcome any suggestions of the STAP to forward to the Chairs for consideration.*

More specific comments on the Working Groups

Our comments are based on the Annexes in the main document but we have also checked in the six Scientific Annexes provided. The quality of the documentations in these annexes seems to vary considerably. Again a strong scientific leadership for the whole project could help overcome this.

*We believe that this leadership exists within the capability of the Synthesis Panel membership, and this will also be addressed in considering the role of the coordinators within the Project Executing Agency.*

Some comments across the working groups are:

a) Scaling issues: Some of the information (e.g. IPCC scenarios) are available mostly at the global level, and yet the coral abundance, reef biodiversity etc is a t local and at best regional level. How would these be incorporated into the models?

*Reconciling the variations in scale between organisms, communities, their habitats and ecosystems is a fundamental challenge that is a foundation of this targeted research. These are questions that have been explored in the literature since the mid-1990s, and are being examined as part of this project. One such approach looks to rule-based modelling that explores differences in scales as a consequence of the agents that run independently and then interact within the system ( <http://www.ncoremiami.org/WaterModel.htm> ). While the appropriate modelling approaches are being considered, the working groups have prioritized many of the investigations with differences of scale in mind. This is clear within technical annex #1, where the working group has prioritized its investigations to deal with the molecular mechanisms of coral reef bleaching as the pre-requisite to ecological studies that will examine its cause and effect under various forms of stress.*

b) Some of the modelling work mentioned in various work in the appendix is hard to do on land let alone an “open” system as that of coral reefs. We are not convinced that enough thought has been given to this critical section in all the working groups.

*Comment noted. There is value in each of the working groups developing need-specific models in conducting (or evaluating) targeted research within a given working group’s activities that may or may not contribute to the larger issue of decision support and field validation for a larger expert system. This is somewhat of a separate issue from the design and development of a larger decision support tool. In addition to any MDS tool developed by the MDSWG, the Synthesis Panel will have a role in decision support for the overall project. However, we accept the comment that discussion of specific modelling within each of the working groups, and their relationships and inputs to a decision support model can be clarified within the project Brief (see Brief section E.3).*

c) Only \$3.0 million are allocated to "linking scientific knowledge to management", the same amount that is allocated to project administration. If the former is an important goal of the project, is this level of funding proportionately adequate? Perhaps the team might wish to revisit this funding allocation.

*We appreciate the need to allocate resources in a way that is consistent with our assessment of the importance of the various components. While \$11 Million in GEF (\$20 Million overall) may seem like a lot to allocate to Targeted Research, the scope of this effort is quite large relative to the available*

*resource envelope. Because of the Project's complexity, Project administration and management will be crucial to ensuring that technical components are well executed. The challenge will be to increase the envelope for these technical elements, through additional co-financing, not to reduce the overall allocation for administration. The bulk of project administrative costs will be covered through co-financing.*

**Specific comments on each of the working groups proposed work:**

1. Bleaching Working Group: has some weaknesses. Some parts of the summary of the proposed work are excellent, however, other portions of the summary are less thorough, and give the impression that little or no work has been done in the three activities listed in the first paragraph. We can only assume that since some of the processes involved, eg. changes in physiology to individuals reef systems, globe, are long-term that data needed on this would be somehow (through individuals and institutions involved?) be incorporated in the project.

*This comment appears to be restricted to the summary presented within the Draft Brief, as opposed to the more detailed presentation within the technical annex for this working group, which is much more comprehensive in the description of priorities and work programs. The above comments will be taken into consideration during final approval of the document; however, it should be noted that the Working Group has made significant progress in prioritising the relevant hypotheses for each of the three activities, although it cannot be expected that these would all be addressed in comprehensive detail in the pilot work during the Block B phase. This Working Group has made significant progress in understanding the physiology to date, but as stated in the response in a), above, it has prioritized its investigations to deal with the molecular mechanisms of coral reef bleaching first, as the pre-requisite to ecological studies that will examine its cause and effect under various forms of stress as the project gets underway.*

2. Diseases Working Group: overall good.

3. Connectivity – various issues need to be improved, such as:

*The connectivity work in Mesoamerica has had a healthy head-start due to prior research there by a significant percentage of working group members (Sale, Cowen, Steneck and Butler, and the inclusion of experts like Thorrold, Planes and Jones). Some parts of the research are straightforward and will work; others are more risky. For example, the studies of coral larval dispersal may hit difficulties not yet foreseen. The modelling goal using fish recruitment and lobster recruitment as data to test the accuracy of dispersal models should work, and if we can build good dispersal models, these can then derive connectivity estimates. Otolith chemistry will either be superb or disappointing, but if the latter, we will know that investing in it is not warranted. The same goes for assignment tests using genetic data. The proposal is structured on the understanding that there will be mid-course corrections, as is the case in any research project worth funding. The track-records of the working group members as leaders within their fields should instil more confidence than is apparent by the STAP comments.*

a. It is not clear as to what techniques will have to be developed and which ones will be further expanded.

*There is considerable technique development in: otolith chemistry - finding ways to label otoliths and, perhaps, using otolith cores as signals of natal locations, coral genetics – finding markers that show relationships in time and space, coral ecology – developing immunogenetic probes to identify planula larvae, physical oceanography – using neutral density beads to mimic dispersing eggs or planulae. Most of the work, however, uses known methodology in novel ways or in novel combinations, such as a) the suite of activities planned at a spawning aggregation to yield data on larval dispersal and subsequent locations of the aggregated adults, b) using otolith cores as signals for natal locations for fish recruiting*

*across a region, c) using genetic assignment tests to assign larval fish or coral recruits to specific source populations, d) using data on recruitment patterns of fish or lobster as a way of testing the accuracy/realism of models of dispersal (much modelling seems to be done without any effort to see if the model is realistic, and dispersal is a complicated process). In many instances it is the particular combination of approaches, frequently from different disciplines, that is novel, and potentially able to actually measure connectivity.*

b. How long would it take to do develop the tools to identify and monitor stress and would these techniques be easily and quickly transferable to the other regions?

*Connectivity is an intrinsic property of open ecological systems. It occurs in the presence and in the absence of stresses on those systems (it may or may not be modified by the stress). We need to learn how to measure it, because knowledge of connectivity is essential if we are to manage these systems in any spatially-explicit way – such as through creation of networks of no-take zones.*

c. Is any of the information transferable to other regions and coral reefs with different history, biodiversity and set of stresses?

*Yes, all of it. But with the usual caveat: one measurement yields one result – it gives us a clue about scale, but we won't appreciate the variance within that scale of response until more results are obtained. If we discover that larval Nassau grouper from the Glovers Reef spawning aggregation site, spawned in February 2006 end up on reefs stretching from Turneffe to northern Belize, and on Chinchorro, Cozumel, and Key West, that tells us a lot about dispersal of that species that year in that site. We will not even know if that was an exceptional year (or an exceptional site), but we will know a lot more about it than we do now. At present we know a) that a proportion (small or large – not really sure) of one small damselfish, spawned at Lizard Island, settled to sites at Lizard Island one year (retained on scale of 5km), and that larvae of one small wrasse recruiting to sites on St. Croix USVI were 'predominantly' produced on that island rather than elsewhere in the Caribbean (retained on scale of 20-50km).*

d. Are the researchers concentrating on “keystone species” so they may obtain a good understanding of the critical processes?

*No. Reasons for species selection vary: Nassau grouper – typical of aggregating spawners, has functioning site near research facility at Glover's Reef, there is on-going research on this population, it is a charismatic species, and Belize has recently protected all spawning aggregation sites. Therefore, this is a good opportunity to give them data about how one site functions. Bicolor damselfish – typical non-aggregating spawner, easily recognized so field collections can be done by local stakeholders, common and widely distributed. Spiny lobster – economically most valuable fishery species in Caribbean, has very long larval life relative to fish being used, or to corals. Montastrea –largest reef-building genus within the Caribbean; existing genetic and juvenile work in progress, widely distributed, abundant. We are focusing heavily on fish because the chance of success seems greater with them (more effort has already been expended to measure fish connectivity than is case for other reef species), and because they are economically important (to both fisheries and tourism).*

e. Is there a logic for choosing to concentrate on lobsters, groupers and snappers?

*See above.*

4. Restoration Working Group: well presented summary of the intended work, although again it would have been useful to say if pilot or other work suggests that the experimental work being suggested can be done over the spatio-temporal scale of the project.

5. Remote sensing Working Group: this seems to promise a great deal and we are not sure if it can deliver. Some of the techniques are a challenge in land-based systems and we are not convinced that these

can be done in the coral reef systems. Further information on how the project team plans to address this would be useful.

*The reviewers' point out that some of the objectives for this WG are challenging and difficult to accomplish on land. They request clarification but do not specify which issues they consider to be particularly difficult. Therefore, this response focuses on those generic remote sensing questions which are applicable to terrestrial systems.*

*1. Firstly, it is important to point out that the RSWG has met on four occasions and has rigorously reviewed the feasibility of all projects under consideration. Some of these were considered too challenging given the immaturity of the science and limited resources available. These issues will be revisited before the second phase of the study.*

*2. One of the reasons the RSWG is able to propose a great deal of research activity is that the RSWG have acquired considerable co-funding (note that NOAA is a significant co-funder of our effort as per STAP comment #5 above).*

*3. Spectral unmixing: The process of spectral unmixing is challenging in any environment and especially so through an aquatic medium. There are two key problems:*

*a) Determining the depth of the overlying water column without field data. The RSWG have already solved this problem using mathematics and optimisation routines (Hedley & Mumby 2003). Essentially, if the spectral imagery has more spectral bands than there are substratum classes on the seabed, then a series of simultaneous equations can be solved to estimate depth. Specifically, the method inserts a potential depth value and determines whether the equations are compatible after Gaussian elimination. The process is repeated with varying depth estimates until equations become compatible, giving the correct estimate of depth. The required inputs are (i) the diffuse attenuation coefficient of each spectral band and (ii) the end member spectra of individual substratum types or a combination thereof. Both can be determined from the imagery with minimal field work (approx. one day of ground survey).*

*b) Applying a linear unmixing method. Once the influence of depth is removed by adjusting reflectance values to uniform depth (e.g. the surface), an unmixing algorithm must be applied. Most methods make the simplifying assumption that spectra mix in a linear relationship to the composition of substrata in the pixel. The RSWG undertook pilot work during the Block B phase and tested whether a linear unmixing method will represent coral and algal mixtures. Experiments were carried out at Heron Island (Australia) and Palau. Our results show that linear mixture models are a fair representation of coral/algal mixes with accuracies upward of 70% (considered high for such analyses in terrestrial systems). The paper is accepted for publication in the journal Coral Reefs (Hedley et al. 2003). The RSWG aims to improve on these accuracies by developing non-linear mixture models, better able to deal with the irregular shapes of corals. To do this, the WG members are developing a new form of radiative transfer modelling that uses radiosity methods. Radiosity methods were developed by the computer graphics industry to give stunningly realistic representations of sunlight in animations (e.g. the movie, "Shrek"). The RSWG is developing these methods further to resolve how light interacts with corals and algae. The net outcome of this research is that managers will be able to monitor the health (coral and algal cover) of their reefs using airborne remote sensing and future satellite sensors which will have an adequate number of spectral bands. This provides greater spatial representation of the state of reefs and releases staff from the extremely time-consuming process of monitoring reefs in situ.*

*4. The detection of change in reef systems*

*Change detection is a major area of remote sensing research both in terrestrial and aquatic systems. The RSWG believe that we are making significant progress in developing promising new methods and most*

*importantly, converting the expression of remote sensing science into that used by coral reef managers. This latter objective is vital if managers are to make greater use of remote sensing (and in so doing, undertake management more cost-effectively). For example, the standard presentation of accuracy for a habitat map involves confusion matrices. However, managers are concerned with achieving a certain statistical power in detecting say a 10% change in coral cover over the course of a year using Analysis of Variance. We are bridging this gulf in statistical methods by undertaking ANOVA power-analysis with remotely sensed data (e.g. Mumby et al. 2001).*

*Many of the methods the RSWG is developing for change detection rely on changes in the texture and local autocorrelation in reflectance. These methods have already been developed (LeDrew et al. 2000) and there is compelling evidence that the texture varies between many reef habitats (Mumby & Edwards 2002). To investigate these questions further, the RSWG are using an innovative approach in which several images are acquired in rapid succession (e.g. 2 months). Atmospheric conditions differ amongst images just as they would if using a longer time series. However, if the RSWG makes the reasonable assumption that the status of reefs has not changed between images, then texture of individual reef habitats can be compared from image to image. Indeed, with the field surveys planned at each study site, the RSWG will be able to determine how depth, water turbidity, and biogeographic regions influence the separability of reef habitats by each method.*

#### *References:*

- Hedley JD, Mumby PJ, Joyce KE, Phinn SR (2003) Spectral unmixing of coral reef benthos under ideal conditions. Coral Reefs (in press)*
- Hedley JD, Mumby PJ (2003) Spectral unmixing and the resolution of depth from remotely sensed data of aquatic systems. Limnology & Oceanography 48: 480-488*
- LeDrew E, Wulder M, Holden H (2000) Change detection of satellite imagery for reconnaissance of stressed tropical corals. IGARSS 2000, Hawaii CD-ROM, IEEE International Geoscience and Remote Sensing Society.*
- Mumby PJ, Edwards AJ (2002) Mapping marine environments with IKONOS imagery: enhanced spatial resolution does deliver greater thematic accuracy. Remote Sensing of Environment 82: 248-257*
- Mumby PJ, Chisholm JRM, Hedley JH, Clark CD, Jaubert J (2001) A bird's-eye view of the health of coral reefs. Nature 413 (6852): 36-36*

6. Modelling and Decision support Working Group: this is the weakest WG in terms of the information presented. We are not sure if there is sufficient data available to develop an expert system. What are some of the challenges and can they be overcome? How will field validation be done? This is not trivial and should be clarified (see point 13 above). 12 major sets of models are being proposed and it is not clear how they will be integrated; there will be challenges in terms of information available and their spatio-temporal scales and yet this does not come across in the summary presented. We are not convinced that the research will lead to definite management implications

*Comments noted, and will be taken into consideration.*

*The concern about whether or not our work will improve management also indicates that we have not gotten a simple point across: A well-built GIS of a reef and adjacent land almost always improves management decision-making. Where it does not, it is usually because it was built and then never used effectively by managers and policy-makers, or there is a failure in political will. Any good GIS of such a system combined with appropriate documentation also establishes a detailed case history of trials, successes and failures in managing a coral reef. There is no more useful guidance for improving coral reef management globally than providing access to well understood case histories. This is the reason we*

*are using such an approach in working with the initially limited number of sites within the four regions (and Centers of Excellence), and in coordinating the work of the various working groups. The aim of the MDS is to build good, easily-used GIS systems, and then to carefully add to their capabilities by augmenting them with other decision support capabilities (including simulation), filtered via validation. As long as we are improving GIS for reef management purposes, then we are extremely likely to be improving reef management.*

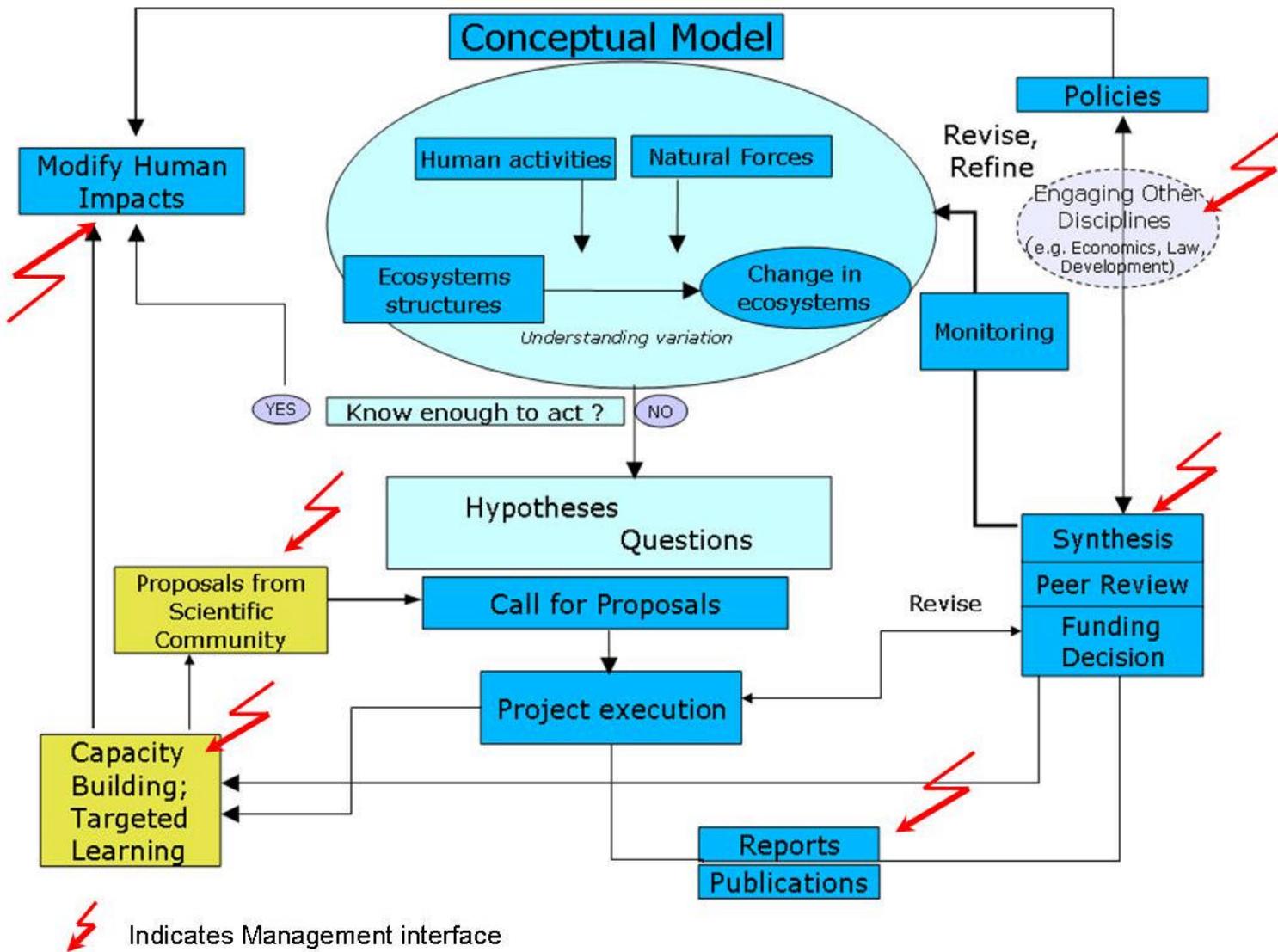
Some minor points on the main project proposal

- Section B, page 2 onwards. It would be worth mentioning climate variability as well as climate change is being considered; is “unprecedented” bleaching and not “unprecedented mortality” on page 3. The section does need to mention the temporal aspects and the potential time lags that might be of relevance to the coral reef systems  
*Comments noted.*
- Would the TR really lead to a “new generation of trained scientists” (page 20) in 5 years?  
*The team believes that the case has been clearly made within the Brief that this is not the intent. A “new generation of trained scientists” is intended to take place over the life of the three phases (15 years) of the project.*

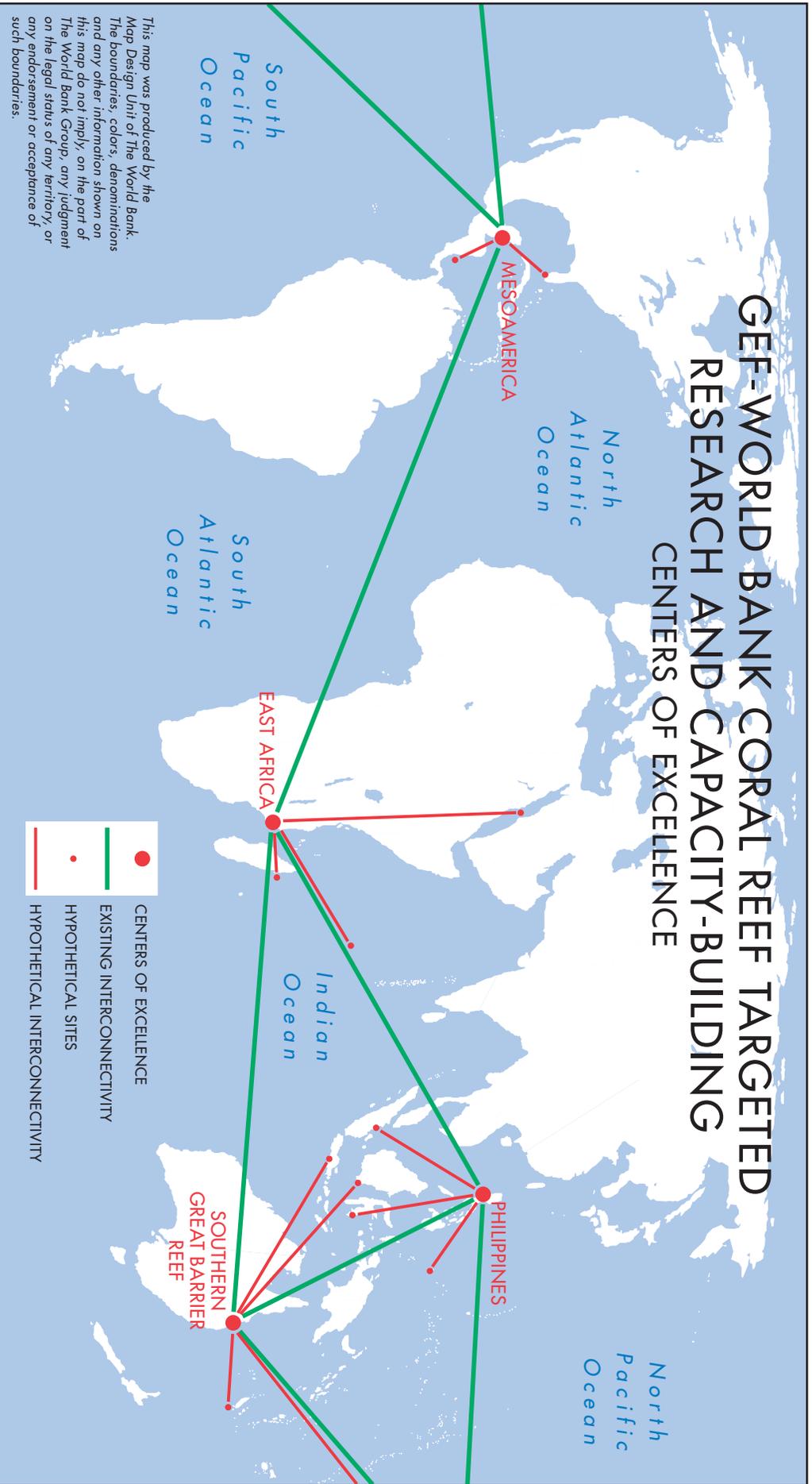
**Annex 13: Hardwiring Links between Science and Management:  
Activities Matrix and Project Conceptual Model  
WORLD: Coral Reef Targeted Research and Capacity Building for Management**

Matrix of Activities: Hardwiring Links between Science and Management

	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>
Working Groups	Managers represented within WGs/ongoing dialogue with end user reference group  Outreach to local communities and managers during training workshops  Prototype of Model for Decision Support Tool designed with management/ decision-maker community	Managers represented within WGs/ongoing dialogue with end-user reference group  Outreach to local communities and managers via training workshops (e.g. in use of new info and tools to enhance coral reef monitoring through e.g., GCRMN and ReefCheck)	Managers represented within WGs/ongoing dialogue with end user reference group  Outreach to local communities and managers during training workshops (e.g., dissemination of new diagnostic and spatial planning tools as they come on line)	Managers represented within WGs/ongoing dialogue with end user reference group  Outreach to local communities and managers during training workshops	Managers represented within WGs/ongoing dialogue with end user reference group  Outreach to local communities and managers during training workshops  Prototype DS model for at least 2 COEs up and running
Synthesis Panel (includes coral reef managers)	Annual Meetings including dedicated session with Managers/Policy-makers  Peer Review of annual work-programs by peer review panel, which includes managers  Production & dissemination of State-of-Knowledge reports for each WG, including Primer on Restoration and Remediation of Damaged Reefs and Remote Sensing Applications for Coral Reef management to serve as Baselines.	Annual Meetings including dedicated session with Managers/Policy-makers (\$75K)  Peer Review	Multi-disciplinary symposium hosted at the Bank with NAS, NGOs, and specialists in public policy, law economics, and social development (\$40K + additional co-financing from partners )  Peer Review	Annual Meetings including dedicated session with Managers/Policy-makers (\$75K)  Peer Review	Major all-project symposium at the end of Phase I, to include all GEF coral reef and related LME projects.  Peer Review  Production of Policy Briefs based on WG Findings for dissemination to managers and policy-makers
Centers of Excellence	Outreach activities to engage local managers/decision-makers (\$10K each year)	Regional Workshop for Decision-Makers (\$75K per COE) Outreach activities to local managers/decision-makers (\$10K each year)	Outreach activities to engage local managers/decision-makers (\$10K each year)	Outreach activities to engage local managers/decision-makers (\$10K each year)	Regional Workshop for Decision-Makers (\$75K per COE)
Other  Links to ongoing programs like GCRMN and Reef Check	Feeding scientific results to MPA Knowledge Networks (established by TNC, WWF, WCS & CI) throughout Project Life.	Presentation on science-based management at the International Tropical Marine Ecosystems Management Symposium (ITMEMS3)	Linking scientific results to coral reef Targeted Learning Component of GEF IW:LEARN Project (\$175K) for coral reef managers	Session for Managers and Policy Makers at the 11th International Coral Reef Symposium (Ft. Lauderdale, FL)	



# GEF-WORLD BANK CORAL REEF TARGETED RESEARCH AND CAPACITY-BUILDING CENTERS OF EXCELLENCE



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# GEF-WORLD BANK CORAL REEF TARGETED RESEARCH AND CAPACITY-BUILDING CARIBBEAN REGION

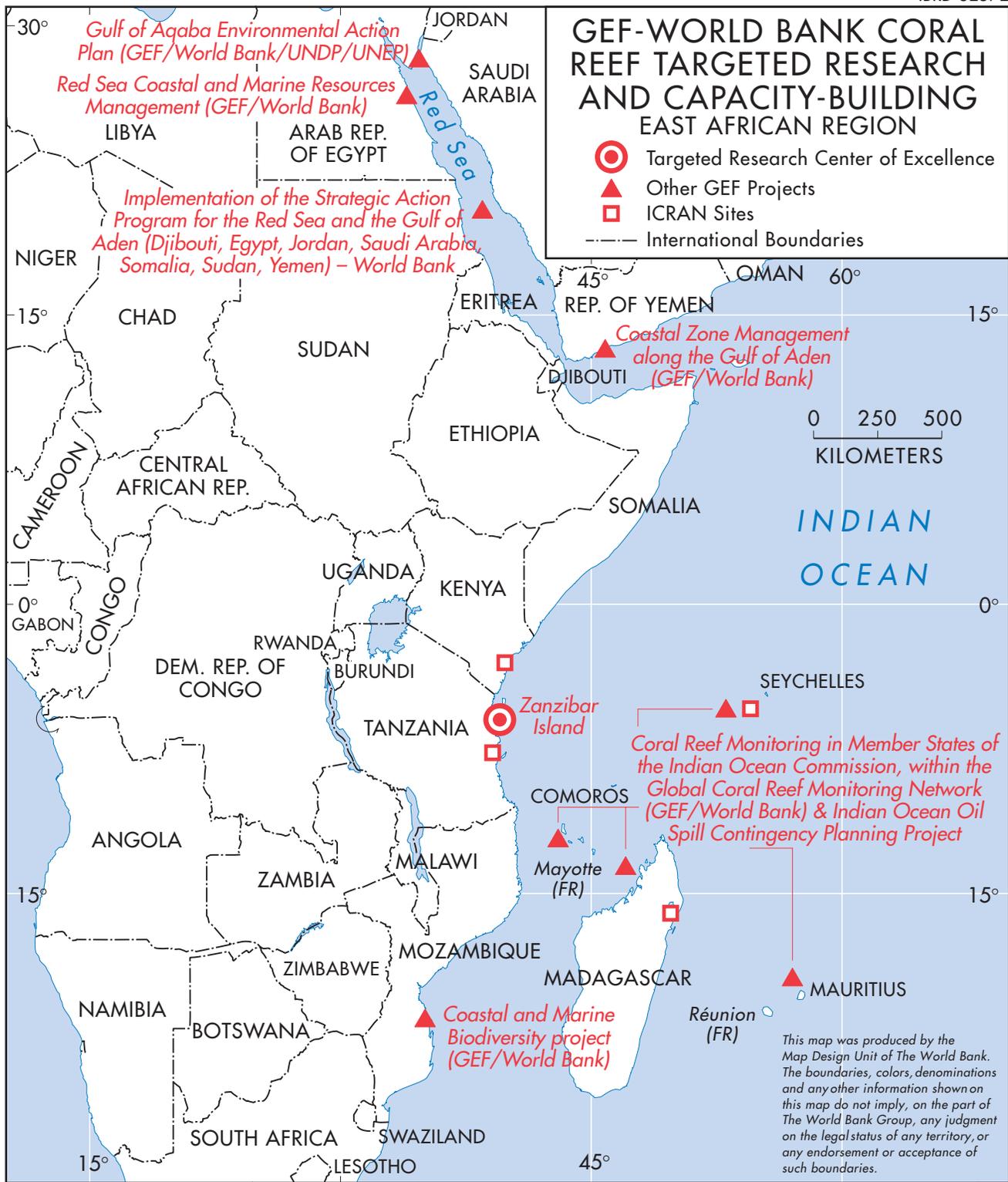
- ⊙ Targeted Research Center of Excellence
- Mesoamerican Barrier Reef (MBRS)
- ✕ UNDP Site
- ▲ Other GEF Projects
- ICRAN Sites
- International Boundaries

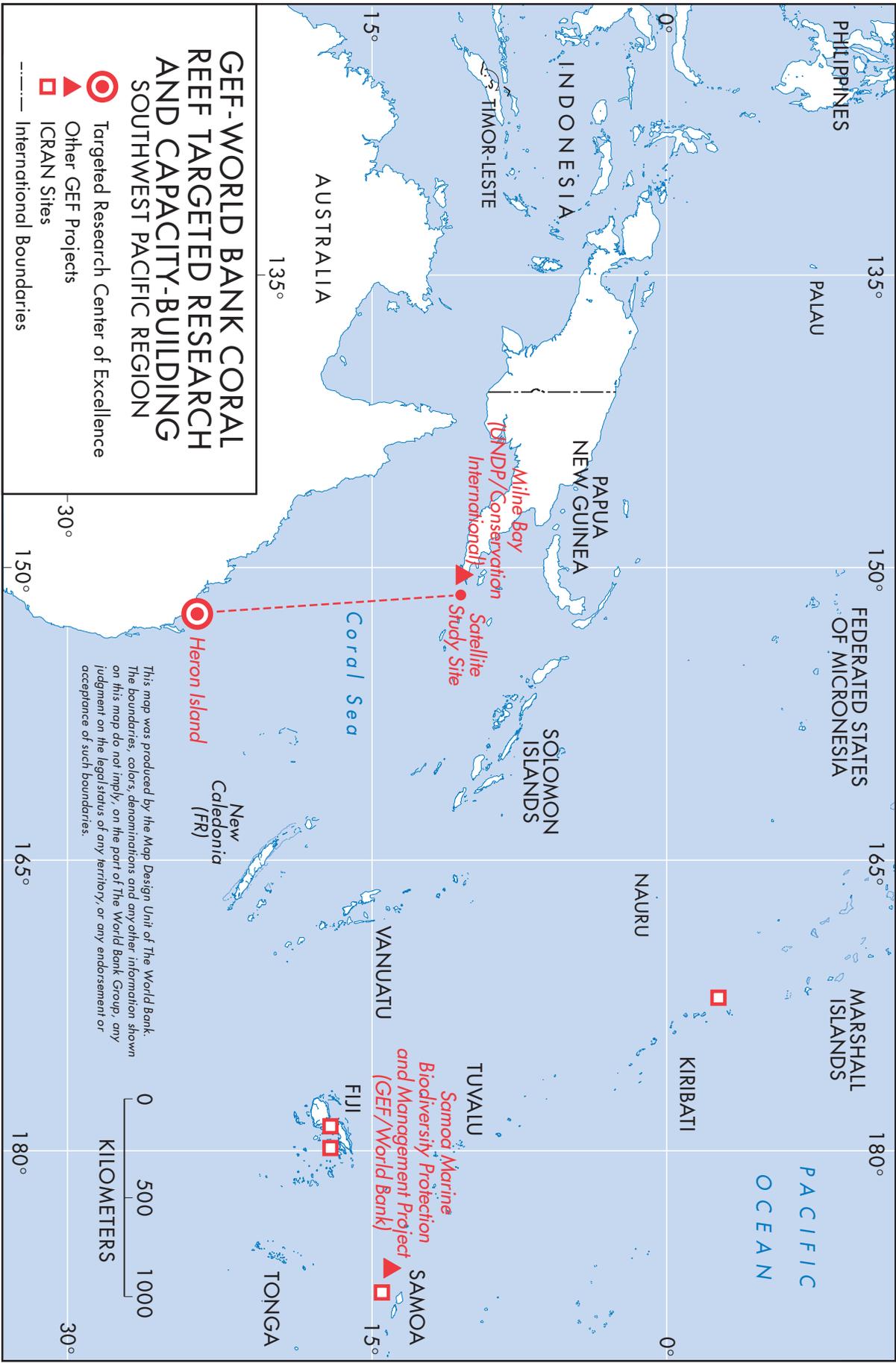


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