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THE CORAL REEF TARGETED RESEARCH AND CAPACITY-BUILDING FOR MANAGEMENT PROGRAMME AND ITS RELEVANCE TO THE CONVENTION ON BIOLOGICAL DIVERSITY

Note by the Executive Secretary

I. INTRODUCTION

1. Reaching the 2010 target as it relates to marine and coastal ecosystems requires urgent and cooperative efforts by a number of actors, including international organizations and initiatives, regional organizations, local governments, research facilities and non-governmental organizations. The research community has an important role to play, not only in monitoring progress towards the 2010 target, but also in addressing the remaining knowledge gaps that will enable us to better manage marine and coastal resources. As stated in section II of annex I to decision VII/5, research efforts oriented towards the information needs of management ensure that management decisions are based on the best available science in the context of the precautionary approach.

2. The present document introduces the Coral Reef Targeted Research and Capacity-Building for Management Programme. This new initiative addresses scientific information gaps relating to the health and resilience of coral-reef ecosystems worldwide, and will thus strengthen the scientific base and practical capacity for management and policy-making, with the aim to reach the target of reducing the rate of biodiversity loss in coral reef ecosystems by the year 2010. The initiative is supported by the Global Environment Facility (GEF), the World Bank, the University of Queensland, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United States National Oceanic and Atmospheric Administration (NOAA), and research institutions in Mexico, the Philippines and the United Republic of Tanzania. The initiative implements a number of the components of the work plan on coral bleaching (decision VII/5, annex I, appendix 1), in particular those related to management actions in support of reef resilience, rehabilitation and recovery; information gathering; and capacity-building. It also seeks to implement the

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assessment, management and capacity-building components of the work plan on physical degradation and destruction of coral reefs (decision VII/5, annex I, appendix 2).

3. As the results of this initiative become available in the coming years, they will be reported on in more detail, with a focus on their relevance to the 2010 target, and the related subtargets that will be adopted by the Conference of the Parties at its eighth meeting in the context of the programmes of work on marine and coastal biological diversity and island biological diversity.

II. TARGETED RESEARCH AND CAPACITY-BUILDING

4. The Coral Reef Targeted Research and Capacity-Building for Management Programme (TR Programme) has been established to address fundamental information gaps in our understanding of coral reef ecosystems, so that management options and policy interventions can be strengthened globally.

5. Although opinions abound as to the causes of coral reef degradation, the cumulative and interactive effects of different kinds of stress on coral reefs and the implications for long-term sustainability of these ecosystems are simply unknown. While managers struggle to maintain a balance between use and conservation in deciding among complex trade-offs, we do not know enough about the fundamental factors affecting coral reefs in many areas to make practical management decisions. We are also not adequately equipped with the understanding and the tools needed to manage and plan for changes brought about by the transformation of these ecosystems—especially over the past thirty years.

6. For the first time, the collective efforts of many of the world's leading coral-reef scientists will be coordinated to address outstanding questions about the health and resilience of coral reefs. The Programme aims to: (i) address key gaps in knowledge and technology required for ecosystem-based management of coral reefs; (ii) promote learning and capacity-building in countries where coral reefs are found; and (iii) effectively link science to management and policy. The Programme will be implemented in phases over 15 years. It will focus initially in four coral-reef regions of the world—Mesoamerica, South-east Asia, Eastern Africa and Australasia—establishing and strengthening Centres of Excellence for science based management in these regions.

7. To address key knowledge gaps, the Programme will support targeted investigations carried out by scientific working groups comprised of developed and developing country researchers. The working groups will be coordinated around six key themes:

(a) Coral bleaching and local ecological responses;

(b) Connectivity and large-scale ecological processes;

(c) Coral diseases;

(d) Coral restoration and remediation;

(e) Remote-sensing;

(f) Modelling and decision support.

8. A synthesis panel of scientists and other professionals will be responsible for the overall quality and direction of the research. They will ensure that the research is responsive to management, is integrated across themes and regions, and that the results are linked to other disciplines, such as economics, sociology and law to inform policies and governance arrangements at the local, national and regional scales.

9. The research objectives of the six working groups is described briefly below. For more information, the reader is directed to http://www.gefcoral.org.

A. Bleaching and local ecological responses

10. Corals bleach in response to a range of environmental stress -from localized, anthropogenic stress (like declining water quality, sediment and nutrient run-off, changes in salinity and pH) to climate-change-related stress. While it is known that corals bleach when sea surface temperatures exceed their thermal tolerance levels, the mechanism is poorly understood. Understanding the physiology of bleaching in corals and the differential tolerance of algal symbionts to heat and other forms of stress may explain why some corals bleach more readily than others. It may also shed light on questions of adaptation and whether corals may develop resistance to environmental change through changes in the relative proportion of strains of heat- (and other stress) tolerant zooxanthellae that colonize them. Unravelling these relationships is essential to understanding current changes in patterns of coral diversity and reef-community structure and to predicting changes that will occur in the future, under various scenarios of global change. The goal is to help reef managers: refine early-warning systems for bleaching; stimulate development of bio-indicators of different kinds of stress; and refine projections of future change on coral reefs and the implications to society.

B. Connectivity and large-scale ecological processes

11. Coral reefs are patchily distributed in the oceans and connected by currents that move in complex and variable ways, particularly in coastal waters and in atoll chains. These currents transport the coastal sediment and pollutant run-off, nutrients, and, especially, the pelagic larvae of most reef species. Connectivity measures the flux of these items between locations. Coral-reef managers must understand how nutrients, sediments, pollutants, and larvae arrive at and leave their coral reef areas. Most of the transfer of non-living materials is determined by local and regional hydrodynamics. The transfer of organisms is more complex since there are two components: the passive transport by currents; and additional movements due to the sensory and behavioral responses of the larvae. The most important component of the transfer of larvae is ensuring that they are upstream of the breeding populations.

12. Knowledge of connectivity patterns among coral reef organisms is essential to carrying out site-based management of these and associated ecosystems, and to improving the design and implementation of networks of marine protected areas. Most marine protected area design and implementation uses “educated guesses” to select the appropriate size and location, but there is little information to determine whether these guesses are correct. Pressures on reefs will continue to increase with growing coastal populations, and more direct exploitation of reef resources. Therefore, it is increasingly important that marine protected areas be designed using well determined patterns of connectivity between target populations. Explicit data on demographic connectivity are essential to develop models of recovery rates from broad-scale disturbances such as massive bleaching events, severe hurricanes, outbreaks of disease or chronic over-fishing. Thus, the Connectivity Working Group will assess the source of larvae, the transport and dispersal patterns, and finally the successful recruitment processes into the receiving population.

C. Coral diseases

13. There has been an unprecedented increase in coral disease over the last 20 years, which has contributed significantly to major coral losses. Disease outbreaks cause not only coral loss, but also cause significant changes in community structure, species diversity and abundance of reef organisms. While diseased-related damage of coral reefs has been well documented in the Caribbean, the status of disease throughout the Indo-Pacific is largely unknown. Preliminary surveys in Australia, the Philippines, and East Africa reveal significant and damaging new diseases in all locations surveyed. Current research indicates that there is a connection between climate warming and increased incidence of disease, and that disease outbreaks are threshold phenomena associated with warming environments in many ecosystems. Coral reefs appear to be among the most susceptible due to a very narrow thermal threshold for coral health. The coral bleaching during the 1997/98 El Niño was the most massive and devastating ever recorded, and it is probable that much of the mortality was due to opportunistic pathogens, which accelerated the death of bleached corals.

14. It is probable that deteriorating environmental conditions influence disease by altering host pathogen interactions. For example, warmer waters could affect basic biological and physiological properties of coral, and change the balance between opportunistic pathogens and the natural ability in corals to fight them. Other stresses include nutrient loading, which could enhance pathogen growth, and sedimentation, which could decrease coral resistance.

15. Little is known about the organisms that cause disease in corals. Of the 18 or so disease symptoms described, the infectious agent is known for only five, and reservoirs have only been identified for only black band disease and aspergillosis. Exploring even basic questions is hampered by: (i) the global nature of the problem; (ii) an overall lack of resources; and (iii) a lack of expertise and technology in developing countries. In response, the Coral Disease Working Group will: (i) identify major coral diseases; (ii) assess the impact of coral disease on coral reef biodiversity and community structure, (iii) explore prevalence of disease in stressed environments and the role of chronic stress in the incidence of disease; (iv) assess the range of known coral pathogens; and (v) evaluate effectiveness of various antimicrobial agents in controlling the spread of disease.

D. Coral restoration and remediation

16. Recent degradation of coral reefs has stimulated greater attention to remediation and restoration mechanisms for reefs that have been damaged, especially through human pressures. The early initiatives focused more on creating artificial reefs, or more accurately, "fish-aggregating devices" in areas without existing coral structures to enhance fisheries production or promote dive tourism. While these initiatives are still being expanded, more recent attention has been directed towards restoring degraded coral reefs through a wide range of remediation and restoration mechanisms. These include habitat modification, coral transplantation, species re-introduction, and recruitment potential enhancement. Some interventions involve large-scale structures designed to facilitate natural colonization of reef species, while others use simpler and cheaper approaches. Reef remediation and restoration will continue to have a more important role in reef recovery in the future, but the technologies are still being developed, and not ready to implement at large spatial scales.

17. The underlying principle of the Restoration and Remediation Working Group is that removing the source of stress is the first priority toward restoration. However, if large areas of reefs have been degraded and natural recovery is not predicted in the short-term, it may be essential to enhance recovery through artificial means. The Group is examining the efficacy and cost effectiveness of restoration and remediation techniques, including the following:

(a) The scientific protocols necessary to design and implement restoration strategies;

(b) Baseline data for developing effective criteria;

(c) The efficacy and feasibility of restoration and remediation techniques;

(d) Prospects for enhancing natural recovery; and

(e) Opportunities to combine reef remediation with small and micro-enterprise at the local level.

E. Remote sensing

18. Most remote sensing of coral reefs has been conducted on an ad-hoc basis with little consistency or recognition of the limitations for wide-scale application. For example, some aspects of coral reef health can be resolved on shallow reefs in French Polynesia, but it is not known whether this can be applied in Jamaica, for instance, where the reefs have different organisms, are in deeper water, and where there is higher suspended sediment in the water column. Without an assessment of the limitation of coral-reef remote-sensing, the technology may be oversold or deployed for unrealistic management objectives, resulting in an inappropriate use of financial resources.

19. The Remote-Sensing Working Group will measure the limitations of coral reef remote sensing by combining modelling and field experiments. Models will predict the ability of a remote sensing

instrument to detect the slight differences in bottom reflectance that distinguish the cover of corals from macro-algae. The challenge is to combine knowledge of the physics of light passing through the water, with the interaction of light between complex mixtures of reef organisms. The methods developed in the computer graphic industry are used to divide coral structures into thousands of individual patches, each of which has a particular reflecting surface. Sunlight is reflected and scattered in predictable directions on the reef and it is possible to calculate the signal recorded by the sensor of the net light that reflected back through the water and atmosphere. Computer models will be refined and tested in the laboratory and the field conditions in a large-scale remote sensing experiment.

20. The group will provide tools to identify various coral reef habitats and possibly predict the cover of corals and algae on a reef, using high resolution imagery and direct field surveys. There is a wealth of satellite and photographic data for reefs, with some from World War II. The group will try to improve methods for detecting changes in reef condition indirectly using remote sensing, to assist managers to quantify the rate of change in coral reef habitats over large spatial scales at different time intervals.

21. Recent remote-sensing research has improved the detail of reef maps, but the interpretation of these maps for management and assessing biodiversity has received relatively little attention. The Targeted Research project will improve taxonomic capacity within the Centres of Excellence to allow scientists to prepare habitat maps for priority areas in the region and to provide technical assistance to the other scientific working groups. The Remote-Sensing Working Group will compile many oceanographic and atmospheric remote sensing products in an International Oceanographic Atlas and make them available for coral reef and coastal management within a single website.

F. Modelling and decision support

22. The Modelling and Decision Support Working Group aims to create an integrated model of the human-based coral reef ecosystem at each site. The group will assist decision makers and local reef users understand the dynamics of the whole system—both the biophysical and the socio-economic component—of which they are a part. The task is multi-disciplinary, multi-scaled and highly spatial. It deals with the complexity of biophysical coral reef system drivers together with the equally complex human socio-economic aspects. The research is within the new discipline of complex systems science that started in the 1980s and is an area of active research in analytical and modelling techniques. There are many institutes, major government research initiatives and university centers and consortia around the world promoting this approach; some will be involved in this component. Not all the effort is directed at sustainability issues, but some also will attempt to break down stress-response relationships to identify cause and effect of coral reef decline.

23. Complex systems are rarely predictable, and modelling them will require constructing a series of clusters of sub-models to help understand dynamics between sub-components of the system, which can serve as building blocks in the construction of the whole. Clusters of models are particularly effective when several disciplines are involved, or when the questions posed are evolving. In some traditional 'unified' model domains, such as oceanography or meteorology, where the range of disciplines is restricted and the questions clear, clustering is becoming the strategy of choice.

24. This exploration can become an integral part of the policy development process in an ongoing iteration between scientists and decision makers. Using visualization techniques involving maps and other spatially explicit media will help engage different classes of users and help them to understand the tradeoffs of different coral reef use options. Through modelling, it is possible for decision makers not only to see the consequences of their policies, but to identify synergies across sectors which can reinforce sustainable outcomes for coral reefs. Faced with alternative scenarios, coral reef managers are in a better position to optimize environmental, social or economic objectives and to select the most cost-effective interventions to mitigate unwanted impacts.
