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MARINE AND COASTAL BIOLOGICAL DIVERSITY: PROGRESS REPORT ON THE IMPLEMENTATION OF THE PROGRAMME OF WORK, INCLUDING THE INTEGRATION OF CORAL REEFS

Note by the Executive Secretary

Executive summary

The present note has been prepared by the Executive Secretary to report on substantive issues within the programme of work on marine and coastal biological diversity for consideration of the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), in particular the integration of coral reefs into the programme of work as enabled by decision V/3. This concerns two sub issues: (i) coral bleaching, and (ii) physical degradation and destruction of coral reefs.

In response to decision V/3, paragraph 4, on coral bleaching, an operational objective 2.3 has been developed, and a specific work plan containing a number of activities for its implementation has been elaborated, on the basis of the priority areas for action, adopted by the Conference of the Parties at its fifth meeting (decision V/3, annex), taking into account the ongoing initiatives of other relevant organizations.

In response to decision V/3, paragraph 8, on physical degradation and destruction of coral reefs, the present note contains information on the effects of physical degradation and destruction of coral reefs and the significant threat they pose to the biological diversity associated with coral reef ecosystems. It also contains proposed draft elements of a work plan to control human-induced causes of physical degradation and destruction of coral reefs for the consideration of SBSTTA.

Suggested recommendations

SBSTTA may wish to:

(a) Endorse the following text as operational objective 2.3, for the integration of coral reefs into programme element 2 of the programme of work on marine and coastal biological diversity:

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Operational objective 2.3. : To gather and assimilate information on, build capacity to mitigate the effects of, and to promote policy development and implementation strategies to address the impacts of coral bleaching and related mortality on coral-reef ecosystems and the human communities which depend upon coral reef services, including through financial and technical assistance.

(b) Invite the Executive Secretary to promote and implement the specific work plan on coral bleaching, as contained in annex I to the present note, to be implemented in close collaboration with the International Coral Reef Initiative and its partners;

(c) Welcome the continued collaboration between the Secretariat of the Convention on Biological Diversity and regional seas programmes of the United Nations Environment Programme (UNEP), and endorse the efforts of the Executive Secretary to develop joint work plans with these Programmes, particularly in relation to coral reefs and operational objective 2.3 of the programme of work on marine and coastal biological diversity;

(d) Take note of the analysis of the effects of the physical degradation and destruction of coral reefs as contained in annex II to the present note;

(e) Develop elements, drawing upon the suggestions in annex III to the present note, for the integration of the issue of the physical degradation and destruction of coral reefs into programme element 2 of the programme of work on marine and coastal biological diversity.

CONTENTS

I. INTRODUCTION

1. At its fifth meeting, the Conference of the Parties to the Convention on Biological Diversity in its decision V/3, made a number of requests to both the Executive Secretary and SBSTTA. Following a recommendation of the meeting of the SBSTTA Bureau on 25 September 2000, SBSTTA at its sixth meeting will address only the substantive issues related to coral reefs, particularly coral bleaching and the physical degradation and destruction of coral reefs. Other issues arising from decision V/3 will be addressed after the seventh meeting of SBSTTA, at its eighth or ninth meeting. The present note provides a progress report on the integration of coral reefs into the programme of work, while a more detailed report of progress in the implementation of the programme of work on matters other than coral reefs is provided in the information document UNEP/SBSTTA/6/INF/1.

II. INTEGRATION OF CORAL REEFS INTO THE PROGRAMME OF WORK ON MARINE AND COASTAL BIOLOGICAL DIVERSITY

2. At its fifth meeting, the Conference of the Parties, in decision V/3, decided to integrate coral reefs into programme element 2 of the programme of work (paragraph 3), and noted that the work element was enabled at the fifth meeting and would have a minimum three-year time schedule (paragraph 1).

3. In paragraph 4 of the same decision, the Conference of the Parties requested the Executive Secretary to integrate fully the issue of coral bleaching into the programme of work and to develop and implement a specific work plan on coral bleaching, taking into account the recommendations set out in the annex to the decision.

4. The Executive Secretary convened a liaison group meeting on coral reefs between 24 and 29 October 2000, in conjunction with the 9th International Coral Reef Symposium and the meeting of the Coordinating and Planning Committee of the International Coral Reef Initiative, to assist him in the development of a specific work plan on coral bleaching. Participants in the meeting represented the following organizations: the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC/UNESCO), the Secretariat of the International Coral Reef Initiative (ICRI), the Convention on Wetlands, the United Nations Foundation, the International Center for Living Aquatic Resources Management (ReefBase), IUCN-The World Conservation Union, the National Center for Caribbean Coral Reef Research, the National Marine Fisheries Service of the United States National Oceanographic and Atmospheric Administration (NOAA), the United States Environmental Protection Agency, the Centre for International Environmental Law, and four regional seas conventions or action plans. Further contributions to the work plan were sought from the Secretariat of the United Nations Framework Convention on Climate Change, the Intergovernmental Panel on Climate Change, the Food and Agricultural Organization of the United Nations, the Global International Waters Initiative, the Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the participants in the ICRI Coordinating and Planning Committee.

5. The specific work plan on coral bleaching, contained in annex I below, was developed on the basis of the priority areas for action on coral bleaching, endorsed by the Conference of the Parties and annexed to its decision V/3, and took into consideration ongoing activities of relevant bodies, including in particular the activities of the International Coral Reef Initiative (ICRI) and its partners. A list of such ongoing activities is provided, and additional specific tasks identified are inserted under each of the priority activities.

6. In paragraph 8 of decision V/3, the Conference of the Parties agreed that physical degradation and destruction of coral reefs also pose a significant threat to the biological diversity of coral-reef ecosystems, and therefore, decided to expand its request to SBSTTA to make an analysis of this threat and to provide relevant information to the Conference of the Parties. The Executive Secretary used the holding of the liaison group meeting on coral reefs to prepare a description of various aspects of this threat, its impacts on biological diversity and to identify potential response measures to control the threat and mitigate its impacts. This description is presented in annex II to the present note. Additionally, to assist SBSTTA in the development of elements for a work plan on the physical degradation and destruction of coral reefs, the Executive Secretary has prepared draft elements contained in annex III below.

Annex I

SPECIFIC WORK PLAN ON CORAL BLEACHING

Objective (i.e., operational objective 2.3 of the programme of work on the biological diversity of marine and coastal ecosystems): To gather and assimilate information on, build capacity to mitigate the effects of, and to promote policy development and implementation strategies to address the impacts of coral bleaching and related mortality on coral-reef ecosystems and the human communities which depend upon coral reef services, including through financial and technical assistance.

Activities

1. Information gathering

(a) Implement and coordinate targeted research programmes, including predictive modelling, that investigate: (1) the tolerance limits and adaptation capacity of coral-reef species to acute and chronic increases in sea-surface temperature; (2) the relationship among large-scale coral-bleaching events, global warming, and the more localized threats that already place reefs at risk; and (3) the frequency and extent of coral-bleaching and related mortality events, as well as their impacts on ecological, social and economic systems.

Ongoing initiatives

(i) The "Ad Hoc Study Group on Indicators of Coral Bleaching and Subsequent Effects" was established September 2000 under the auspices of IOC/UNESCO with three major objectives: to develop possible molecular, cellular, physiological, and community indicators of coral bleaching that are reliable in their ability to detect early stress signals; examine potential mechanisms of reef corals for adaptation/acclimatization to global environmental change; investigate long-term response of reef corals to large scale changes in environmental variables. The group will meet annually for three years and distribute findings through annual reports and a final publication.

(ii) The Global Coral Reef Monitoring Network (GCRMN) is a global network of coral reef scientists, Governments and local communities for monitoring and assessment of coral reefs, in terms of both biophysical and socio-economic parameters needed for management. GCRMN is co-hosted by the Australian Institute of Marine Science and the World Fish Center (ICLARM). ICLARM also host ReefBase, the official database of GCRMN, with data of over 8,000 coral reefs over the world. UNEP, together with IOC/UNESCO, is a sponsor of the GCRMN and a member of the GCRMN Management Group and the GCRMN Scientific and Technical Advisory Committee.

(iii) GCRMN has developed a comprehensive *Status of Coral Reefs of the World* report to be updated every two years, with the most recent edition published in October 2000.

(iv) UNEP, through GCRMN, emphasizes the importance of monitoring socio-economic parameters to achieve sustainable use of coral reef ecosystems. A socio-economic manual has recently been developed (October 2000) for monitoring of these parameters for enhanced management capacity.

(v) Contributing to GCRMN are existing regional projects. Regional coral reef monitoring networks within GCRMN exist for the Indian Ocean and the Wider Caribbean funded by World Bank, with the goal of assisting in the conservation of the rich biodiversity of coral reefs and their socio-economic value, and in the sustainable management of their resources, through a monitoring network.

(vi) Under the International Coral Reef Action Network (ICRAN), the World Conservation Monitoring Centre (WCMC) and ICLARM are exploring the integration and availability of map-based products through the WCMC website and through ReefBase.

(vii) Some projects within the CORDIO programme in the Indian Ocean region focus on determining the socio-economic impacts of coral mortality and options for mitigating these through management and development of alternative livelihoods.

Specific tasks in addition to ongoing initiatives

(i) Provide scientific information on the survival of reef-building corals under global warming to allow some prediction of the adaptation and survival of the biological diversity of coral reefs in coming decades;

(ii) Compile information on existing networks, databases and websites which can provide up-to-date information of the status of coral reefs and their threats; and assess the quality of the data they contain and methodologies used for data collection and analysis;

(iii) Strengthen networks for data collection and dissemination of information on coral-reef status and interpretation of long-term trends resulting from global climate change and anthropogenic stresses to assist effective management and conservation;

(iv) Develop further target research programmes that investigate the impacts of coral bleaching and coral mortality events on social and economic systems;

(v) See activity (k) (i) below.

(b) Implement and coordinate baseline assessments and long-term monitoring to measure the biological and meteorological variables relevant to coral bleaching, mortality and recovery, as well as the socio-economic parameters associated with coral-reef services.

Ongoing initiatives

(i) The objectives of the Ad Hoc Study Group on Indicators of Coral Bleaching and Subsequent Effects under activity (a) above include the identification of biological indicators that would facilitate long-term monitoring.

(ii) GCRMN currently serves as a network for coral reef assessments and monitoring of biological variable relevant to coral bleaching, mortality and recovery, as well as many socio-economic parameters associated with coral-reef services (see activity (a)).

(iii) Data repository and dissemination systems such as ReefBase may offer time-line biological data.

(iv) GCRMN, in coordination with the World Bank, IUCN, the Australian Institute of Marine Science and UNEP regional seas programmes is targeting existing or planned marine protected areas as the focus of some of their monitoring activities. The sites may offer valuable baseline data and serve for long-term monitoring.

(v) GCRMN is currently developing rapid assessment methodology for socio-economic and biophysical parameters in the Eastern African region, especially for use in developing countries where limited resources do not always allow for regular high-intensive monitoring.

(vi) The UNEP Division of Environmental Information, Assessment and Early Warning coordinates a variety of information available from remote sensing technologies and organizations that facilitates dissemination of such information. They are well suited to coordinate assessment of meteorological variables relevant to coral bleaching, mortality and recovery.

(vii) WCMC and ICLARM are exploring the integration and availability of map-based products through the WCMC website and through ReefBase.

Specific tasks in addition to ongoing initiatives

(i) Identify pilot projects that establish training programmes and survey protocols and enhance availability of expert advice at a range of scales, including classification of scale data.

(ii) Support ongoing assessment and monitoring initiatives, such as those of UNESCO, ICRAN, the regional seas conventions and action plans, GCRMN, UNEP and CORDIO.

(c) Develop a rapid response capability to document coral bleaching and mortality in developing countries and remote areas including establishment of training programmes, survey protocols, expert advice, and contingency fund or rapid release of special project funding.

Ongoing initiatives

(i) The objectives of the Ad Hoc Study Group on Indicators of Coral Bleaching and Subsequent Effects referred to under activity (a) above include the identification of physiological early-stress indicators in corals.

(ii) The Sida-SAREC and World Bank programme on coral-reef degradation in the Indian Ocean, was initiated as a response to the 1998 coral-bleaching event (CORDIO).

(iii) GCRMN is currently developing rapid assessment methodology for socio-economic and biophysical parameters in the Eastern African region, especially for use in developing countries where limited resources do not always allow for regular high-intensive monitoring (ReefCheck).

(iv) Within the ICRAN strategic plan, it is intended that these capabilities will be developed and made widely available.

(v) The UNEP Division of Environmental Information, Assessment and Early Warning coordinates a variety of information available from remote sensing technologies and organizations that facilitates dissemination of such information.

Specific tasks in addition to ongoing initiatives

(i) Develop standardized training modules and manuals on detection and documentation of coral-bleaching events, mortality or recovery monitoring

(ii) Organize annual meetings in each region on coral-reef assessment and monitoring methods with particular emphasis on documenting coral bleaching, bleaching related mortality and subsequent recovery. These should be integrated into existing programmes, where possible (regional seas conventions and actions plans may have the best capacity to implement these measures).

(d) Encourage and support countries in the development and dissemination of status-of-the-reefs reports and case-studies on the occurrence and impacts of coral bleaching and related mortality.

Ongoing initiatives

(i) GCRMN has developed a comprehensive *Status of Coral Reefs of the World* report to be updated every two years, with the most recent edition published in October 2000. This report is largely based of national and regional contributions.

(ii) The Secretariat of the Convention on Biological Diversity, in accordance with decision V/3, paragraph 7, invited Parties to submit case-studies for dissemination through the clearing-house mechanism. The national reporting mechanism of the Convention on Biological Diversity facilitates the collection of information on the status of coral reefs and case-studies on the occurrence and impacts of coral bleaching.

(iii) The CORDIO Status Report 2000 offers reporting opportunities on the status of the reefs for Indian Ocean countries. The dissemination of this information through the CORDIO newsletter has facilitated further communication and coordination on local impacts.

Specific tasks in addition to ongoing initiatives

(i) Support and expand existing networks and initiatives at the regional and national level conducting coral-reef status assessments and monitoring.

(ii) Strengthen dissemination of existing assessment and monitoring information on status of coral reefs and their threats through existing networks (Under the ICRAN strategic plan, this is a core role of GCRMN and ReefBase).

(e) Extend the use of early-warning systems for coral bleaching by:

(i) Enhancing current NOAA AVHRR Hot Spot mapping by increasing resolution in targeted areas and carry out ground-truth validation exercises;

(ii) Encouraging space agencies and private entities to maintain deployment of relevant sensors and to initiate design and deployment of specialized technology for shallow-oceans monitoring;

(iii) Making the products of remote sensing readily accessible at low cost to coral-reef scientists and managers worldwide with a view to those scientists and managers that are based in developing countries.

Ongoing initiatives

(i) The UNEP Division of Environmental Information, Assessment and Early Warning coordinates a variety of information available from remote sensing technologies and organizations that facilitates dissemination of such information.

(ii) Under the ICRAN, WCMC and ICLARM are exploring the integration and availability of map-based products through the WCMC website and through ReefBase that include satellite and aerial imagery.

Specific tasks in addition to ongoing initiatives

(i) Expand the use of existing early warning systems (e.g. NOAA early warning mapping) and support the development of Web-based early warning systems.

(ii) Develop local community capacity for remote and local level validation exercises.

(iii) Develop mechanisms to make accessible high-resolution multi-spectrum imagery worldwide.

2. Capacity-building

(f) Support the training of and career opportunities for marine taxonomists, ecologists, and members of other relevant disciplines, particularly at the national and regional level.

Ongoing initiatives

(i) Various ongoing training activities not necessarily related to coral bleaching but to coral conservation issues, e.g. the Ramsar Wetlands for the Future training initiative for Latin America and the Caribbean; the regional seas programme for Caribbean protected areas managers; various activities supported by aid agencies and global and regional development banks.

(ii) Many other training activities are carried out as components of wider projects and programmes. GCRMN is building capacity for coral-reef monitoring and assessments through training workshops, especially in developing countries.

Specific tasks in addition to ongoing initiatives

(i) Further incorporate or support the issue of coral reefs and bleaching in the capacity building activities of multilateral environmental agreements (e.g. Ramsar Convention, Cartagena Convention) and of their respective contracting parties.

(ii) Develop standardized training modules and manuals on detection and documentation of coral-bleaching events and subsequent recovery.

(iii) Organize annual meetings in each region on coral-reef assessment and monitoring methods with particular emphasis on documenting coral bleaching, bleaching related

mortality and subsequent recovery. These should be integrated into existing programmes, where possible.

(iv) Create scholarship trust funds in each region of the regional seas programmes to provide scholarships at graduate/postgraduate level to at least two people per region to undertake studies on coral-reef ecology and management.

(v) Promote exchange programmes between countries and/or regions.

(vi) Promote further coordination and collaboration of ongoing regional activities.

(vii) Promote the inclusion in national reports under the regional seas conventions, the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change a section for reporting of ecological and socio-economic impacts of coral-bleaching events.

(viii) Add coral bleaching to the national biodiversity strategies and action plans under the Convention on Biological Diversity.

(g) Encourage and support multidisciplinary approaches to coral-reef research, monitoring, socio-economics and management.

Ongoing initiatives

(i) ICRI and GCRMN activities are intended to encourage and support multidisciplinary approaches to coral reef research, monitoring, socio-economics and management.

(ii) Regional seas programmes through the ICRAN strategic plan and existing programmes like CORDIO, and the UNEP Caribbean Environment Programme are increasing regional capacity towards monitoring, socio-economics and management, as related to coral bleaching. The four regions currently active under the ICRAN strategic plans are South—East Asia, Pacific, Caribbean and Eastern Africa.

Specific tasks in addition to ongoing initiatives

(i) Develop a formal network of agencies in developed and developing countries, which agree to an annual exchange of staff in areas relevant to coral-reef management.

(ii) Gather and assimilate information on existing training programmes on integrated coastal area management, best practices and related issues to sustainable management of coral reefs.

(iii) Develop and/or expand training opportunities for fishers, protected area managers and related marine resource managers at the national and regional levels, on resource assessment, monitoring, user impact, ecosystem approaches to marine and coastal resource management, surveillance and enforcement, local community integration, and in setting and measuring the achievement of management performance goals and indicators.

(iv) See activity (k) (ii) below.

(h) Build stakeholder partnerships, community participation programmes, and public-education campaigns and information products that address the causes and consequences of coral bleaching.

Ongoing initiatives

(i) ICRI and the International Tropical Marine Ecosystems Management Symposium (ITMEMS) are building the foundation of new ICRI action.

(ii) A number of existing education and capacity-building projects within the regional seas programmes serve to raise awareness regarding coral bleaching.

(iii) IUCN, the Secretariat of the Convention on Biological Diversity, USAID and WWF have produced a publication *Management of Bleached and Severely Damaged Coral Reefs*, to contribute to effective and immediate management action to aid reef protection and

regeneration, and to enhance research to develop the necessary tools and measures for long-term success. In addition, the publication is intended to raise awareness of the urgent need to take all possible actions to reduce the impact of climate change on coral reefs.

(iv) The WWF approach to worldwide coral reef conservation (CoralWeb): training of resource managers, increasing education, raising awareness, and implementing site-based reef management projects to help groups of stakeholders achieve their goals in reef management and sustainable economic development, including through the development of alternatives to destructive practices.

(v) The International Coral Reef Information Network (ICRIN) is the primary public awareness mechanism of the ICRI, and thus serves to disseminate public information products that address the causes and consequences of coral bleaching.

Specific tasks in addition to ongoing initiatives

(i) "Bridge the gap between global and local action through the creation of national and sub-regional coral-reef initiatives" (see ICRI and the International Tropical Marine Ecosystems Management Symposium on Building the Foundation of New ICRI Action).

(ii) Package relevant information from status-of-reefs reports, *Reefs at Risk*, etc., into effective practical materials for general public, the media, private sector and policy makers

3. Policy development / implementation

(i) Use existing policy frameworks to implement the multiple conservation measures outlined in the Renewed Call to Action of the International Coral Reef Initiative, and develop and implement comprehensive local-to-national-scale integrated marine and coastal area management plans that supplement marine protected areas.

Ongoing initiatives

As an example, relevant regional activities within the Wider Caribbean are carried out, *inter alia*, in the framework of:

- The Cartagena Convention and its protocols on oil spills, land-based sources of marine pollution and specially protected areas and wildlife
- Regional ICRI Framework for Action
- Association of Caribbean States (ACS)
- Central American Commission on Environment and Development (CCAD)
- CARICOM

Specific tasks in addition to ongoing initiatives

(i) Assess relevant actions of existing frameworks and how these are directly addressing the integrated marine and coastal areas management, in particular coral-reef issues.

(ii) Integrate in existing policies at the regional and national levels the priority issues identified by ICRI and the International Tropical Marine Ecosystems Management Symposium (ITMEMS).

(iii) Make use of the regional seas programmes and other regional agreement (i.e. shipping, fisheries, trade and land-based sources of marine pollution) as vehicles to develop and implement policies related to coral-reef management and protection.

(j) Identify and institute additional and alternative measures for securing the livelihoods of people who directly depend on coral-reef services.

Ongoing initiatives

Some projects within the CORDIO programme in the Indian Ocean region focus on determining the socio-economic impacts of coral mortality and options for mitigating these through management and development of alternative livelihoods. Development is needed of further target research projects that investigate the impacts of coral bleaching and mortality events on social and economic systems in other regions.

Specific tasks in addition to ongoing initiatives

(i) Compile information on the socio-economic impacts of coral bleaching on communities dependent on coral reefs.

(ii) Support and expand existing projects that assess the impacts of coral bleaching on communities dependent on coral reefs, such as the CORDIO project in the Indian Ocean.

(iii) Develop pilot projects for transitioning dependent communities to alternative and sustainable livelihoods.

(k) Initiate efforts to develop joint actions among the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the Convention on Wetlands to:

(i) Develop approaches for assessing the vulnerability of coral-reef species to global warming;

(ii) Build capacity for predicting and monitoring the impacts of coral bleaching and related mortality;

(iii) Identify approaches for developing response measures to coral bleaching;

(iv) Provide guidance to financial institutions, including the Global Environment Facility (GEF), to support such activities.

Ongoing initiatives

(i) The Executive Secretary has transmitted the view to the United Nations Framework Convention on Climate Change (UNFCCC) that there is significant evidence that climate change is a primary cause of the recent and severe extensive coral bleaching, and that this evidence is sufficient to warrant remedial measures being taken in line with the precautionary approach. In this regard, the Secretariat of the Convention on Biological Diversity, the Secretariat of the UNFCCC, and the Intergovernmental Panel on Climate Change (IPCC) have initiated dialogue to explore the integration of biological diversity concerns into the implementation of the UNFCCC and its Kyoto Protocol.

(ii) GEF Caribbean project on climate change adaptation (CPACC project).

Specific tasks in addition to ongoing initiatives

(i) Promote and implement joint work plans with other relevant agreements, organizations and initiatives, including the Commission on Sustainable Development, FAO, regional seas conventions and action plans, regional trade and economic organizations, the Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities, ICRI and the Man and Biosphere Programme. In particular, assess and coordinate activities that have been agreed within multilateral environmental agreements about coral reefs.

(ii) Gather the outputs of the Caribbean GEF project on climate change adaptation (CPACC project) as a contribution to activities (k) (i)-(iv) above, and disseminate relevant findings through the clearing-house mechanism and other mechanisms.

(iii) Further development of response measures to coral bleaching and potential guidance to financial institutions, including the GEF may be needed.

(l) Encourage FAO and regional fisheries organizations to develop and implement measures to assess and mitigate the impacts of sea-surface temperature rise on fisheries.

Specific tasks

(i) Investigate potentially deleterious effects of changes in oceanographic patterns and resulting impacts on target fish stocks resulting from sea-surface temperature rise.

(ii) Establish no-fishing zones and limitation on fishing gear to protect breeding grounds and provide fish with a refuge.

(iii) Enforce legislation prohibiting destructive fishing practices that further damage coral-reef ecosystems.

(iv) Investigate strategies for management of coral-reef fisheries that are demonstrably sustainable with respect to fished stocks and the ecosystems that produce them (in collaboration with FAO).

(m) Emphasize that coral bleaching can be monitored as an early warning of the impacts of global warming on marine ecosystems and that the collapse of coral-reef ecosystems could impact ecological processes of the larger marine system of which coral reefs are a part.

Specific tasks

(i) Recognizing that coral bleaching is a cumulative stress response (i.e. global warming is the most widespread stressor, but known human induced stresses exacerbate events), develop education programmes addressing an ecosystem approach to coral-reef management and the relation between ecological parameters of coral reefs, sea-surface temperature rise and other human-induced stresses.

(ii) Investigate the relationship between coral-bleaching events and long-term meteorological data.

(iii) Develop educational programmes on the relationship between coral reefs and larger marine systems (e.g. impacts of coral-reef loss on fisheries, local communities etc).

(n) Emphasize the interdependencies and uncertainties in the relationships among marine, terrestrial, and climatic systems.

4. Financing

(o) Mobilize international programmes and mechanisms for financial and technical development assistance, as well as national and private sources to support implementation.

Specific tasks

(i) Promote programmes that identify the relationships among financial and technical development assistance and environmental project funding.

(ii) Identify financial and technical assistance mechanisms of national and private sources to assistance communities impacted by coral bleaching.

Ways and means: Activities under this operational objective will be implemented primarily at the national and regional levels under the guidance of the Executive Secretary and SBSTTA, and in collaboration with relevant organizations and agencies, recognizing the value of the capacity established through ICRI and its operational units.

Timing of expected outputs: 2000 onwards (minimum three-year time schedule)

Annex II

PHYSICAL DEGRADATION AND DESTRUCTION OF CORAL REEFS

INTRODUCTION

1. In its decision V/3, the Conference of the Parties to the Convention on Biological Diversity decided to integrate coral reefs into programme of work on marine and coastal biological diversity and requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to carry out an analysis of the effects of physical degradation and destruction of coral reefs with a view to providing relevant information and advice to the Conference of the Parties. The present note has been prepared by the Executive Secretary to assist SBSTTA in its analysis.

2. Section I of the present note describes the current status and trends of coral-reef ecosystems at the global and regional levels, while Section II describes the proximate and underlying causes of physical degradation and destruction of coral reefs, including some elements of the socio-economic consequences of their loss. Section III discusses some of the current response measures taken to control, mitigate and prevent the physical degradation and destruction of coral reefs. Some draft elements of a work plan under the programme of work on marine and coastal biological diversity for future action within the Convention process are set out in annex III below.

I. STATUS AND TRENDS OF CORAL REEFS

3. Coral reef ecosystems exhibit both high levels of biological diversity and significant productivity; therefore, they are both of ecological importance to the Parties of the Convention on Biological Diversity and of socio-economic importance to human populations for the goods and services they provide. Indeed, the southern Asia region has both the largest area of coral reefs in the world with the richest biological diversity, while the coral reefs are under the greatest threats from human activities (Wilkinson, 2000). In terms of socio-economic importance, one recent estimate is that coral reefs provide human populations with living resources and services (such as tourism returns and coastal protection) worth about US $375 billion each year (Constanza *et al*., 1997).

4. By 1992, 10% of the world's reefs were lost, and 30% were in a critical state. The global 1998 *Reefs at Risk* analysis from the World Resources Institute suggested that 27% of the world's existing reefs were under immediate threat of significant damage and a further 31% under a medium level of risk (Bryant *et al*., 1998).

5. Assessments to late 2000 now indicate that 27% of the world's reefs have been effectively lost, with the largest single cause being the massive climate-related coral bleaching event of 1998. While there is a good chance that many of the 16% of damaged reefs will recover over time, some predict that half will never adequately recover (Wilkinson, 1998, 2000). The latest global predictions suggest that a further 14% of the world's coral reefs will be lost by 2010, and another 18% in the 20 years following (Wilkinson, 2000), without reductions in the current human-induced stresses on reef ecosystems from growing coastal populations and economies. This means that 59% of the world's reefs are under immediate threat of loss within several decades.

Regional status of coral reefs (based on Wilkinson, 2000)

Arabian/Persian Gulf region: The near-shore reefs of the Arabian/Persian Gulf were severely damaged by severe coral bleaching in 1996 and 1998, while offshore reefs were less affected. Major coral bleaching occurred in late 2000 in the northern Gulf, while Red Sea reefs remain predominantly healthy with few localized anthropogenic stresses. Rapid growth in tourism and shipping present the potential for growing physical degradation and destruction in the region.

South Asia: Most coral reefs in the region were severely affected by the extreme climate events of 1998, most significantly in the Maldives, Sri Lanka and parts of western India. These losses have added to the major human-induced damage off the mainland of India and Sri Lanka particularly from coral mining, over-fishing and land-based pollution.

Eastern Africa: Significant levels of sediment runoff, nutrient pollution and over-exploitation of reef resources from growing populations remain the largest threats to coral reefs in the region. There was a massive coral-bleaching event and subsequent coral mortality with the El Niño climate switch of 1998, with some areas losing up to 80% of live corals, particularly parts of Kenya and Tanzania.

Southern Indian Ocean: The reefs of the northern part of the region suffered damage during 1998 as a result of the El Niño event, with losses of 80 to 90% of the corals in parts of the Comoros and of the Seychelles. Coral reefs of Madagascar continue to be under very high human-induced threats.

Southern Asia: Some reefs in the region were damaged by the 1998 bleaching event, but the region is the center of a live fish trade worth over US $1 billion per year, with virtually all reefs being physically damaged or destroyed by destructive cyanide and blast fishing methods.

East Asia: The reefs of southern Japan and Taiwan were severely affected by coral bleaching and mortality during the 1998 La Niña climate switch in the region. There are many reports of coral losses of 30 to 60% with some losses as high as 80 to 90%. Some localized extinctions of prominent corals have been reported.

Australia and Papua New Guinea: Australian coral reefs continue to have the lowest levels of human-induced impacts of any continental reefs. In general, they are considered to be in good to excellent condition, although problems with sediment and nutrient run-off from land-based sources have been identified on the Great Barrier Reef. Increasing pressure from professional and recreational fishing is now being experienced and a population explosion of crown-of-thorns starfish is currently attacking offshore reefs. Most of the reefs of Papua New Guinea are in generally very good condition, except for localized areas of damage from excessive logging and increasing levels of exploitation on near shore reefs.

Micronesia: Coral reefs of Micronesia remain predominantly in good to excellent condition, although some damage from coastal development activities on the high islands and over-fishing around centers of population has been experienced. Most of the region has escaped damage from the 1997-1998 bleaching event; however, there were significant losses of coral around Palau.

Southwest Pacific: While this region escaped major bleaching in 1997-1998, it was damaged by relatively severe coral bleaching between February and April 2000 with extensive mortality in some parts of Fiji and the Solomon Islands. Human impacts on these reefs are steadily increasing but still concentrated at a few sites per country, mainly around the capital cities and in lagoons. Most reefs in the region remain in healthy condition, with some local over-fishing for subsistence and small-scale commercial activities.

Southeast Pacific: Most of the coral reefs in this region remain healthy, with few human-induced threats, concentrated around population centers and within enclosed lagoons. Considerable shoreline modification on these islands for tourism developments has resulted in damage to the near shore reefs, but the outer reefs facing the ocean show no real impacts. Fishing pressures are increasing in the region and there are increasing conflicts between fishers and tourist operators.

North-east (American) Pacific: Strong population and economic growth in the Hawaiian Islands is resulting in considerable local damage to reefs around the major population centers and tourist operations, while all coral reefs are experiencing increased fishing pressure. Collecting for the aquarium trade has caused major depletion of some species. In contrast, the scattered islands are under minimal human-induced threats and none experienced climate related bleaching in 1998.

The American Caribbean: The region is experiencing significant problems with over-fishing and physical damage to coastal nursery areas of mangrove forests and seagrass beds. The primary threats to coral reefs off Florida are pollution from agriculture and growing tourism and recreational fishing industries.

Northern Caribbean and Western Atlantic: Primary threats to coral reefs in Jamaica, Haiti and the Dominican Republic are over-fishing and pollution, while over-exploitation is less significant in Cuba, Bahamas, Turks and Caicos Islands. Reefs in Bermuda and Cayman Islands are healthy, resulting largely from the demands of the tourism industry. White-band disease has caused a reduction of *Acropora* spp. and reefs close to land still show low cover (e.g., coral cover in northern Jamaica dropped from 52% in the 1970s to 3% in the early 1990s, but is gradually recovering (currently 10-15%). Bleaching in 1998 was severe in places, but there was little or no mortality. Much of the tourism development based of the coral reefs is poorly planned and results in sediment run-off and nutrient pollution damaging the reefs.

Central American: Though most of the region escaped the Caribbean bleaching events in 1995 and 1998 and the intense Hurricane Mitch, also in 1998, coral reefs from the Mexican Yucatan to Nicaragua were heavily impacted, with losses in coral cover of 15 to 20% across the region with some losses as high as 75% in parts of Belize. Throughout large parts of the region there are intense fishing pressures (Honduras and Nicaragua, and Verecruz and Campeche in Mexico), and major damage to reefs from sediment runoff because of poor land-use.

The Eastern Antilles: Within the region, primary island threats are currently over-exploitation, sedimentation and nutrient pollution to near-shore coral reefs. Coral cover on some islands has dropped recently due to the passage of hurricanes and coral bleaching, with St. Lucia experiencing a decline from 50% to 25% at a depth of 3 metres and from 35% to 17% at 10 metres.

South America: Coral reefs in the region experienced significant declines in the 1980s and early 1990s due to both natural and human-induced stresses. Repeated coral bleaching episodes have resulted in cumulative mortalities, while human-induced threats from increased sediment and nutrient pollution on the near shore reefs have resulted from deforestation, poor agricultural practices and diversion of rivers. Offshore reefs are being increasingly over-exploited for fisheries, coral rock and sand, resulting in distinct declines of coral cover and fish populations.

II. POSSIBLE CAUSES OF PHYSICAL DEGRADATION AND DESTRUCTION OF CORAL REEFS

A. Natural causes

6. Physical degradation and destruction of coral-reef ecosystems may be caused by a variety of natural causes including cyclones, hurricanes, typhoons, volcanism, earthquakes and tsunamis. These factors can cause significant physical damage to the structure of coral reefs, thus altering habitat, biological diversity and ecosystem function. For example, the April 2000 cyclone Tessi impacted fringing reefs of Magnetic Island, Australia, causing a grand mean coral cover reduction of 38%, a 49% reduction in total algal cover, a 50% reduction in sponge cover and a 40% reduction in soft coral cover. These changes resulted in significant changes in the biological diversity in benthic organisms in the local area (Ayling and Neale, 2000).

B. Uncertain causes

Predators, algal grazers and disease

7. In the last twenty years, two of the three major reef-building corals in the Caribbean region, have succumbed to white-band and black-band diseases caused by a microbial consortium of a cyanobacterium *Phormidium sp.*, the sulfide oxidizing bacterium *Beggiatoa spp.*, sulfur-reducing bacteria, as well as other bacteria. Additionally, an important algal-grazing urchin suffered mass mortality in the same region, resulting in the overgrowth of reefs by macroalgae (Wilkinson, 2000).

8. Other recent population explosions of the crown-of-thorns starfish (*Acanthaster planci*) in some regions are contributing to a reduction in coral species diversity at the local and restricted level. *Acanthaster* preys upon selective coral species that may change coral-species biological diversity when the species that recruit to replace those consumed are not the same. This process is poorly understood at

present, as recruitment is largely dependent on the species of settlement-ready larvae present at the time of substrate availability.

9. Algal-grazing sea urchins (*Echinometra* and *Diadema* spp.) in many countries are contributing to a reduction in coral species diversity when populations increase to a point at which their grazing prevents coral recruitment. Such population increases may be attributed to a number of individual or synergistic factors, such as predator species reduction, excess nutrients on coral reefs or a variety of other factors. Other organisms that have been identified contributing to a reduction in coral species in case-studies include grazing parrotfishes (Scaridae) and several species of sponges. In some case-studies, the identified predators, algal grazers or pathogens have been identified as invasive alien species, contributing to shifts in ecosystem dynamics, species diversity and occasionally significant changes to ecosystem function (Lessios *et al.*, 2000).

Global climate change

10. As the recent report *Status of Coral Reefs of the World: 2000* (Wilkinson, 2000) has shown, coral-bleaching events related to periodic climatic events remain the primary threat to coral reefs on the global scale. The increase in sea-surface temperature associated with the major El Niño and La Niña climate switches in 1997-1998 resulted in extensive coral bleaching and mortality over large portions of the Indian Ocean and Southeast and East Asia. On some reefs, there were mortality levels greater than 90% leaving some reefs almost bare of corals and with early indication of major shifts in the population structures. The critical feature of recent coral-bleaching events are that areas have been struck indiscriminately, irrespective of the status of reef health; impacts have been felt both on pristine, remote reefs and on reefs already under major human-induced stresses.

11. Some of the changes recently caused by periodic climate events, including coral bleaching are not necessarily permanent (Cesar *et al*., 1997). However, often human-induced stresses causing physical degradation and destruction to coral-reef organisms exacerbate the effects these events or limit the recovery capability of reef ecosystems.

C. Human-induced causes

12. Human-induced causes of the physical degradation and destruction coral-reef ecosystems having direct and immediate effects are relatively well documented. Many of these causes are amenable for local management by Parties with coral reefs, such as small island developing States, whereas natural causes, or causes of external origin to these countries are beyond the capacity for direct management.

13. The *Reefs at Risk* report (Bryant *et al*., 1998) presents a map-based assessment of potential threats to coral-reef ecosystems around the world. It drew upon 14 data sets, information of 800 sites known to be degraded by human-induced causes, and scientific expertise to model areas where reef degradation is predicted to occur, given existing human pressures. The results of that study indicate that:

(a) Fifty-eight percent of the world's reefs are potentially threatened by human activity, ranging from coastal development and destructive fishing practices to overexploitation of resources, marine pollution, and runoff from inland deforestation and farming;

(b) Overexploitation and coastal development posed the greatest threat in one of the studies considered. Each threat individually was shown to affect a third of all reefs. In other words, globally, 36% of all reefs are classified as threatened by overexploitation, 30% by coastal development, 22% by inland pollution and erosion, and 12% by marine pollution. When these threats are combined, 58 percent of the world's reefs are at risk;

(c) Coral reefs of South-East Asia, the most species-rich on earth, are the most threatened of any region; more than 80 percent are at risk (under medium and high potential threat), and over half are at risk, primarily from coastal development and fish-related pressures;

(d) At least 11% of the world's coral reefs contain rich reef-fish biodiversity and are under high threat from human activities. These "hotspots" areas include almost all Philippine reefs, and coral

communities off the coasts of Indonesia, the United Republic of Tanzania, the Comoros, and the Lesser Antilles in the Caribbean;

(e) The Pacific, which houses more coral-reef area than any other region, is also the least threatened, with about 60% of the reefs at low risk.

Overfishing

14. Many coral-reef species, including giant clams, sea cucumbers, sharks, lobsters, large groupers, snappers, and wrasses are directly over-harvested. Reduced numbers of these desired species are driving increased fishing pressure, including destructive practices, to previously untouched and remote coral-reef areas. The reduction of large predatory fish may affect not only fisheries, but also the tourist industry, as many recreational divers are eager to see both large predators and abundance of small colorful fish.

15. Over-fishing of target species may have a variety of effects on coral-reef ecosystems far beyond the impact on individual target species. This reduction may further population increases of destructive species, such as the crown-of-thorns starfish, or have far greater impact to the ecosystem function as a whole. Evidence suggests that removal of key herbivore and predator species may ultimately cause large-scale ecosystem changes. The removal of triggerfish has been linked with explosions in burrowing urchin populations, their prey, which subsequently accelerate reef erosion through feeding activities (Bryant *et al.*, 2000).

16. In the Caribbean, decades of over-fishing has led, in many places, to very low levels of grazing fish species. Because of this, herbivorous sea urchins have played an increasingly important role in keeping down algal growth. In the 1980s, huge numbers of these urchins succumbed to disease. Without grazing fish or urchin populations, and spurred on in many areas by organic pollution, algae quickly dominated the reefs, inhibiting coral settlement and sometimes overgrowing living corals (Bryant *et al*., 2000).

17. Excessive collection for a live fish trade and excessive souvenir trade may have similar impact through the removal of keystone species or the removal of species numbers beyond sustainable levels.

18. There is currently a poor understanding of the principles of sustainability of coral-reef fisheries with respect either to the stocks targeted or to the ecosystem that supports them. Most reef fisheries are multi-species fisheries and the relative contribution of any species to the overall catch varies from year to year. Most reef species are characterized by highly variable recruitment and there is little understanding of the extent to which populations can be fished before there is a significant impact. There is a need to increase understanding of these factors and the consequences for coral-reef ecosystems of selective removal of top predators.

Coastal development

19. Extensive coastal development may contribute to the physical degradation and destruction of coral reefs in both direct and indirect ways. Dredging for shipping channels and harbours and the filling of shallow reef areas directly contributes to a reduction in coral-reef coverage.

20. Additionally, sedimentation, both from urban areas and from logging activities within watersheds, smothers corals and prevents the symbiotic algae and the coral polyps from capturing sunlight and plankton. These problems are particularly acute close to estuaries of rivers and urban centres, as well as within high rainfall regions (Cesar, 2000). Ultimately, sedimentation of enclosed areas may result in localized eutrophication, under which few organisms may survive.

21. Indirectly, poorly planned urban, industrial and port developments further contribute to the destructive effects of land-based sources pollution to the marine environment; either directly through the contamination of water sources or indirectly through contaminated sediment. Watersheds cleared of their forests and other vegetation covers are vulnerable to erosion and flooding. During high water periods, silt and pollutants within these basins are carried far beyond the normal plume, or the area where coral-reef growth would normally be limited by river discharges, had they been intact (Bryant *et al*., 1998).

Destructive fishing practices

22. Blast fishing, fishing with cyanide and other poisonous chemicals, and trawling on deeper reefs directly damage coral reefs and disrupt reef ecosystems. Because these methods are generally non-selective, large numbers of other species, along with undersized target species, may be swept up in nets or killed by poisons or explosives in the process. As not all fishing methods are destructive, this is less of a widespread threat to coral-reef ecosystems than over-exploitation (Bryant *et al*., 1998), but may cause greater physical degradation and destruction.

23. Blast fishing inherently destroys stony corals and kills fish and invertebrates in a large surrounding area. The resulting changes may lead to a decrease in biological diversity through a reduction in livable niches or through changes in ecosystem dynamics. A cost-benefit analysis at the society level was recently calculated with an economic model for one blast fishery, showing the economic cost to society to be four times higher than the total net private benefits from blast fishing in areas with high potential value of tourism and coastal protection (Pet-Soede *et al*. in Cesar, 2000).

24. Fishing with cyanide or other poisons to stun and capture live aquarium and food fish for the restaurant retail business and the aquarium trade kills larvae of many coral-reef organisms and may add to the bleaching of corals. Mous *et al*. (2000 in Cesar, 2000) point out that the habitat destruction through poison fishing is not as large as earlier anticipated. Estimates of the reef-degrading capacity of the cyanide fishery for food fish on Indonesia's coral reefs amount to a loss of live coral cover of .047 to .060 percentage points per year. This is significantly less than the threats noted for blast fishing (3.75% percentage points per year), or coral-bleaching events.

Coral mining

25. Coral mining for lime production is a source of income and subsistence in many developing countries. The lime is processed into plaster or mixed with cement to reduce costs for local construction. However, the associated damage to the environment is significant, not only through physical destruction of coral reef, thereby damaging its coastal protection function and reducing biological diversity, but also through contributing to logging of secondary forests for fuel wood to process the lime. A recent cost benefit analysis by Ohman and Cesar (in Cesar, 2000) looked at case studies in Sri Lanka and Indonesia, each demonstrated significant societal costs of such operations.

Land-based pollution

26. Municipal sewage and solid waste, chemical discharges from factories upstream, fertilizer and urban storm-water run-off and other pollution originating in watershed areas all contribute to the physical degradation and destruction of coral-reef ecosystems.

27. Pollutants from sewage, urban run-off and agricultural activity may include nutrients, such as nitrogen and phosphorus, causing an over-production of algae. When the algae die, the bacteria that decomposes their remains use much of the oxygen dissolved in the water, leading to the death of other organisms and a change in ecosystem dynamics. Pollutants may also include heavy metals, such as arsenic, cadmium, chromium, copper, nickel, lead and mercury. Many marine species concentrate heavy metals in their tissues, becoming highly contaminated in the process. Additionally, persistent organic pollutants are commonly found in land-based runoff of some regions, posing additional human-health risk to the use of coral-reef resources or to resources feeding on coral-reef resources.

Marine-based pollution

28. Oil and chemical spills and the deliberate discharge of oily ballast water by passing ships pose a potential, but poorly documented, threat to the physical well-being of coral-reef ecosystems. This threat, however, is thought to be less significant (Bryant *et al*., 1998) than land-based sources.

29. Oil or chemical spills can either smother or poison corals and associated coral-reef organisms. Studies on the impact of oil discharges into the Arabian Gulf during the Iran-Iraq and Gulf Wars indicate that spill are associated to short-term declines in many fish and other species (Bryant *et al*., 1998). In

1986, a major spill off the mouth of the Panama Canal was linked to significant losses of coral diversity and cover in heavily affected areas (Bryant *et al*., 1998).

30. The discharge of ballast water from ships, however, may pose a more significant threat to coral-reef ecosystems as a primary vector in the transport of invasive alien species, and pose unknown destructive threats to individual coral reefs ecosystems and to their associated socio-economic values.

Recreational misuse

31. Although tourism in coastal areas and the recreational use of coral-reef ecosystems may serve as the best potential sustainable alternative to more consumptive and destructive activities, it may also contribute to the physical degradation and destruction of coral reefs. Physical damage can be caused during coastal development for tourist activities and can be caused by ship or boat grounding, anchor damage, souvenir-collecting or physical contact from divers and swimmers.

32. Aside from the ecological threats that these activities pose to coral-reef biological diversity, they additionally threaten the socio-economic values associated with the goods and services provided by coral-reef ecosystems. The following table presents the value of total net benefits to individuals and total net losses to society, at 10% discount rate and for a 25-year time-span, in 1000 United States dollars per square kilometre.

Total net benefit/loss from coral-reef threats (in US dollars per square kilometre)

Threat	*Total net benefits to individuals*	*Total net losses to society*
Poison fishing	33	43-476
Blast fishing	15	98-761
Coral mining	121	176-903
Sedimentation from logging	98	273
Overfishing	39	109

Source: Cesar, H. ed., 2000. *Collected Essays on the Economics of Coral Reefs.* Department for Biology and Environmental Science, Kalmar, Sweden.

D. Underlying causes

33. Although, each of the human-induced causes for physical degradation and destruction discussed directly contributes to the threat to coral-reef biological diversity, underlying each of these causes are societal components driving the destructive activities. In considering the development of appropriate response measures to address these threats, it is important to identify those underlying societal causes, such as incomplete knowledge, lack of conviction, inadequate laws or enforcement, lack of economic alternatives, high population growth, lack of effective management or limited human or financial resources.

E. Interactions

34. Recent studies have demonstrated that the primary threat to coral-reef ecosystems is coral bleaching resulting from a variety causes (Wilkinson, 2000). Sea-surface temperature rise and periodic climate events are believed to be a significant, if not primary, source of the recent increase in coral-bleaching events. A variety of other stresses discussed in this note similarly may contribute to such events, in addition to directly causing independent physical degradation and destruction.

35. Despite the current lack of knowledge of the impact of individual causes and the poor understanding of the interactions between causes, it is clear that a number of the human-induced causes are directly affecting the biological diversity of coral-reef ecosystems, a number of which a known to be human-induced and within the capacity for Parties to address. One recent report indicates that globally, 36% of all reefs are classified as threatened by overexploitation, 30% by coastal development, 22% by inland pollution and erosion, and 12% by marine pollution (Bryant *et al*., 1998).

36. Although healthy coral-reef ecosystems have significant capacity to both resist and recover from natural disturbances, coral reefs in a compromised state from physical degradation have limited capacity to do the same. Additionally, the destruction of associated habitats, such as mangroves and seagrass beds, which serve as nursery areas for many reef species, contributes to the limited capacity of coral-reef ecosystems to recover from natural or human-induced physical degradation and destruction.

Box

Regional and global coral-reef organizations and initiatives

The International Coral Reef Initiative (ICRI) is a partnership of governments and international and intergovernmental organizations, with the objectives of mobilizing global support for coral-reef actions. ICRI currently serves as the primary global forum for coordination on issues related to coral-reef ecosystems.

The International Coral Reef Action Network (ICRAN) was initiated by ICLARM and UNEP to develop and keep up-to-date a strategic plan of priority actions for conservation and management of coral reefs and related ecosystems. The core objectives of the strategic plan are to create a global network of successful integrated coastal management and marine protected area models and to use these to extend management to other areas.

The Global Coral Reef Monitoring Network (GCRMN) is a partnership of existing monitoring activities by communities (using the Reef Check system), governments and scientists organized into a global network of regional nodes that provide facilities, training and experience to communities and governments to promote and coordinate monitoring of coral reefs.

The Coral Reef Alliance (CORAL) is a member supported non-profit organization building public awareness with recreational users and community organization through various educational programmes.

The International Coral Reef Information Network (ICRIN) is a global public awareness initiative coordinated by CORAL, serving as a worldwide communication center on coral-reef education and conservation.

The International Center for Living Aquatic Resources (ICLARM) – The World Fish Center is a non-governmental, non-profit organization focused on food security and poverty eradication in developing countries. ICLARM serves as the host for ReefBase, the global database of information relevant to global coral reefs.

Atlantic and Gulf Rapid Reef Assessment (AGRRA) is an international collaboration of researchers and managers designed to evaluate reef condition throughout the Caribbean and Gulf of Mexico using a rapid assessment protocol.

The Caribbean Coastal Marine Productivity Program (CARICOMP) is a regional scientific program, studying land-sea interaction processes in the Caribbean coastal zone. The program focuses on monitoring of undisturbed sites to distinguish natural from anthropogenic disturbance and contributes coral-reef data to ReefBase as part of the GCRMN.

Coral Reef Degradation in the Indian Ocean (CORDIO) is a regional programme investigating the ecological and socioeconomic consequences of the mass bleaching of corals during 1998 in the Indian Ocean and the subsequent degradation of coral reefs.

III. RESPONSE MEASURES

37. The physical degradation and destruction of coral-reef ecosystems threatens the biological diversity and the socio-economic values associated with the goods and services coral-reef ecosystems provide. In the past, the major action to conserve coral reefs has been to reduce direct human impacts of land-based pollution and sediment releases and over-exploitation of living resources through the establishment of marine and coastal protected areas (Wilkinson, 2000). With the realization of the extent of recent coral-bleaching events and the identification of sea-surface temperature rise, as well as direct

human impact as contributing factors, the urgency in reducing human pressures through the application of sound management so that coral-reef ecosystems may recover from inevitable bleaching events has become evident.

38. Protected areas still can play a significant role in this process through minimizing human-induced physical degradation and destruction to coral-reef ecosystem within their boundaries, but a number of factors are important for their success in doing so: sufficient size to protect larval dispersal, governance with clear resource boundaries, well defined resource rights, accountable monitoring and enforcement systems, graduated sanctions, accessible conflict resolution mechanisms, and state recognition of user-designed management strategies. Globally, more than 400 protected areas contain coral reefs; however, most of these sites are very small, with more than 150 being less than one square kilometer in area. At least 40 countries lack any marine protected areas (Bryant *et al*., 1998).

39. There are a number of regional and global organizations and initiatives addressing threats to coral-reef ecosystems, including the effects of physical degradation and destruction. Within the Convention process, the development of response measures should both draw upon the experience gained by these initiatives and avoid unnecessary duplication of efforts in order to maximize organizational and national resources.

40. Several other organizations are also currently engaged in a variety of coral-reef conservation activities including the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the World Conservation Union (IUCN), the United Nations Environment Programme (UNEP), and the UNEP – World Conservation Monitoring Centre (WCMC), the World Bank – Environment Department, as well as others.

41. The development of a specific work plan addressing the physical degradation and destruction of coral-reef ecosystems, aside from coral bleaching, may serve to harmonize ongoing initiatives addressing these threats at the national, regional and global level. It may further serve to prioritize existing initiatives and mobilize funding institutions toward the common goal of conservation and sustainable use of coral-reef living resources and the maintenance of the important services provided by these ecosystems.

42. SBSTTA may wish to consider the draft elements in annex III below for the development of a specific work plan addressing the effects of the physical degradation and destruction of coral-reef ecosystems, recognizing the importance of the conservation of the ecosystems to the conservation and sustainable use of marine and coastal biological diversity and the maintenance of the ecosystem services they provide.

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Annex III

DRAFT ELEMENTS OF A WORK PLAN ON PHYSICAL DEGRADATION AND DESTRUCTION OF CORAL REEFS

Objective (to be integrated into the programme of work on the biological diversity of marine and coastal ecosystems as operational objective 2.4): To assess the biological and socio-economic consequences of physical degradation and destruction of coral reef ecosystems; and to identify and promote management practices, methodologies and policies to reduce and mitigate impacts upon marine and coastal biological diversity and to restore and rehabilitate damaged coral reefs.

Activities

(a) *Assessments and indicators*. To provide a comprehensive analysis of the status and trends of global coral-reef ecosystems, including determination of indicators for continued monitoring and determination of ecological and socio-economic impacts of coral-reef degradation and destruction.

(b) *Management*. To identify management practices, technologies and policies that promote the conservation and sustainable use of coral-reef ecosystems and their associated marine biological diversity, with a view to addressing recognized threats (i.e., overfishing, coastal development, destructive fishing practices, land-based pollution, marine-based pollution and recreational use) and identifying sustainable management approaches.

(c) *Capacity-building*. To strengthen the capacities of Parties, regions, local communities and other stakeholders, to manage sustainably coral-reef ecosystems and their associated marine biological diversity so as to maintain their ecosystem benefits and to promote awareness and responsible action to prevent and mitigate physical degradation and destruction of coral reefs and its effects on marine biological diversity.

(d) *Financing*. To recognize and promote existing programmes and mobilize further mechanisms for financial and technical development assistance to support implementation of activities addressing the physical degradation and destruction of coral reefs.

(e) *Education and public awareness*. To educate and inform the public, policy makers and other stakeholders of ecological and socio-economic values of coral-reef ecosystems and the importance of an ecosystem approach towards their conservation and sustainable management.

Ways and means. Activities under this operational objective will be implemented primarily at the national and regional levels under the guidance of the Executive Secretary and SBSTTA, and in collaboration with relevant organizations and agencies, recognizing the value of the capacity established through ICRI and its operational units.
