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PROGRESS MADE IN THE IMPLEMENTATION OF THE SPECIFIC WORK PLAN ON CORAL BLEACHING

Note by the Executive Secretary

1. In paragraph 74 of its decision X/29, the Conference of the Parties requested the Executive Secretary to prepare a report on the progress made in the implementation of the specific work plan on coral bleaching, adopted in decision VII/5 (appendix 1 of annex I), and make it available for consideration at a future meeting of the Subsidiary Body on Scientific, Technical and Technological Advice prior to the eleventh meeting of the Conference of the Parties. The Conference of the Parties requested that the report should also identify barriers to implementation and ways to overcome them as well as identify specific actions to mobilize financial resources and provide guidance to relevant financial institutions, including the Global Environment Facility, to support the implementation of the specific work plan on coral bleaching.

2. Pursuant to this request, the Secretariat of the Convention commissioned a report on the progress made in the implementation of the specific work plan on coral bleaching.

3. An earlier draft of this report was circulated for peer-review through notification SCBD/STTM/DC/RH/VA/78671 (2012-012), dated on 23 January 2012.

** Reposted to include the following footnote: "The designations employed and the presentation of material in this note do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries" as well as an editorial change on page 27.

* UNEP/CBD/SBSTTA/16/1.

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PROGRESS MADE IN THE IMPLEMENTATION OF THE SPECIFIC WORK PLAN ON CORAL BLEACHING

EXECUTIVE SUMMARY

STATUS AND TRENDS OF CORAL BLEACHING

1. **Since the global mass coral bleaching event in 1998 there have been a number of severe regional-wide bleaching events around the world** with extensive bleaching of corals and high levels of mortality. The two outstanding bleaching events were the bleaching of the Caribbean in 2005 and the 2010 event centered around the Southeast Asia and the Coral Triangle which was reported as one of the most severe recorded. Almost 40% of coral reefs globally had experienced thermal stress levels high enough to cause a severe bleaching event up to 2007.

2. **Climate change will increase the severity and incidence of coral bleaching throughout tropical seas in 21st century**. Future projections indicate that the majority (98%) of the world's coral reefs will experience bleaching events at least once every five years by the end of this century.

3. **Both local and global stressors can compound the effects of bleaching on coral reefs.** Increasing levels of CO_2 will reduce coral survivorship and growth through the effects of warming (bleaching) and acidification respectively. This in turn will decrease reef resilience by reducing the threshold at which local stressors such as herbivore overfishing and nutrification drive coral reef communities from a coral-dominated to an algal-dominated state. Bleached corals also appear to be more susceptible to coral diseases which are increasing in prevalence and geographic distribution.

A. Progress made in the implementation of the Specific Work Plan on Coral Bleaching

Management actions and strategies to support reef resilience, rehabilitation and recovery

4. **Considerable progress has been made to enhance reef resilience** through the development of resilience assessment protocols, toolkits and frameworks. There has been a concerted effort to better understand reef resilience and develop management actions or strategies to enhance resilience and support reef rehabilitation and recovery. Resilience principles have been applied to coral reef management activities and incorporated into the design of new MPAs and networks in most coral reef regions around the world. However, there are still large areas of reefs where resilience has not been quantified.

5. **Detailed coral bleaching response plans have also been developed and implemented** in a few locations such as the Great Barrier Reef and Florida. Guidance has also been provided to develop a more simplified version of a response plan for sites where implementation resources are limited.

6. **Climate change action plans for specific coral reef areas** have been developed and implemented by some countries such as Australia for the Great Barrier Reef (GBR). These plans can improve the understanding of climate change vulnerabilities and enable the identification and testing of adaptation strategies to build reef resilience.

7. **MPA coverage in tropical waters has increased considerably** since the adoption of the coral bleaching work plan. Globally, approximately 27% of coral reefs were located within some form of MPA by the end of 2010 although the area protected varies considerably between regions. However, their effectiveness in meeting conservation and management objectives is low in many coral reef regions.

Information gathering

8. There has been **a significant increase in the availability of information on the status and function of species and habitats within coral reef ecosystems** since the work plan was developed.

9. **Improved monitoring of coral reefs and coastal communities has generated both ecological and socio-economic data** that is fed into well-coordinated data management systems. The assessment and reporting of coral bleaching events has also markedly improved with bleaching observations stored in open access databases such as ReefBase.

10. Of particular note has been **the increase in the socio-economic monitoring of coastal communities that rely on coral reefs for food or income** through the Global Socioeconomic Monitoring Initiative for Coastal Management (SocMon). The SocMon Initiative has grown considerably over the last decade and has produced regional guidelines for the Caribbean, Western Indian Ocean, Southeast Asia, Pacific and South Asia. A global assessment of tropical coastal socio-economic conditions in 2008 was produced while a draft set of indicators to assess the community-level social vulnerability to climate change have recently been released for field testing.

11. **The ability to predict coral bleaching events through remote sensing and modelling of warming has improved dramatically**. Early warning systems are in place both at the regional and global level to alert coral reef managers of the likelihood of coral bleaching. The NOAA's Coral Reef Watch programme has continued to develop a range of tools to quickly identify areas at risk of bleaching. When bleaching conditions occur, these tools can be used to trigger bleaching response plans and support appropriate management decisions.

12. **Targeted research on coral bleaching** has been conducted by many research institutions and conservation-based organizations around the world. Scientific knowledge on coral bleaching was reviewed in some detail in 2009. Since the adoption of the work plan, researchers have broadened the field of investigation to include other climate change effects such as ocean acidification and the interaction between both global and more local stressors on coral reefs. A specific targeted research programme that has involved a considerable amount of work on coral bleaching is the Coral Reef Targeted Research for Capacity Building and Management Program (CRTR).

Capacity-building

13. **A number of partnerships** (e.g. the Resilience Network, IUCN CCCR) and community participation programmes (LMMA networks) have been set up or expanded since the adoption of the coral bleaching work plan. In addition to existing networks (e.g. ICRAN) these partnerships and programmes have increased the number of education and training opportunities to improve understanding of the causes of coral bleaching and the ecological and societal impacts of bleaching events, and also provide training in resilience assessment techniques.

14. **Multi-disciplinary approaches to coral reef research** have been successful in providing training for local researchers and conservation practitioners in coral reef regions whilst also developing guidance for managers and conducting much needed targeted research programmes.

15. **A range of tools, guides and protocols have also been developed in relation to coral bleaching and management** including the Reef Resilience (R^2) toolkit, bleaching and resilience assessment protocols, coral bleaching response plans, climate change action plans for coral reefs and managers guides to coral bleaching. However, there are still many coral reef nations that have not yet developed or implemented resilience or bleaching protocols for assessment and management, although this is regarded as a priority by many Governments.

16. **Overall, the capacity of coral reef nations to manage coral bleaching events has increased since the adoption of the coral bleaching work plan.** However, the increase in national capacity varies considerably between nations and regions with some least developed nations still lacking the human and/or technical resources to implement coral reef management programmes that include measures to document and manage the effects of climate change stressors such as bleaching.

Policy development and implementation

17. There has been **improved recognition by Parties, other Governments and relevant regional organizations/initiatives of the need for integrated or ecosystem based marine and coastal area management incorporating marine, terrestrial, and climatic considerations** when undertaking activities such as MPA network development, land use planning and watershed management approaches; fisheries policy and the provision of alternative livelihoods for people relying on coral reef resources.

18. **Regional efforts to develop and implement policy** that contribute to the delivery of the coral bleaching work plan occur through the UNEP Regional Seas Programmes (RSP). Regional

treaties or agreements that contribute to the protection of coral reef ecosystems are in place in a number of regions for programmes on MPA networks, land-based pollution and climate change impacts.

19. The vulnerability of coral reef ecosystems to anthropogenic stressors and the importance of coral reefs to humanity have been recently recognized by the United Nations General Assembly Resolution 65/150 on the protection of coral reefs for sustainable livelihoods and development and by the United Nations Secretary General's report.

Financing

20. Progress has been made to mobilize international programmes and mechanisms for financial and technical development assistance to address the causes and consequences of coral bleaching. Government programmes of some developed nations (e.g. the U.S. Coral Reef Conservation Program) have prioritized key stressors to improve reef resilience in national waters and overseas territories while the GEF and World Bank supported Phase One of the Coral Reef Targeted Research (CRTR) Program.

21. **Regional Programmes** such as the Caribbean and Micronesian Challenges or the Coral Triangle Initiative have been successful in mobilizing funds from a variety of sources including overseas aid from developed nations, development banks and the private sector. As well as direct donor or Government funding for project implementation there are concerted efforts to ensure the financial sustainability of the initiatives over the long-term through the formation of trust funds.

22. **Innovative financing mechanism**s have also been established to provide funding for large-scale approaches, particularly in the Pacific. The Phoenix Islands Protected Area (PIPA) is partly financed by an innovative "reverse fishing license" which funds an endowment to cover core management costs and compensate the government for the foregone commercial fishing license revenues. The Palau Green Fee, a tax that tourists pay when leaving the country is being used by community-based conservation groups to help manage the Protected Areas Network.

B. Barriers to implementation

23. **Mass coral bleaching events are a relatively 'new' phenomenon and there are still many gaps in our knowledge and understanding of bleaching effects and impacts**. There are still many questions being asked by researchers and conservation practitioners that will take time, and sufficient funding, to answer. Furthermore, we are not only dealing with the effects of increasing sea surface temperatures but also with ocean acidification and the interaction between these two climate change stressors and other more localised threats such as overfishing or eutrophication.

24. **Baseline information for coral reef ecosystems such as benthic cover or reef fish data is lacking in many regions making accurate resilience assessments of reefs more difficult**. Where monitoring data is being collected it often remains at a 'standard' level to assess coral reef status and has not been expanded to incorporate resilience criteria.

25. **The scientific knowledge of resilience in coral reefs is still at an early stage** and uncertainties in our understanding make it more difficult to design resilience-based spatial management systems involving MPAs. The existing knowledge of resilience-based management and planning approaches is also relatively new with approaches only tested in a few locations.

26. **A number of challenges in the practical management of coral bleaching** were identified. There was a lack of understanding and perception of concepts such as resilience by reef managers and the interaction between global and local threats in enhancing the resilience of coral reefs. In addition many communities have not fully accepted the reasoning behind conservation tools such as MPAs and are reluctant to assimilate further resilience-based mechanisms.

27. **Insufficient capacity** in developing nations to fully implement the specific work plan, or effectively manage coral reefs without even considering climate change impacts, remains a key barrier. Combined training and awareness programmes in reef resilience assessment and management

have been provided in some regions in a few locations but need to be an integral part of national climate change action plans with adequate support through various partnerships.

28. **Financing** the required level of support to address climate change impacts on coral reefs through the implementation of the specific work plan is, along with the capacity issue, the most important obstacle to progress. One barrier highlighted is the lack of a contingency fund that can be quickly accessed to support a rapid response to mass bleaching events. It is also important to ensure that funding continues after bleaching events for ongoing monitoring to document secondary effects (e.g. coral disease outbreaks) and support long-term management goals.

C. Specific actions undertaken to mobilize financial resources required for implementation

29. Specific actions included conducting in-depth discussions with Governments to secure adequate research funding for bleaching and resilience related work, liaising with partner organizations to provide match funding, and applying for international grants such as those provided by NOAA's CRCP. The setting up of endowment funds to finance regional approaches such as the Micronesia Challenge was highlighted as were the formation of sustainable finance plans and the establishment of National Climate Funds.

30. **Other potential sources of funding for activities directly or indirectly related to the work plan implementation** included multilateral climate change adaptation funds predominantly managed by UNFCCC, GEF and the World Bank and also unilateral climate funds. More market-based financial resources, such as Payment for Ecosystem Services (PES) or blue carbon schemes for coastal carbon sink ecosystems are currently in their infancy but expected to provide significant funding within the next decade. There is also considerable potential to increase the involvement of the private sector, particularly tourism, in tropical coastal ecosystem management through direct funds, incentives, compensation payments or user fees. Other financing mechanisms are the use of environmental bonds for climate resilience and adaptation projects such as the World Bank Green Bond; the polluter pays principle (PPP) for both chronic and acute pollution of coral reef ecosystems and green taxes similar to the green fee system in Palau.

D. Conclusions and future priorities

Information Generation

31. **There is a need to improve and simplify tools and guidance for managers on reef resilience indicators and methodologies** to assess vulnerability, resilience and adaptation opportunities for dependent communities. Some of the current resilience assessment protocols are quite data intensive and require a high level of expertise. A more simplified but still scientifically accurate assessment protocol with reliable and 'user-friendly' resilience indicators can help to increase the uptake of resilience-based assessments and increase the area of coral reef assessed.

32. **Greater emphasis is needed to evaluate and quantify the socio-ecological impacts and implications of repeated mass bleaching events**. The long-term effect of bleaching episodes compounded by other stressors (both local and global threats) is a key area that requires immediate and systematic investigation through research and assessment programmes. In terms of global impacts related to climate change, extensive information is needed for ocean acidification impacts but also for other effects such as tropical storm incidence and severity and sea level rise.

33. It is important to **determine and quantify the linkages between ecological and social variables and also the inter-relationship between ecological responses to bleaching (and other stressors) and the vulnerability of dependent communities and industries.** Quantifying or accurately predicting the socio-economic effects of coral reef degradation on coastal communities and other stakeholders will assist in effective adaptation planning.

34. **Continued support to global initiatives to document and report on status and trends on coral reefs as an aide to national decision-making is needed**. Expansion of monitoring efforts at the national and regional level to include previously un-assessed coral reef areas and make monitoring more systematic will help to identify both resilient areas and those most in need of strong management.

Practical management

35. **Coral reef management should be conducted within an integrated ecosystem-based approach** that considers the full range of impacts that a particular reef system is subjected to and seeks to address the underlying drivers of localised threats both on land and at sea. Management needs to consider not just rising sea temperatures and coral bleaching events but also the effects of ocean acidification, tropical storms and increased sea level and the interaction between these.

36. There should be **greater integration of resilience principles into management planning at the national and regional level.** National coral reef action plans need to be in place for all coral reef countries that incorporate climate change effects and resilience-based approaches and are regularly updated to represent current scientific knowledge. Management of coral bleaching events in many countries can be improved if there are coral bleaching response plans in place. Support should be provided to develop and ensure the effective implementation of integrated ecosystem-based management approaches for coral reefs and associated ecosystems.

Capacity-building

37. **There is still a great need to improve capacity to manage coral bleaching and other stressors on coral reefs across a range of scales**. Firstly, there needs to be greater exchange of scientific, technical, and socio-economic information as it relates to coral reef degradation. Key scientific knowledge and management experiences should be available to coral reef managers in all countries to enable informed decision-making. Resilience training that encompasses all potential climate change effects on coral reefs for that country or region needs to be developed, tested and disseminated. Where successful management approaches are identified for areas such as coral reef protection, resilience building, adaptation and the use of new technologies, they should be shared both within countries and at the regional level through exchange programmes. These best practices need to be incorporated into both national and regional governance frameworks and reef management strategies.

38. **Training programmes need to include a substantial educational component to increase the understanding of new and established concepts for effective reef management**. Increased support for coral reef action networks and other partnerships focussed on addressing the key issues for coral reefs and their management is required. There also needs to be better coordination of coral reef between different levels (local, provincial, national) and between the various agencies (government, non-government, community) to improve monitoring and management effectiveness.

Financing

39. A key priority is to **establish a readily accessed contingency fund to enable more rapid and increased reef monitoring in response to bleaching events**. Rapid provision of funds is essential to activate bleaching response plans so that a thorough assessment of the event can be carried out.

40. The projected increase in severe bleaching events in the near future emphasises the need for increased levels of financing as climate change and other localized impacts become more common and intense. **The funding base for coral reef management needs to be expanded and diversified**. Innovative and diverse financing mechanisms, especially linked to the private sector, should be supported. Climate change funding for adaptation of tropical coastal communities also needs to be increased either via existing multilateral climate funds or through the establishment of national climate funds.

Policy frameworks

41. **There is a need to improve linkages between agencies such as the Secretariat of the Convention on Biological Diversity, the Secretariat of UNFCCC and FAO** to enhance regional and international efforts to address the negative effects of climate change on marine biodiversity, ecosystem services and dependent populations.

42. **Further regional initiatives and agreements and transboundary collaboration should also be encouraged and supported**. Regional or national policies to address localised threats are still lacking in some cases and should be prioritised through support for policy development in those countries or regions. The success of regional initiatives such as the Micronesia Challenge has shown how useful partnerships are to tackle issues at the national and regional scale. Further partnerships to set regional policy can initiate improved management of coral reefs.

I. INTRODUCTION

Tropical coral reefs are thought to be one of the most vulnerable ecosystems to future climate change, threatening ecosystem function and the millions of people depending on those ecosystems for food, income and shoreline protection[123]. Projected climate change impacts on coral reef ecosystems, with varying degrees of certainty, include:

- More intense tropical storms which are a source of localized physical destruction on reefs
- Changes in regional rainfall and river flow regimes with likely more extreme rainfall events and more intense droughts that could affect the periodic extent of freshwater onto reefs
- A gradual rise in sea level that will affect light penetration and also the availability (increase and decrease) of suitable areas for corals to live
- Changes in large-scale and regional atmospheric (e.g., El Niño–Southern Oscillation (ENSO) events; prevailing weather patterns) and ocean circulation patterns that will affect connectivity between reefs
- Changes in ocean chemistry due to about one-third of the excess atmospheric carbon dioxide being absorbed by the oceans, which is lowering their pH and decreasing the ability of marine calcifying organisms such as corals to form their skeletons and shells
- Ocean warming that causes heat stress in corals and triggers coral bleaching

The effect of ocean warming on coral reefs is well documented.[4] When corals are stressed by environmental factors they exhibit a stress response known as bleaching. This can be defined as the loss by the coral animal of all or some of their symbiotic algae and photosynthetic pigments with the result that the white calcium carbonate skeleton becomes visible through the translucent tissue layer.[5] Corals are known to bleach in response to a range of environmental stresses such as low salinity, pollution, or unusually high or low water temperatures. Previously, bleaching occurrences were only observed on small spatial scales in response to localized stresses. The relatively new phenomenon of large-scale mass coral bleaching, caused by heat stress, is clearly related to climate change. Since the 1980s, coral reef bleaching, caused by unusually high sea temperatures, has had devastating and widespread effects worldwide.[6] Abnormally high ocean temperatures (1–2°C greater than the usual annual maximum) can cause mass coral bleaching events where numerous corals of many different species across a large area bleach simultaneously.[7] A rise in the occurrence of abnormally high ocean

[1] Hoegh-Guldberg O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Mar Freshw Res 50: 839–866.

[2] Hughes TP, Baird AH, Bellwood DR, Card M, Connolloy SR, et al. 2003. Climate change, human impacts, and the resilience of coral reefs. Science 301: 929–933.

[3] Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, et al. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318: 1737–1742.

[4] Oppen, M.J.H. and Lough, J.M. (eds). 2009. Coral bleaching patterns, processes, causes and consequences. Ecological Studies 205. 178 pp. Heidelberg, Germany: Springer.

[5] Ibid.

[6] Baker, A.C. et al. 2008. Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook, Estuar. Coast. Shelf Sci. doi:10.1016/j.ecss.2008.09.003.

[7] Hoegh-Guldberg O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Mar Freshw Res 50: 839–866.

temperatures in recent years[8] has led to more frequent, intense and widespread mass bleaching events[9]. Human-induced climate change is highly likely (>90% certainty) to have played a role in mass bleaching event in Caribbean during 2005.[10]

Bleached corals (and other affected reef fauna that have symbiotic algae) can either die or survive bleaching depending on the duration and degree of temperature stress. Frequent or severe bleaching can lead to a reduction in the reproductive capacity, growth, disease resistance and/ or survivorship of affected corals at large geographic scales.[1112] Mass bleaching events have resulted in high mortality of reef-building corals on numerous occasions, most notably in 1998 during the global event but also more recently in the Caribbean (2005) and Southeast Asia (2010). The remaining coral reefs are often characterised by lower coral cover, reduced abundance of affected coral species and lower structural complexity. Coral bleaching has contributed to significant reductions in live coral cover at regional scales.[1314]

The impacts of mass bleaching events on coral reef biodiversity are significant and are predicted to increase as the frequency and intensity of bleaching events rises. Tropical coral reefs are the world's most biodiverse marine ecosystems and home to one-third of all described marine species.[15] Mortality of reef building corals can result in population declines for many species, a loss of coral diversity and changes in community composition. An assessment of reef building corals for the IUCN Red List in 2008 indicated that the extinction risk for many corals is now much greater than it was before recent massive bleaching events.[16] Reef fauna that solely rely on live corals for food (obligate corallivores), habitat or are in close association with a host coral colony (obligate symbionts) can also be severely affected by bleaching events.[17] Obligate crustacean symbionts are reduced in abundance through direct mortality or leave the host coral colony and are more prone to predation. Other obligate symbionts and parasites closely associated with affected corals such as ciliate protozoans, flatworms, copepods, cirripeds, decapod crustaceans (crabs, shrimps), and fishes are also likely to experience high mortality during bleaching events.[18]

Obligate corallivores fish show marked declines in abundance due to bleaching events. Species in the families Gobiidae, Pomacentridae, Monacanthidae and Chaetodontidae, generally die within weeks of the disappearance of their coral prey and habitat niche[19]. Other functional groups such as facultative corallivores and micro-invertebrate feeders are also vulnerable to climate change impacts as these

[8] Eakin, C. M., J. M. Lough, and S. F. Heron. 2009. Climate Variability and Change: Monitoring Data and Evidence for Increased Coral Bleaching Stress. In: M. J. H. Oppen and J. M. Lough, eds. Coral Bleaching. Vol. 205, Ecological Studies. Heidelberg, Germany: Springer.

[9] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[10] Donner SD, Knutson TR, Oppenheimer M (2007) Model-based assessment of the role of human-induced climate change in the 2005 Caribbean coral bleaching event. Proc Natl Acad Sci U S A 104: 5483–5488.

[11] Hoegh-Guldberg O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Mar Freshw Res 50: 839–866

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[13] Gardner TA, Cote´ IM, Gill JA, Grant A, Watkinson AR (2003) Long-term region-wide declines in Caribbean corals. Science 301:958–960

[14] Bruno JF, Selig ER (2007) Regional decline of coral cover in the Indo-Pacific: timing, extent, and subregional comparisons. PLoS ONE 2:e711. doi:10.1371/journal.pone.0000711

[15] Reaka-Kudla, M.L. (1997) Global biodiversity of coral reefs: a comparison with rainforests. In: Reaka-Kudla, M.L., Wilson, D.E. (eds.) Biodiversity II: Understanding and Protecting Our Biological Resources. Joseph Henry Press

[16] Carpenter, K.E. et al. 2008. One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Science 321, 560

[17] Baker, A.C. et al. 2008. Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook, Estuar. Coast. Shelf Sci. doi:10.1016/j.ecss.2008.09.003

[18] Ibid

[19] Ibid

groups are vulnerable to a loss in structural complexity.[20] Severe bleaching events can result in a significant loss of coral reef structural complexity, which is critical for the provision of habitat to support high levels of biodiversity. Population shifts in reef-dwelling organisms have been observed, notably for reef fish[2122] Loss of reef structure following disturbances such as mass bleaching events reduces predator-free space for small fishes[23], making them highly vulnerable to population declines. Coral associated fishes that require coral structure for shelter, reproduction or larval settlement sites have shown marked declines following habitat loss.[24] Local extinction of some reef fish species has been reported after the 1998 coral bleaching event.[25]

Coral bleaching, along with disease, are cited as the critical drivers of the decline of reef building corals which led to 200 species being listed as threatened with extinction.[26] Increasing frequency of severe bleaching events is likely to increase the risk of extinction for corals and associated reef fauna. If bleaching events become very frequent, many species may be unable to re-establish breeding populations before subsequent bleaching causes potentially irreversible declines. In addition increasing ocean acidification is predicted to make large areas of the ocean inhospitable for coral reefs by 2030.[2728] Other localised stressors on coral reefs such as overfishing and pollution can compound the effects of climate change by reducing ecosystem health and resilience. Stressors can also interact synergistically to increase the impact on reef ecosystems. The functional loss of reef ecosystems will threaten the physical structure of reefs and their coastal protection function and have significant economic effects on food security for millions of people dependent on reef fish. The loss of reef ecosystems would lead to large-scale loss of global biodiversity.[29]

At the fourth Conference of the Parties (COP) to the Convention on Biological Diversity (CBD), in its decision IV/5, the COP expressed their deep concern at the extensive and severe coral bleaching which occurred in the Indian Ocean, caused by abnormally high water temperatures in 1998. It also recognized the potentially severe loss of biological diversity and consequent socioeconomic impacts of coral bleaching and noted this occurrence as a possible consequence of global warming.

In light of this, the COP requested the Scientific Body on Scientific, Technical and Technological Advice (SBSTTA) to make an analysis of the coral bleaching phenomenon and to provide relevant information to the fifth meeting of the Conference of the Parties. On this basis, in order to assist the work of SBSTTA, the Executive Secretary of the Convention convened an Expert Consultation on Coral Bleaching which took place in Manila, Philippines, during October 1999. The main outcomes of the meeting were a report[30] and a series of recommendations made by the expert consultation on coral

[20] Graham, N.A.J., Wilson, S.K., Jennings, S., Polunin, N.V.C., Bijoux, J.P. & Robinson, J. 2006. Dynamic fragility of oceanic coral reef ecosystems. Proc. Natl Acad. Sci. U.S.A., 103, 8425–8429.

[21] Jones GP, McCormick MI, Srinivasan M, Eagle JV. 2004. Coral decline threatens fish biodiversity in marine reserves. Proc Natl Acad Sci U S A 101: 8251–8253

[22] Munday PL, Jones GP, Pratchett MS, Williams AJ. 2008. Climate change and the future for coral reef fishes. Fish Fish 9: 261–285

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[24] Bellwood, D.R., Hoey, A.S., Ackerman, J.L., Depczynski, M., 2006. Coral bleaching, reef fish community phase shifts and the resilience of coral reefs. Global Change Biology 12, 1587–1594.

[25] Graham, N.A.J., Wilson, S.K., Jennings, S., Polunin, N.V.C., Bijoux, J.P. & Robinson, J. 2006. Dynamic fragility of oceanic coral reef ecosystems. Proc. Natl Acad. Sci. U.S.A., 103, 8425–8429.

[26] Carpenter, K.E. et al. 2008. One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Science 321, 560

[27] Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, et al. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318: 1737–1742

[28] Veron, J.E.N., O. Hoegh-Guldberg, T.M. Lenton, J.M. Lough, D.O. Obura, P. Pearce-Kelly, C.R.C. Sheppard, M. Spalding, M.G. Stafford-Smith, & A.D. Rogers (2009) The coral reef crisis: The critical importance of <350 ppm CO2. Marine Pollution Bulletin (58).

[29] Carpenter, K.E. et al. 2008. One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Science 321, 560

[30] UNEP/CBD/JM/Expert/2/3

bleaching[31], including the outline of a programme of work for better understanding the causes and minimizing the effect of coral bleaching. The recommendations and outline of a programme of work from the expert consultation were used to draw up the specific work plan on coral bleaching which was adopted by the COP in its decision VI/3, amended by decision VII/5.

In its decision X/29 (paragraph 74), the COP requested the Executive Secretary to prepare a report on the progress made in the implementation of the specific work plan on coral bleaching, adopted in decision VII/5 (appendix 1 of annex I), and make it available for consideration at the sixteenth meeting of the SBSTTA, scheduled for 30 April to 4 May 2012. The COP requested that the report should also identify barriers to implementation and ways to overcome them as well as identify specific actions to mobilize financial resources and provide guidance to relevant financial institutions, including the Global Environment Facility, to support the implementation of the specific work plan on coral bleaching.

Pursuant to the above request, this report was prepared, with the financial support by the Government of Japan through Japan Biodiversity Fund, to provide an assessment of the progress made in the implementation of the specific work plan on coral bleaching by Parties, other Governments, relevant organizations, and indigenous and local communities, the identified barriers to implementation and the ways to overcome them. Specific actions reported by Parties and others to mobilise financial resources are also provided along with further suggestions for financing sourced from the literature. Guidance on how relevant financial institutions can further support the implementation of the specific work plan on coral bleaching is also provided. A number of suggestions are made on how the specific work plan can be updated in light of the increased understanding of climate change impacts on coral reefs.

The information sources for preparing this report include: (i) the compilation of information available in 3rd and 4th national reports; (ii) submissions made by Parties, other Governments and organizations in response to the CBD notification (Ref. No. 2011-167, issued on 7 September 2011); and (iii) research of additional information and relevant documents.

II. CORAL BLEACHING: STATUS AND TRENDS

Mass coral bleaching events have been increasing in frequency and severity over the last three decades as sea temperatures have risen over time[32]. The mass coral bleaching event in 1998 was a global phenomenon affecting entire coral reef ecosystems and killing an estimated 16% of the world's tropical corals[33], with greatest mortality (50 – 90%) recorded in the central and western Indian Ocean[34]. There were more than 1400 reported bleaching events in 1998 alone, almost four times the number of bleaching events reported prior to that year[35]. Since the extreme of 1998 the number of reported bleaching events has steadily increased with large-scale mass bleaching events observed in 2002, 2005 and 2010. The increase in reported bleaching events is both a reflection of rising sea surface temperatures and increased monitoring, awareness and communication of bleaching events[36]. The number of counties reporting bleaching events to ReefBase between 1980 and 2010 is documented in Figure 1 along with the severity of the event.

Figure 1: Reported Bleaching Events between 1980 and 2010 (source: ReefBase)

[31] UNEP/SBSTTA/5/Inf.6

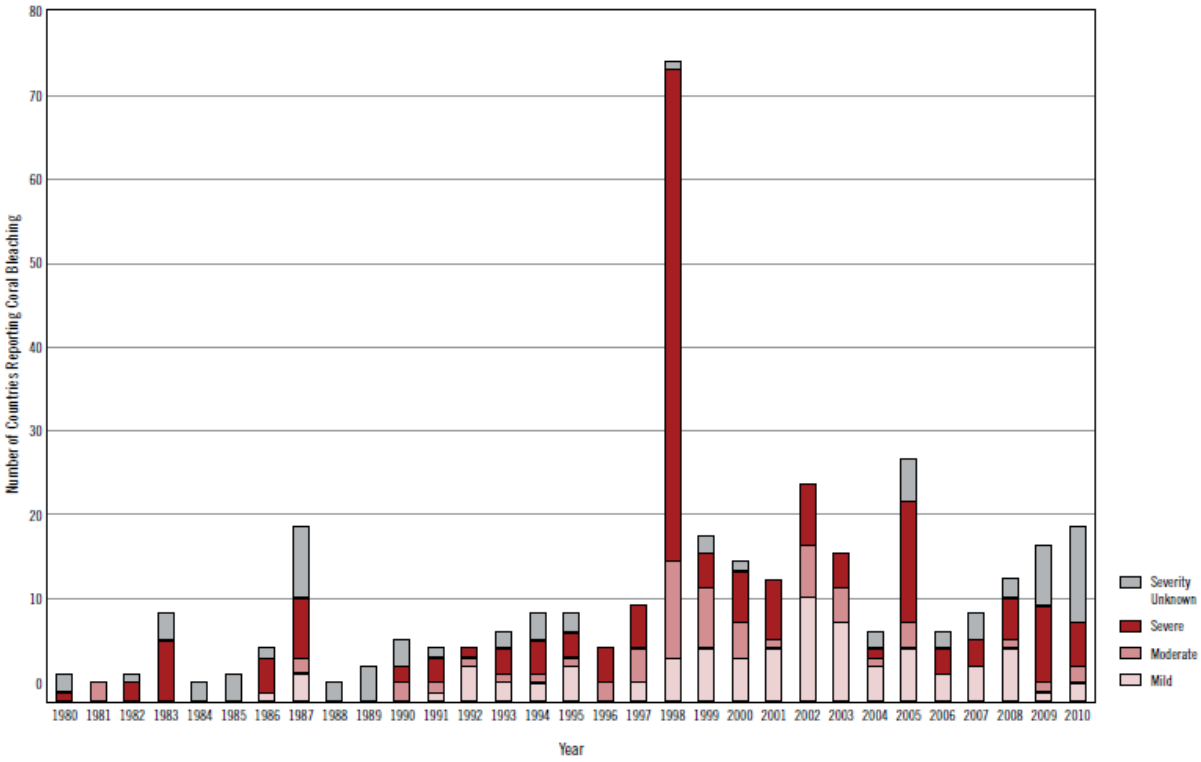
[32] Eakin, C. M., J. M. Lough, and S. F. Heron. 2009. Climate Variability and Change: Monitoring Data and Evidence for Increased Coral Bleaching Stress. In M. J. H. Oppen and J. M. Lough, eds. Coral Bleaching. Vol. 205, Ecological Studies. Heidelberg, Germany: Springer

[33] Wilkinson C. 2008. Status of the Coral Reefs of the World: 2008. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia.

[34] Goreau, T., McClanahan, T., Hayes, R. and Strong, A. 2000. Conservation of coral reefs after the 1998 Global Bleaching Event. Conservation Biology 14: 5-15.

[35] www.reefbase.org

[36] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.



Global thermal stress on coral reefs has been estimated for the period 1998 – 2007 by plotting observed bleaching events recorded in the ReefBase database and satellite measurements[37] of severe thermal stress (Figure 2) where a Bleaching Alert level 2[38] has been recorded at locations at least once between 1998 and 2007[39]. The level of threat produced by these thermal stress measurements for major coral reef regions and selected key nations with large coral reef areas (Table 1) indicates that almost 40% of coral reefs globally had experienced thermal stress levels high enough to cause a severe bleaching event up to 2007 with higher percentages in some regions (e.g. Indian Ocean and Atlantic) and many countries (e.g. Fiji, Maldives, Bahamas).

Table 1; Bleaching Threat to Coral Reef regions and selected Countries (adapted from Burke et al., 2011).

Region	Reef Area (km^2)	% Global Reef Area	Severe Thermal Stress (1998 – 2007) (%)	Coastal Population '000
Atlantic	25 849	10	56	42 541
Australia	42 315	17	33	3 509
Indian Ocean	31 543	13	50	65 152
Middle East	14 399	6	36	19 041
Pacific	65 972	26	41	7 487
Southeast Asia	69 637	28	27	138 156
Global	**249 713**	**100**	**38**	**275 886**

[37] The U.S. National Oceanic and Atmospheric Administration (NOAA) Coral Reef Watch program uses satellites to monitor sea surface temperature (SST) to determine when and where coral bleaching may occur. Their methodology for predicting bleaching is based on abnormally high and sustained SSTs, measured in "degree heating weeks" (DHW), where one DHW is equal to one week of SST 1°C warmer than the historical average for the warmest month of the year

[38] A Degree Heating Week value of 8 that typically causes severe bleaching and some coral mortality

[39] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

Selected				
Indonesia	39 538	16	16	59 784
Philippines	22 484	9	47	41 283
Papua New Guinea	14 535	6	54	1 570
Fiji	6 704	3	54	690
Maldives	5 281	2	74	357
Saudi Arabia	5 273	2	47	7 223
Madagascar	3 934	2	41	2 235
Cuba	4 920	2	36	4 430
Bahamas	4 081	2	47	303
Hawaii (U.S.)	3 834	2	11	1 209

The last two large scale mass bleaching events in 2005 and 2010 occurred in the hottest years on record for surface temperatures[40]. The 2005 bleaching event was centred on the Caribbean region and caused severe bleaching with between 50 and 95 % of coral colonies bleached[41]. Subsequent levels of overall coral mortality ranged from 10 to 50% with some genera experiencing higher mortality levels in certain locations (e.g. 73% of all *Diploria* and *Colpophyllia* colonies in Trinidad and Tobago). Increased prevalence of disease following bleaching was reported from many islands of the Lesser Antilles as stressed corals were more susceptible to infections[42]. Many of the stressed and diseased colonies subsequently died in 2006.

The more recent mass bleaching event in 2010 affected a much wider area globally with bleaching reported from more than 25 countries, mainly in the Indian Ocean and Southeast Asia. Other regions also reporting bleaching were the southern Arabian Gulf[43], central Pacific (Hawaii) and the Caribbean. Severe levels of bleaching occurred in parts of Indonesia such as Aceh in Sumatra where sea surface temperatures were 4 degrees higher than the long-term average for the region. Coral mortality levels were high (e.g. 80% for *Acropora* colonies) and the event was reported to be one of the most rapid and severe mortality events ever recorded[44]. High bleaching levels were reported in other parts of Indonesia such as Sulawesi, with bleaching also recorded across the archipelago at moderate levels to West Papua. Other countries in the region that were affected were Malaysia, the Philippines, Cambodia and India.

Future predictions of mass bleaching events based on projected temperatures have suggested that severe bleaching of reefs will occur over the next two to three decades[45][46][47]. A recent report, 'Reefs at Risk Revisited', using the best-available models that combine NOAA's methodology for predicting bleaching episodes with estimates of future sea surface temperature due to climate change to predict

[40] http://www.noaanews.noaa.gov/stories2011/20110112_globalstats.html

[41] Wilkinson, C., Souter, D. 2008. Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, 152 p.

[42] Ibid

[43] Riegl BM, Purkis SJ, Al-Cibahy AS, Abdel-Moati MA, Hoegh-Guldberg O. 2011. Present Limits to Heat-Adaptability in Corals and Population-Level Responses to Climate Extremes. PLoS ONE 6(9): e24802. doi:10.1371/journal.pone.0024802

[44] Inside Reef Newsletter. 2010. Indonesian Marine Science News 6th Edition. Wildlife Conservation Society Indonesia Marine Program, June 2010.

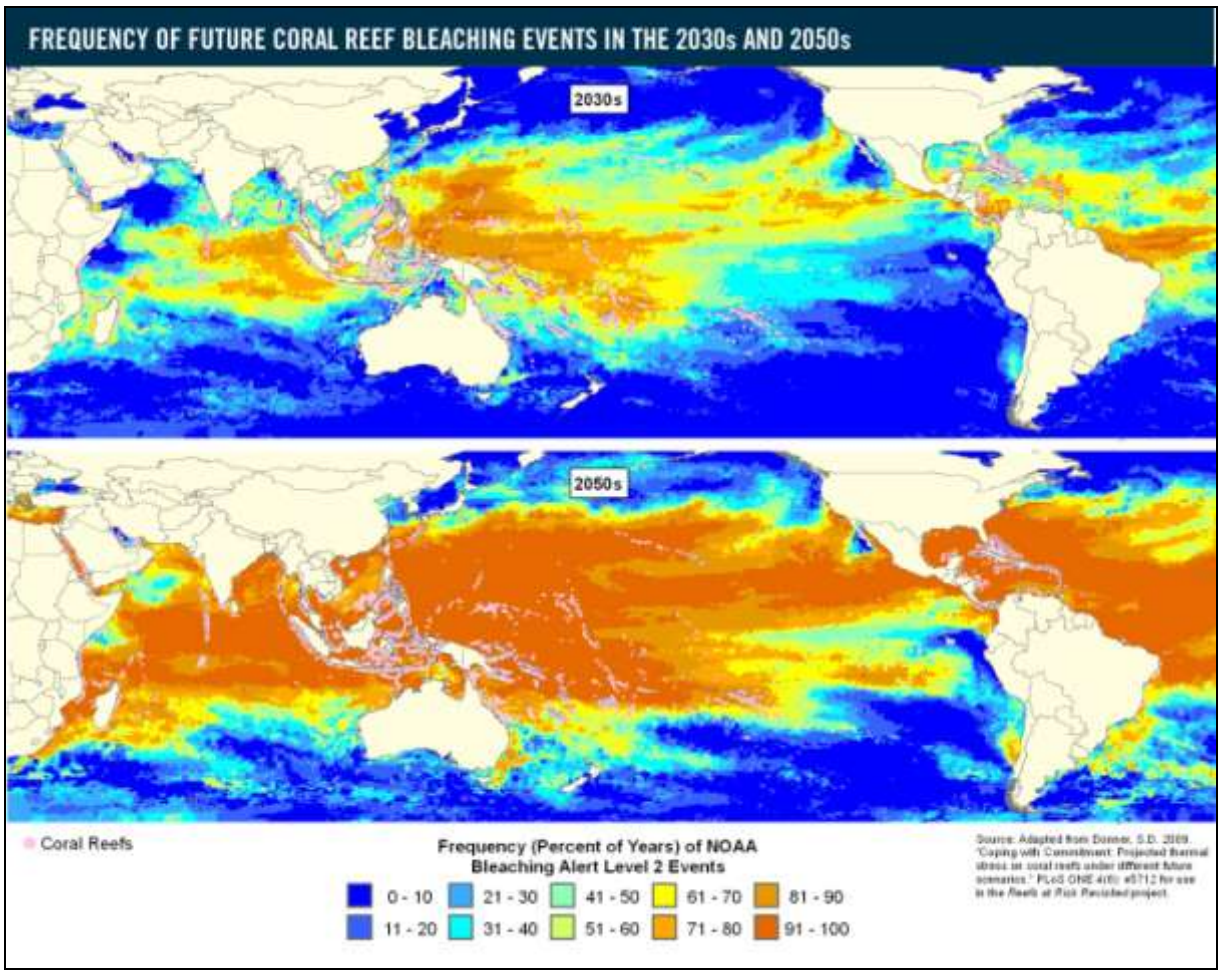
[45] Hoegh-Guldberg, O. 1999. Climate Change, Coral Bleaching and the Future of the World's Coral Reefs. Marine and Freshwater Research 50: 839–866

[46] Sheppard, C. R. C. 2003. Predicted Recurrences of Mass Coral Mortality in the Indian Ocean. Nature 425: 294–297.

[47] Donner, S. D., W. J. Skirving, C. M. Little, M. Oppenheimer, and O. Hoegh-Guldberg. 2005. Global Assessment of Coral Bleaching and Required Rates of Adaptation under Climate Change. Global Change Biology 11: 2251–2265.

the frequency of bleaching episodes in two decades in the next fifty years[48]. The frequency of Bleaching Alert Level 2 for the decades 2030 to 2039 and 2050 to 2059 based on an IPCC A1B ("business-as-usual") emissions scenario is provided in Figure 2. This modelling predicts that the majority (98%) of the world's coral reefs will experience bleaching events at least once every five years by the end of this century[49]. In fact the committed warming from the accumulation of greenhouse gases in the atmosphere up until the year 2000 alone is sufficient to cause the majority of the world's coral reefs to experience harmfully frequent thermal stress events by the year 2100[50].

Figure 3 (after Burke et al., 2011)



The above scenarios are based on the predicted threat of severe bleaching events according to thermal stress but do not take into account the influence of other stressors on the susceptibility of corals to bleaching. Both local and other global threats can reduce the ability of a corals to withstand or survive a bleaching event. Local stressors such as increased pollution and sedimentation from land-based sources, physical damage to the reef and the over-exploitation of marine resources can all act to compound the effects of bleaching on corals. Bleached corals also appear to be more susceptible to predators such as the crown-of-thorns starfish (COTS) and to coral diseases. COTS and particularly

[48] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[49] Donner, S. 2009. Coping with Commitment: Projected Thermal Stress on Coral Reefs under Different Future Scenarios. PLoS ONE 4: e5712.

[50] Ibid

disease outbreaks often occur following coral bleaching events[5152]. The increased prevalence of coral diseases in recent years has been linked to degraded water quality and also warming due to climate change[53]. Other more global threats can also influence bleaching susceptibility. Ocean acidification, a predictable consequence of increasing atmospheric carbon dioxide (CO_2)[54], can increase the likelihood of temperature-induced coral bleaching[55]. Studies have shown that high CO_2 levels can act in synergy with elevated temperatures to lower the thermal bleaching thresholds of both corals and crustose coralline algae (CCA)[56]. The productivity and calcification of CCA were also significantly reduced in such conditions indicating that CCA is highly sensitive to changes in acidity and the effects are exacerbated by higher temperatures. CCA are an important settlement cue for invertebrate larvae including corals and contribute significantly to reef accretion and cementation[57]. A decline in CCA abundance can therefore have potentially dramatic ecological consequences for coral reefs. It has been suggested that sensitive reef-building species such as CCA may be pushed beyond their thresholds for growth and survival within the next few decades[58].

The effects of multiple stressors on coral reefs which include both global (CO_2-derived) stressors (acidification and thermal stress) and local threats including pollution, overfishing and physical damage have been forecast for the years 2030 and 2050[59]. By 2030 more than 90% of coral reefs will be threatened with almost 60% facing high, very high or critical threat levels. In 2050 almost no reefs will be under low threat and three-quarters will be at or above a high threat level. These projections assume that current local threats remain constant and do not account for changes in human pressure, management or policy.

The interaction between global stressors (acidification and warming) and key local-scale processes (herbivory and nutrification) that are altered through overfishing and pollution respectively has recently been modelled for coral reefs[60]. The study found that increasing levels of CO_2 will reduce coral survivorship and growth through the effects of warming (bleaching) and acidification respectively. This in turn will decrease reef resilience by reducing the threshold at which local stressors such as herbivore overfishing and nutrification drive coral reef communities from a coral-dominated to an algal-dominated state. Reduced resilience is likely to be a consequence of both global and local stressors working both independently and synergistically. The reduction or removal of local threats is regarded as a key aspect of promoting reef resilience to global stressors caused by climate

[51] Bruno, J. F., E. R. Selig, K. S. Casey, C. A. Page, B. L. Willis, C. D. Harvell, H. Sweatman, and A. M. Melendy. 2007. Thermal Stress and Coral Cover as Drivers of Coral Disease Outbreaks. PLoS Biol 5: 1220–1227

[52] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[53] Harvell, C. D., and E. Jordán-Dahlgren. 2007. "Coral Disease, Environmental Drivers, and the Balance between Coral and Microbial Associates." Oceanography and Marine Biology: an Annual Review 20: 58–81

[54] Doney, S.C., Fabry, V.J. Feely, R.A., and Kleypas, J.A. 2009. Ocean acidification: The Other CO_2 problem. Ann. Rev. Mar. Sci. 1: 69-192.

[55] Anthony, K. R. N., D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Hoegh-Guldberg. 2008. "Ocean Acidification Causes Bleaching and Productivity Loss in Coral Reef Builders." Proceedings of the National Academy of Sciences 105: 17442.

[56] Ibid

[57] Birrell CL, McCook LJ, Willis BL, Diaz-Pulido G (2008) Effects of benthic algae on the replenishment of corals and the implications for the resilience of coral reefs. Oceanogr Marine Biol Ann Rev 46:25–64.

[58] Anthony, K. R. N., D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Hoegh-Guldberg. 2008. "Ocean Acidification Causes Bleaching and Productivity Loss in Coral Reef Builders." PNAS 105: 17442

[59] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp. (Table 4.10).

[60] Anthony, K. R. N., J. A. Maynard, G. Diaz-Pulido, P. J. Mumby, P. A. Marshall, L. Cao, and O. Hoegh-Guldberg. 2011. Ocean acidification and warming will lower coral reef resilience. Global Change Biology. 17: 1798-1808.

change and may buy time for responses to climate change to take effect[61]. In particular local reef management efforts to maintain high herbivore grazing and low nutrients have the potential to play a critical role in maintaining coral resilience while CO_2 concentrations are stabilized[62]. Moreover, future predictions of the frequency and severity of coral bleaching events affecting a coral reef need to take into consideration the multiple interactions between global and local stressors (e.g. bleaching-acidification interactions or bleaching/acidification/herbivore overfishing/nitrification dynamics).

Future predictions are subject to a number of uncertainties and limitations[63]. The many factors that influence coral bleaching at multiple scales are not completely understood but the use of thermal stress remains the best indicator at the present time even though it cannot always predict the occurrence and severity of bleaching. Making projections using climate-based models means relying on a number of assumptions about future greenhouse gas emissions, models of ocean chemistry and estimates of atmospheric and ocean warming and the thresholds for damaging bleaching. The complexity of coral reef systems and the range in bleaching thresholds between coral species also means that future projections are somewhat simplistic but are currently the 'best-guess' of future coral reef status. Projections incorporating the predicted increase in local threats over the coming decades coupled with the effects of climate change stressors are needed. Similarly, making future projections for a range of management scenarios and factoring in the economic costs and benefits of management or policies would be highly useful for decision-makers.

The global economic impact of coral bleaching events has been estimated for moderate and severe levels of bleaching[64]. Total costs of bleaching over a 50 year time horizon with a 3% discount rate were estimated at more than US$ 84 billion for severe levels and US$ 20 billion for moderate levels. When split into three categories of fisheries, tourism and biodiversity, the tourism value is highest with nearly US$ 40 billion in the severe bleaching case, followed by fisheries (US$ 23 billion) and biodiversity (US$ 22 billion) (Figure 12). At a regional level the highest costs of bleaching were in Australia (US$ 28.4 billion) and Southeast Asia (US$ 38.3 billion). These estimates are almost 10 years old and do not take into account the added effects of ocean acidification or the interaction between global and local stressors. A slightly more recent estimate for the Great Barrier Reef predicts that the Australian economy could lose between US$2.2 billion and US$5.3 billion over the next 19 years due to degradation of the GBR caused by global climate change[65]. The projected effect of climate change on catch potential in global fisheries indicates a decline of 40% in tropical waters by 2055[66] but the socio-economic impacts have not been estimated for this.

[61] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[62] Anthony, K. R. N., J. A. Maynard, G. Diaz-Pulido, P. J. Mumby, P. A. Marshall, L. Cao, and O. Hoegh-Guldberg. 2008. Ocean acidification and warming will lower coral reef resilience. Global Change Biology. 17: 1798-1808

[63] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[64] Cesar, H., Burke, L. and Pet-Soede, L. 2003. The economics of worldwide coral reef degradation. Cesar Environmental Economics Consulting.

[65] Hoegh-Guldberg, O., and H. Hoegh-Guldberg. 2004. Implications of Climate Change for Australia's Great Barrier Reef. Sydney, Australia: World Wildlife Fund

[66] Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R.E.G., Zeller, D., Pauly, D., 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology 16, 24–35.

III. PROGRESS MADE ON THE IMPLEMENTATION OF THE SPECIFIC WORK PLAN ON CORAL BLEACHING

The specific work plan on coral bleaching[67] was adopted in 2004 to provide guidance to Parties on priority areas for action, grouped under five broad headings: Management actions and strategies to support reef resilience, rehabilitation and recovery; Information Gathering and Targeted Research; Policy development and implementation; Capacity Building and Financing. This section provides an overview of global progress towards these priority objectives supplemented by case studies to illustrate advances and challenges in national contexts. The overview is primarily based on information provided by Parties and Organisations in response to the request for information by the CBD Secretariat in September 2011 and supplemented by more general information extracted from National Reports and other sources. Specific responses to the request for information are summarised in annex I. A summary of some of the activities undertaken by Parties as part of their National Biodiversity Action Plans that support the implementation of the work plan are also provided in Annex 2.

As well as the efforts by Governments and international agencies to implement the coral bleaching work plan the extensive activities of non-governmental organisations (NGO's), research institutes and universities should also be recognized for each of the following themes.

1. Management actions and strategies to support reef resilience, rehabilitation and recovery

Since the adoption of the specific work plan on coral bleaching there has been a concerted effort to better understand reef resilience and develop management actions or strategies to enhance resilience and support reef rehabilitation and recovery. There is improved understanding of resilience factors and availability of generic protocols to assess vulnerability and inform management decision making. The advances made since 2005 have built on the key achievements made just prior to the adoption of the CBD work plan. In 2004 WWF, the World Fish Center and the Great Barrier Reef Marine Park Authority (GBRMPA) released a Global Protocol for Assessment and Monitoring of Coral Bleaching[68] whilst a reef resilience toolkit designed for reef managers was first released by The Nature Conservancy (TNC) in the same year and was updated in 2008[69]. GBRMPA, IUCN and NOAA produced a coral bleaching guide for reef managers in 2006[70]. The IUCN Climate Change and Coral Reefs Marine Working Group (formerly the IUCN Resilience Science Working Group), focused on coral bleaching, resilience and climate change, was also established in 2006. The main goal of the working group is to draw on leading practitioners in coral reef science and management to streamline the identification and testing of management interventions to mitigate the impacts of climate change on coral reefs. Through the work of this group the key factors that are important in determining the resistance or resilience of corals to bleaching have been described along with a preliminary list of tools and strategies to enhance coral reef resilience[71]. Subsequently, the improved understanding of resilience factors has enabled the further development of the R^2 toolkit and the production of a rapid assessment protocol focused on coral bleaching and thermal stress to assess the resilience of coral reefs[72]. This protocol has been tested in a number of coral reef regions including

[67] Adopted by the Conference of the Parties in its decision VI/3 and amended by decision VII/5 (Appendix 1 of Annex 1)

[68] Oliver, J, Marshall PA, Setiasih N, and L Hansen (2004) A global protocol for assessment and monitoring of coral bleaching. WorldFish Center and WWF Indonesia, Jakarta, Indonesia

[69] TNC. 2004. R^2- The Reef Resilience Toolkit CD-ROM by The Nature Conservancy (http://www.reefresilience.org/).

[70] Marshall P, Schuttenberg H. 2006. A Reef Manager's Guide to Coral Bleaching. Great Barrier Reef Marine Park Authority, Townsville, Australia.

[71] Grimsditch, G. D., and R. V. Salm. 2006. Coral Reef Resilience and Resistance to Bleaching. Gland, Switzerland: IUCN

[72] Obura, D.O. and Grimsditch, G. (2009). Resilience Assessment of coral reefs – Assessment protocol for coral reefs, focusing on coral bleaching and thermal stress. IUCN working group on Climate Change and Coral Reefs. IUCN, Gland, Switzerland. 70 pp.

East Africa[73], the Western Indian Ocean[74] and the Caribbean[75]. Furthermore resilience principles have been applied to coral reef management activities and incorporated into the design of new MPAs and networks in most coral reef regions around the world[76]. To date resilience principles have been applied in 17 reef sites located in the Caribbean and Indo-Pacific[77]. Box 1 provides an example of the progress made to support reef resilience at one of these sites, in Palau.

Detailed coral bleaching response plans have also been developed and implemented in a few locations such as the Great Barrier Reef[78] and Florida. Guidance is provided in the R^2 toolkit to develop a more simplified version of a response plan for sites where implementation resources are limited. Although significant progress has been made regarding the testing and refining of resilience assessment protocols there is a need for further testing and validation in a wider range of locations and regions. Many of the protocols developed to date are also rather detailed, requiring a medium to high level of expertise and considerable data collection. The development of a more practical and simplified assessment protocol using clearly defined resilience indicators is currently in progress. Guidance on using reef resilience data in spatial planning is also in preparation supported by IUCN, TNC, UNEP and a number of academic institutions. For example the Australian Institute of Marine Science (AIMS) is developing modelling tools which show that water quality mitigation in combination with spatial planning for reef connectivity is an effective way to maximize coral reef resilience. Climate change action plans for specific coral reef areas have been developed and implemented by some countries such as Australia for the Great Barrier Reef (GBR). These plans can improve the understanding of climate change vulnerabilities and enable the identification and testing of adaptation strategies to build reef resilience. The GBR Climate Change Action Plan addresses risks from coral bleaching, as well as other risks resulting from elevated atmospheric greenhouse gas concentrations through four key objectives: targeted science; building ecosystem resilience; supporting adaptation in industries and communities; and reducing climate footprints[79].

[73] Grimsditch G., Tamelander J., Mwaura J., Zavagli M., Takata Y., Gomez T. (2009) Coral Reef Resilience Assessment of the Pemba Channel Conservation Area, Tanzania. Gland, Switzerland: IUCN. 40pp.

[74] Obura, D. O. 2009. Coral Reef Resilience Assessment of the Nosy Hara Marine Protected Area, Northwest Madagascar. Gland, Switzerland: IUCN. 35pp

[75] IUCN (2011). Coral Reef Resilience Assessment of the Bonaire National Marine Park, Netherlands Antilles. Gland, Switzerland: IUCN. 51pp

[76] http://www.reefresilience.org/Toolkit_Coral/C8_CaseStudies.html

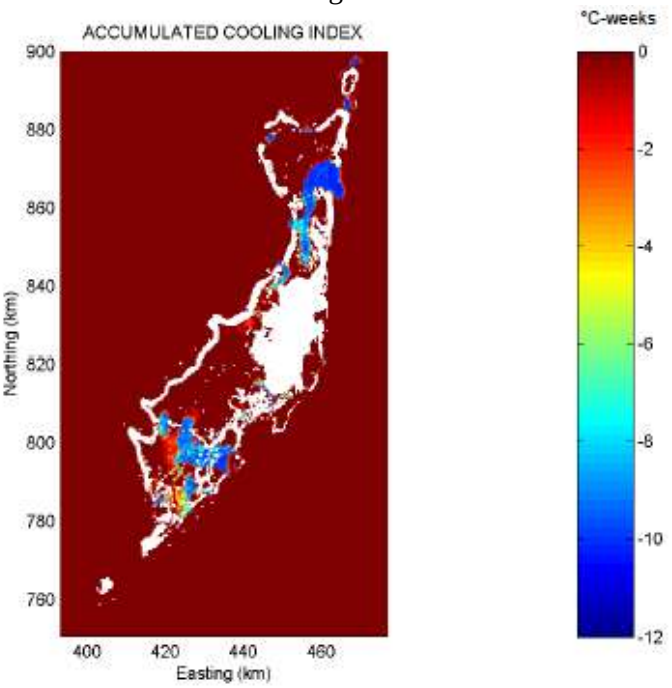
[77] Although not yet in the Middle East / Red Sea or South-east Asia / Japan.

[78] GBRMPA 2011. Coral Bleaching Response Plan 2010-2011. Great Barrier Reef Marine Park Authority, Australian Government. 36 pp.

[79] Great Barrier Reef Climate Change Action Plan 2007-2011. Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Australian Government.

Box 1: Enhancing Reef Resilience in Palau using heat stress modelling

A number of organisations (NOAA, TNC and AIMS) provided support to the government of Palau to implement a Protected Areas Network (PAN) based on resilience principles. The resilience assessment protocol was firstly applied by TNC in Palau to provide a resilience data layer that could feed into the PAN design.



The Palau model of thermal capacitance, expressed as surface-cooling degree weeks.

Part of this process involved producing a heat stress model for Palau to predict areas that may resist temperature change and remain cooler during a bleaching event*. To do this, physical parameters such as current strength, bathymetry and vertical temperature profile over a tidal cycle (1 month) were fed into a model. The resulting map provided an overall picture of thermal capacity for Palau's coral reefs. The blue regions represent the most cooling at the surface due to mixing and hence represent the regions with the lowest temperature variability and high thermal capacitance. This provides the organisms that live there with greater protection against thermal stress. The red regions are the opposite, having little mixing, high temperature variability, and low thermal capacitance. These areas are at greater risk of thermal stress. This information was considered in the design of the Palau PAN. The innovative techniques and methodologies used to produce the heat stress model for Palau provide an extremely useful tool for future MPA/PAN design.

* Skirving, W.J., S.F. Heron, C.R. Steinberg, C. McLean, B.A.A. Parker, C.M. Eakin, M.L. Heron, A.E. Strong, and L.F. Arzayus. 2010. *Determining Thermal Capacitance for Protected Area Network Design in Palau*. Silver Spring, MD: NOAA Coral Reef Conservation Program. NOAA Technical Memorandum CRCP 12. 317 pp.

A number of Marine and Coastal Protected Area (MCPA) networks have also included climate change resilience principles in their design, including those in Palau, the Mesoamerican Reef, Quintana Roo, Mexico, Grenada and sites in Indonesia[80]. A study of the efficacy of MPAs in increasing coral reef resilience showed that, on average, coral cover within MPAs remained constant between 1969 and 2006 while coral cover on unprotected reefs decreased with these trends more noticeable in the long-term[81].

[80] UNEP/CBD/SBSTTA/14/INF/2

[81] Selig ER, Bruno JF (2010) A Global Analysis of the Effectiveness of Marine Protected Areas in Preventing Coral Loss. PLoS ONE 5(2): e9278. doi:10.1371/journal.pone.0009278

MPA coverage in tropical waters has increased considerably since the adoption of the coral bleaching work plan. Globally, approximately 27% of coral reefs were located within some form of MPA by the end of 2010 although the area protected varies considerably between regions[82]. For example 75% of Australian reefs are within MPAs while only 12% of coral reefs in the Middle East are spatially protected. A review of CBD National and Voluntary Reports indicated that 94% of Parties stated that the development of new MCPAs was part of their future plans in 2005 (3rd National Report). By 2008-2009 all the 4th National Reports and voluntary reports showed that all reporting countries had established one or several new MCPAs and some had developed national networks[83].

Although MPA coverage of coral reefs is improving there is an issue with their effectiveness. A recent global analysis of over 1000 coral reef MPAs rated for ecological effectiveness by regional experts revealed that almost half (47%) were regarded as ineffective[84]. In terms of management effectiveness only 6% of the world's coral reefs by area were regarded as effective with 13% partially effective. For some regions this level drops considerably, only 3% of coral reefs in Southeast Asia were regarded by experts to be managed either partially or wholly effectively within their MPAs.

2. Information Gathering and Targeted Research

Since the adoption of the coral bleaching work plan there has been a significant increase in the availability of information on the status and function of species and habitats within coral reef ecosystems, although there are stark economies of scale between countries. Long-term coral reef monitoring has further developed to include both ecological and socio-economic information while assessments of bleaching events have become more standardized[85]. The Global Coral Reef Monitoring Network (GCRMN) has continued to grow and provide regular detailed reports on the status of coral reefs around the world[86]. As well as the global reports, regional status assessments have been published to document damaging events[87] including mass coral bleaching[88]. Of particular note has been the increase in the socio-economic monitoring of coastal communities that rely on coral reefs for food or income. The Global Socioeconomic Monitoring Initiative for Coastal Management (SocMon)[89] serves as the socioeconomic monitoring arm of the GCRMN. The SocMon Initiative has grown considerably over the last decade, now operates in six coral reef regions around the world and has produced regional guidelines for the Caribbean, Western Indian Ocean, Southeast Asia, Pacific and South Asia[90]. A global assessment tropical coastal socio-economic conditions in 2008 was produced[91] while a draft set of indicators to assess the community-level social vulnerability to climate change have recently been released for field testing[92].

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[82] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[83] UNEP/CBD/SBSTTA/14/INF/2

[84] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[85] Oliver, J, Marshall PA, Setiasih N, and L Hansen (2004) A global protocol for assessment and monitoring of coral bleaching. WorldFish Center and WWF Indonesia, Jakarta, Indonesia

[86] Wilkinson, C. Status of Coral Reefs of the World: 2008. (Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, 2008

[87] Wilkinson, C., D. Souter, and J. Goldberg. 2005. Status of Coral Reefs in Tsunami Affected Countries: 2005. Townsville, Australia: Australian Institute of Marine Science.

[88] Wilkinson, C., Souter, D. 2008. Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, 152 p

[89] http://www.socmon.org/default.aspx

[90] http://www.socmon.org/publications.aspx

[91] Loper, C. and 11 co-authors. 2008. Socio-economic conditions along the world's tropical coasts: 2008. SocMon Initiative. 52 pp.

[92] Wongbusarakum, S. and Loper, C. 2011. Indicators to assess community-level social vulnerability to climate change: An addendum to SocMon and SEM-Pasifika regional socioeconomic monitoring guidelines. First draft for public circulation and field testing. SocMon Initiative. 41 pp.

The information collected by GCRMN monitoring programmes feeds into ReefBase[93], the global information system for coral reefs. ReefBase has developed considerably since the adoption of the work plan, and amongst other functions, provides country level data for the status of coral reefs and resources, key threats to reefs and their management including monitoring programmes and the use of protected areas. ReefBase also provides an up to date global record of bleaching observations that can be presented graphically using the online Geographic Information System (ReefGIS). Coral reef information hosted on the online Ocean Data Viewer[94] has been updated for global warm water coral reef distribution in 2010 and the coral data layer is currently being standardized to better support monitoring and assessment at local scales[95].

There has been a substantial improvement in the detection and reporting of potential bleaching events through the development of global and regional early warning systems. The NOAA's Coral Reef Watch programme[96] has continued to develop a range of tools to quickly identify areas at risk of bleaching. When bleaching conditions occur, these tools can be used to trigger bleaching response plans and support appropriate management decisions. The continuous monitoring of Sea Surface Temperatures (SST's) at global scales provides researchers and stakeholders with tools to understand and better manage the complex interactions leading to coral bleaching. Products, like 'Hotspots' and 'Degree Heating Weeks' monitor SST anomalies and accumulated heat stress at relatively low resolution (0.5° or ~ 50 km)[97]. The Bleaching Outlook System uses global SST forecast models to provide outlooks of bleaching thermal stress[98]. Information for large-scale bleaching thermal stress events is available weeks to months in advance which can be very useful for coral reef managers and researchers. Building on the pioneering work at NOAA the Australian Government developed ReefTemp[99][100], a high resolution remote sensing application for the Great Barrier Reef that can detect sea surface temperature and coral bleaching risk at the scale of an individual reef (~ 2 km). Australia has also been developing a long-term bleaching forecasting system using the Predictive Ocean Atmosphere Model for Australia[101]. Other regional early warning systems are also in place for Florida, the Mesoamerican Barrier Reef and the Western Indian Ocean.

Targeted research on coral bleaching has been conducted by many research institutions and conservation-based organisations around the world. Scientific knowledge on coral bleaching was reviewed in some detail in 2009[102]. Since the adoption of the work plan on coral bleaching, researchers have broadened the field of investigation to include other climate change effects such as ocean acidification[103] and the interaction between both global and more local stressors on coral

[93] http://www.reefbase.org/main.aspx

[94] http://data.unep-wcmc.org/about

[95] http://icriforum.org/sites/default/files/ICRIGM26-MR-UNEP-WCMC.pdf

[96] http://coralreefwatch.noaa.gov/satellite/index.html

[97] Strong, A. E., F. Arzayus, W. Skirving, and S. F. Heron. 2006. Identifying coral bleaching remotely via Coral Reef Watch: Improved integration and implications for changing climate, in Coral Reefs and Climate Change: Science Management, (Coastal and Estuarine Studies), vol. 61, pp. 163–180.

[98] Liu, G., L.E. Matrosova, C. Penland, D.K. Gledhill, C.M. Eakin, R.S. Webb, T.R.L. Christensen, S.F. Heron, J.A. Morgan, W.J. Skirving and A.E. Strong . 2009. NOAA Coral Reef Watch Coral Bleaching Outlook System. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida: 951-955.

[99] http://www.cmar.csiro.au/remotesensing/reeftemp/web/ReefTemp_application.htm

[100] Maynard, J.A., Turner, P.J., Anthony, K.R.N., Baird, A.H., Berkelmans,, R., Eakin, C.M, Johnson, J., Marshall, P., Packer, G.R., Rea, A. and Willis, B.L. 2008. ReefTemp: An interactive monitoring system for coral bleaching using high-resolution SST and improved stress predictors. Geophysical Research Letters 35. doi:10.1029/2007GL032175

[101] http://poama.bom.gov.au/

[102] Van Oppen, M.J.H. and Lough, J.M. (eds). 2009. Coral bleaching patterns, processes, causes and consequences. Ecological Studies 205. 178 pp.

[103] Anthony, K. R. N., D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Hoegh-Guldberg. 2008. "Ocean Acidification Causes Bleaching and Productivity Loss in Coral Reef Builders." Proceedings of the National Academy of Sciences 105: 17442

reefs[104][105]. Socio-ecological studies of coastal communities adjacent to, and often dependent upon, coral reefs and their vulnerability to climate change effects is also a growing field of interest[106]. A specific targeted research programme that has involved a considerable amount of work on coral bleaching is the Coral Reef Targeted Research for Capacity Building and Management Program (CRTR)[107]. This multi-disciplinary international research initiative is working on six research themes (bleaching, disease, connectivity, remote sensing, restoration, and modelling and decision support), all of which are relevant to the coral bleaching work plan. For example, the CRTR bleaching working group has focussed on a number of research areas including: the susceptibility and tolerance of corals to rising sea temperatures; the impact of global climate change on coral reef ecosystems; management tools to identify and monitor stress on coral reefs; and understanding of the socio-economic implications of climate change[108]. The CRTR program has produced a range of useful tools and products that will provide critical guidance for future coral reef management.

The type of information gathered by Parties at the national level is summarised in Annex 2. Barbados provides an example of the activities being conducted, and demonstrates the challenges and advances made to fully implement the work plan (Box 2).

Box 2. Barbados: Implementation of the Coral Bleaching Work Plan

The Coastal Zone Management Unit (CZMU) of Barbados conducts a long-term coral reef monitoring program which is a national assessment every 5 years. In combination with coral bleaching surveys this information is being used to get an accurate picture at the long term effects of coral bleaching on reef health. The CZMU has completed multiple coral bleaching assessments (2005, 2006, 2009, 2010) to monitor bleaching onset, severity and resulting mortality with the data published in two papers in association with the University of the West Indies. Bleaching survey data is submitted to NOAA Coral Reef Watch and ReefBase contributing to global databases. The national budget for coral reef related activities is limited which can restrict the frequency or extent of activities and can potentially limit the ability to conduct rapid assessments.

To provide real-time measurement of sea temperatures (to compare to remote SST estimates) on Barbadian reefs the CZMU has installed in situ Hobo temperature probes at 8 reef sites around the island that continuously collect temperature data.

Barbados participates in global coral reefs programs as an active member of ICRI and also acts as a hub for coral reef related activities in the region, hosting regional workshops for coral reef and coastal zone management. The country has limited capacity to adequately consider climate change threats to coral reefs and has not yet completed a resilience assessment of the island's reefs. Barbados has implemented a coastal zone management plan but does not have a specific coral reef action plan.

[104] Veron, J.E.N., O. Hoegh-Guldberg, T.M. Lenton, J.M. Lough, D.O. Obura, P. Pearce-Kelly, C.R.C. Sheppard, M. Spalding, M.G. Stafford-Smith, & A.D. Rogers (2009) The coral reef crisis: The critical importance of <350 ppm CO2. Marine Pollution Bulletin (58).

[105] Anthony, K. R. N., J. A. Maynard, G. Diaz-Pulido, P. J. Mumby, P. A. Marshall, L. Cao, and O. Hoegh-Guldberg. 2011. Ocean acidification and warming will lower coral reef resilience. Global Change Biology. 17: 1798-1808.

[106] Cinner, J.E., McClanahan, T.R., Graham, N.A.J., Daw, T.M., Maina, J., Stead, S.M., Wamukota, A., Brown, K., and Bodin, Ö. 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Global Environmental Change 22: 12–20.

[107] http://www.gefcoral.org/Home/tabid/2967/language/en-US/Default.aspx

[108] Coral Reef Targeted Research Program. 2009. Bleaching and Related Ecological Factors: CRTR Working Group Findings 2004-2009. 127 pp. (http://www.gefcoral.org/LinkClick.aspx?fileticket=zv3UV2E9Dzg%3d&tabid=3301&language=en-US)

3. Capacity-building

The capacity of coral reef nations to manage coral bleaching events has increased since the adoption of the coral bleaching work plan through the efforts of governments and NGOs, often working together in partnerships. However, the increase in national capacity varies considerably between nations and regions with some least developed nations still lacking the human and/or technical resources to implement coral reef management programmes that include measures to document and manage the effects of climate change stressors such as bleaching.

There has been a substantial increase in the opportunities for training to understand the causes of coral bleaching, the ecological and societal effects of bleaching events and the theory and practice of reef resilience. The Reef Resilience Partnership and Network has conducted training programmes for reef managers and conservation practitioners in more than 50 countries located in a number of regions (Southeast Asia, Caribbean, W. Pacific, South Asia, Western Indian Ocean, and the Red Sea) since 2004, based on the Reef Resilience (R^2) toolkit. As well as mentor training an online course is available that aims to provide coral reef managers, trainers, and policymakers with guidance on building resilience to climate change into the design of Marine Protected Areas (MPAs) and daily management activities[109]. The online course has been completed 700 people in over 70 coral reef nations to date (TNC, Annex 1). Training the trainers workshops have also been held in the Caribbean and Pacific with further ones planned for Southeast Asia and the Western Indian Ocean. Government organisations from developed nations are also operating training programmes to build understanding and capacity in responding to coral bleaching events, including early warning and prediction, rapid assessment, communication and management interventions, both within their overseas jurisdictions and in other countries (e.g. NOAA, Annex 1). The value of coral reefs in terms of ecosystem services and direct revenue from tourism was also part of the capacity building component of the South East Asia Coral Bleaching Rapid Response project (CSIRO, Annex 1). Need-based learning exchanges have also been held to share the latest science and application of resilience with coral reef managers. For example a Hawaii/Palau exchange addressed threats to watersheds and management strategies while a bleaching monitoring and analysis workshop was held in Bali.

Networks continue to be a key mechanism for capacity building. As well as the resilience network mentioned above a number of other networks are important for increasing understanding of coral bleaching and other direct or indirect anthropogenic effects on coral reefs and how to best manage these stressors. The Locally Managed Marine Area (LMMA) Network[110] is the driving force behind community-based capacity building in the western Pacific and parts of Southeast Asia with a particular emphasis on community-based adaptive management. The LMMA network works closely with the SocMon Initiative to deliver training in socio-economic assessment techniques to local practitioners and communities. The International Coral Reef Initiative (ICRI) has also been instrumental in training and capacity building through its operational arm, the International Coral Reef action Network (ICRAN)[111]. Activities to improve coral reef management through capacity building have included the implementation of a training of trainers programme in MPA management and organizing specific training workshops and sessions at the International Tropical Marine Ecosystems Management Symposia for bleaching rapid response and management to enhance resilience[112].

A range of tools, guides and protocols have also been developed in relation to coral bleaching and management since the coral bleaching plan was adopted including the R^2 toolkit, bleaching and resilience assessment protocols, coral bleaching response plans, climate change action plans for coral reefs and managers guides to coral bleaching. However, there are still many coral reef nations that

[109] http://www.reefresilience.org/Training_Online.html

[110] http://www.lmmanetwork.org/home

[111] http://www.icran.org/index.html

[112] http://www.itmems.org/index.htm

have not yet developed or implemented resilience or bleaching protocols for assessment and management, although this is regarded as a priority by many Governments.

Multi-disciplinary approaches to coral reef research have also focused on capacity-building in coral reef nations and raising awareness of climate change and coral reefs through the communication of scientific research findings. An example is the GEF Coral Reef Targeted Research Program (Box 3) that has conducted both in-country capacity building via regional nodes and developed a range of tools and guidelines for coral reef management.

Box 3. The Coral Reef Targeted Research and Capacity-Building for Management

The CRTR Program is a global initiative conducting research, training and knowledge exchange activities through four geographic nodes (Centres of Excellence) in the Philippines, Mexico, Zanzibar (Tanzania) and Australia. The Programme supports a network of international researchers and students from 23 countries, the majority of which are developing coral reef nations.

In country capacity building activities have included:

- Conducting training workshops focusing on regionally emerging issues within the six research themes at the Centres bringing together coral reef researchers from different countries in the regions;
- increasing the coral reef research and training capacity of the Centres of Excellence, to extend information and skills to local and regional stakeholders, managers and researchers;
- Implementing community-based research projects such as the coral reef restoration project in Bolinao (Philippines) or the use of local traditional knowledge to help inform policy development in Tanzania.

A Local Government Initiative was also completed to assist local government 'green' their policies and business practices to align them with factors essential to coral reef health and productivity. To achieve this, the Initiative developed the ability of the Centres of Excellence to partner with local governments throughout the target regions and educate and help them adopt these 'green' practices. The outcomes and products of the Local Government Initiative included:

- Better informed local government leaders who understand the implications of their development policies and business practices on coral reefs;
- Commitment by local leaders to change day-to-day business that threatens coral reef ecosystem health and productivity by adopting reef-friendly practices; and
- A 'demonstration' effect which encourages other local government officials to take action and champion needed reforms
- A Practical Guide to Coral Reef-Friendly Practices for Local Governments

Further details on these capacity building initiatives can be found on the CRTR website (http://www.gefcoral.org/Home/tabid/2967/language/en-US/Default.aspx) along with project reports, tools and guidelines.

The CRTR Program is a partnership between the GEF, the World Bank, The University of Queensland, NOAA and approximately 50 research institutes around the world.

4. Policy development and implementation

Policy development that directly or indirectly supports the implementation of the coral bleaching work plan has occurred at a range of levels, from community-based laws to restrict fishing or designate locally managed MPAs[113] to global resolutions to protect coral reef for sustainable livelihoods and development[114]. Global policy recommendations have focused, amongst others, on

[113] Govan, H., Tawake, A. and Tabunakawai, K. 2006. Community based marine resource management in the South Pacific. Parks Vol 16 No 1 Community Conserved Areas pp. 63-67.

[114] UNGA Resolution 65/150

reducing primary localized stressors such as overfishing and pollution, increasing MPA coverage and effectiveness, building consensus and capacity to improve management and governance and increasing socio-ecological resilience in the face of climate change[115] [116] [117] [118]. The degree of analysis to produce these comprehensive recommendations for policy and action has been extensive. The critical issue is to ensure that recommendations for action are taken on board by policy makers, written into legislation and implemented effectively.

The vulnerability of coral reef ecosystems to anthropogenic stressors and the importance of coral reefs to humanity have been recently recognized by the UNGA Resolution 65/150 on the protection of coral reefs for sustainable livelihoods and development and by the United Nations Secretary General's report. This report recommended that UN-Oceans could play an expanded role to ensure coordinated and coherent action across the United Nations system with respect to coral reef protection. The creation of a specialized Coral Reefs Task Force under its umbrella, comprising experts of its respective member organizations and collaborating with national Coral Reef Task Forces, could be considered.

The annual resolutions of the UNGA on oceans and law of the sea also support the implementation of the coral bleaching work plan by addressing a number of issues related to coral reefs including coral bleaching and other stressors such as ocean acidification, risks to marine biodiversity, coral reef and integrated watershed management, and economic assessment techniques for non-use value of coral reefs[119].

The extent to which legislation has been established or reformed to protect coral reef ecosystems from localized stressors varies considerably between countries ranging from specific acts to conserve coral reefs such as the Coral Reef Conservation Act in the United States to a lack of comprehensive policy for integrated watershed management in China[120]. There is also a lack of specific policy to mitigate the effects of climate change on coral reef environments for many Parties. Australia does have such policies in place and is implementing them with full support provided by the Government. An example is the development and implementation of the Great Barrier Reef Climate Change Action Plan (Box 4).

[115] Wilkinson C. 2008. Status of the Coral Reefs of the World: 2008. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia

[116] GLOBE Action Plan for Coral Reefs. 2010. GLOBE International Commission on Land Use Change and Ecosystems and the Zoological Society of London. 58 pp.

[117] Burke, L., Reytar, K., Spalding, M. and Perry, A. 2011. Reefs at Risk Revisited. World Resources Institute, Washington DC, USA. 114 pp.

[118] UNGA 2011. Protecting coral reefs for sustainable livelihoods and development. Report of the Secretary General, August 2011. 26 pp.

[119] UNGA Resolution 65/37A (various paragraphs)

[120] GLOBE Action Plan for Coral Reefs. 2010. GLOBE International Commission on Land Use Change and Ecosystems and the Zoological Society of London. 58 pp. (Appendix)

Box 4: The Great Barrier Reef Climate Change Action Plan, Australia

The Australian Government commissioned a national Biodiversity Vulnerability Assessment to help increase understanding of how to prepare for future climate change, including the Great Barrier Reef. The GBR vulnerability assessment provided the information required to develop a comprehensive climate change action plan. The GBR Climate Change Action Plan outlines a coordinated response to the threat of climate change for the GBR. It identifies strategies for direct actions and partnerships that will increase the resilience of the GBR to climate change. This will help minimise impacts on GBR industries such as tourism, commercial and recreational fishing. The action plan is underpinned by the knowledge, partnerships and adaptation measures that have been established in the first three years of the GBR Climate Change Response Program, funded by the Australian Government through the Australian Greenhouse Office and the GBRMPA.

The action plan is built on well-established resilience principles and outlines a five year program of actions that reef managers can take, in collaboration with stakeholders and other partners, to minimise the damage caused by climate change. The action plan is closely coordinated with other relevant science and adaptation initiatives, including the National Climate Change Adaptation Framework and research programs funded by the Marine and Tropical Sciences Research Science Facility (MTSRF) and the Australian Research Council. It also complements the climate change response strategies of the Queensland government and the GBR marine tourism industry. The plan is organized around four objectives: targeted science, a resilient GBR ecosystem, adaptation of industries and regional communities, and reduced climate footprints.

Further information: www.climatechange.gov.au and www.gbrmpa.gov.au

International collaboration to conserve and manage coral reefs in terms of policy development and implementation is occurring through joint actions between United Nations agencies. The Convention on Biological Diversity (CBD) and the Ramsar Convention on Wetlands have been collaborating through joint work plans (JWPs) since 1999 and progress has been made regarding policy development for the tropical coastal zone in the third and fourth JWPs. For example, the third joint work plan (2002-2006) made progress in developing and implementing principles and guidelines for Integrated Coastal Zone Management (ICZM) and the designation of mangroves and coral reefs and Wetlands of International Importance[121].

The CBD and the Food and Agriculture Organization of the United Nations (FAO) also have a joint work plan which is in its second iteration (2011-2020). However, it is predominantly focused on terrestrial environments and its overarching goal is to synergize the implementation of the FAO Commission on Genetic Resources for Food and Agriculture's Multi-Year Plan of Work with the CBD Strategic Plan for Biodiversity 2011-2020. CBD-FAO collaboration more relevant to coral reefs, fisheries and climate change occurs through the UN-Oceans Task Force, Global Partnership Climate, Fisheries and Aquaculture (PaCFA)[122], a voluntary global level initiative among some 20 international organizations and sector bodies concerned with climate change interactions with global waters and living resources and their social and economic consequences. Formed in 2010, PaCFA is a relatively new initiative and will require more time to make a significant contribution to the implementation of the coral bleaching work plan. Another example of collaboration between FAO and the CBD is the co-convening of a FAO/UNEP Expert Meeting on Impacts of Destructive Fishing Practices, Unsustainable Fishing, and Illegal, Unreported and Unregulated (IUU) Fishing on Marine Biodiversity and Habitats in 2009, the report of which was distributed at the subsequent SBSTTA meeting in 2010[123].

[121] UNEP/CBD/COP/7/INF/27
[122] http://www.climatefish.org/index_en.htm
[123] UNEP/CBD/SBSTTA/14/INF/6

There is no joint work plan between CBD and UNFCCC at the present time although collaboration does occur through the Joint Liaison Group, mainly to exchange information in order to support the implementation of the Conventions at the National level[124]. It does appear that closer bilateral collaboration between CBD and both FAO and UNFCCC (or trilateral – CBD/FAO/UNFCCC) in the form of joint work plans would enable implementation of joint programmes of work to address climate change issues affecting tropical marine fisheries and biodiversity. There is a need to improve recognition of linkages between coral reef conservation and global climate system by the CBD and UNFCCC. Collaborative efforts between CBD and FAO could plan to develop and implement measures to document and manage the socio-ecological impacts of climate change on coral reef fisheries.

Founded at the CBD first Conference of the Parties in 1994, the International Coral Reef Initiative (ICRI) is an informal partnership among governments, international organizations, and NGOs which promotes implementation of relevant international conventions and agreements and mobilizes governments to improve management, capacity and political support. A range of ICRI decisions and recommendations have been adopted on subjects such as climate change, coral bleaching and MPAs, coral reef resilience, acidification, coral reef fisheries and MPAs. ICRI is currently revising its Framework for Action as a basis to achieve the sustainable management of coral reefs and associated ecosystems and will incorporate the latest recommendations relating to climate change impacts.

Regional efforts to develop and implement policy that contributes to the delivery of the coral bleaching work plan occurs through the UNEP Regional Seas Programmes (RSP). Regional treaties or agreements that contribute to the protection of coral reef ecosystems are in place in a number of regions. For example the RSP regions for East Africa, South-East Pacific, and Wider Caribbean all have Protocols specifically aimed at promoting the establishment of MPAs. A review of national and regional networks of marine protected areas showed that regions with a strong coordinating framework and supporting treaty or agreement, such as those participating in Regional Seas Programmes (RSP), have generally progressed the furthest in MPA network implementation[125]. Protocols to address land-based pollution are also in place and are implemented by initiatives such as Integrating Watershed and Coastal Area Management (IWCAM) project in the Caribbean region. This project also produced a toolkit for amending or drafting legislation to support the protocol concerning pollution from land-based sources and activities (LBS Protocol)[126]. A more directly relevant initiative in an RSP region is the development of a Strategic Action Plan on Effects of Climate Change on Marine Resources by the Regional Organization for Conservation of Environment of the Red Sea and Gulf of Aden (PERSGA).

Major regional initiatives for the conservation and sustainable use of coral reefs have also contributed to the work plan implementation, including the Coral Triangle Initiative, the Micronesia Challenge, the Caribbean Challenge and the Western Indian Ocean Partnership. All these initiatives are directly tackling climate change impacts in the regions in an effort to safeguard the resilience of coastal and marine ecosystems and the provision of ecosystem services for sustainable livelihoods.

The establishment of large MPAs that contain extensive areas of coral reef are also a noteworthy contribution to implementation. In the last few years large tropical MPAs have been created in the Pacific (North-west Hawaiian Islands, Mariana Trench, Kiribati) and the Indian Ocean (Chagos). In addition, existing large MPAs such as the Great Barrier Reef Marine Park have been re-zoned, increasing the area protected from all extractive pressures from 5% to 33%, with measurable benefits. Overall the rezoning contributed to the protection of biodiversity, enhancement of ecosystem resilience, and increased the social and economic values of the GBR[127].

[124] Eleventh Meeting of the Joint Liaison Group of the Rio Conventions, April 2011, Bonn, Germany

[125] UNEP-WCMC. 2008. National and Regional Networks of Marine Protected Areas: A Review of Progress. UNEP-WCMC, Cambridge

[126] Toolkit for Institutional, Policy and Legislative Improvements in Support of the IWCAM Approach in Caribbean SIDS. — GEF-IWCAM 2008

[127] McCook, L.J. and 20 others. 2010. Adaptive management of the Great Barrier Reef: A globally significant demonstration of the benefits of networks of marine reserves. PNAS 107 no. 43 18278-18285

There has also been improved recognition of the need for more integrated or ecosystem based marine and coastal area management that takes into consideration terrestrial, marine and climatic issues. In fisheries management a precautionary or ecosystem-based approach has been adopted by a number of coral reef nations and regions as well as bans on destructive fishing methods and practises such as shark finning. Trawling bans have recently been implemented in Venezuela, Belize and Hong Kong (People's Republic of China) while Palau and the Maldives have banned shark finning within their Exclusive Economic Zones. Progress has been made on the development and implementation of MPA networks at both the national and regional level. Coherent MPA networks are in place in Australia as part of the Marine Bioregional Program and also in Palau. A number of other coral reef nations are currently developing national MPA networks including Brazil and Colombia. Regional networks are in place or currently being developed for the Mesoamerican Barrier Reef, the Red Sea and Gulf of Aden, the Sulu-Sulawesi Marine Ecoregion, the Western Indian Ocean and East Africa[128]. Integrating watershed and coastal zone management is also underway in some regions (e.g. the IWCAM project in the Caribbean) but still lacking in others. Finally, increasing the social resilience of tropical coastal communities and industries to adapt to climate change[129] within an ecosystem-based adaptation (EBA) approach is becoming more recognized and is thought to be a cost-effective method to adapt to climate change[130]. The EBA approach is an important component of some national and regional efforts to protect and sustainably manage coral reefs.

5. Financing

Financing of activities to support the implementation of the coral bleaching work plan has progressed well for certain aspects of the work plan but the level of funding available can be highly variable between Parties. Developed nations such as the U.S.A. and Australia have invested considerable government funds on coral reef conservation and management activities within their jurisdiction. Well supported programmes such as NOAA's CRCP or Australia's coral reef research and management work conducted at GBRMPA and AIMS continue to provide new products and global systems for use by reef managers and researchers (e.g. CRCP's Coral Bleach Watch programme) and science-based recommendations to inform and improve management (e.g. Reef Manager's Guide to Coral Bleaching produced by NOAA, GBRMPA and IUCN). Funds are also made available to advance coral reef conservation at the international level such as NOAA's coral reef conservation grant program and the coral reef conservation fund. However, it should be noted that well developed nations such as the U.S.A. or Australia are not very representative of the ability of coral reef countries to finance their own marine and coastal zone management. Many nations are severely lacking the finances required to support effective management of local threats let alone climate change impacts.

There has been success in the mobilization of international programmes for financial and technical development assistance to address the consequences of coral bleaching and to improve our understanding of mass bleaching events. The Global Environment Facility has supported directly relevant programmes such as the Coral Reef Targeted Research and Capacity Building for Management work over Phase 1 of the project and a large number of projects within its Biodiversity, International Waters and Climate Change programmes that directly or indirectly contribute to the sustainable management of coral reefs and their resources. Projects have been implemented by GEF's agencies; the World Bank, UNDP, UNEP and FAO. An example of a relevant project is the Coral Reef Rehabilitation and Management Project (COREMAP) in Indonesia which has been running since 1998 and is now moving into Phase III. GEF-funded coastal zone, watershed and fisheries

[128] UNEP-WCMC. 2008. National and Regional Networks of Marine Protected Areas: A Review of Progress. UNEP-WCMC, Cambridge.

[129] Marshall, N.A., Marshall, P.A., Tamelander, J., Obura, D., Malleret-King, D. and Cinner, J. 2009. A Framework for Social Adaptation to Climate Change: Sustaining Tropical Coastal Communities and Industries. IUCN, Gland, Switzerland. 36 pp.

[130] The World Bank. 2010).The Economics of Adaptation to Climate Change. Final Synthesis Report – Final Consultation Draft. August 2010. The World Bank, Washington DC. 79 pp.

management projects conducted in coral reef nations have also contributed indirectly to the delivery of the work plan by combatting localised stressors on coral reefs.

The GEF are also involved in funding regional initiatives such as the Coral Triangle Initiative (CTI) and the Caribbean Challenge, supporting a number of projects within the regions under these programmes. A significant amount of funding is being generated from a range of sources for these regional initiatives and challenges. As well as direct donor or Government funding for project implementation there are concerted efforts to ensure the financial sustainability of the initiatives over the long-term through the formation of trust funds. As part of the Caribbean Challenge a consortium of organisations (World Bank-GEF, TNC) and Governments are establishing a set of financial mechanisms (regional and national level trust funds) that provide sustainable funding for protected area systems, which will help to eliminate the issue of inadequate and unreliable funding. A similar approach was taken by the Micronesia Challenge to set up the Micronesia Challenge Endowment Fund and is underway for the Coral Triangle Initiative (Coral Triangle Partnership Fund).

Innovative financing sources have also been established to provide funding for large-scale approaches, particularly in the Pacific. The Phoenix Islands Protected Area (PIPA), formally established in 2008 by Kiribati, is partly financed by an innovative "reverse fishing license" which funds an endowment to cover core management costs and compensate the government for the foregone commercial fishing license revenues. The Palau Green Fee, a tax that tourists pay when leaving the country, raised USD $1.3 million in the first nine months of operation, and is being used by community-based conservation groups to help manage the Protected Areas Network.

At the smaller scale private sector partnerships such as Marine Conservation Agreements (MCA's) can also provide funds to help conserve and manage coral reefs, often within a marine protected area. A well-known example is the Chumbe Island Coral Park in Tanzania, a privately managed and financially self-sustaining marine reserve. More recently, and since the adoption of the coral bleaching work plan, MCAs have been set up in Fiji for sustainable live rock harvesting and in Indonesia to establish and manage a no-take MPA in Raja Ampat[131].

IV. BARRIERS TO IMPLEMENTATION, POTENTIAL SOLUTIONS AND FUTURES PRIORITIES

A. Barriers to implementation of the work plan on coral bleaching

The main barriers to the implementation of the specific work plan on coral bleaching that were provided by Parties in response to the request for information are summarised in Table 1. Significant barriers were highlighted for four main areas: data and information limitations, practical management strategies, capacity to monitor and manage and financial limitations. This section provides an overview of the main perceived barriers to implementation and also refers to relevant barriers previously identified by the CBD process for the implementation of the Marine and Coastal Programme of work prior to the CBD COP 10[132].

One of the main barriers in combatting mass coral bleaching events is that the phenomenon is relatively 'new' and there are still many gaps in our knowledge and understanding of bleaching effects and impacts. For example the understanding of which factors influence the frequency and intensity of bleaching and the species-specific and geographic responses to elevated SST events is incomplete, so identification of heat resistant sites and the connectivity among reefs (source and sink reefs) remains challenging despite their key contributions to reef resilience and the design of mutually replenishing MPA networks. There are still many questions being asked by researchers and conservation practitioners that will take time, and sufficient funding, to answer. This is coupled with the fact that we are not only dealing with the effects of increasing SSTs but also with ocean acidification and the interaction between the two climate change stressors. The additional input of more localised stressors such as overfishing or nutrification into the equation is also an area that is need of considerable further investigation.

[131] http://www.mcatoolkit.org/Field_Projects/Field_Projects.html

[132] UNEP/CBD/SBSTTA/14/INF/2

Baseline information for coral reef ecosystems such as benthic cover or reef fish data is lacking in many regions making accurate resilience assessments of reefs difficult. Where monitoring data is being collected it often remains at a 'standard' level to assess coral reef status and has not been expanded to incorporate resilience criteria. Factors such as lack of training in resilience assessment techniques and insufficient logistical or human resources to collect more detailed information on coral reefs are common. Responding quickly to bleaching events can be problematic in that funds or personnel are not often readily available to begin monitoring immediately. Complete assessment of bleaching events to track bleaching, measure mortality, and identify patterns of resistance are key requirements to refine our knowledge of bleaching resilience (resistance and recovery). A rapid response is necessary to ensure full tracking of the bleaching and mortality and adequate study of the patterns so that these can be related to mitigating factors.

The scientific knowledge of resilience in coral reefs is also still at an early stage and uncertainties in our understanding make it more difficult to design resilience-based spatial management systems involving MPAs. The existing knowledge of resilience-based management and planning approaches is also relatively new with approaches only tested in a few locations. Considerably more testing and refinement of management processes in a range of coral reef habitats and regions is required to produce a practical generic resilience-based approach that can then be adapted to different situations according to known local ecological criteria.

Our understanding of the relationships between bleaching effects and vulnerability of coastal communities and other stakeholders is also rather lacking. Future studies also need to include the socio-economic impacts of other climate change stressors such as ocean acidification, rising sea level and tropical storm incidence and possibly changes in ocean currents.

A number of challenges in the practical management of coral bleaching were also identified (Table 1). As well as logistical challenges associated with the scale of mass bleaching events and the availability of technically trained managers and staff for bleaching assessment a number of Parties reported that reef managers are not always convinced by the resilience-based argument. There can be a lack of understanding and awareness that reducing localised stressors will significantly contribute to climate change resilience of coral reefs. Secondly changing attitudes of reef managers to understand that climate change is not just a global problem and is relevant to local management can be difficult. In addition many communities have not fully accepted the reasoning behind conservation tools such as MPAs and are reluctant to assimilate further resilience-based mechanisms. Coping with existing issues such as illegal fishing or local water pollution can be taxing enough for communities and managers without having to consider other more 'indirect' threats linked to climate change, even though the two types of stressor are both part of a resilience-based approach.

Lack of support by management agencies to take concerted action at a regional scale was also highlighted, making it difficult to implement effective programmes at this level in areas such as Management Actions, Information Gathering, Capability Development and Policy Development. Regional partnerships involving both developed and developing countries are critical to ensure sufficient action is taken to manage coral bleaching events and other climate-related impacts. Regional or international partnerships can help to extend the resources of developing nations to better tackle assessment and management issues related to coral bleaching and other climate change impacts, particularly for implementing an integrated ecosystem-based approach over a wide area.

Insufficient capacity in developing nations to fully implement the specific work plan, or effectively manage coral reefs without considering climate-change impacts, remains a key barrier. Increasing institutional, logistical and management capacity to fully address coral bleaching events and other climate change impacts on coral reefs will require a considerable increase in support and diverse and innovative ways to generate the required level of support. Combined training and awareness programmes in reef resilience assessment and management have been provided in some regions in a few locations but need to be an integral part of national climate change action plans and supported by partnerships with regional or international coral reef 'centres of excellence' and / or NGOs. Providing technical support to produce climate change action plans for coral reefs at the national or sub-national level should be regarded as a new high priority.

Financing the required level of support to address climate change impacts on coral reefs through the implementation of the specific work plan is, along with the capacity issue, the most important obstacle to making progress. One barrier highlighted by a number of parties is the lack of a contingency fund that can be quickly accessed to support a rapid response to mass bleaching events. The formation of a 'coral bleaching rapid response contingency fund' would enable bleaching events to be assessed thoroughly from the start of the event. Current levels of bureaucracy connected to the release of funds have contributed to the slow response time. As well as the quick release funds in bleaching response situations it is also important to ensure that funding continues after bleaching events for on-going monitoring to document secondary effects (e.g. coral disease outbreaks) and support long-term management goals e.g. for resilience-based management and ecosystem-based adaptation.

Many of the barriers identified for the implementation of the programme of work on marine and coastal biodiversity[133] also apply to the specific work plan on coral bleaching. Not including the barriers already mentioned above the following points are relevant:

- Lack of political commitment and support, and unstable political situations
- Lack of integration of environmental, social and economic objectives
- Institutional and policy obstacles and weaknesses
- Low awareness: by the general public, biodiversity managers, and/or politicians
- Limited or low involvement of indigenous and local communities and various stakeholders
- Lack of economic incentives

Further detail for each of the above points is available in the report submitted to SBSTTA 14.

There were a few responses provided by Parties for 'specific actions undertaken to mobilize financial resources required for implementation'. Actions included conducting in-depth discussions with Government to secure adequate research funding for bleaching and resilience related work, liaising with partner organisations to provide match funding, applying for international grants such as those provided by NOAA's CRCP. The setting up of Endowment funds to finance regional approaches such as the Micronesia Challenge was highlighted as was the formation of sustainable finance plans (e.g. the FSM Protected Areas Network Sustainable Finance Plan currently in development). FSM also mentioned that supplemental National or Sub-national public fund allocations were being made available for coral reef related projects. Some Parties such as Brazil have established National Climate Funds that can be used to finance some activities related to the specific work plan. International NGO's mobilise funds through a number of sources including foundations, private individuals and government grants.

As well as the actions summarised above, there are a number of other potential sources of funding for activities directly or indirectly related to the implementation of the specific work plan. One major source which is starting to be utilised are climate change adaptation funds which are thought to be a key target for enhancing coral reef resilience and enabling social adaptation over the long-term[134]. There are five multilateral climate funds that support adaptation in developing countries which can potentially be used to finance coral reef activities: UNFCCC Adaptation Fund, the World Bank's Climate Investment Fund's Pilot Programme for Climate Resilience (PPCR), the European Union's Global Climate Change Alliance (GCCA) and two funds managed by GEF that are part of the UNFCCC — the Least Developed Countries Fund and the Special Climate Change Fund[135]. GEF funds are also available through the Small Grants Programme (SGP), part of the Strategic Priority on Adaptation (SPA). This supports community-based adaptation (CBA) interventions that increase resilience to the adverse impacts of climate change of vulnerable countries, sectors, and communities. There was a considerable increase in adaptation finance from dedicated climate financing instruments

[133] UNEP/CBD/SBSTTA/14/INF/2

[134] GLOBE Action Plan for Coral Reefs. 2010. GLOBE International Commission on Land Use Change and Ecosystems and the Zoological Society of London. 58 pp.

[135] The World Bank (2010) World Development Report 2010. Development and Climate Change. The World Bank, Washington DC, 417 pp.

in 2011, up from 8% of total climate finance ($587 million) to 21% ($957 million)[136]. Unilateral climate funds are also available. A recent example is the financing agreement signed in late 2011 by The Secretariat of the Pacific Community (SPC) and the Deutsche Gesellschaft für Technische Zusammenarbeit (GIZ) to assist coastal communities to adapt to climate change effects.

Other forms of funding which are more market-based, such as Payment for Ecosystem Services (PES) or blue carbon schemes for coastal carbon sink ecosystems such as mangroves and seagrass beds are currently in their infancy but are expected to provide significant funding within the next decade[137]. There is also considerable potential to increase the involvement of the private sector, particularly tourism, in tropical coastal ecosystem management through direct funds, incentives, compensation payments or user fees. Other financing mechanisms that could support activities are the use of environmental bonds for climate resilience and adaptation projects such as the World Bank Green Bond or the Great Barrier Reef Foundation's Coral Reef Bond; the polluter pays principle (PPP) for both chronic and acute pollution of coral reef ecosystems and green taxes similar to the green fee system in Palau.

B. Action to remove barriers, conclusions and future priorities

Actions taken by responding Parties to remove or reduce barriers to the implementation of the specific work plan are summarised in Table 1 (in bold in the right-hand column) along with specific suggestions to enable and enhance implementation. The priority areas for action that will best support the implementation are provided below and grouped under five main headings; information generation, practical management, policy and frameworks, capacity building and financing.

Information Generation

There is a need to improve and simplify tools and guidance for managers on reef resilience indicators and methodologies to assess vulnerability, resilience and adaptation opportunities for dependent communities. Some of the current resilience assessment protocols are quite data-hungry and technically complicated and require a high level of expertise. Training programmes are therefore correspondingly extensive, take some time and are costly. A more simplified but still scientifically accurate assessment protocol with reliable and 'user-friendly' resilience indicators can help to increase the uptake of resilience-based assessments and increase the area of coral reef assessed (funding permitting).

Greater emphasis is needed to evaluate and quantify the socio-ecological impacts and implications of repeated mass bleaching events. As coral reefs become more heat stressed and suffer continued periods of mortality through bleaching and secondary processes (e.g. coral disease outbreaks) it is important that we understand the effect this has on the ecosystem services provided by the reef ecosystem such as the provision of food and income or coastal protection from storm surges. The long-term effects of bleaching episodes in combination with other stressors (both local and global threats) is a key area that requires immediate and systematic investigation through research and assessment programmes. In terms of global impacts related to climate change, extensive information is needed for ocean acidification effects but also for other impacts such as tropical storm incidence and severity and sea level rise.

Greater research emphasis is also required to determine and quantify the linkages between ecological and social variables and the inter-relationship between ecological responses to bleaching and other stressors and the vulnerability and resilience of dependent communities and industries. A thorough understanding of how much localised threats need to be reduced to achieve a significant increase in coral reef resilience will help managers to prioritise action. Similarly quantifying or accurately

[136] Nakhooda, S., Caravani, A., Bird, N. and Schalatek, L. 2011. Climate Finance Fundamentals. Adaptation Finance. Climate Finance Policy Brief No.3 Heinrich Böll Foundation North America and Overseas Development Institute (www.climatefundsupdate.org)

[137] GLOBE Action Plan for Coral Reefs. 2010. GLOBE International Commission on Land Use Change and Ecosystems and the Zoological Society of London. 58 pp.

predicting the socio-economic effects of coral reef degradation on coastal communities and other stakeholders will assist in effective adaptation planning.

There also needs to be continued support to global initiatives to document and report on status and trends on coral reefs as an aide to national decision making. Initiatives such as GCRMN and ReefBase require support for on-going monitoring, assessment and documentation of coral reef status. Expansion of monitoring efforts at the national and regional level to include previously un-assessed coral reef areas and make monitoring more systematic will help to identify both resilient areas and those most in need of strong management.

Improving the availability of coral bleaching warnings to remote coral reef areas through better communication linkages (e.g. internet access) will enable reef managers to plan and implement bleaching response programmes more effectively and lead to more complete data-sets of bleaching events.

A recent assessment of the vulnerability of tropical Pacific coral reefs to climate change outlined the important knowledge gaps and information needs for this region[138] which are generally applicable to all coral reef regions of the world (Box 5).

Box 5 Some Key Research Questions for coral reefs and climate change

- How will the climate change at the scale of individual countries and their coastlines? Global models for how climate change is projected to affect coral reef regions must be 'downscaled' to provide information which managers and policy makers in coral reef countries can use to respond to the regional and local problems.
- How is warming and acidification affecting the early life history stages of corals and other key reef-building organisms? What are the knock-on effects of these types of influences on the fundamental biology of coral reef organisms?
- What important synergies might occur between the projected changes to SST and ocean acidity, and other factors such as the possibility of more intense tropical storms?
- Is the restoration and remediation of coral reefs damaged by climate change feasible, either biologically or economically?
- What are the most effective management strategies for reefs that have suffered short- and long-term coral bleaching episodes? For example, should a fishing closure be put in place until a reef has recovered from a severe bleaching event?
- Are current monitoring protocols adapted to climate change? What needs to be done to monitor reefs and their communities to separate local versus global effects?
- What are the likely consequences of very rapid rates of sea-level rise for coral reef nations?
- How should management strategies change as the ecological community composition of coral reefs varies from, for example, branching corals to more massive corals and macroalgal-dominated seascapes?

(Adapted from Hoegh-Guldberg et al., 2011)

Practical management

It is essential that coral reef management is undertaken through an integrated ecosystem-based approach that considers the full range of impacts that a particular reef system is subjected to and seeks

[138] Hoegh-Guldberg, O., Andréfouët, S., Fabricius, K.E., Diaz-Pulido, G., Lough, J.M., Marshall, P.A. and Pratchett, M.S. 2011. Vulnerability of coral reefs in the tropical Pacific to climate change. In: J.D. Bell, J.E. Johnson and A.J. Hobday (eds.) Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change. Secretariat of the Pacific Community, Noumea, New Caledonia.

to address the underlying drivers of localised threats both on land and at sea. Management needs to consider not just rising sea temperatures and coral bleaching events but also the effects of ocean acidification, tropical storms and increased sea level and the interaction between these. There should be greater integration of resilience principles into management planning at the national and regional level. National coral reef action plans need to be in place for all coral reef countries that incorporate climate change effects and resilience-based approaches and are regularly updated to represent current scientific knowledge. Where knowledge for management is lacking a precautionary approach is necessary. Management of coral bleaching events in many countries can be improved if there are coral bleaching response plans in place. Support should be provided to develop and ensure the effective implementation of integrated ecosystem-based management approaches for tropical waters. Part of this approach should focus on the protection and restoration of blue carbon in coral reef associated ecosystems such as mangroves and seagrass beds, which will increase coastal and coral reef resilience, contribute to climate change mitigation and also provide a mechanism to support management. It is also critically important to increase the involvement of coastal communities and other local stakeholders in coral reef and coastal zone management and mechanisms to achieve this should be developed.

Capacity-building

There is still a great need to improve capacity to manage coral bleaching and other stressors on coral reefs across a range of scales. A few key priority areas are highlighted here. Firstly, there needs to be greater exchange of scientific, technical, and socio-economic information as it relates to coral reef degradation between Parties and particularly to developing countries. Key scientific knowledge and management experiences should be available to coral reef managers in all countries to enable informed decision-making. Further training in local languages should be provided to managers and decision-makers in terms of the existing tools and methodologies for responding to bleaching events, including early warning prediction, rapid assessment protocols, communication and management intervention. Resilience training that encompasses all potential climate change effects on coral reefs for that country or region needs to be developed and tested. Where successful approaches are identified for management areas such as coral reef protection, resilience building, adaptation and the use of new technologies, they should be shared both within countries and at the regional level through exchange programmes. This best practise needs to be incorporated into both national and regional governance frameworks and reef management strategies.

Training programmes also need to include a substantial educational component to increase the understanding and awareness of new and established concepts for effective reef management. The degree of training in ecosystem-based management that includes resilience principles and EBA needs to be scaled up considerably to ensure effective coverage in all coral reef regions. Increased support for coral reef action networks and other partnerships focussed on addressing the key issues for coral reefs and their management is required. The International Coral Reef Action Network has played a key role over the last two decades in building capacity for management. Re-invigorating ICRAN to play an important part in the establishment of integrated ecosystem-based management of coral reefs and ecosystem-based adaptation for coastal communities and stakeholders should be considered. There also needs to be better coordination of coral reef between different levels (local, provincial, national) and between the various agencies (government, non-government, community) to improve monitoring and management effectiveness.

Financing

A key priority in terms of funding is to establish a readily accessed contingency fund to enable more rapid and increased reef monitoring in response to bleaching events. Rapid provision of funds is essential to activate bleaching response plans quickly enough so that a thorough assessment of the event can be carried out. The projected increase in severe bleaching events in the near future emphasises the need for readily-sourced funds but also the fact that increased levels of financing will be required as climate change and other localised impacts become more common and intense. It is therefore critical that the funding base for coral reef management is expanded and diversified. Innovative and diverse financing mechanisms, especially linked to the private sector, need to be

expanded. Climate change funding for adaptation of tropical coastal communities also needs to be increased either via existing multilateral climate funds or through the establishment of national climate funds. Raising greater awareness within the public and private sectors and with donors about the growing threats to coral reefs and the critical need for protection and effective management measures should be regarded as a top priority.

Policy frameworks

As noted in Chapter 3 there is a need to improve linkages between key agencies such as the CBD Secretariat, UNFCCC Secretariat and the FAO in order to enhance regional and international efforts to address the negative effects of climate change on marine biodiversity, ecosystem services and dependent populations.

Further regional initiatives and agreements and trans-boundary collaboration should also be encouraged and supported. Regional or national policies to address localised threats are still lacking in some cases and should be prioritised through support for policy development in those countries. The success of regional initiatives such as the Micronesia Challenge has shown how useful partnerships are to tackle issues at the scale of coral reef regions. Further partnerships to set regional policy can also initiate improved management of coral reefs. Parties should also be encouraged to join existing regional agreements (e.g. one of the ‘challenges’) or initiatives (for example, the UNEP Regional Seas Programme) to benefit from these partnerships.

Table 1. Main Barriers to the Implementation of the Work Plan on Coral Bleaching and ways to overcome them
Note: actual responses detailing on-going activities to address barriers are highlighted in **bold** in the column to the right.

Barrier	Specific challenges	Responses and Suggestions to overcome Barriers
Information Limitations	Specific data collection (early warning systems, rapid response capability, climatic vulnerability) is often not prioritized due to limited capacity for basic monitoring and resource assessment. Lack of understanding of the effects of ocean acidification on coral reefs Limited research infrastructure (e.g. dedicated (and funded) marine research capabilities) in many countries; Data gaps in baseline information for shallow water ecosystems in many areas making MPA designation and resilience assessment more difficult Significant quantities of data are required and involve sophisticated processing to capture vulnerabilities of coral reef species and habitats to climate change; Critical science and knowledge regarding resilience remains insufficient to enable the selection and design of MPAs and networks will high levels of confidence Resilience-based reef management and planning approaches contain many assumptions and uncertainties and require further testing and validation to improve their reliability and relevance The inter-relationship between reef responses to bleaching and the vulnerability and resilience of dependent communities and industries has not been awarded sufficient scientific and planning/management attention	Support coral bleaching studies evaluating and quantifying impacts and implications of repeated bleaching events both in ecological/biodiversity and socio-economic terms Support research on ocean acidification and the interaction with other stressors to increase the understanding of: • reef resilience in terms of acidification and multiple stressor effects • the implications of ocean acidification for coral reefs and dependent communities and potential management and mitigation strategies **Increase scientific support for research and monitoring in countries lacking capacity through training and mentoring** **Use of research findings to provide guidance on management actions to reduce climate change impacts on reef ecosystems** Ensure continued support to strengthen global initiatives to regularly and accurately document and report on coral reefs status and trends (e.g. GCRMN) and make information increasingly useful for national as well as global reporting and decision support Increase involvement of Parties, especially ones most vulnerable to reef loss, in regional partnerships and networks to support assessment and adaptation Catalyse interest among the science community to tackle essential knowledge gaps in practical resilience and ocean acidification science and put in place readily accessed sources of funding to support this Systematic testing and validation of resilience-based management and planning approaches **Development of approaches for integrating ecological resilience into spatial conservation planning on coral reefs** **Development of tools and approaches for vulnerability mapping, ecosystem-based adaptation, and ecosystem-based marine and coastal resource management**

Practical Management Strategies	Garnering community support and understanding for MPA goals and objectives is an on-going challenge and made more difficult by climate change; Generating support for resilience as a mechanism to combat climate change requires attitudinal shifts in management and stakeholder communities Ecosystem based and broad scale integrated management measures require significant institutional and staffing infrastructure (e.g. scaling up to MPA networks) which is often lacking and can delay single site-based management implementation Difficult for research agencies to catalyse action by management agencies across multiple countries which may translate into effective programs for Management Actions, Information Gathering, Capability Development and Policy Development Lack of appropriate mechanisms for tracking and monitoring of management action during mass bleaching events Challenges of surveillance and enforcement in widely scattered remote reef systems coupled with poaching and weak governance	Develop mechanisms to involve stakeholders and communities in marine resource management within and beyond MPAs boundaries **Development of National Coral Reef (Action) Plans** Support training and awareness programmes for communities, stakeholders and managers in resilience theory and practise and provide training in multiple languages Strengthen management of coral reefs to safeguard areas that are particularly resistant to bleaching, areas that exhibit high resilience or adaptive capacity, as well as areas that sustain coastal populations **Strengthening of partnerships to improve guidance for managers on reef resilience indictors and methodologies to assess reef resilience, vulnerability assessment, and adaptation specific to coral reef ecosystems and dependent communities** Further refinement of management and planning approaches based on research and critical review of past experiences, including ecosystem-based adaptation planning Implement mechanisms to evaluate the effectiveness of coral reef management practices and to monitor management action during mass bleaching events
Capacity Challenges	Human and technical capacity for implementation remains limited, especially in developing countries and SIDS with vast geographic ranges, remote islands and atolls; Lack of scientific publications by developing nation authors on coral reef ecology and climate change Lack of coordination between the different coral reef actors involved in research, management and resource use and also within management agencies at the local and national level	Increase the number of regional or international action networks to support capacity building and ecosystem-based adaptation approaches Build capacity for incorporation of best practice into national and regional governance frameworks as well as reef management and coastal development planning Facilitate collaboration and coordination between agencies and levels through third parties (e.g. NGOs) and widely disseminate the specific work plan between the different actors involved in its implementation
Financial Limitations	Funding needs for long term monitoring are significant and are currently not well supported The complex funding environment makes it challenging to mobilize contingency funds quickly to respond to bleaching	Establish a rapid bleaching response contingency fund to enable increased reef monitoring and the review and revision of resilience principles in response to major bleaching events Increase financial support through multilateral agencies, particularly via

	events; Continuation funding to support capacity development and training of reef managers is necessary in periods between bleaching events. Insufficient funding to run and manage research and monitoring programmes in all reef areas	climate funds, to implement activities relevant to the specific work plan but also to broader climate change impacts on coral reefs **Development of National Climate Funds to fund relevant activities** Enhance private sector engagement to support activities contributing to the specific work plan, including by identifying and replicating successful models
Other challenges	Lack of political will – slows development and application of adaptation strategies Lack of public awareness of coral bleaching / climate change effects on coral reefs	Increase engagement with decision makers at multiple levels through science-based advocacy and communications strategies to raise awareness Develop outreach campaigns in different media on the issue of coral bleaching and how to support national efforts to manage bleaching events

V. CONCLUSIONS

Tropical coral reefs have been under intense anthropogenic pressure in heavily populated or utilised areas for decades and have declined in health and status significantly. Management efforts initially focussed on tackling direct local stressors such as overfishing, habitat destruction and pollution. The additional threats caused by climate change are now setting unprecedented challenges for reef managers and decision makers. Providing sufficient scientific, technical and financial support for management to respond to this global challenge is crucial if coral reefs are to survive as a functional ecosystem into the next century.

The adoption of the specific work plan on coral bleaching sought to address the combined challenges set by local and global threats to coral reefs. However, the work plan was primarily drawn up to respond to mass coral bleaching events and in its present form does not adequately take into consideration other global impacts on coral reefs caused by climate change, most notably, ocean acidification, but also the effects of tropical storms and rising sea levels. There is a need to update the specific work plan to incorporate recommendations for activities to assess and respond to these additional and significant stressors. In particular, the current and projected impacts of ocean acidification need to be integrated into management frameworks alongside the interaction with local stressors as our understanding of multiple stressors improves. A number of suggestions for action were provided by Parties, summarised in Table 1, and can be used as a starting point to develop these new recommendations. Of particular importance is the need to understand and respond to the interaction between multiple stressors in various combinations (e.g. bleaching-acidification-overfishing-nutrification) which can combine synergistically to negatively affect coral reef ecosystems.

Substantial progress has been made since the work plan was adopted but many recurrent capacity and financial challenges remain which preclude significant progress in some regions. A detailed breakdown of the work plan is available in Annex 3 and provides an assessment of the implementation of each action point grouped under the five main headings. Suggestions for the reprioritisation of action points according to progress made for implementation are also provided.

The implementation of the specific work plan by Parties has been rather patchy. More developed coral reef nations have invested significantly in the detection, assessment and management of mass coral bleaching events and provided systems for global public use such as the early warning tools developed by NOAA's CRCP. Generic bleaching assessment and management protocols have been produced that can be applied to different coral reef regions. Climate change impacts have also been fully incorporated into coral reef management frameworks in a few countries. Conversely, many countries are still struggling to cope with localised stressors and do not have the capacity or funds to fully incorporate climate change effects into coral reef or coastal management programmes. Significant capacity building is required to incorporate climate change into coral reef action plans and enable effective implementation of these. An increase in the number of training and awareness programmes is needed for reef managers and stakeholders to improve the understanding of 'new' concepts such as resilience and provide managers with the skills to undertake 'climate-smart' assessments of coral reefs.

The thorny issue of financing coral reef management at the scale required to tackle both local and global stressors remains a critical area. A number of suggestions were made in Chapter 4 to address this, including developing innovative and diverse mechanisms to generate finance, especially involving the private sector and blue carbon schemes, and increasing the funding available within multilateral or national climate funds for climate change adaptation on tropical coasts. Significant investment will be needed over the coming decades as climate change impacts increase in frequency and intensity.

Pooling expertise and resources through the formation of strong regional or sub-regional partnerships can help developing nations meet management goals. A notable success story over the last few years has been the establishment of regional 'challenges' such as the Coral Triangle Initiative or the Micronesia Challenge. Greater collaboration is also required at the international level. For example

collaboration between the CBD and the UNFCCC is one of the actions within the work plan that has not been adequately addressed to date. Setting up a joint plan of work to tackle climate change and biodiversity issues for tropical coastal environments will raise the awareness and level of activity globally to protect and manage coral reefs and associated ecosystems.

Broadening the remit of the coral bleaching work plan will help managers to understand the vulnerability of their reef systems to multiple stressors and to plan proactively for climate risks and associated secondary effects. Ecosystem-based adaptation (EBA) provides reef managers with the means to manage coral reefs as socio-ecological systems undergoing change, predominantly caused by climate modification. The resilience of ecological systems can be enhanced if management is effective. Social systems that rely or heavily depend on coral reefs also need to be made resilient to climate related impacts through EBA. Adaptation strategies that aim to enhance the resilience of ecosystems to enable the continued provision of goods and services can be particularly important for vulnerable communities that are often directly dependent upon natural resources[139]. There is a growing body of evidence to suggest that EBA can be a cost-effective strategy across the major adaptation sectors[140]. Furthermore EBA strategies often address multiple coastal management goals and can provide multiple benefits[141]. EBA uses natural assets to enhance societies' adaptive capacity and prepare for future (sometimes unpredictable) alterations to their surroundings[142]. An EBA approach is already being used in a number of regions for coral reef and coastal zone management[143] [144].

The specific work plan on coral bleaching has significantly contributed to the establishment of a more integrated approach to coral reef management through addressing both global change and more localised threats to coral reef ecosystems. Since the work plan was adopted there has been increased recognition of the range of climate change related impacts on coral reefs. The work plan can continue to be a driver of informed and improved coral reef management but should be revised and renamed to incorporate other climate change impacts on coral reefs, particularly the threat of ocean acidification and the interaction with other stressors.

[139] Hale, L.Z. and 20 other co-authors. 2009. Ecosystem-based Adaptation in Marine and Coastal Ecosystems. Renewable Resources Journal 25: 21-28

[140] Campbell A., V. Kapos, A. Chenery, S.I. Kahn, M. Rashid, J.P.W. Scharlemann, B. Dickson. 2009. The linkages between biodiversity and climate change mitigation UNEP World Conservation Monitoring Centre.

[141] Hale, L.Z. and 20 other co-authors. 2009. Ecosystem-based Adaptation in Marine and Coastal Ecosystems. Renewable Resources Journal 25: 21-28

[142] Herr, D. and Galland, G.R. 2009. The Ocean and Climate Change. Tools and Guidelines for Action. IUCN, Gland, Switzerland. 72 pp.

[143] Green, A., S.E. Smith, G. Lipsett-Moore, C. Groves, N. Peterson, S. Sheppard, P. Lokani, R. Hamilton, J. Almany, J. Aitsi and L. Bualia. 2009. Designing a Resilient Network of Marine Protected Areas for Kimbe Bay, Papua New Guinea. Oryx 96:2

[144] Howard, M and Taylor, E. Ecosystem-based Adaptation in the Seaflower Marine Protected Area, San Andreas Archipelago, Colombia. A Community-based Approach. In: Andrade Pérez, A., Herrera Fernandez, B. and Cazzolla Gatti, R. (eds.). 2010. Building Resilience to Climate Change: Ecosystem-based adaptation and lessons from the field. Gland, Switzerland: IUCN. 164 pp.

Annex I: Activities reported by Parties, other Governments, relevant organizations, and indigenous and local communities to implement the Specific Work Plan on Coral Bleaching

Priority Areas	Activities	Implemented by
1. Management actions and strategies to support reef resilience, rehabilitation and recovery	NOAA's Coral Reef Conservation Program prioritised actions to address the impacts of climate change, fishing and land-based sources of pollution to coral reef ecosystems in 2009. Climate goals focus on increasing coral reef resilience through effective management strategies, understanding and addressing risks and vulnerabilities, providing forecasts and projections, and intervening to reduce the stress and impacts of climate change and ocean acidification. Goals to reduce the impacts of fishing and land-based sources of pollution also contribute to increasing reef resilience by reducing localized stressors to coral reefs. NOAA, with partners (TNC and AIMS) completed a project in support of TNC and the government of Palau to implement a Protected Areas Network (PAN) based on resilience principles. This project produced a heat stress model for Palau to predict areas that may resist temperature change and remain cooler during a bleaching event	NOAA, United States of America
	Implementation of the Great Barrier Reef Climate Change Action Plan is improving understanding of climate change vulnerabilities and enabling the identification and testing of adaptation strategies to build the resilience of the GBR to climate change, including coral bleaching Increased the area of the Great Barrier Reef Marine Park protected from all extractive pressures from 5% to 33%. Representative areas of all bioregions were protected, encompassing a mosaic of areas to maximise the resilience of the reef system to climate change. Developed partnerships with the tourism industry to examine the feasibility and efficacy of short-term management interventions to reduce severity of bleaching or to facilitate recovery after bleaching. Implementation of a program (through partnerships with other government agencies, reef industries and landholders) to identify, implement and justify actions that can reduce localised stressors on reefs to increase their resilience to coral bleaching. Includes a strategic program to reduce land-based sources of pollution and stewardship action plans for coral-based fisheries	GBRMPA, Australia

	Provision of a strong scientific basis for action through a combination of experimental and observational studies, and the development of models for predicting the ecological consequences of coral bleaching events. Development of a quantitative framework for reef resilience (Anthony et al. 2011) in collaboration with international resilience experts and key reef stakeholders which can significantly improve strategies to support reefs resilience Providing managers with tools to identify reef recovery processes, ecosystem elements most sensitive to climate change and other local scale stressors.	AIMS, Australia
	Investigations into the role of ocean currents in mitigation of mass bleaching events have been undertaken in Western Australia, where widespread bleaching has recently occurred in the context of contrasting warm and cool (up-welling) current regimes. Implemented the South East Asia Coral Bleaching Rapid Response project (2010) in collaboration with NOAA and DSEWPAC. The project aimed to measure the economic impacts of the 2010 mass bleaching event and strengthen the understanding of the underpinning biophysical drivers to minimise community impacts of future events. Investigated the impacts of bleaching on reef ecology, diver perceptions of reef quality, and tourism economics across a range of dive destinations in the Greater Coral Triangle countries.	CSIRO, Australia
	Developed specific resilience principles to apply to coral reef conservation and incorporated these principles into the design and implementation of MPAs in Indonesia (7 locations), Palau, Papua New Guinea, Solomon Islands and Mozambique Development of resilience assessment and monitoring protocols and application of the protocol in Indonesia, Palau and Mozambique to provide a resilience data layer to assist with MPA network design or NP zoning Development of a framework for the analysis, interpretation, application and communication of resilience assessment results to specific management recommendations related to MPA planning and management	The Nature Conservancy and other members of the Reef Resilience Partnership and Network (WWF, IUCN, GBRMPA, NOAA, WCS)
	Implemented a number of programmes as part of national or regional initiatives:	Federated States of

	Micronesia Challenge (MC) Marine Measures Indicators Pacific Islands Managed and Protected Areas Community (PIMPAC) FSM Coral Ecosystem Monitoring Program: Pohnpei State Marine Protected Areas Network and the Forestry Sector's "Ridge-to-Reef" Management Approach Micronesia Locally Marine Managed Areas (LMMA) Network involving Community-based Adaptive Management and the Reef Resilience Network	Micronesia (FSM)
	Identification and monitoring of most affected coral areas during the mass bleaching events of 2005 and 2010 Laboratory-based research to assess the tolerance of coral species from the Colombian Caribbean sensitive to mass bleaching events, to increased temperature and light intensity levels Development of guidelines for the management of coral reefs as a tool to control and adapt to impacts of climate change (e.g. bleaching). Proposed courses of action include: Implement / use tools to predict massive bleaching events by means of an alarm system (NOAA CoralWatch reports and the INAP Project / INVEMAR meteorological and oceanographic station). Implemented coral nursery pilot projects (*Acropora palmata* and *Acropora cervicornis*) in 2010 in some Caribbean protected areas, which will identify the appropriate methodologies to pursue reef recovery actions.	Colombia
	Barbados has adopted a "total resource conservation" approach to resilience; meaning that all coral reefs and coral habitats have protected status within Barbadian waters. Both the Fisheries and Coastal Zone Management Acts make the harvesting or damage of coral illegal (fines imposed for damage to reef habitat). Applies to all coral within the island's territorial waters and the EEZ. The Coastal Zone Management Unit (CZMU) has implemented and maintained a mooring buoy program for dive boats to avoid anchor damage to coral reefs and thereby improve resiliency to bleaching events. Designation of no-anchor areas adjacent to the Bridgetown Port in order to specifically avoid anchor damage to a reef habitat within the traditional port	Barbados

	anchoring area for commercial vessels. This will improve resiliency and enhance connectivity between the southern and western reef systems of the island. Enforcement of coral transplantation requirements if development is to occur on reef as a last resort (avoidance of building on reef is primary strategy). The CZMU and the Environmental Protection Department have developed marine pollution control legislation to set standards for pollutant discharge and improve water quality in the vicinity of reef habitat (Marine Pollution Control Act). Standards are either as strict or stricter than those specified under the Land Based Sources of Marine Pollution Protocol of the Cartagena Convention.	
	A number of activities have been undertaken related to development and implementation of management strategies to support reef resilience, rehabilitation and recovery. The International Coral Reef Action Network (ICRAN), , provided a means for consolidating technical and scientific expertise in reef monitoring and management to create strategically linked actions across local, national and global scales. Implemented between 2000 and 2010 ICRAN, along with other ICRI networks has been key in implementing the specific work plan on coral bleaching. Generic guidance to incorporate resilience principles into MPA planning has been developed, and initiatives to provide guidance on using reef resilience data in spatial planning are underway involving academic institutions, IUCN, TNC and UNEP.	UNEP
	No specific management activities relating to coral bleaching but there is some coral reef bleaching research being conducted at Brazilian universities	Brazil
2. Information Gathering and Targeted Research	Supporting multiple efforts to provide synoptic observations of regional scale ocean acidification in the Caribbean Basin and global model simulations of the vulnerability of coral reef ecosystems to climate impacts (i.e., increasing sea surface temperature, ocean acidification, and changing ocean circulation) to inform management strategies. The climate impact modelling includes forecasts of bleaching frequency and trajectories of coral cover under different future emission scenarios to help guide greenhouse gas management, policy decisions, and management strategies.	NOAA, United States of America

	NOAA Coral Reef Conservation Program (CRCP) and its federal, state, local and international partners contribute information to the GCRMN reports. The CRCP also coordinates the SocMon Initiative, which facilitates community-based socioeconomic monitoring to understand dependence on reef resources, perceptions of resource condition, threats to marine and coastal resources, and support for management actions. New guidelines and indicators have been developed for areas where climate change impacts are in important issue so that information can be collected to inform management needs and adaptive management. Supported a response to the 2010 Southeast Asia bleaching event (in partnership with local NGOs and the government of Australia) to test methods to assess the economic impact of the event and of management actions taken to respond to the event. Produced a range of communication tools and materials including *A Reef Manager's Guide to Coral Bleaching* (in partnership with the GBRMPA, the Department of State and other partners), educational materials on coral bleaching and ocean acidification, articles in magazines, public service announcements, etc. to support education and raise awareness about the impacts of climate change and coral bleaching on coral reefs. Supports the Florida Reef Resilience Program (FRRP), through a Cooperative Agreement with The Nature Conservancy, who work together to develop strategies to improve the health of Florida's reefs and enhance the sustainability of reef-dependent commercial enterprises and recreational activities. The FRRP members respond to and monitor mass bleaching events in Florida and were active participants in the development of the *Climate Action Plan for the Florida Reef System 2010-2015*. The Virgin Islands Reef Resilience Program is under development. Developed an experimental Seasonal Coral Bleaching Thermal Stress Outlook as a most forward looking contribution to NOAA's satellite based products that make up a Global Early Warning System (Coral Reef Watch) for bleaching events. The Outlook informs users around the world of the potential occurrence, general spatial pattern, estimated intensity and duration of high water temperatures that may lead to mass coral bleaching over the next bleaching season to give more lead time to prepare for bleaching events and management	

	actions/strategies they might take to address local stressors during this time. The Early Warning System includes website and Google Earth based products as well as an email based Satellite Bleaching Alerts for 227 locations globally. These products feed into global (ReefBase) and regional (Mesoamerican Coral Reef Watch Program, Florida BleachWatch, etc.) programs that organize citizen-based monitoring of bleaching and dissemination of outreach materials pertaining to coral reefs and coral bleaching. The CRCP has provided instrumentation in Kimbe Bay, Papua New Guinea (SST loggers, Autonomous Reef Monitoring Structures for biodiversity, etc.) to support local NGOs and The Nature Conservancy in the evaluation of the effectiveness of the MPA network that was designed through the application of resilience principles.	
	Supported research that: • Has enabled reef managers to identify areas that show resilience to climate change-related stressors through improved understanding of bleaching thresholds and modelling of spatial risk. • Has informed reef managers about the factors that support resilience of coral reefs to climate change. This work has been fundamental to implementation of key management initiatives aimed at further building the resilience of the Great Barrier Reef to climate change, including the Reef Water Quality Protection Plan. • Advanced the understanding of connectivity patterns in coral and fish populations as a basis for resilience-based management of coral reef systems Annual implementation of a Coral Bleaching Response Plan, which includes an advanced early warning system, community-based monitoring program and scientific impact assessment program. Observations and impacts on the ecosystem are reported throughout summer in regular Coral Bleaching Bulletins and in the annual End-of-summer Overview Report. Data are also provided to ReefBase and reports made available to the GCRMN. This program of activity is strongly linked to the AIMS Long Term Monitoring Program. The Australian Coral Bleaching Response Plan has been adopted as the model for Coral	GBRMPA, Australia

	Bleaching Response Plans in coral reef regions around the world. Produced a range of communications tools and materials, including A Reef Manager's Guide to Coral Bleaching, a series of fact sheets on coral bleaching and climate change, and a suite of products to support education of tourism operators and reef guides.	
	Information gathering is through state-of the art observation systems (e.g. IMOS/QIMOS) combined with experimental studies of processes and the development and testing of environmental and ecosystem models. This approach is key to understanding the marine environment and the biological and ecological impacts expected under climate and ocean change. Research covers multiple spatial and temporal scales and operates on levels from cell and organism to ecosystem. Studies on coral bleaching resistance and recovery are providing important information regarding adaptation and acclimatisation in corals, helping to produce realistic risk projections for Australia's coral reefs to climate change. Recently produced, in collaboration with GBRMPA, a summary of the status of coral bleaching risks on Australia's coral reefs.	AIMS, Australia
	PACCSAP (Pacific - Australia Climate Change Science and Adaptation Planning Program) includes two projects dealing with coral bleaching: 1. Seasonal prediction of extreme ocean temperatures/coral bleaching. 2. Projected increases in the severity and frequency of coral bleaching due to ocean warming and acidification. Development and operation of ReefTemp, a mapping product that provides information on coral bleaching risk for the Great Barrier Reef region. It is a collaborative project between CSIRO Marine and Atmospheric Research, the GBRMPA and the Bureau of Meteorology. Climate change projections for the Great Barrier Reef include increased frequency and severity of mass coral bleaching events. ReefTemp produces high-resolution now-casts of bleaching risk and provides an improved ability to monitor heat stress in the Great Barrier Reef. The South East Asia Coral Bleaching Rapid Response was a collaboration between CSIRO, NOAA and DSEWPAC.	CSIRO, Australia

	Implemented rapid ecological assessments across many parts of Indonesia, Micronesia, Melanesia, and Mozambique. Currently, TNC is leading a collaborative study (with WCS, ReefCheck Indonesia, GBRMPA and international experts) of the impact of 2010 coral bleaching on differerent reefs in Indonesia to test resilience principles. Applied the resilience assessment protocol at different sites as listed above, including an assessment of the intensity and impact of bleaching on coral reefs at Wakatobi NP in 2010. Completed sea surface temperature analysis and modelling for the Coral Triangle, including projections for seawater warming to 2100 and implications for coral reef management Will be coordinating the analysis of sea surface temperatures in Palau to contribute to development of a nationwide protected area network (PAN) Compiled, with ReefCheck Indonesia, bleaching records across Indonesia in 2010 and developed a bleaching alert newsletter for distribution to partners Implementing comprehensive resilience assessments of the reefs in Palau in 2012, together with the Palau International Coral Reef Center, to contribute a resilience data layer for the PAN establishment Completing, with local partners, a resilience analysis for the Savu Sea MPA Hosted a workshop on Ocean Acidification (OA) in partnership with the Palau International Coral Reef Center (PICRC),). The workshop brought together global experts in ocean acidification and coral reef management from leading institutions. The objectives were to identify factors likely to affect coral reef ecosystem vulnerability to ocean acidification and to identify knowledge gaps and research priorities needed to integrate vulnerability to ocean acidification into conservation planning and management. Workshop participants committed to establish a targeted Ocean Acidification Research and Adaptive Management Program in Palau that will build local capacity and generate locally, regionally and globally relevant outcomes to inform resilience-based management under a changing climate. By testing the research priorities identified at the workshop, we will improve our knowledge of the impacts of OA on coral reefs and inform our efforts to integrate OA into MPA network design and management.	TNC

	FSM Coral Ecosystem Monitoring Program MC Measures Database (in development) Reef Resilience Network	FSM
	Long-term monitoring of relevant biological and physico-chemical variables to generate information on health and dynamics of coral reefs in Colombia (Colombia Coral Reef Monitoring System or SISMAC) Monitoring most affected coral areas during the mass bleaching events of 2005 and 2010 (impacts and recovery). Identifying relationships between abnormal environmental conditions (temperature increases of sea surface, "El Niño" and "La Niña" events) and the occurrence of mass bleaching events Identification of zooxanthellae clades sensitive to climate change in the Colombian Caribbean Studies of the influence of increased temperature on coral reef ecological interactions (e.g. sponge-coral competition). Research to assess the connectivity between coral reef areas of the MPA system in the Colombian Caribbean, using the genetic structure and gene flow between populations of reef-building corals as indicators; to strengthen the criteria for selection and design of MPAs as an adaptation strategy to climate change. Reporting of bleaching events on global information networks (ReefBase Web site); SISMAC Database - Colombia Coral Reef Monitoring System	Colombia
	Multiple coral bleaching assessments (2005, 2006, 2009, 2010) to monitor bleaching onset, severity and resulting mortality with bleaching survey data submitted to NOAA Coral Reef Watch and ReefBase. The Coastal Zone Management Unit conducts a long-term coral monitoring program (national assessment every 5 years), and this in combination with the bleaching surveys is being used to get an accurate look at the long term effects of coral bleaching on reef health. Installation of in situ Hobo temperature probes at 8 reef sites around the island that continuously collect temperature data on the reef itself (vs. satellite sea surface temperature measurement).	Barbados

	GCRMN Update World's foremost global initiative dedicated to monitoring the status of coral reefs, including bleaching. Releases periodic global status reports (1998, 2000, 2002, 2004, 2008, with a report under preparation for 2012). Thematic reports address specific issues, including a detailed report on the Caribbean bleaching in 2005. The Status of Coral Reefs in East Asian Seas report 2010 includes a regional overview of severe bleaching in 2010. A Pacific Coral Reef Status and Outlook report will be released in 2011. The GCRMN SocMon initiative has developed methodological guidance for socioeconomic assessment of coral reef areas, including the implications of bleaching, and conducted assessments through regional networks. A GCRMN study underway entitled "Enhancing the Management Relevance of Reef Monitoring in a Changing World" aims to guide future monitoring in assessing climate change impacts and generating recommendations for management and development. UNEP serves on the GCRMN Management Group and administers funding for global coordination of GCRMN. Reports and findings by GCRMN and ICRAN are disseminated broadly including through the web portals ICRIforum.org and ReefBase.org. Coral reef resilience science has moved forward significantly, reflected in peer-reviewed publications on the subject. Methods for assessing coral reef resilience and resistance to bleaching have been developed through an initiative involving and/or supported by, among others, IUCN, TNC and UNEP. Reef resilience assessments have been carried out at sites in all major reef regions.	UNEP
	National Coral Reef Monitoring Program since 2002 which was updated to assess coral health status (bleaching and disease). Monitoring of bleaching events with data compared to SST anomolies and temporal variation. Coral reef monitoring of Federal MPAs incorporated into the regular marine monitoring program. University research programmes include coral reef bleaching studies, temperature and zooxanthellae photosynthesis studies for endemic species and climate change mesocosm experiments based on studies in Australia and Mexico (Coral Vivo Project). Field-based research on mesophotic reefs on the Abrolhos Bank.	Brazil
3. Capacity Building		

	Supporting training and capacity building for coral reef managers around the world in coral bleaching response and building resilience to climate change through partnerships with NGOs and other government agencies (especially TNC, US Department of State, and GBRMPA). Training workshops have covered approaches for responding to coral bleaching events, including early warning and prediction, rapid assessment, communication and management interventions. Training offered to reef managers in all seven US jurisdictions as well as key international areas. International trainings, working with the Coral Reef Alliance, have occurred in Indonesia and Mexico. Florida, Hawai'i, and the US Virgin Islands have bleaching response plans in place that cover bleaching as well as other crisis response (storms, invasive species, disease, etc.). American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and Puerto Rico all have draft response plans. NOAA is also a partner with USAID, the Department of State and the Coral Triangle Support Partnership (TNC, CI and WWF) in the US Coral Triangle Initiative Support Program for the areas of climate change adaptation, MPAs, and ecosystem approaches to fisheries based management to support coral reefs, fisheries and food security in that region. Trainings and efforts to build capacity of MPA managers to more effectively manage coral reef and coastal areas are a focus, with emphasis on reducing local stressors to increase reef resilience are being led by the NOAA Office of National Marine Sanctuaries.	NOAA, U.S.A
	Through partnerships with NGOs and other government agencies, GBRMPA has developed tools and resources to support coral reef managers in responding to coral bleaching events (both tactical and strategic), especially through improved understanding and application of resilience principles into design and management of protected areas. Supporting training and capacity building for coral reef managers around the world in coral bleaching response and building resilience to climate change through partnerships with NGOs and other government agencies (especially TNC and NOAA). Training workshops have covered approaches for responding to coral bleaching events, including early warning and prediction, rapid assessment, communication and management interventions	GBRMPA, Australia
	Building strong research capacity in the area of climate and ocean change, recruiting new research scientists into the climate change and ocean acidification team in 2011 including oceanographic modellers, geneticists, physiologists and	AIMS, Australia

	ecologists. Building a $50 million new experimental facility (SeaSim) to support research activities addressing critical questions about synergies between climate change impacts (including coral bleaching) and local scale stressors such as water quality.	
	Lead implementing agency for the South East Asia Coral Bleaching Rapid Response, a collaboration between CSIRO, NOAA and DSEWPAC	CSIRO, Australia
	Provided both self (online) and mentor guided training of trainers based on the Reef Resilience Toolkit; Conducted Training of Trainers (ToT) Workshops in the Caribbean and Pacific. Further ToT workshops are planned in Southeast Asia in 2012 and East Africa in 2013; Implemented and continue to deliver (along with NOAA, and CORAL) regional resilience training across the tropics to local partners and field practicioners); Training of a range of government and academic partners in Raja Ampat in reef fish tagging methods to study spawning aggregations Production of a quarterly e-newsletter "Reef Resilience Review" which highlights funding opportunities, network activities, and new publication and resources on resilience. Conducted webinars (Hot Topics for coral reef managers) on topics ranging from coral bleaching to facilitation techniques for managers. Conducted a number of need-based learning exchanges to share the latest science and application of resilience with coral reef managers (e.g., Hawaii/Palau exchange to address threats to watersheds and management strategies, Bleaching monitoring and analysis workshop in Bali) Facilitated the translation of the book "Coral Reefs and Climate Change" and Coral Watch materials to Bahasa Indonesia. Standard training materials and the R^2 toolkit are being translated into Bahasa, French and Spanish.	TNC
	Various Capacity Building activities have been implemented as part of the Pacific Islands Managed and Protected Area Community (PIMPAC) and the Micronesia LMMA Network	FSM
	Participation of the National Parks Unit of Colombia in a forum and training workshop conducted by TNC on coral reef resilience in 2009 Development of a Masters course to include coral bleaching as a thesis topic.	Colombia

	Preparation of a draft preliminary economic valuation of coral reefs in MPAs Provision of education campaigns and programs to coastal communities by MPA staff	
	Hosting of regional workshops which featured representatives from a wide cross-section of Caribbean countries: The Eastern Caribbean Coral Reef Monitoring and Crime Scene Investigation for Coral Reef Damage workshop in 2008, which gave regional reef managers an improved understanding of the reef monitoring occurring throughout the region and promoted best practices for coral reef assessments The Caribbean Regional Workshop on Integrated Coastal Zone Management in 2011 which featured bleaching-related discussions.	Barbados
	Reef management capacity building, including management of bleached reefs, training of trainers for reef management, and com-management has been carried out through ICRAN and its partner institutions, including UNEP and Regional Seas Conventions and Action Plans. Bleaching rapid response and management trainings have also been conducted through ITMEMS organized by ICRI and ICRAN. GCRMN continues to build reef assessment capacity	UNEP
	Undergraduate and postgraduate courses on coral reef research at a number of Brazilian Universities Training courses for volunteers and local guides in coral reef monitoring including bleaching as part of the National Coral Reef Monitoring Program	Brazil
4. Policy development and implementation		
	As part of its policy to focus on three primary threats to coral reefs, the CRCP supports scientific research to increase the understanding of coral reef ecosystem response to increasing sea surface temperature and other climate impacts and to ocean acidification to inform management and policies that conserve and protect coral reefs.	NOAA, U.S.A.
	Worked with over 85 experts to develop and apply an approach for assessing the vulnerabilities of coral reef species to climate change. This work has been published as The Great Barrier Reef and Climate Change: A Vulnerability Assessment. The Australian Government has worked with relevant state government agencies and fishery management agencies, in collaboration with fishery industry	GBRMPA, Australia

	organisations, to review fishery management arrangements, support stewardship and enforce legislation to protect coral reef ecosystems and fishery resources to improve reef resilience	
	Management planning and policy decision tools for coral reefs under climate change are being developed at AIMS in collaboration with major university partners (UQ) and key stakeholders (GBRMPA). This work will result in the first risk and vulnerability maps for Australian reefs, initially for the Great Barrier Reef. Partnerships between AIMS and DCCEE to ensure science targets are fully aligned with policy needs in a changing climate and ocean. This partnership is focused on understanding the complex landscape of climate and ocean change threats to the goods and services provided by tropical marine ecosystems, and what options for adaptation and mitigation measures are most viable. The development of Australia's first National Strategic Framework for Ocean Acidification is being led by AIMS, ANU and the Office of the Chief Scientist of Australia. The purpose is to guide policy on the development of plans to safeguard Australia's marine goods and services in a warming and acidifying ocean.	AIMS, Australia
	Worked with and advised policy makers in local and national level governments on the adoption of resilience principles for coral reef conservation, particularly the establishment of resilient MPA networks and zoning of large MPAs for resilience . Worked effectively with multiple partners to establish the Micronesia Challenge and Coral Triangle Initiative and include climate resilient MPA networks as a foundational strategy	TNC
	Development of FSM Protected Areas Network Policy and Fisheries Policy Ratification and implementation of MC Marine Measures	FSM
	Establishment of two "no take" fishing zones encompassing coral reef locations on the island; at Folkestone Marine Park and within the Carlisle Bay Protected Area.	Barbados
	The UNEP Coral Reef Unit have overall aims to: build consensus on actions to bring to sustainable levels the principal causes of coral reef decline; mobilize an international response, provide leadership in the UN system and the international	UNEP

	community and promote effective and coordinated efforts under global and regional multilateral agreements; and facilitate and encourage financing for coral reef projects. ICRI, ICRAN and GCRMN have been among the primary vehicles for implementing the CRU mandate. UNEP continues its active involvement in ICRI and GCRMN. A range of ICRI decisions and recommendations have been adopted, related to, inter alia, climate change, coral bleaching and MPAs, coral reef resilience, acidification, trade, disease, SIDS, different aspects of fisheries, MPAs, reef monitoring etc.	
	Taken several measures to protect coral reefs, most notably, the law of environmental crimes and the law of the national system of protected areas Implemented a biodiversity national strategy and a climate change national plan	Brazil
5. Finance		
	Supports domestic US and international partners with management authority (federal, state and local) in activities to help conserve and protect coral reef ecosystems through internal NOAA funds, external grants, and cooperative agreements in the seven US states and territories with coral reef ecosystems, as well as its four international priority geographies (the Insular Caribbean, Micronesia, Samoa/Southwest Pacific, and the Coral Triangle).	NOAA, U.S.A.
	AIMS research activities are supported by a combination of Government support (appropriation) and external funding. AIMS' total revenue is around A$50 million per year with around 40% from external sources.	AIMS, Australia
	Provided advice, guidance, and funding for establishment of the Micronesia Conservation Trust fund that supports the Micronesia Challenge jurisdictions establish and manage resilient MPAs Raises funds from foundations and private individuals as well as governmental aid agencies to support joint coral reef resilience projects, training and other activities with national and local partners	TNC
	Finance provided through sub-national public fund allocations and Bilateral or Multilateral Cooperative Agreements and Grants	FSM
	Bilateral and multilateral funding agreements, including a notable matching grants scheme through a donation to the United Nations Foundations in support of ICRAN.	UNEP

	Funding from international agencies (GEF, UNDP, World Bank) for recent and planned activities: Development of a project to support the definition and implementation of pilot adaptation measures and policy options to foresee the impacts of climate change (INAP project), funded by the World Bank GEF resources.; Starting a GEF-UNDP Project for the Implementation of a Subsystem of Marine Protected Areas for the conservation of coastal marine ecosystems	Colombia
	Creation of a Government Climate Fund that can fund some relevant activities	Brazil

Annex II: Examples of activities by Parties that support the implementation of the specific work plan on coral bleaching.

(Information provided in the 3rd or 4th National Reports submitted to the CBD)

Priority area	Country	Nature of approach
1. Management actions and strategies to support reef resilience, rehabilitation and recovery	Bahamas	Two areas of the Andros Barrier reef protected and a large expanse of the North Bight mangrove and wetland became part of the National Park System Some systematic long-term coral reef monitoring at the ecosystem level
	China	Establishment of eight coral reef reserves with a total protected area of 562 km^2 Implementation of ICZM and reef restoration programmes
	Cook Islands	Establishment of a network of marine raui (traditional marine protected area) which cover almost 10% of the coral reef area. Regular monitoring of coral reef lagoons on four islands
	Indonesia	Long-term coral reef monitoring as part of the Coral Reef Rehabilitation and Management Program (COREMAP) Implementation of the Coral Triangle Initiative to address key issues related to: seascapes priorities, the ecosystem approach, marine protected areas, climate change adaptation, and threatened species
	Malaysia	National Action Plan for the Management of Coral Reefs in 2008 plan includes strategies on conservation, resource management, education, communication, integrated planning, capacity building, recognition of local communities and stakeholder interests, management processes and legislation
2. Information Gathering and Targeted Research	Belize	The Caribbean Community Climate Change Centre and the World Bank are conducting coral reef resilience research in order to assess the effects of climate change impacts on the reef ecosystem. Establishment of a Synoptic Monitoring Programme as part of the Meso-American Barrier Reef System Project (MBRS)
	Brazil	Brazilian Coral Reefs Conservation Program with the objective to establish a network for the protection of corals has published of the Atlas of Coral Reefs in Brazilian Protected Areas; run a campaign for responsible conduct in reef environments; manages the National Coral Reef Monitoring Program; and the research-based Living Coral Project Project Global Climate Change and Coral Bleaching in Brazil is a scientific study to evaluate the effects of the sea water temperature increase on coral zooxanthellae, and the capacity of corals to tolerate and/or adapt to abrupt environmental changes

Priority area	Country	Nature of approach
	Indonesia	WWF Indonesia manages a coral reef monitoring programme at a number of sites on Bali, Papua, Java, and Sulawesi. Resilience assessments and regular monitoring for bleaching have been conducted as part of the Friends of the Reef programme.
	Israel	National Monitoring Program for the Gulf of Eilat, implemented by the Interuniversity Institute in Eilat, with the following objectives: • Test and assess the state of the Gulf of Eilat ecosystem • Define criteria for the "health" of the Gulf of Eilat ecosystem • Determine the impact level of different pollution sources on the state of the ecosystem. • Issue alerts on potential dangers to the system. • Establish a computerized database of oceanographic data for the Gulf of Eilat • Consolidate and propose recommendations for environmental
	Seychelles	Seychelles National Climate Change Committee (NCCC) coordinates the development and implementation of the national climate change programme. Recent NCCC projects: • "Integrated Coastal Zone Management in the Seychelles" which included monitoring of coastal sea-circulation and beach erosion, monitoring changes in plankton and coral reef benthic communities and assessment of cost-effective adaptation options for sea level rise. • "Monitoring and assessment of the effects of climate change on fisheries in the Seychelles", implemented by Seychelles Fishing Authority (SFA), involving coral reef and marine environmental monitoring and fish stock assessment.
3. Capacity Building	Indonesia	Stakeholder partnerships, community participation programmes and public education campaigns on corals have been collaboratively conducted by MMAF, Ministry of Forestry, Ministry of Culture and Tourism, COREMAP, relevant NGOs and professional organizations.
	Belize	Education and training opportunities for schools, teachers and the general public have been facilitated through many different agencies. Institutions actively involved in education, training and awareness programmes include the Mesoamerican Barrier Reef System Project among many others. Training opportunities have been offered to fishermen to introduce alternative livelihood options, primarily in the tourism trade.
	Jordan	Collaboration with other countries and entities such as the European Union (EU) for capacity-building and improvement of management of marine and coastal resources through training and directed courses

Priority area	Country	Nature of approach
		held in other more advanced countries. One example of capacity building is the establishment of a specialized environmental laboratory. Other tasks of training are also coordinated with the Marine Science Station in the City of Aqaba.
	Samoa	Several training workshops, seminars and other activities completed in conjunction with specific projects – e.g. • GEF-SGP workshop on marine based community projects in Tafagamanu in 2008. • Community-based training in coral gardening and replanting techniques by METI (local NGO), and MAF between 2004 and 2008as part of several GEF-SGP funded marine conservation projects.
	Sudan	A number of scientists have been trained (via training workshops organized by PERSGA) in marine protected area management and field surveys, integrated coastal zone management, environmental impacts of development projects, management of solid wastes in industrial areas, and improvement of wastewater management. Demonstration activities for coral reef monitoring (funded by PERSGA) are being carried out by Sudanese scientists
4. Policy development and implementation	Antigua and Barbuda	National coral reef targets and goals for Antigua and Barbuda were developed in 2009 as part of the national GEF project, Sustainable Island Resource Management Mechanism (SIRMM). Examples of targets are Target 1.3 to Conserve 10% of reefs for Dive Tourism only, and Target 1.6: Ecosystems protection incorporated into Climate Change Adaptation Strategy Aspects of the coral reef work plan addressed in the NBSAP include fisheries management, increasing environmental awareness of fishers and developing a coral reef monitoring programme
	Maldives	Biodiversity considerations appear in the plans, policies and activities of the Environmental sector. The Maldives National Adaptation Program of Action (NAPA 2007) contains specific adaptation needs and measures to protect coral reef biodiversity including: • Providing alternatives to coral and sand as construction materials and enforce the ban on coral mining. • Enhancing the capacity for waste management to prevent pollution of the marine environment. • Formulating and implementing an oil pollution contingency plan. • Acquiring appropriate sewage treatment technologies. • Establishing marine protected areas. • Establishing an information base on coral reefs and climate change.

Priority area	Country	Nature of approach
		• Undertaking monitoring and research to prevent coral diseases and rehabilitate coral reefs. • Developing measures to protect coral reefs from development activities. The Maldives National Strategy for Sustainable Development (NSDS 2009) also identifies a goal with operational objectives, corresponding targets, and proposed actions on protecting coral reefs. Three targets identified to achieve this goal are giving protected status to 5% of coral reefs, banning reclamation of reef areas and fish breeding grounds and banning export of reef fish.
	Mauritius	The Fisheries and Marine Resources Act makes provision for the sustainable use of the marine resources by requiring the implementation of: • Closed seasons to coincide with the peak-spawning season of most reef fishes; introduction of a 2 year moratorium inhibiting harvesting of sea cucumber starting 2009; • Control on the use and ban on certain types of fishing gear, continuing buy back scheme for nets, promotion of FAD fishery are all measures introduced for reducing pressure on the lagoon. • The establishment and management of six fishing reserves and two marine parks in Mauritius and 5 designated marine reserves and 1 marine park in Rodrigues; • Rehabilitation of Mangrove areas and propagation at new sites Implementation of the "Africa Adaptation Project: Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Mauritius" with the objective to integrate and mainstream climate change adaptation into the institutional framework and into core development policy, strategies and plans of Mauritius.
	Saint Lucia	Fishing restrictions were imposed in order to protect the biodiversity of the environment: • Establishment of a fisheries advisory committee, fisheries access agreements, local and foreign fishing licensing, • Governs fish processing establishments, fisheries research, fisheries enforcement and the registration of fishing vessels; • Provides for conservation measures such as prohibiting the use of any explosive, poison or other noxious substance for the purpose of killing, stunning, disabling, or catching fish; close seasons, gear restrictions; • Creation of marine reserves; • Creation of new regulations for the management of fisheries as and when necessary

Priority area	Country	Nature of approach
	Thailand	Department of Marine and Coastal Resources drafted strategic and action plans on coral reef management. The overall target of the strategic plan is to have 96,000 rais (approx. 38,000 acres) of coral reefs effectively managed within a 5 year period, with community's participation in integrated management.
5. Finance	Maldives	Central government financial support and overseas donor assistance provide the main funding resources, with a very limited amount of private sector funding support. Environmental protection has consistently accounted for less than 1% of the total over a 6 year period. Overseas Development Assistance (ODA) is a significant part of the Maldivian government's revenue, accounting for over 40% of total government revenue in 2007 but environmental spending comprises just 3% of all donor support to the Maldives.
	Samoa	Eleven GEF-SGP community based conservation projects targeting mangroves (5) and coral reefs (6) received funding between 2007 and 2008. Cyclone Emergency Recovery Project - Coastal Ecosystems Recovery component (CERP-CER): Recovery/improved resilience of coastal ecosystems affected by the previous cyclones. Arrangements and partnerships with CERP Steering Committee (Ministry of Natural Resources, Environment and Meteorology, Ministry of Finance, Ministry of Works, Transport and Infrastructure, METI (local NGO), IPA, MWCD, World Bank). Cyclone Emergency Recovery Project Small Grant Scheme (CERP-SGS) aimed to 1. Strengthen the resilience of coastal communities and groups vulnerable to the impacts of natural hazards by supporting local community groups, NGOs and other eligible entities carry out non-structural and practical interventions at the community levels. 2. Provide opportunities for direct community involvement in coastal hazard management. Timeframe: 2005-2009. Arrangements and partnership with CERP Steering Committee (MNRE, MoF, MWTI, METI, IPA, MWCD, WB). Samoa's Marine Protected Area (MPA) Project aimed to empower village communities with the capacities for conserving and using sustainably their coastal and deep sea marine resources. Timeframe: 2000-2009. Arrangements and partnership with MNRE, local communities, MAF, CI. Programme of Works for Protected Areas Project: Establishment of protected areas & rehabilitation of degraded ecosystems from 2008-2009. Arrangements and partnership: PoWPA Steering Committee (MNRE, MAF, MWCD, SUNGO, Vaiusu bay communities.
	Singapore	The Coral Nursery Project, a collaboration between NParks, National University of Singapore (NUS), National Environment Agency (NEA) and Keppel Corporation, focused on the ex-situ conservation of corals and aimed to enhance the ecological health of corals by maximizing the survival potential of

Priority area	Country	Nature of approach
		naturally occurring "corals of opportunity" (corals fragmented by impact). Timeframe: 2007-2009.
	Kenya	The Kenya Marine and Fisheries Research Institute's (KMFRI) research efforts in corals and mangroves attracted donor funding by many international institutions including the European Union, the FAO, USAID, UNESCO, UNEP and the Belgian Government in the framework of the Kenya-Belgium Project in Marine Sciences.
	Belize, Guatemala, Honduras and Mexico	The Mesoamerican Barrier Reef System (MBRS) Project assisted in concretizing the Tulum Declaration, which calls for the sustainable use and protection of the Barrier Reef System and its biodiversity. The MBRS Project was funded by the Global Environment Facility (GEF) and the Governments of Belize, Guatemala, Honduras, and Mexico. It was implemented by the World Bank and executed by the four countries through CCAD. The MBRS project was executed by the Project Coordinating Unit (PCU) on behalf of CCAD, with headquarters in Belize City, Belize. Funds available for the implementation of the project activities were shared among the four countries, on an annual basis, according to its operational plan. More than $11.6 million US dollars were disbursed to the four countries of the MBRS region during the life of the project.

Annex III

ASSESSMENT OF THE IMPLEMENTATION OF THE SPECIFIC WORK PLAN ON CORAL BLEACHING AND SUGGESTIONS FOR REPRIORITIZATION

Section	Work Plan Action	Implementation	Importance	Change Priority?
1.	**Management Actions and Strategies**			
1.a.i.	Identification of coral-reef areas that exhibit resistance and/or resilience to raised sea temperatures	Partly – some areas identified but many more required	Highest Priority	No
1.a.ii.	Identification, development, testing and refinement of management regimes to enhance reef resilience to and recovery from raised sea temperatures and/or coral bleaching, through the application of, *inter alia*, appropriate protective status, reduction of reef stressors, management of reef communities, etc.	Partly – management regimes developed but require further testing in a range of reef areas and further refinement	Highest Priority	No
1.a.iii.	Investigation of factors that enable such resistance such as, *inter alia* cool currents, cold upwellings, genetic tolerance in certain species and genotypes of corals to raised sea temperatures, presence and necessary abundance of reef associated biodiversity that imbues reef systems with resilience to raised sea temperatures and/or coral bleaching;	Partly – good progress for coral genetic work and resilience criteria but less so for environmental variables. Further development of resilience indicators required	Priority	No
1.a.iv.	Investigation of the role(s) of sea currents, local and larger scale, in the resistance and/or resilience of coral reefs to raised sea temperatures and/or coral bleaching.	Partly – e.g. thermal tolerance research by NOAA in Palau	Priority	No
1.b.i.	Establish or expand as appropriate, and begin to implement, international support programmes to developing countries, countries with economies in transition, and in particular, least developed countries and small island developing states, to support such activities	Partly – some international support programmes available but not all LDC's and SIDs are fully involved	Highest Priority	No
1.c.i.	Explore utility and feasibility of short-term management interventions to reduce severity of bleaching or to facilitate recovery after bleaching	Partly – e.g. GBRMPA working with the tourism industry	Highest Priority	No
1.c.ii.	Instigate and support initiatives for marine protected areas managers where resilience principles are being actively applied and tested	Partly – support available in some locations through the reef resilience network	Highest Priority	No
1.c.iii.	Encourage the application of resilience principles in coral reef areas	Minimal	Highest	No

	outside marine protected areas		Priority	
1.d.i.	Establish programmes that provide information and resources to support understanding and application of resilience principles into the design (of MPAs and MPA networks)	Partly – Programmes are in place but need to be implemented in more localities	Highest Priority	No
1.e.i.	Assist reef managers to identify, implement and justify actions that can reduce localized stressors on reefs that will increase reef resilience to mass bleaching	Partly – Assistance provided but geographic coverage needs to increase	Highest Priority	No
2.	**Information Gathering**			
2.a.i.	Document instances of mass bleaching, and the impacts of coral-bleaching and coral-mortality events on social and economic systems, and provide relevant information to the Secretariat through the GCRMN	Partly – good documentation of bleaching events but impacts on socio-economic systems requires further work	Highest Priority	No (for socio-economics)
2.a.ii.	Compile, and disseminate through the clearing-house mechanism, current 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	Not known – information for survival is available but not sure if it has been compiled and disseminated	Highest Priority	?
2.a.iii.	Collaborate with the GCRMN to 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	Partly – ReefBase and Reefs at Risk Revisited for status and threat level but data quality and methods used in other studies are not always available	Priority	No
2.a.iv.	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.	Partly – GCRMN networks and Reef Resilience Network strengthened but long-term trends data not widely available	Priority	No
2.a.v.	Support further targeted research programmes that investigate: a. The mechanisms that cause of mass bleaching specifically, explanations for variation in bleaching patterns, identification of bleaching thresholds, and synergistic relationships between local threats and warming seas. b. The impacts of coral bleaching and coral mortality events on social and economic systems; c. Management options to building reef resilience to mass bleaching on both short- and long-time frames;	a. Yes – via various research programmes b. Partly – some economic data but less work on social impacts c. Partly – by using MPA networks and minimising local threats	Priority	No

2.b.i.	Implement baseline assessments and long-term monitoring to measure the extent and severity of coral bleaching, mortality and recovery and identify reef areas that exhibit resistance and/or resilience to raised sea temperatures	Partly – good implementation of assessments in some countries but less so in others	Highest Priority	No
2.b.ii.	Compile information on the socio-economic impacts of coral bleaching on communities dependent on coral reefs	Partly – SocMon recently released a draft set of indicators to assess the community-level social vulnerability to climate change for field testing	Highest Priority	No
2.b.iii.	Widen, as necessary, the research on socio-economic impacts of coral bleaching on communities dependent on coral reefs	Partly – but for overall climate change impacts e.g. in the Western Indian Ocean	Highest Priority	No
2.b.iv.	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	Yes – Reef Resilience Network training programmes	Highest Priority	No
2.b.v.	Support ongoing assessment and monitoring initiatives, such as those of UNESCO, ICRAN, the regional seas conventions and action plans, GCRMN, UNEP and CORDIO;	Yes – on-going support required	Priority	No
2.b.vi.	Encourage and facilitate large-scale (ecosystem) monitoring programs that can generate an understanding of the large scale (both temporal and spatial) impacts of coral bleaching, with a particular focus on the cumulative ecosystem-level impacts of successive coral bleaching events	Partly – significant work completed at the regional scale in the Western Indian Ocean but less work on cumulative impacts	Priority	No
2.c.i.	Support the development of standardized training modules and manuals on detection and documentation of coral-bleaching events, mortality or recovery monitoring	Yes – bleaching assessment toolkits and guidelines developed	Highest Priority	Yes - downgrade
2.c.ii.	Build capacity and facilitate the development and implementation of coral-bleaching response plans, taking into account expert guidance, by organizations responsible for managing and conserving coral reefs	Partly – response plans are in place in some countries but not others	Highest Priority	No
2.c.iii.	Organize, in conjunction with relevant agencies and organizations, 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	Partly – annual meetings occur in some regions through Coral Reef Task Forces, but are absent or less frequent in other regions	Priority	No
2.d.i.	Strengthen dissemination of existing assessment and monitoring	Yes – available through	Highest	Yes -

	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)	ReefBase	Priority	downgrade
2.d.ii.	Include coral bleaching in existing national biodiversity strategies and action plans under the Convention on Biological Diversity.	Partly – include in some national strategies and action plans but not others (capacity issue)	Priority	No
2.d.iii.	Support and collaborate with GCRMN the expansion of existing networks and initiatives at the regional and national level conducting coral-reef status assessments and monitoring.	Partly – further expansion is recommended to incorporate all coral reef nations	Priority	No
2.e.i.	Recognizing that coral bleaching is a cumulative-stress response (i.e. global warming is the most widespread stressor, but known localized human-induced stresses exacerbate events), develop education programmes addressing an ecosystem approach to coral-reef management and the relation between coral-reef health, resilience and other human-induced stresses	Partly – ecosystem- and resilience-based programmes developed but not implemented in all regions	Highest Priority	No
2.e.ii.	Encourage space agencies and private entities to maintain deployment of relevant sensors and to initiate design and deployment of specialized technology for shallow-oceans monitoring;	Not known	Priority	?
2.e.iii.	Expand the use of existing early warning systems and support the development of Web-based early warning systems and other means (for example, in situ temperature loggers);	Yes – web-based early warning system(s) available and other regional systems in place. Some further expansion possible	Priority	No
2.e.iv.	Encourage mechanisms to make accessible high-resolution multi-spectrum imagery at low cost to coral-reef scientists and managers worldwide with a view to those scientists and managers that are based in developing countries;	Not known	Priority	?
2.e.v.	Work with the UNEP Division of Environmental Information, Assessment and Early Warning, GCRMN and other relevant organizations to develop local community capacity for remote and local level validation exercises, and training in interpretation of weather patterns related to the onset of bleaching;	Not known	Priority	?
2.e.vi.	Assist in developing and enhancing national and regional capacities of developing coastal States, and in particular small island developing States, on monitoring, interpretation, and application of climatic and oceanographic data related to the onset of bleaching	Partly – through regional initiatives and targeted research and capacity programmes (e.g. CRTR)	Priority	No

2.f.i.	Support initiatives to build capacity among reef managers to access and apply scientific information relevant to climate change and coral bleaching	Partly – via the Reef Resilience Network but should be scaled up	Highest Priority	No
2.f.ii.	Develop and support initiatives to foster active working relations between scientists and managers that can increase capacity to effectively respond to global change threats to local reefs;	Partly – e.g. the CRTR Project	Priority	No
2.f.iii.	Encourage investigations into the relationship between coral-bleaching events and long-term meteorological data.	Yes – partly – used for bleaching event predictions and projections	Priority	No
3.	**Capacity Building**			
3.a.i.	Support activities aimed at building awareness and capacity relating to implementation of tools for responding to mass bleaching events	Partly – e.g. via the Reef Resilience Network but should be scaled up	Highest Priority	No
3.b.i.	Develop and/or expand training opportunities for protected area managers, fishery 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	Partly – via ICRAN, Regional Initiatives, ITMEMS and international / national NGOs but needs further expansion to reach more managers and stakeholders	Highest Priority	No
3.b.ii.	Encourage a network of reef management agencies in developed and developing countries, and encourage relevant exchange programmes between countries and/or regions involved in coral-reef management with particular emphasis on coral bleaching, bleaching related mortality and subsequent recovery	Partly – development or strengthening of some networks e.g. via CORDIO or other regional programmes	Highest Priority	No
3.b.iii.	Gather, and disseminate through the clearing-house mechanism, information on existing training programmes on integrated coastal area management, best practices and related issues to sustainable management of coral reefs	Yes – available via ICRAN, IUCN, (FAO) and UNEP	Highest Priority	No
3.b.iv.	In recognition of the important implication of climate change for coral reefs, encourage and facilitate greater understanding within agencies responsible for reef management about coral bleaching and related global change issues for coral reefs;	Partly – but further understanding of global climate change issues is needed	Priority	Yes – upgrade
3.b.v.	Encourage incorporation or support the issue of coral reefs and bleaching in the capacity building activities of multilateral environmental agreements (e.g. Ramsar Convention, Cartagena	Partly – also need to incorporate other global change issues such as ocean acidification	Priority	Yes – upgrade

	Convention) and of their respective contracting parties;			
3.b.vi.	Collaborate with GCRMN and other relevant organizations to develop standardized training modules and facilitate programs to build capacity in detection and documentation of coral- bleaching events and subsequent recovery, based on international Protocols and Manager's Guides currently under development;	Yes – standardized modules and protocols available	Priority	Yes – downgrade
3.b.vii.	Organize, in conjunction with relevant agencies and organizations, regular 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	Partly – regular meetings occur in some but not all regions.	Priority	No
3.b.viii.	Create scholarship trust funds in each region of the regional seas programmes to provide scholarships at graduate/postgraduate level for studies on coral-reef conservation and management, giving special consideration to small island developing States	Not known	Priority	?
3.b.ix.	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.	No – should be revised to include all global change impacts e.g. ocean acidification	Priority	No
3.c.i.	Support ICRI and GCRMN activities that encourage and support multidisciplinary approaches to coral-reef research, monitoring, socio-economics and management	Partly – not all countries are involved in GCRMN or ICRI	Highest Priority	No
3.d.	Build stakeholder partnerships, community participation programmes, and public-education campaigns and information products that address the causes and consequences of coral bleaching	Partly – need to broaden to include all climate change impacts	Highest Priority	No
3.d.i.	Bridge the gap between global and local action through the creation of national and sub-regional coral-reef initiatives	Partly – via ICRAN – but need to re-start and expand ICRAN initiatives at the national and sub-regional level	Priority	Yes - upgrade
3.d.ii.	Collaborate with relevant organizations to compile and disseminate relevant information from status-of-reefs reports, *Reefs at Risk*, etc., and examples of effective practical materials for general public, the media, private sector and policy makers.	Partly – Reefs at Risk Revisited (2011) GLOBE Action Plan for Coral Reefs (2010) targeted legislators	Priority	No
3.d.iii	Collaborate with relevant organizations to develop educational	Not known	Priority	No

	programmes on the relationship between coral reefs and larger marine systems (e.g. impacts of coral-reef loss on fisheries, local communities etc.).			
4.	**Policy Development and Implementation**			
4.a.				
4.a.i	Integrate in existing policies at the regional and national levels the priority issues identified by ICRI and ITMEMS;	Partly – integrated into some national and regional policy (e.g. Regional 'Challenges')	Priority	No
4.a.ii	Assess relevant actions of existing policy frameworks and how these are directly addressing the integrated marine and coastal areas management, in particular coral-reef issues;	Not known	Priority	No
4.a.iii	Make use of the regional seas programmes and other regional agreements (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;	Partly – but further development required	Priority	No
4.a.iv	Identify and institute additional and alternative measures for securing the livelihoods of people who directly depend on coral-reef services:	Partly -	Priority	No
4.a.v.	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	Partly – but further expansion into all coral reef regions required	Highest Priority	No
4.a.vi	Develop pilot projects for transitioning dependent communities to alternative and sustainable livelihoods	Minimal – requires considerable attention	Highest Priority	No
4.b.	Initiate efforts to develop joint actions, including between national focal points, among the CBD, the UNFCCC, and the RAMSAR Convention to:	Unknown -joint actions in place between the CBD and RAMSAR but not between CBD and UNFCCC	Highest Priority	No
4.b.i.	Develop approaches for assessing the vulnerability of coral-reef species to global warming	Unknown	Highest Priority	No
4.b.ii.	Build capacity for predicting, monitoring and managing the impacts of coral bleaching and related mortality	Unknown	Highest Priority	No
4.b.iii.	Identify approaches for developing response measures to coral bleaching	Unknown	Highest Priority	No
4.b.iv.	Provide guidance to financial institutions, including the Global Environment Facility (GEF), to support such activities	Unknown	Highest	No

			Priority	
4.b.v.	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;	Unknown	Priority	No
4.b.vi.	Gather the outputs of the Caribbean GEF project on climate change adaptation (CPACC project) as a contribution to activities (i)-(iv) above, and disseminate relevant findings through the clearing-house mechanism and other mechanisms;	Unknown	Priority	No
4.b.vii.	Further development of response measures to coral bleaching and potential guidance to financial institutions, including the GEF may be needed;	Unknown	Priority	No
4.b.viii.	Develop, through a transparent consultative process, a list of international research priorities to support reef management information needs and to guide funding institutions	Unknown	Priority	No
4.c.i.	Establish no-fishing zones and limitations on fishing gear to protect breeding grounds and provide fish with refuges as well as increase reef resilience	Partly – no-fishing zones and gear restrictions established in many countries	Highest Priority	No
4.c.ii.	Enforce legislation prohibiting destructive fishing practices that further damage coral-reef ecosystems and reduce reef resilience	Partly – national and local legislation established in some countries	Highest Priority	No
4.c.iii.	Encourage investigations of potentially deleterious effects of changes in oceanographic patterns and resulting impacts on target fish stocks resulting from sea-surface temperature rise;	Partly – modelling work published as a global study but not for individual stocks – possible for stocks as methodology in place.	Priority	No
4.c.iv.	In collaboration with FAO, investigate strategies for management of coral-reef fisheries that are demonstrably sustainable with respect to fished stocks and the ecosystems that produce them.	Not known - but best practise fisheries management case studies available	Priority	No

5.	**Finance**			
5.a.i.	Identify financial and technical assistance for the implementation of this work program	Partly – financial assistance provided by developed countries both unilaterally and multilaterally but many developing countries could not fully implement the work plan due to lack of technical capacity and funding	Highest Priority	No
5.a.ii.	Identify financial and technical assistance mechanisms of national and private sources to assistance communities impacted by coral bleaching	Partly – via Climate Funds for (ecosystem-based) adaptation funding to build socio-ecological resilience	Highest Priority	No
5.a.iii.	Promote programmes that identify the relationships among financial and technical development assistance and environmental project funding.	Not known	Priority	?
